Biosciences for Antibiotic Resistance: A mixed methods study assessing the level of knowledge and learning experiences among preregistration nursing students in Uganda

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List of tables and figures

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Abstract

Biosciences form the basis on which our understanding of human biology and body functions is established. They guide nurses to detect risks to health and improve and sustain health through informed decisions. Task-shifting has expanded the scope of practice for nurses in Uganda and increased the need for improved understanding and application of bioscience knowledge in clinical practice. In Uganda, there is limited evidence of the success of current science teaching in supporting the retention and application of biosciences in clinical practice.

Antibiotic resistance, a bioscience concept on the preregistration curriculum and applicable to clinical practice, was used in this study as an indicator of the level of bioscience knowledge among nursing students. The aim of this study was to understand nursing students' current level of bioscience knowledge, the associated factors, and their experiences of learning and applying biosciences in Uganda.

This study utilized a two-phase sequential explanatory design. Phase one used two sources of data. Initially, secondary data originally collected from 203 students in one university was used to assess performance between bioscience and non-bioscience courses. Then, a quantitative cross-sectional descriptive survey was used to understand the level of explicit knowledge of antibiotic resistance and the factors associated with acquisition of that knowledge. Data were collected from 207 students in the 3rd and 4th year, across four universities. Phase two utilized a hermeneutic phenomenological design to explore students' experiences of learning and applying biosciences in clinical practice. Qualitative data was collected using three focus groups (n = 19) from one university, to explain and expand on the quantitative results.

Failure rates in biosciences and non-biosciences were 15% and 0.5% (n = 203) respectively. The bioscience and non-bioscience scores were statistically significant for each student (Z= -11.203, p = 0.000) and by group (p = 0.000). Higher failures rates of 21.3% (n = 207) were recorded from the survey data. Sixty percent and 70% (n = 207) of the students failed core bioscience knowledge and clinical application questions on antibiotic resistance, respectively. Only 30% reported good antibiotic use and 48% passed questions on antibiotic resistance. Overall bioscience success was statistically associated with age group (p = 0.033), route of entry on the nursing program (t = 13.438, p = .001), employment status (p = 0.001), and university (p = 0.025). Core bioscience knowledge was significantly associated with the university of study (p = .000). Clinical application of bioscience knowledge was significantly

associated with age group ($p = 0.049$), route of entry ($z = -3.307$, $p = 0.001$), and employment status ($z = -3.277$, $p = 0.001$).

Four themes emerged from the qualitative phase: the bioscience curriculum; teaching methods; clinical supervision; and assessment and feedback. There was consensus that the bioscience portion of the nursing curriculum was crowded. Students perceived lectures to be ineffective in conveying complex bioscience concepts. Medical doctors on the wards were perceived to be the most important resource of bioscience knowledge, although integration to clinical nursing practice was limited. Bioscience teaching in practice settings was sidelined in favour of clinical nursing skills. There was a general lack of clinical supervision. The model of clinical supervision was perceived to be ineffective in supporting the integration and application of biosciences. Participants expressed dissatisfaction with their assessments and feedback due to poor alignment with teaching, assessor absenteeism, and reduced time allocated to assessments. This limited their ability to identify learning gaps and improve on bioscience knowledge and application to clinical practice.

Nursing students in Uganda struggle to retain and apply biosciences. Several challenges within their universities and clinical placement sites contribute to the bioscience problem. This study calls for reforms in bioscience curricula, teaching, clinical supervision, and assessments to support registered nurses to competently tackle healthcare challenges such as antibiotic resistance upon graduation.

Chapter 1: Introduction

This chapter presents nursing in Uganda, the context in which the study took place. It discusses how the shortage of physicians increased reliance on nurses and how this has expanded the role of nurses. It also introduces the registered nurses, a more recent addition to the nursing workforce in Uganda, compared to contexts such as the UK. Although the preregistration curriculum in Uganda has a strong bioscience presence, Preregistration Nursing Students appear to struggle to learn and apply biosciences in clinical practice. We know very little about biosciences within nursing education and practice in Uganda. For example, there is limited evidence on the level of explicit bioscience knowledge that nursing students currently have as they exit formal education and enter practice. We do not yet know which factors inherent within the students, academic contexts, and clinical practice contexts promote or impede retention and application of biosciences. This thesis addresses the need for nurse education needs to re-examine the curriculum and strengthen the science component and application of aspects such as antimicrobial resistance and COVID-19, which are currently threatening the strides made in healthcare.

Nursing in Uganda

As in many other countries, nurses and midwives constitute the largest healthcare workforce in Uganda, a percentage as high as 80% according to the Ministry of Health Uganda (MoH, 2007). Nurses and midwives form the backbone of the healthcare service provision in Uganda (Nursing Now, 2018), especially in rural areas where over 75% of the population resides according to the World Bank estimates (World Bank, 2021). Uganda not only has a shortage of healthcare professionals, but also inequitable distribution and inappropriate skills mix between rural and urban areas (AHWO, 2009). For example, the county's central region (including the capital, Kampala) employs about over 65% of the nurses and midwives, 71% of the doctors, and about 81% of the pharmacists (AHWO, 2009). The distribution of nurses in Uganda stands at 40% in urban areas, yet these only serve 13% of the entire populace (MoH, 2010). The 2010/2011-2014/2015 Health Sector Strategic Plan reported a 53% nurse vacancy rate at the lowest level (Health Centre II).

The shortage of doctors and meagre healthcare budgets have constrained Uganda's ability to successfully attract and retain the required numbers and quality of physicians (Ssengooba et al., 2017). As a result, Uganda has increasingly relied on nurses and other non-

physician health professionals to deliver healthcare services to the public (Dawson et al., 2015). This greatly expanded nurses' roles, thrusting them into roles they were not formally prepared and adequately supported to undertake (Afolabi et al., 2019; Ssengooba et al., 2017). For example, the pre-service training of enrolled (certificate) nurses predominantly focusses on procedural skills and the associated treatment (Shariff, 2014). Their educational assessments are primarily on factual recall and skills demonstration of defined skills (Yvonne Botma, 2014). A recent review of the curriculum for certificate nurse training was largely in response to the increasingly common trend where enrolled nurses take on task-shifted roles with minimum supervision (MoES, 2018).

The inappropriate skills mix and inequitable distribution of the health workforce especially in the rural areas where most of the population lives prompted Universities to adopt a Community Based Education curriculum. It would give students in the healthcare professions the opportunity to practice in rural contexts, with the hope that they will feel comfortable to work in similar areas during their career. Although the literature on the success of the CBE curriculum in Uganda is limited, a systematic review of the factors influencing health workers to work in rural areas across the six countries that form the East African Community (EAC), suggests that the determinants of the distribution of health workers are complex. These factors are individual, health facility-based, and health system-based in nature.

For example, Namusoke Kiwanuka et al. (2017) suggested that individual factors were the primary reasons for retention of rural health workers in Eastern Uganda. Muthuri et al. (2020) agreed, stating that whereas the demotivating factors to working in rural areas were mainly organizational or structural in nature, personal factors were dominant in influencing health workers' decisions to continue working in rural settings. Namusoke Kiwanuka et al. (2017) described them as "a balance between the cost of leaving and the cost of living", further noting that these depended on the person's age and their stage in their career.

Secondly, altruism strongly determined the distribution of health workers in rural areas across the EAC. For example, many studies reported health workers working way beyond the hours stipulated in their contracts and giving extra support to their patients. Many health workers wanted to serve the community, promote behavioural change, and reported feeling a sense of personal responsibility to care (Chin-Quee et al., 2015; Kaye et al., 2010; Mpembeni et al., 2015; Sanou et al., 2016). Other personal factors cited included staying near

their own families, maintaining community ties, as well as having opportunities to invest and accumulate wealth in more familiar contexts (Muthuri et al., 2020; Namusoke Kiwanuka et al., 2017). Job security and stability emanating from holding a permanent and pensionable job, as is the case for most public sector jobs, motivated many of them to stay on their jobs (Namusoke Kiwanuka et al., 2017).

Lastly, the health workers who stayed on in rural settings were inclined to overlook the poor infrastructure and adapt to their work environment, citing that the situation was generally similar across the country. They seemed resigned to the fact that the situation would not change much soon and that migrating to other parts of the country was pointless and unrealistic (Namusoke Kiwanuka et al., 2017). Although there is a consensus that availing accommodation for staff near their workplace likely motivated the rural healthcare workforce to stay, it was not always the case in Eastern Uganda. For example, availability of staff accommodation was viewed as a source of stress for staff who had heavy workloads due to understaffing because they risked being compelled to work longer shifts (Namusoke Kiwanuka et al., 2017). Although this was a concern, it was not enough for them to quit their rural jobs. What was unbearable was the lack of equipment because it limited their ability to utilize their knowledge and skills amidst other shortages. Delayed salaries and inadequate compensation were also cited as deterrents, but they reportedly managed these by taking on other additional jobs to supplement their incomes (Namusoke Kiwanuka et al., 2017). The above discussion suggests that adopting a CBE curriculum for health professions students is only part of the solution to the longstanding inequitable distribution of healthcare services especially for the majority poor who live in rural areas.

Nurses in Uganda work in a variety of contexts from private and public facilities to Private-not-for Profit (PNP) organisations and from the lowest level of healthcare (Health Centre 2 facilities) to the national referral hospitals. Task shifting, the process of assigning roles of more highly skilled personnel to lower cadres, is a common practice in Uganda (Baine & Kasangaki, 2014). Nurses and clinical officers (non-physician clinicians) in Uganda perform roles such as prescription of some medications, circumcision, eye cataract removal, and setting up of intravenous lines that were traditionally the responsibility of doctors (Baine & Kasangaki, 2014). Although there is no official policy or implementation plan backed up by resources and training, task shifting has been successfully implemented in the diagnosis and management of malaria (Hopkins et al., 2007), HIV/AIDS (Vasan et al., 2009),

tuberculosis (Baine & Kasangaki, 2014), and family planning services (Aradhya, 2009) among others. This has greatly expanded the roles of the nurses.

Registered nurses have been linked to better patient outcomes than other nurses with lower qualifications (Aiken et al., 2012) owing to their training which equips them with higher thinking, decisions making, and clinical reasoning skills in clinical practice (Abedi et al., 2019). They however felt insufficiently valued in the clinical settings due to tensions and a lack of salary differentiation to diploma nurses (Abedi et al., 2019). The public sector in Uganda has been largely unsuccessful in attracting and retaining RNs in sufficient numbers largely due to low pay and a lack of clear career pathways. The government, through the Ministries of Health and Education, recognizes the value that RNs add to the healthcare setting (Katungi et al., 2016) and have encouraged nursing leaders to support lower cadre nurses to upgrade and obtain higher qualifications (Abedi et al., 2019). The attempt to bridge the career trajectory of lower cadre nurses to upgrade to registration status and other degrees has not come with a commensurate commitment from the government to support and sustain such a transition. For example, the government of Uganda promised to increase the salary of nurses and midwives (Abedi et al., 2019), proposed a new scheme of services for nursing and midwifery professionals (Ministry of Public Service, Uganda, 2017), but has failed to implement these to date. These and other challenges have sustained the desire for many registered nursing students to work abroad upon completion of their degree. For example, Nguyen et al. (2008) found that 70% (n=139) of preregistration nursing students in one Ugandan university intended to work abroad within five years of graduation. This finding is in keeping with the more recent study by Abedi et al. (2019), where participants in focus groups expressed a desire to work abroad upon obtaining their nursing degree. This may further contribute to staff shortages.

Pre-registration Nursing education in Uganda

In this project, a pre-registration nursing student is defined as an individual who is undergoing training in a Bachelor of Science in Nursing program in an accredited university in Uganda or one who has graduated with a Bachelor of Science in Nursing degree but has not yet been licenced to practice by the Uganda Nurses and Midwives Council (UNMC). Preregistration nursing students come straight from school and therefore have no prior clinical experience. On the other hand, a top-up degree student is a nursing student who

already holds a diploma in nursing and is registered on a Bachelor of Science in Nursing degree program in an accredited university. In this study, registered nurse includes all nurse graduates with a Bachelor of Science in Nursing degree registered and licenced to practice nursing in Uganda. This is equivalent to the Registered Bachelor of Science in Nursing professional according to the UNMC cadre nomenclature.

The first Bachelor of Nursing degree students in Uganda were enrolled in 1993, in Makerere University College of Health Sciences (Leffers et al., 2014, p. 277). Before then, nurses had limited opportunities to upgrade their training, with many opting for horizontal academic progression, where they obtained multiple certificates and diplomas in different nursing /midwifery specialities (Leffers et al., 2014) but with limited career paths. Other universities, such as Mbarara University of Science and Technology (MUST) followed in 1999 (MUST, n.d.). To date, Uganda boasts of eleven universities offering Bachelor of Nursing degrees, with many others coming up, although the quality and relevance of the programs are yet to be documented (MOH Nursing Department, 2016). According to a document stipulating the minimum standard for courses of study for the BNS program in Uganda (Matua, 2010), the goal of starting the BNS degree in Uganda was to prepare a multi-skilled nursing professional who would meet the healthcare needs of the public in all settings and initiate, support, and participate in health research. Abedi et al. (2019) concur noting that RNs were better able to make critical clinical decisions and participate in health systems reforms. Elsewhere, RNs are reported to be better prepared to engage in research and leadership and community outreaches (Grobler et al., 2016). These expectations justify the need for a stronger bioscience presence on the pre-registration nursing degree.

In Uganda, pre-enrolment requirements on to the Bachelor of Science in Nursing (BSN) program are strict. Candidates wishing to enrol onto the BSN degree should possess a strong science background, usually gained at Advanced levels (A-Levels). They must have obtained a good grade in biology and chemistry. In addition, they should have passed other subjects such as mathematics, physics, or nutrition. Those upgrading from the diploma in nursing should have a good science background at ordinary level (O-Levels) or Advanced level (A-level), plus at least two years' clinical nursing experience.

There is a strong presence of biosciences on the BSN curriculum, although its implementation and evaluation are not yet researched. The biosciences courses include medical microbiology, human anatomy, physiology, biochemistry, pharmacology, pathology,

and pathophysiology, predominantly taught in the first two years. The bioscience courses are broadly standardized across the universities and approved by the Ministry of Education, Science, Technology, and Sports through the National Council of Higher Education (NCHE) before enrolment of students. There is limited literature on the nature and outcomes of pre-registration nursing in Uganda and as such, no studies have been undertaken among this cohort of students about bioscience learning. Anecdotal reports suggest that pre-registration nursing students in Uganda struggle to learn and apply biosciences in clinical practice, even though there is a strong presence of biosciences on the curriculum.

Motivation for the Study

There is universal consensus on the relevance of biosciences in the application and improvement of nursing care (Jordan & Potter, 1999; Prowse, 2003; Wynne et al., 1997). Indeed, there is appreciation of the contribution that biosciences have made to the knowledge base on which clinical nursing practice decisions are based (Jensen et al., 2018; Prowse & Lyne, 2000). Jordan and Potter (1999); Prowse (2003); Wynne et al. (1997) agree that nurses recognise the need to learn biosciences and their contribution to the improvement of nursing care. Others maintain that biosciences should form a significant component of nursing knowledge (Prowse & Lyne, 2000) and before pre-registration nursing students graduate, they should possess sufficient knowledge and understanding of the bioscience of the healthy and sick to support safe and effective clinical practice (Fawcett et al., 2016).

According to the WHO (2018), communicable diseases dominate the disease burden in Uganda, accounting for over 50% of mortality and morbidity. They include malaria, tuberculosis, HIV/AIDS, respiratory and diarrhoeas, epidemic prone diseases, and vaccine preventable diseases. Nurses in Uganda routinely encounter patients with these life-threatening conditions which require the application of bioscience knowledge. Antimicrobial resistance is rampant in Uganda (Bebell et al., 2017) and without antimicrobial stewardship, cross infection and resistance can adversely affect patients and communities. Task shifting[1] makes the nurses' roles more complex and increases the bioscience knowledge base required to practice competently. Without a sound understanding of biosciences, nurses in Uganda may not adequately perform their roles in the ever-changing health environment. This is even

[1] Task shifting is the system whereby specific roles are assigned, where appropriate, to health workers with less training and lower formal qualifications. In this case, nurses perform some of the roles traditionally done by medical doctors.

more important when nurses are the only healthcare personnel available as in many lower health facilities (Nabirye et al., 2014). Even at these facilities, nurses should be able to recognise actual and potential problems and instigate actions to counteract them in a timely manner before referral.

Such complex roles require understanding of biosciences, acquired through deep learning, so that the nurse can apply critical thinking and problem-solving skills to actual or potential clinical problems. Anecdotal reports show that some nurses in Uganda cannot integrate biosciences in their practice, let alone understand the rationale behind nursing interventions. This signals a knowledge gap. For example, nurses have been reported to prescribe antibiotics to treat viral infections, or even treat infections for which such medications are not indicated (Mbonye et al., 2016). Some nurses prescribe antibiotics to patients with malaria, especially children under five years (Means et al., 2014). Such practices may contribute to antimicrobial resistance, wastage of resources, and increase patient adverse outcomes.

Nursing education faces challenges such as a shortage of learning and teaching resources, such as textbooks and labs for bioscience education in Uganda. Although I could not find literature to attest to this, most nurse educators tasked to teach biosciences struggle to obtain learning materials that are customized to learning biosciences for nursing students. Akinsanya and Hayward (1980) pointed to the scarcity of books and other learning materials that integrate biosciences within nursing in other countries. In addition, anecdotal information suggests that bioscience subjects account for a significant proportion of retake examinations for nursing students in Uganda in the first two years. Similarly, high failure rates are reported among nursing students in other countries (Bakon et al., 2016; Jensen et al., 2018; McVicar et al., 2014). For example, the average failure rate of bioscience subjects in Norway was 22% (Fjelde & Ruud, 2016).

Biosciences are often taught in ways that are decontextualized from nursing practice, often as discrete courses, usually delivered by a scientist, in a non-clinical/non simulated environment (Craft et al., 2013; McVicar et al., 2015). Universities often employ medical doctors or scientists (microbiologists, pharmacists, and biochemists), who may not be embedded in the nursing context, to teach bioscience courses. For example, in one public university in Uganda, biosciences are mostly taught by doctors, biochemists, medical microbiologists, and pharmacists. From my experience as an undergraduate student, there

was limited bioscience integrated with nursing practice. It appeared that the science behind what nurses were doing was hidden or implied.

In addition, lecturers in public universities often teach large and mixed student groups comprising of medical, nursing, medical laboratory, and pharmacy students. With such arrangements, student nurses are not likely to be encouraged to assimilate bioscience to nursing practice right from the start of the degree program. Although such a practice may reflect the interdisciplinary nature of the healthcare context in which RNs operate, it raises concerns about how such pedagogical practices can support nursing students to understand the importance of biosciences in their professional practice. It appears that nursing students are left to integrate biosciences to nursing practice when they are confronted with problems in the clinical area (Jensen et al., 2018). It may make contextualization of biosciences to nursing practice difficult for nursing students. In addition, nursing curricula in Uganda, as in the UK (Akinsanya, 1987; Taylor et al., 2015), do not clearly set standards on the scope and depth of biosciences that preregistration students should learn in order to practice competently. These are often vague and ill-defined.

Globally, there is a lack of knowledge on how best to teach biosciences and a persistent lack of consensus on the best strategies to use within nursing (Ralph et al., 2017), which hinders pedagogical advancement in this area. Presently, there is little understanding of whether the current teaching strategies in academic and clinical contexts are successful in supporting the translation of bioscience knowledge to clinical practice among preregistration nursing students in Uganda. The level of bioscience knowledge that nursing students retain and apply in clinical practice is unknown. Understanding the current level of explicit knowledge that nursing students currently have may help us to understand the success of the current teaching approaches of biosciences in Uganda. Consequently, it will give us insight into how successful the current teaching strategies are in supporting retention and application of biosciences to clinical nursing practice. We also have limited understanding of the experiences of learning and applying biosciences among preregistration nursing students.

Explicit knowledge is organised knowledge such as that found in books, journals, and other documents while implicit (tacit) knowledge is non-codified and is often personal or experience based (Botha et al., 2014). Exploring the students' experiences of learning and applying biosciences may help us to understand the efficacy of the support students currently receive and how we can improve it to promote retention and transfer. Although knowledge is

a mixture of implicit and explicit kinds and both kinds are useful, explicit knowledge is more formalized and is easier to identify, store, and retrieve. In contrast, tacit knowledge is less organised, comprising cultural beliefs, attitudes, values, cognitive representations, skills, competences, and expertise. This knowledge resides in the practitioner. Explicit knowledge is also referred to as 'know-what' while tacit knowledge is sometimes referred to as 'know-how'.

How Antibiotic Resistance Sits in This Study

This study focussed on the bioscience portion of the preregistration curriculum. As mentioned earlier, there are seven bioscience courses on the nursing curriculum in Uganda. Assessing the assessing students' knowledge in each course would be unrealistic practically and logistically. A more practical way to assess the level of bioscience knowledge among preregistration nursing students in this context would be identifying a relevant bioscience aspect already present on the bioscience curriculum, possibly bringing together several bioscience subjects and one which is applicable in practice as a relevant indicator of science learning and application.

Antibiotic resistance (ABR), an area of biosciences on the preregistration-nursing curriculum, was used as a relevant indicator of the level of bioscience knowledge among nursing students in Uganda. This is because first, understanding ABR and its importance to clinical nursing practice requires knowledge of several bioscience subjects such as anatomy, physiology, microbiology, pathophysiology, and pharmacology. A scientific understanding and application of ABR knowledge in clinical nursing practice requires integration of the above-mentioned bioscience subjects in addition to social sciences, nursing sciences, and humanities (Jensen et al., 2018), bringing it all in one whole.

Secondly, although biosciences are taught as discrete courses, they are implicitly embedded in all aspects of clinical nursing practice. ABR is a concept which nursing students can directly apply in clinical practice. This is because nurses occupy a unique position in healthcare, where they prepare, administer, prescribe, and monitor the side effects of antibiotics (Ellen et al., 2017). The nurses' role encompasses care, infection prevention, and control, collection of samples for laboratory investigations, patient/family education on rational use of antibiotics thereby contributing to slowing the trend of ABR. They can review medications and ensure that cultures are completed before antibiotics are started (Edwards et al., 2011). All

these require a bioscience base for successful application to clinical practice. Therefore, using ABR a concept intimately linked with the RNs' role as an indicator of bioscience knowledge supported our understanding of the level of bioscience knowledge among this cohort of students.

Antibiotic Resistance, Antimicrobial Resistance, and Antibiotic Stewardship

Antibiotic stewardship (ABS) is an umbrella term encompassing approaches within organisations or health systems to prolong the effectiveness of existing antibiotics (Bartlett, 2011). ABS would include initiatives such as those targeting reduction of spread of bacteria and those which promote prudent use of antibiotics (Charani & Holmes, 2013; Dar et al., 2016). Antibiotic resistance (ABR) happens when bacteria continue to survive in the presence of antibiotics that once treated the infection arising from their presence (Bebell & Muiru, 2014). It is a natural phenomenon which occurs with or without the presence of antibiotics. However, bacteria develop resistance faster when exposed to antibiotics through appropriate or inappropriate use (Bartlett, 2011). Antimicrobial Resistance (AMR) happens when microorganisms such as bacteria, viruses, fungi, and parasites mutate over time and are no longer sensitive to medicines that were used to treat them (WHO, 2020). Antimicrobial stewardship (AMS) refers to an approach within an organisation of health system to promote and monitor prudent use of medicines used to treat infections caused by bacteria, viruses, parasites, and fungi to conserve their future usefulness. As earlier indicated, this study will use antibiotic resistance (ABR) as an indicator of bioscience knowledge but will also explore the wider aspects relating to ABR such as of AMR, and stewardship practices.

Aim of the study

The aim of this study was to understand nursing students' current level of knowledge of biosciences (antibiotic resistance), the factors associated with that knowledge, and how they currently learn and apply bioscience knowledge in clinical practice.

Research Questions

1. What level of explicit knowledge of Antibiotic Resistance do nursing students currently have as they complete their degree program and enter practice?
2. What factors are associated with acquisition of bioscience knowledge among nursing students completing their preregistration nursing degree in Uganda?
3. How do nursing students learn biosciences in the classroom and on clinical placements?
4. What are the students' perceptions of the support they receive to learn and apply biosciences?
5. What factors affect the application of bioscience knowledge to clinical practice among nursing students in Uganda?

This chapter has given an overview of the expanded role of nurses in Uganda. It has explained the current knowledge gap in biosciences in nursing education in Uganda, justifying the need for this study. Chapter two will review the literature on the history of the bioscience problem, explaining the place and relevance of biosciences in nursing education and practice. It will discuss why nursing education urgently needs to streamline bioscience curricula, the clinical learning environment, and clinical supervision such that students can link and apply science to clinical practice.

Chapter three introduces the methodology of this research. It summarises my epistemological position. It will discuss the two phases of this study and the methods used to select the target population, sampling, data collection, analysis, and ethical considerations. Phase 1 first compares student performance between bioscience and non-bioscience courses using secondary data. It suggests that a significant proportion of nursing students currently struggle to learn and pass biosciences compared to non-bioscience courses. Then, it assesses the level of explicit knowledge of Antibiotic Resistance, among preregistration nursing students nearing completion of the degree program. It also identifies the factors associated with the level of bioscience knowledge among the students in Uganda.

Chapter four presents the quantitative and qualitative findings from this study. The findings include the level of explicit knowledge on Antibiotic Resistance and the factors associated with that knowledge. It presents the findings on the students' experiences of learning and applying biosciences in clinical practice. It explores how preregistration-nursing students learn biosciences in the classroom and on clinical placements, the support they receive to learn and apply biosciences and the factors that affect their retention and application of biosciences to clinical nursing practice.

Chapter five brings together the findings from Phase 2. I will explain the research findings and reflect on the meanings of these results considering the quantitative findings and the context in which the study took place. The results will be organized around the themes identified from the data.

Chapter six discusses the quantitative and qualitative results, bringing them into one whole. It will explain the implications of the findings on bioscience teaching and learning in the classroom and clinical contexts. I will explain the research implications reflecting on current nursing practice in Uganda and previous studies in other contexts where applicable. Chapter seven makes conclusions and reviews findings, reflecting on the strengths and weakness of the study. It makes general and specific recommendations arising from the findings of this study and proposes areas of future research.

Chapter 2: Literature Review

Introduction

This chapter will explore bioscience curricula, the teaching, learning, and assessment of biosciences, and the importance of linking science teaching to clinical practice. It will discuss the relevance and place of biosciences within nursing and the relationship between nursing and the medical profession regarding biosciences. In addition, it will discuss the challenges of biosciences among nurse educators, registered nurses, and nursing students. I will draw on the expanded role of nurses due to task shifting to argue for a stronger link between science teaching and clinical nursing practice in the face of global threats such as antimicrobial resistance.

Literature Search Strategy

The purpose of conducting literature reviews is to gather existing sources of information about a specific research topic thereby providing readers with a comprehensive summary of current evidence (Steen & Roberts, 2011). In this thesis, the literature review provides a background to the bioscience problem and justification for this study. According to Lingard (2018), literature reviews also critically map the development of knowledge, presenting an evolving understanding of the concept under study. Standard literature reviews broadly take on two approaches: systematic reviews and narrative or traditional reviews (Ferrari, 2015), each varying in objectives and methods.

Systematic reviews employ rigorous criteria to identify and evaluate relevant literature (Cronin et al., 2008) relying on stringent methods to analyze the strengths and quality of well-defined research questions (Dewey & Drahota, 2016). They follow well planned protocols laid down before embarking on the review. Systematic reviews give step by step comprehensive criteria they followed in searching databases and gray literature sources which other researchers can replicate. This means that the reviewers give details of the search terms used, time frames, and databases searched, and results obtained.

Unlike systematic reviews which employ rigid scientific criteria to answer specific research questions, narrative reviews critique and summarize literature around a specific concept to provide a comprehensive summary of evidence (Cronin et al., 2008). Researchers undertake narrative reviews to identify gaps, refine research questions and avoiding

duplication of already existing research in addition to justifying the need for further research. A researcher who believes that both positivist and interpretivist paradigms contribute to knowledge would find narrative reviews useful. This is because they may not be strict about the nature of the methodology applied in the primary studies if they pass the quality checks and contribute to understanding of the subject (Ferrari, 2015). In seeking to comprehensively understand the aspects on and relating to a specific aspect, researchers may seek to capitalise on the strengths of positivist and interpretivist paradigms to answer research questions. Although narrative reviews may be useful in this respect, they may be prone to selection bias if inclusion criteria are not systematic and clearly well-defined.

The narrative literature review was the most suitable approach for this study because it provided a comprehensive summary of evidence in this area. It was flexible and allowed me to conduct periodic searches as the study developed and new findings emerged. In addition, it helped to study development of biosciences in related professions such as medicine. It was also important in mapping the development of research in this area and the direction of future research thereby supporting me to identify knowledge gaps.

During the process of gathering and reviewing literature relevant to this study, I adopted a pragmatic epistemological position. I selected concepts relating to the bioscience problem: nursing curricula, teaching strategies, the clinical learning context, biosciences in nursing practice, clinical supervision of nursing students, ABR practices in nursing practice, and implications of task-shifting to the scope of practice for nurses. I searched for literature pertaining to how these concepts influence and relate to the bioscience problem thus adapting a narrative literature review.

The literature pertaining to this study were identified in two major phases. First, searches were run at the beginning and regularly during the study to ensure that emerging evidence was incorporated in the literature review and discussion chapters. Initial searches were limited to the importance of biosciences to RNs, issues around biosciences in academic and clinical practice settings such as bioscience curricula, teaching strategies used in academic settings, the complexity of biosciences, who, what, and the scope of bioscience knowledge needed by RNs. I included literature on ABR and ABS in the process of designing the survey. As more evidence emerged from the findings from Phase 1, I included more literature on the clinical learning environment, the associations between bioscience success and prior science backgrounds and students' age groups. Then, following the qualitative data

collection, new themes emerged from the participants' experiences of learning biosciences. I searched literature pertaining to these new themes to understand the existing literature around them and locate the position of this new evidence within the already existing body of knowledge. I included literature on clinical supervision, medical ward rounds, assessment, and feedback.

I initially sought to review evidence on the bioscience problem in the Ugandan context and searched for possible evidence in similar African countries. Published research evidence on the bioscience problem was limited in Uganda and Africa. Although contextual variations between Low- and Middle-Income Countries (LMICS) and High-Income Countries (HICs) may vary, I widened my search to include research evidence from HICs given that evidence on the bioscience problem was limited in Africa. I conducted an electronic search to gather relevant literature from various databases including Education Resources Information Center (ERIC), Medline, British Nursing Index, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Google Scholar, Science Direct and Scopus for the period between 1960 to 2021, but with emphasis on the last ten years (2011-2021). I obtained more literature from the references and citations of the papers extracted from the original searches.

As recommended by Bettany-Saltikov (2016), the Population, Intervention, Comparative intervention, Outcome (PICO) approach was used to guide the search and select the keywords. The following keywords were used: nursing students OR preregistration nursing OR nurse education OR nursing OR Bachelor of Nursing AND biosciences OR biological sciences OR anatomy, OR physiology, OR pathophysiology, OR pharmacology, OR biology, OR biomedicine, OR biophysics. Other key words included antibiotic resistance, antimicrobial resistance, and antimicrobial stewardship. The searches returned primary and secondary studies mainly conducted in the UK, Australia, New Zealand, South Korea, and Norway. Most of the evidence from HICs like the USA and Canada was on antimicrobial resistance and task-shifting not specifically on biosciences in nursing education and therefore was excluded. Articles outside of nursing, medicine, health sciences, higher education or social sciences were also excluded as well as those that were not written in English and those which could not be translated to English.

Table 1: Summary of the Literature Search Strategy for this Study

Criterion	Details
Key words used	**Initial search** Nursing students OR preregistration nursing OR nurse education or nursing OR Bachelor of Nursing OR undergraduate nursing AND Biosciences OR biological sciences OR anatomy OR physiology OR pathophysiology OR pharmacology OR biology OR biomedicine OR biophysics. **Subsequent search** Clinical supervision OR Supervision OR Nursing supervision OR mentorship OR Preceptorship. Medical ward rounds OR multidisciplinary ward rounds OR patient-centered rounds OR ward rounds OR rounding OR Physicians' rounds. Assessment OR evaluation OR OSCE OR OSPE OR oral OR Viva OR examination. **Other search terms:** Antibiotic resistance, antibiotic stewardship, antimicrobial resistance, and antimicrobial stewardship
Databases searched	ERIC, Medline, British Nursing Index, CINAHL, Google Scholar, Science Direct, Scopus
Limits applied	Title and Abstract Journal and Article Nursing/health/medicine and higher education/social sciences only Time from 1960 to 2021 English only.

Biosciences in Nursing Curricula.

The nursing profession is founded on knowledge from nursing sciences, social sciences, humanities, and biosciences, meaningfully harmonized to create optimal practice (Jensen et al., 2018). In the UK., biosciences include subjects such as human anatomy, physiology, pathology, biochemistry, genetics, cell biology, pharmacology, and microbiology (Taylor et al., 2016). Directive 2005/36/EC of the European Parliament and the Council on the recognition of professional qualifications added bacteriology, virology, parasitology, hygiene, biophysics, radiology, and dietetics to the list of basic science courses for general nursing (EC, 2005; NMC, 2010). Although there is no prescribed national preregistration-nursing curriculum in Uganda (MOH Nursing Department, 2016), the preregistration nursing degree includes the following bioscience courses: biochemistry, anatomy, physiology, pharmacology, microbiology, pathology, and pathophysiology. These courses are compulsory for all nursing students and are mainly taught in year 1 and year 2.

Bioscience courses were introduced on the nursing curriculum in the UK in 1922 (Bendall & Raybould, 1969). Before the late 1970s, the biomedical model of care dominated nursing (Davis, 2010). Hardy (1978) (as cited in Casey, 1996) explained that the biomedical model dictated what type and scope of bioscience knowledge nurses needed, and nursing as a profession had limited opportunity to influence this knowledge. The biomedical model supported teaching of biosciences in nursing and relied on medicine to link with biosciences. As such, nursing has not distinctly developed its own bioscience body of knowledge.

In the 1980s, nursing tried to distinguish itself as an autonomous profession within healthcare. Following critique of the limitations of the biomedical model, psychological disciplines were given greater attention, inevitably reducing the curriculum time dedicated to biosciences (Wynne et al., 1997). Since then, the value of biosciences within the nursing profession has progressively diminished (Clarke, 1995; Larcombe & Dick, 2003; Wynne et al., 1997). Jordan (1999); Logan and Angel (2011); and Taylor et al. (2015) reiterated this view, affirming that as nursing shifted from the biomedical model, increasing importance has been placed on the behavioural and social sciences, at the cost of biosciences. Many nurse educators have been seen to equate the presence of biosciences in the nursing curricula as promoting the biomedical model (Taylor et al., 2015). Current literature suggests that this debate is continuing. For example, Taylor et al. (2015) reported that despite repeated calls to adopt a collaborative approach between nurse educators and bioscience lecturers to enhance biosciences within nursing curricula, bioscience lecturers reported feeling side-lined by some

nursing program leads when developing standards relating to biosciences knowledge and application. They were not sufficiently involved in designing the bioscience curriculum in five of the ten UK HEIs surveyed (Taylor et al., 2015). They proposed that collaboration would most likely improve when the NMC develops quality outcomes or benchmarking frameworks, which explicitly prescribed the quantity of science on nursing curricula.

Whereas the UK NMC (2010) and NICE (Armitage et al., 2007) regard an in-depth knowledge of biosciences as essential for all nurses, reports from the National Student Satisfaction (NSS) survey consistently show a dearth of bioscience content in pre-registration nurse education programs in the UK (Taylor et al., 2015). The gradual decline of biosciences in preregistration nursing curricula in the UK has been widely reported in nursing literature (Davis, 2010; Fawcett et al., 2016), with calls for enhanced bioscience content within the UK nursing curricula (Perkins, 2019; Taylor et al., 2015). According to Taylor et al. (2015), there are wide variations in the content, curriculum time spent on teaching, assessment, depth and scope of bioscience taught within nursing programs in the UK. For example, the total number of hours on the nursing curriculum dedicated to biosciences have reduced to represent only 0.4% to 2.4% of the total preregistration teaching time (Taylor et al., 2015). Many nurse teachers did not give biosciences enough attention, despite evidence that students have consistently asked for more time dedicated to them (Taylor et al., 2015). These variations could be explained in part due to the absence of the NMC guidance, on the scope and depth of biosciences required for competent nursing practice (Taylor et al., 2015). They maintain that NMC who set the standards for nursing and midwifery practice in the UK did not specify the scope of bioscience knowledge required by nurses at the point of registration, leaving the responsibility to individual Higher Education Institutions (HEIs).

This raised concerns as to whether the preregistration bioscience curricula were fit for current practice. They recommended putting together a quality assurance framework to include the minimum required outcomes for biosciences to allow the students to meet the required standard at the point of registration. Recent literature suggests that the NMC has not yet explicitly given guidelines for the minimum bioscience required by nurses at the point of registration (Perkins, 2019), yet recommendations have been made and a learning outcome framework was made five years back (Taylor et al., 2016).

The NMC (2018a) published “new standards of proficiency for registered nurses” which reflected the recent view that the responsibilities of the registered nurse are evolving

(Willis, 2015) and require a better understanding of biosciences than before (Fell et al., 2016), supporting longstanding calls for enhanced biosciences in nursing curricula. According to Perkins (2019), more in-depth bioscience content within nursing curricula is urgently needed to ensure that nurse graduates meet the new NMC standards of proficiency in all fields of nursing.

This situation is not unique to the UK. A study in Australia suggests variations in science content within nursing programs and calls for nationally consistent standards on the teaching of biosciences in nursing curricula (Ralph et al., 2017). Literature on biosciences in nursing and other healthcare professions' curricula in Uganda is currently limited. Our knowledge is restricted to the courses and learning objectives of the various bioscience courses. Literature on whether the bioscience curricula are fit for current and future nursing practice is still lacking. We do not yet know which methods of teaching support retention and application of biosciences among nursing students in Uganda. An inspection of the nursing curriculum of Makerere University (the first public university in Uganda) reveals that a ½ of all the courses in the first (14 of 28) and second year (21 of 38) and about 30% (8 of 27) of all the courses in the third year are biosciences, suggesting a strong bioscience presence. Whereas the presence of biosciences on the pre-registration nursing curricula in Uganda appears to be stronger than in the UK., its implementation and impact on retention and application in clinical practice is not well understood. Anecdotal evidence suggests that many nursing students struggle to pass bioscience courses, suggesting problems in acquiring, retaining, and applying bioscience knowledge.

Research on the presence of biosciences in nursing curricula points to several issues. First, studies report that the pre-registration bioscience curriculum is crowded, with too much content covered (Doggrell & Schaffer, 2016), as cited in studies in the UK (McVicar et al., 2015; McVicar et al., 2010), New Zealand (Montayre et al., 2019), Australia (Davis, 2010; Whyte et al., 2011). Crowding of the curricula presents difficulties for nursing students to dedicate adequate time to bioscience learning. Consequently, the course content is compromised as learners adopt surface learning approaches to pass these courses. A study in the UK. suggested that some nurse graduates enter practice with an average level of understanding, equivalent to GCSE (Campbell & Leathard, 2000) which in most cases does not meet the required professional standards (Davis, 2010; McVicar et al., 2010). McVicar et al. (2015) advised that cramming bioscience content in the first years of the pre-registration nursing degree with the expectation that students will apply the detailed bioscience

knowledge later is counterproductive in enhancing understanding and application of biosciences. Jensen et al. (2018) reiterated this noting that nursing education needs to make biosciences intimately relevant to practice instead of expecting learners to automatically integrate theory and practice when they get to the practice setting, without explicitly making this connection relevant to them right from the classroom.

There is an ongoing debate as to whether the curricula should be structured in a way that bioscience disciplines are taught as discrete courses or be framed through clinical problems such that various bioscience aspects are appropriately integrated throughout the teaching (Smeby & Sutphen, 2014). Current literature suggests that internationally, the majority of HEIs teach bioscience content early on in the curricula, and they hardly feature in the later portion of the undergraduate degree, despite evidence of repeated calls for more biosciences in clinical training for nurses (Barton et al., 2021). For example, biosciences are taught as separate disciplines, with courses often taught exclusively in the first year in Norway (Jensen et al., 2018), and in most universities in Australia (Logan, 2008). A similar practice is reported in New Zealand, although some schools teach biosciences prior to enrolment into the nursing degree (Montayre et al., 2019). In the UK., more hours were dedicated to biosciences in the first year, but the teaching is more varied in year two and three. Among the ten HEIs surveyed by Taylor et al. (2015), three taught biosciences as separate modules in year one, nine integrated or had biosciences as a theme within the curriculum in year two and three whereas one university had separate bioscience teaching in year 2 and 3.

The argument that the ideal bioscience teacher should be a nurse or healthcare professional with a bioscience degree is largely universal (Smales, 2010), but very rare in practice (Taylor et al., 2015). Whereas students value bioscience teachers who can explain scientific concepts in ways that reinforce practice and clinical decision-making in clinical settings (Taylor et al., 2015), it is not always possible. This is because nursing lecturers generally feel inadequately prepared or lack the confidence to teach biosciences (Green et al., 2000; Nicoll & Butler, 1996), leaving scientists who usually lack clinical expertise to link the science to practice (Craft et al., 2013; Smales, 2010). Some studies have proposed collaborations between scientists and nurse educators but this is infrequent (McVicar et al., 2015; Ralph et al., 2017) and may be unpractical and unsustainable given the difficulties in the staffing mix and costs involved for the HEIs (Craft et al., 2013).

Research evidence suggests that nursing students appreciate the clinical relevance of biosciences as they progress on their degree especially during the latter part of their degree (Gordon et al., 2017; Montayre et al., 2019). Teaching most of the clinically relevant bioscience content earlier may be detrimental because they are likely to start appreciating the relevance of the content when most of their formal bioscience instruction has been completed (Birks et al., 2011; Craft et al., 2013) and probably forgotten. Recent studies are calling for biosciences to be embedded throughout the nursing program, especially in the final year (Barton et al., 2021; Craft et al., 2017c; Montayre et al., 2021; Ralph et al., 2017). They maintained that teaching biosciences in the final year is reasonable because the final year is when students typically consolidate clinical practice. It is the time when they mostly appreciate the relevance of biosciences to clinical practice. They reasoned that integrating bioscience teaching within practice potentially provides the greatest impact on learning (Craft et al., 2017c). Spreading the teaching throughout the program may be beneficial to some extent because cramming the difficult and abstract content in the first year when students are new to higher education and have limited clinical experience to link with the science may be too intense for the learners (Jordan et al., 1999).

Barton et al. (2021) studied the connection between students' engagement with biosciences and perceptions of clinical relevance for their clinical roles at different stages of the various nursing programs in three universities in Australia. They found that the students' appreciation of the relevance of biosciences to clinical practice increased as they progressed in their studies. The students also engaged more with biosciences later in their program and saw the depth of bioscience content as useful for their practice compared to the earlier years (Barton et al., 2021). Additionally, the students felt they needed more biosciences than they were receiving as they progressed on the program, a similar finding in other studies (Clancy et al., 2000; Friedel & Treagust, 2005; Gordon et al., 2017). Targeting the teaching to the stage when the students have more positive perceptions to biosciences than in the earlier years (Montayre et al., 2019) and when they can clearly link it to clinical practice may go a long way in bridging the longstanding theory practice gap in nursing.

In a study by Ralph et al. (2017), academics who teach sciences (n =30) and RNs (n = 1808) in Australia underscored the importance of discrete teaching in the first year and integration of the biosciences in the remaining portion of the curriculum. They maintained that whereas standalone subjects have their place, they strongly supported the continuous linkage of the science to practice throughout the program. Like the UK. (Taylor et al., 2015),

the participants in this study noted the variability of science content across the nursing programs and called for a nationally prescribed curriculum with clear and consistent guidelines for the content and teaching of biosciences in nursing curricula (Ralph et al., 2017). In another study in Australia, RNs reflected on the bioscience curricula during their preregistration program. Craft et al. (2017c) reported that although RNs found biosciences more difficult and had more content, they thought that more clinically relevant bioscience content was important for their current practice. They wanted the bioscience teaching extended to the final year of the preregistration nursing degree. Similarly, 2/3 of nursing students in New Zealand felt that biosciences should taught into the third year (Friedel & Treagust, 2005).

Continuing to teach biosciences as distinct courses would be more feasible under the current circumstances, but it is likely to perpetuate the theory-practice gap in biosciences. Confining the large chunk of the biosciences to the first portion of the nursing program may limit the students' ability to understand and later apply them to clinical nursing practice. As recommended by Birks et al. (2011); McVicar et al. (2015); Molesworth and Lewitt (2016), the nursing curricula would rather teach the clinically relevant content throughout the program to improve retention and transfer of knowledge and possibly meet the minimum professional competencies. Nursing education and practice should find a feasible means to ensure that biosciences are integrated throughout the program. The prospect of adapting to the needs of the learners and recommendations from the RNs opens new possibilities for contextualizing science throughout the nursing program and improving retention and transfer among students and RNs.

Teaching Strategies Used in Pre-registration Nursing Education

The bioscience problem within nursing education has persisted for decades, with many students finding the courses difficult (Akinsanya, 1987; Friedel & Treagust, 2005; Jordan et al., 1999; Wong & Wong, 1999). One of the historical factors suggested to contribute to the bioscience problem is the teaching strategies used in bioscience curricula (Davis, 2010; McVicar & Clancy, 2001; Trnobranski, 1993). Nursing education still struggles to provide necessary environments to learn biosciences and organise curricula in such a way that nursing students receive appropriate support as early as possible when covering bioscience courses (McVicar et al., 2015). Some argue that the reductionist way in which bioscience courses are taught do not present holistic view of patients. The current strategies

have been deemed insufficient and/or irrelevant in adequately preparing nursing students for holistic care (Beedholm & Frederiksen, 2015).

There were mixed reports on the influence of various teaching strategies on learning of biosciences, with some criticising (Davies et al., 2000; Durai et al., 2012) and others in support (Al-Modhefer & Roe, 2009; Jordan et al., 1999). In particular, lectures were heavily criticised by Davies et al. (2000) but students viewed didactic learning more positively in the study by Al-Modhefer and Roe (2009). Students also heavily criticised the over reliance on self-directed learning strategies when learning bioscience courses (Courtenay, 1991), with laboratory and clinical learning environments seen as positively promoting learning (Courtenay, 1991; Jordan et al., 1999). Although research findings on this aspect are inconclusive, it appears that a variety of relevant and stimulating strategies should be used to teach biosciences.

Modern approaches have embraced online methods of bioscience delivery. Some have criticized fully online delivery as non-interactive and disconnected strategies as found in a study in Canada (Attardi et al., 2016) and the UK (Green et al., 2006). Conversely, there were those who recognised the advantages of adopting blended approaches in teaching biosciences in the UK. (Glogowska et al., 2011; Swift et al., 2016), consisting of online and face-to-face teaching. Although blended learning was defined and utilized in different ways, they all used a mix of online and face-to-face classroom methods (Montayre et al., 2019). Research on the effectiveness of these methods in supporting retention and application of bioscience knowledge is still limited (Ralph et al., 2017). Modern pedagogies emphasise the idea of the 'independent adult learner' and 'self-directed learning' helping students to continue learning away from the classroom (Levett-Jones, 2005). This is even more important in situations where less time is allocated for teaching. There is some evidence suggesting that the complex nature of biosciences renders them unfit to be taught using online approaches, especially for younger students who value face-to-face approaches (Montayre et al., 2019).

McVicar et al. (2014) reviewed innovative teaching and learning strategies designed specifically to support the teaching and learning of biosciences in preregistration nursing programs. They evaluated the outcomes of the strategies from papers published from 1990 to 2012. Findings revealed that innovations in teaching of biosciences may be effective only if they meet the learning needs of the students. The studies that were met with enthusiasm included those where students accessed the learning material, where tutors were supportive,

and teaching was effective. Many of the studies looked at receptivity of the innovations and did not assess the impact of the intervention on assessment outcomes and on the knowledge and understanding of biosciences after the nursing students transition into registered nursing roles. In other words, the studies largely looked at how students perceived the strategies in terms of benefit but did not objectively measure the effect that the strategies had on learning of biosciences. There was not enough evidence on the wider impact that those innovations had on students' course progression and the benefit of those innovations on the nursing curriculum. McVicar et al. (2014) recommended that research in this area should focus beyond receptivity by students and move to translation of that receptivity into consistently improved learning outcomes.

Similarly, Jensen et al. (2018) reviewed literature on the teaching of biosciences in nursing education. Most of the research reviewed emphasised enjoyment and engagement a factor that was thought to motivate learning. Some of the innovations included games and simulations. These innovations increased student engagement and satisfaction but did not concurrently improve learning of biosciences. Firstly, it seems that there is limited evidence pointing to the teaching strategies that contribute to achievement of learning of objectives among preregistration nursing students. Secondly, the contribution that the teaching innovations have on the application of biosciences in clinical practice is still unknown. Nursing education should audit the relevance and effectiveness of the current teaching methods for biosciences and reinforce those methods that contribute to retention and transfer and exclude those that do not (Ratero et al., 2020).

The Clinical Learning Environment

Although biosciences are theoretical in themselves, their usefulness in healthcare is tied to being applied to clinical problems. For this reason, many nurse academics support the notion that nursing is an applied science (Ralph et al., 2017). In this case, an applied science is one where a theoretical science is adapted for real-world, often for humancentric uses (Feibleman, 1961). It is reasonable to suggest that effective application of biosciences requires teaching that is directed towards practical nursing contexts. Within this this nursing, biosciences can be understood and clinically applied when they are 'nursified'.

The term 'nursification' was used by Stojanovic (2008) to explain the "introduction of nursing culture into midwifery practice" (Mortimer-Jones & Fetherston, 2018, p. 2), although the definition was not given. Mortimer-Jones and Fetherston (2018) later used it to mean

active association of bioscience content with nursing. In this study, nursification is defined as actively linking or integrating of bioscience teaching to nursing practice. “Nursifying” biosciences, brings the clinical context in view of the learners right from the classroom to the clinical placements. For example, using relevant clinical examples to illustrate or explain bioscience principles is more likely to improve retention. Evidence in the UK suggests that nursing students prefer to have contextualized examples of clinically relevant bioscience content in their learning (Davies et al., 2000; Davis, 2010). Similarly, new RNs (Craft et al., 2017c), experienced RNs and Nurse academics in Australia (Ralph et al., 2017) and undergraduate students in New Zealand (Friedel & Treagust, 2005) believed that directing bioscience teaching towards clinical nursing contexts would improve the education quality of science teaching. In addition, nursification of biosciences was also noted to increase motivation to learn and improved learning experiences (Mortimer-Jones & Fetherston, 2018).

As discussed above, nursing students appear to appreciate the need for biosciences as they progress through their program, meaning that they are more likely to ‘nursify’ biosciences in the more clinically intense years, which are usually in the second half of the program. This makes the clinical area the key context where nursification and connection of the dots can happen, at the time when motivation to learn and appreciation of clinical relevance of biosciences is at its peak. Evidence suggests that nursing students have the best opportunity to learn and apply biosciences while on clinical placements. Compared to other contexts, authentic clinical placements provide the best opportunity for students to deepen their bioscience learning (Fell et al., 2016) through interactions with real patients, with real problems, requiring real solutions, with real consequences from the decisions made.

Although the clinical context is the most ideal for nursification of science, it is not an automatic process. This means that students need support to link the science to clinical nursing practice. Nursification of science is complex and requires the learner to bring together different aspects of knowledge into one whole, making sense of that, and acting appropriately and timely. The learner needs to deliberately move bioscience knowledge towards specific ‘illness scripts’ in a reflective and iterative manner (Higgs et al., 2008). For example, when a patient comes with a presenting complaint (illness script), the student considers the related bioscience concepts, drawing on them to understand what lies beneath the patients’ symptoms/signs. The student reflects on these and makes an appropriate decision. Nursification of science also needs time to develop and refine, beyond the limited duration of clinical placements (Logan & Angel, 2011), implying that building these links

goes on into the RN years. Undoubtedly, nursification of science requires support such that students utilize the learning opportunities available in the best possible way.

Generally, nursing students come to the clinical workplace with a "script" of the planned curriculum, with well-written learning objectives, only to find the hidden curriculum sometimes taking precedence. Indeed, when students go on placements, they focus mainly on their learning needs and look to their supervisors, mentors, and other nurses for support. What they perhaps do not realise is that those they look to for learning are taking on complex, and often competing roles. They are working in a different context from the university and have varying goals. The students collide with a workplace culture with conflicting demands for procedural skills and productivity, which can potentially erase bioscience consciousness thereby reinforcing the hidden curriculum. It appears that placement culture can indeed have considerable influence on the value placed on biosciences within clinical contexts and consequently affect the support students are afforded to transfer theory to practice (Fell et al., 2016). Placement attitudes towards biosciences appeared to limit the learning opportunities extended to students in one study in the UK. Where opportunities to learn biosciences were limited in areas where biosciences were largely side-lined (Fell et al., 2016). Therefore, HEIs and placement institutions should make deliberate efforts to minimize the negative effects of the workplace culture on students' learning.

Nursing students are more likely to harness the enormous bioscience learning opportunities embedded within clinical contexts when they are appropriately supported through clinical supervision. Considering the recent emphasis on practice-based learning, mentorship of nursing students is increasingly recognised as the responsibility of nurses. Practice educators need to understand and apply biosciences competently in order to impart accurate information as educators (Montayre et al., 2021). Students in the UK identified a mentors' bioscience knowledge, attitudes towards biosciences, and enthusiasm to teach as important determinants of the support they received to learn biosciences on placements (Fell et al., 2016). In this study, students perceived mentors who lacked sufficient bioscience knowledge as less supportive. Participants from different fields of nursing expressed concern about some of their mentors' insufficient bioscience knowledge.

Some students further stated that mentors who supported them were also enthusiastic and were good teachers in addition to being knowledgeable in science. They expressed this as being able to "push them in bioscience learning" through asking questions and assessing their

knowledge (Fell et al., 2016). This means that supportive mentors were those who used their experience and knowledge of the biosciences to ask relevant questions to validate the underlying science behind the students' clinical decisions. Asking questions appears to motivate learners to think outside the box and make clinical decisions based on bioscience theory. "Pushing to learn biosciences" could also mean that good mentors were those who identified opportunities for linking theory to practice and actively engaged learners to explore them through probing. Mentors who brushed off students when they asked bioscience related questions or those who ignored to test and probe students were perceived as ineffective mentors. Similarly, in Australia, newly qualified RNs linked a mentor's ability to probing through asking questions and validating a learner's bioscience knowledge. On reflection on their preregistration years, these RNs viewed mentors who lacked bioscience knowledge as limiting their opportunity to tap into the rich bioscience learning resource in the clinical area (Montayre et al., 2021).

A student's requirement for support to nursify biosciences did not appear to imply that the nursing students left the responsibility of enhancing bioscience learning during placements to mentors. They recognized that the responsibility to learn rested on them and they needed to proactively seek out relevant learning opportunities, especially in cases where their mentors appeared less knowledgeable or enthusiastic in supporting them. They broadened their pool of healthcare professionals who could support them beyond their mentors in an effort to tap into the wealth of knowledge and experience existing in the clinical context (Fell et al., 2016).

Unlike nursing students who increasingly recognize the relevance of biosciences in practice, mentors do not seem to widely recognize this in clinical practice. There is some evidence to suggest that the degree of importance placed on biosciences in clinical practice could emanate from the views held about the position that biosciences occupy on the continuum of relevance. On one end, some may view biosciences as "factual content that might be used as a tool for practice", reducing the value of biosciences to a resource for nursing practice (Logan & Angel, 2011), rather than an integral part of nursing practice (Hawthorne & Yurkovich, 2002). As discussed previously, nursing is an art and a science and as such nurses are bedside scientists. Such varying levels of relevance placed on biosciences in clinical practice environments raise concerns regarding the quality of support students receive while learning and applying bioscience concepts in clinical practice. Fell et al. (2016) noted with concern, the inconsistencies in the quality of support given to students, the

learning opportunities availed to students, and the importance placed on biosciences in placement education. They went on to suggest that in placement contexts where the emphasis on biosciences and the opportunities to reflect on the underlying science were variable, the importance of biosciences was not well recognised by nurse mentors. As such, they found that biosciences were given greater priority in specialist areas such as critical care, where students reported more support from their mentors.

While procedural skills are developed and refined continuously through the day-to-day nursing care, critical thinking, and decision-making draw from the pool of accumulated scientific knowledge (Montayre et al., 2021). Barton et al. (2021) reiterated this view stressing that well developed skills such as clinical assessment, critical thinking and decision making are all supported by a deep understanding of bioscience. Clinical nursing placements have been noted to side-line bioscience learning in favour of procedural skills (Fell et al., 2016; Logan & Angel, 2011). According to Fell et al. (2016) students noted that more focus was placed on mastering nursing procedures while the bioscience basis of these very skills were largely side-lined. Devaluing biosciences learning in favour of procedural skills may reduce the knowledge base on which learners can draw to critically think and make appropriate clinical decisions. In addition, it may fragment learning into parts instead of learning wholes.

Considering what is at stake for students, RNs, and patients, it is time for nurse education to prioritize bioscience learning alongside other disciplines within clinical practice. Biosciences are not external to nursing and neither are they additions to nursing but are part of nursing and should be given priority just like the skills. First, action needs to be taken to improve the bioscience of the supervisors and clinical mentors such that they can support the students during placements (Montayre et al., 2021). Secondly, prioritizing the application of science to practice from the classroom to the clinical placements would improve bioscience transfer among preregistration nursing students Montayre et al. (2021). Assumptions that students will link bioscience knowledge with practice with limited or no support should be set aside and focus on learning activities that create and sustain bioscience learning and practice (Logan & Angel, 2011).

Biosciences in nursing practice.

The rapid growth of healthcare information and the complexity of medical science necessitate nurses to be both skilful and knowledgeable in the science of disease and

treatments (Birks et al., 2018). A review of nurse education in Australia stressed that future nurses will manage a larger population and patients with more varied healthcare needs due to increased acuity (Schwartz, 2019). In the UK, Lord Willis emphasised that the expectations of today's population are higher than before owing to the complex nature of their healthcare needs (Lord Willis, 2015). In addition, the culture of communication has changed due to the ease of access to information.

Nursing is becoming more autonomous, a position which comes with an expectation of a robust knowledge base to support clinical decisions, avoid harm, and maximize health (Perkins, 2019). Nurses are taking on more diverse and complex roles within a complex and evolving workplace (Evans et al., 2013). There is an increased disease burden, patient acuity, and healthcare budget cuts, all of which call for innovative and responsive nursing care services. Apart from a specialized knowledge base, the public expects nurses to deliver high standards of care (Boud & Falchikov, 2007; McVicar et al., 2015). Today, patients are more active recipients of care (McDermott & Pedersen, 2016), with many asking questions on clinical decisions, treatment options, and disease progression. The nurse needs to be more informed (See et al., 2020) and meet the demands of the changing workplace.

To achieve such expectations nurses should possess an acceptable understanding of the science that underpins their clinical practice (Efstathiou & Bailey, 2012; Taylor et al., 2015). Fawcett et al. (2016) emphasises that the need for RNs to apply bioscience in the clinical context is greater today, given their increased autonomy and the expectation of high standards of patient care (Christensen et al., 2015). Today, patients are more active recipients of care (McDermott & Pedersen, 2016), and appreciate open communication on pathology of disease, treatment options, and prognosis all of which are increasingly becoming the responsibility of nurses (See et al., 2020). The 21st century RN should, therefore, not only be skilled in the science (Birks et al., 2018) but able to communicate science effectively. RNs should meet these changing needs of the clinical context. For example, Molesworth and Lewitt (2016) reported that students perceived RNs as being competent and credible when they demonstrate science communication skills during interprofessional discussions. Nurses who have science communication skills may be better patient advocates, which may lead to better patient experience.

In addition, developments in technology and treatments demand greater and deeper bioscience knowledge (Friedel & Treagust, 2005). New treatments and procedures are

emerging and these increase the demand for sound knowledge of genetics on the part of nurses (Nicol, 2003). Science knowledge supports RNs to communicate to their patients, colleagues, and patients/families appropriately. Indeed, science communication skills are important in the overall healthcare experience of patients and their families. RNs need science knowledge to effectively communicate to patients and their families and justify their clinical decisions to colleagues (Kyriacos et al., 2005). These interactions are important because they ultimately influence the patients' understanding and involvement and ownership of their care. A recent study showed that patients and families trusted nurses who were competent communicators of bioscience concepts using layperson's language (Montayre et al., 2021). Nurses who demonstrated understanding of complex information and communicated it in meaningful ways to their patients reduced the anxieties related to treatment information (Karaca & Durna, 2019).

There is evidence to suggest a widespread general lack of understanding of biosciences among RNs globally. Although cultural influences may affect such claims, the actual or perceived deficiencies in bioscience knowledge are contingent on the clinical context in question. For example, RNs have reported to be lacking the confidence to explain the scientific rationale for their decisions as evidence from Australia (e.g.Craft et al., 2013; Craft et al., 2017c) and New Zealand (e.g. Friedel & Treagust, 2005 and; Johnston, 2012) reveals. A group of newly RNs in Sweden revealed that they were not confident in their bioscience knowledge, especially in anatomy and physiology (Andersson & Edberg, 2010). Similar concerns have been raised in other countries. A survey of 1142 Intensive Care Unit (ICU) nurses across 20 EU countries examined the critical care knowledge of 11 subject areas. The participants achieved comparatively low scores in the ventilation/respiration category, suggesting a deficit of the science in that area (Fulbrook et al., 2012). They suggested greater emphasis on relating the physiology and pharmacology of respiration, infection control and sepsis in an applied manner (Fulbrook et al., 2012), all of which are bioscience concepts. A study among 638 Belgian ICU nurses showed that many struggled to understand the physiology underlying their practice in the prevention of ventilator-associated pneumonia (Labeau et al., 2007).

About 95% of nurses (n = 559) in Korea felt that they were lacking in their bioscience knowledge (Choi-Kwon et al., 2002). The most frequent reasons for this perceived deficiency in the biosciences was that their courses were not linked to what was encountered in practice during their nurse education. The majority (65%) of the respondents believed that linking

biosciences with nursing practice would reduce the deficit among nurses. In addition, 61% felt that integrating biosciences into nursing courses and having nurses teach these would reduce the deficit. What was alarming in this study is that these nurses felt the debilitating effects of their inadequate bioscience knowledge when it came to performing professional nursing roles such as nursing assessment, implementing the nursing care plan, communicating with other healthcare professionals, and educating patients (Choi-Kwon et al., 2002). This may suggest the degree to which deficient bioscience understanding and application may have on patient care in this context.

In the UK, Clancy et al. (2000) reported that RNs who had worked for about 5 years reported having confidence in their own bioscience knowledge but could not confidently explain issues related to biosciences to their patients. Similarly, Campbell and Leathard (2000) in their study of nurses' knowledge of biosciences in a UK setting showed that overall scores were below the pass mark. This study concluded that nurses on average lacked both bioscience knowledge and application to clinical practice. Similarly, (Davis, 2010) found that only twenty percent (n = 42) of nurses surveyed in the their UK study felt their bioscience component had adequately prepared them for their clinical practice.

According to McVicar et al. (2010), nurses in their UK study who rated themselves as having weak bioscience knowledge admitted that the small gain was after graduation when they made connections with clinical practice, suggesting that their preregistration education did not adequately link science to practice. Taylor et al. (2015) supported this noting that although nurses in the UK were becoming more autonomous, taking on newer and more complex roles, such as prescription of medications and advanced practice, they appeared to rely more on protocols and seemed to lack adequate underpinning bioscience knowledge for their practice. Taylor et al. (2015) suggested that the persistent lack of bioscience application could partly stem from a general lack of specified bioscience learning outcomes for year 2 and 3 in the preregistration nursing curriculum, although this is not unique to the UK (Davis & Kimble, 2011; EC, 2005; NMC, 2010).

A recent study among new nurse graduates in Australia explored how they transferred the bioscience knowledge achieved during their preregistration studies to nursing practice. These new nurses may have found biosciences difficult to connect to practice as students, but as new RNs, they made links between the science they retained and their present practice (Montayre et al., 2021). An example in point is when participants reported consulting their

past bioscience notes/learning materials. The bioscience knowledge gained during the preregistration period supported their clinical judgements and helped to build trust with their patients and tailor their nursing care to cater for individual needs (Montayre et al., 2021). Equipped with the bioscience knowledge, these RNs were able to rely on it to speak with conviction. This study gives us an insight into the possibility of RNs to successfully transfer the bioscience learning gained during student years into clinical practice. Although this needs further research in other contexts, it is very encouraging and strengthens the view that improving retention and transfer of bioscience knowledge among preregistration nursing students is likely to improve overall clinical nursing practice among RNs.

The Nurses' Contribution to Antimicrobial Stewardship

From the definition of AMR, clearly, preventing and controlling resistant organisms in healthcare settings requires an understanding of microorganisms, infectious diseases, and management, all of which need a high degree of bioscience application to clinical practice. Nurses and students generally encounter clinical situations requiring recall and application of similar bioscience knowledge. For example, a study in the USA found that infection control, healthcare acquired infections, and disease transmission were rated as very important bioscience topics for nurses working in hospitals because they were routinely encountered in their practice (Durrant et al., 2017). The scope of bioscience knowledge needed depends on the context and scope of practice. For example, a nurse undertaking task-shifted roles in a low resource setting with a shortage of essential medicines, a high burden of communicable diseases and high levels of AMR would need different kinds of knowledge to one in a high-income country with stronger health systems and lower burden of communicable diseases.

AMR is a global public health problem accounting for high mortality and morbidity. Its wide reaching effects are likely to worsen if we do not do enough to reverse the current resistance trends (O'Neill, 2016). In addition to the known drivers of antimicrobial resistance, literature suggests that the COVID-19 pandemic has exacerbated the widespread use of antimicrobials, further contributing to resistance (Razzaque, 2021). For example, retrospective studies conducted by Zhou et al. (2020) and Chen et al. (2020) reported widespread use of antibiotics in the treatment of 191 and the majority of the 99 COVID 19 patients in China respectively. Evidence from a recent systematic review reveals infrequent bacterial co-infection among hospitalized COVID 19 patients, thereby presuming that the majority of them may not require antibiotic treatments (Langford et al., 2020).

Traditional antimicrobial stewardship programs did not fully appreciate and recognise the central role of nurses, seemingly placing nurses as potential rather than actual participants in antimicrobial stewardship (Kirby, 2020). On the contrary, evidence shows that nurses have traditionally participated in Antimicrobial stewardship activities (Olans et al., 2016). Research highlighting this less understood and invisible aspect of antimicrobial optimisation already undertaken by nurses is emerging (Kirby et al., 2020).

Nurses take on roles that influence prescribing in their daily work, even in contexts where prescribing is the remit of doctors. Nurses for example, are instrumental in educating patients, managing other staff, probing, reminding, checking, and querying the prescription decisions, starting antibiotics for septic patients and the intravenous to oral switch (ANA, 2017). They have been shown to hold considerable influence in the choice, timing, and duration of antimicrobials (Olans et al., 2015). Their unique position with the main prescribers and patients ensures prudent use of antimicrobials. Nurses are recognised as the leading bedside patient advocates who monitor the adverse effects of antibiotics and healthcare acquired infections (Medicine, 2011; Murphy, 2014).

The deliberate involvement of nurses in stewardship programs is likely to result in more prudent use of antimicrobials. In Hong Kong, the involvement of nurses in antibiotic audits was associated with significant reductions in inappropriate antibiotic prescriptions (Seto et al., 1996; Wong et al., 2020), although the study focussed on the nurse-physician interactions and leaving out the influences of patients and other workplace factors. Literature points to the increased involvement of nurses in prescription (Delamaire & Lafortune, 2010; Maier, 2019). Undeniably, nurses informally or indirectly support prudent antimicrobial practice because their main nursing activities are interlinked into the very structure of antimicrobial stewardship (Kirby et al., 2020; Olans et al., 2015).

Furthermore, nurses routinely implement infection prevention and management through routinely collection of samples for laboratory investigations such as culture and sensitivity as shown in the systematic review by (Durant, 2017) and other studies in the USA (e.g. Manning et al., 2016; Moore et al., 2019). In the UK, an investigatory procedure such as wound swabbing for culture and sensitivity is considered a core competency of all RNs in the UK (Pattern, 2010). According to the NMC (2008), the nurse is legally accountable for their actions and needs to know the implications of such a procedure. A solid science understanding would support the nurse to understand why, how, and when to take a wound

swab. The nurse would recognize the signs and symptoms of wound infection even before sample collection. Cultures and sensitivity may for example support the decision on whether a wound is colonized, or infected and which antimicrobials will effectively treat the infection. A nurse who understands this science is more likely to recognise the relevance of culture and sensitivity in the choice of antimicrobials and may follow up the patient more rigorously by commencing or advocating for antibiotic phasedown, timeout, or discontinuation depending on the patient's needs. This increased demand underscores the need for nurses to have firmer understanding of the science behind antimicrobials and other medications, infection prevention and control, culture, and sensitivity among others. Thus, nursing education should strengthen the bioscience component of the curriculum to meet this increasing need in clinical practice.

A lack of full integration of antimicrobial stewardship into formal nursing education presents a hindrance (Abbas et al., 2019; Courtenay et al., 2019; Padigos, Ritchie, et al., 2020) and may limit the science knowledge and engagement of nurses involved in stewardship programs. Advancing formal education would go a long way in strengthening stewardship practices among nurses. Padigos, Reid, et al. (2020) stressed that strengthening formal education on antimicrobial stewardship should start from undergraduate education and reinforced in clinical practice and postgraduate programs. While this recommendation was from a study conducted among ICU nurses in Australia, two integrative reviews in general nursing suggest that nurses are lacking in knowledge on concepts surrounding antimicrobial use and optimization (da Silva Felix & Toffolo, 2019; Gotterson et al., 2020). Incorporating antimicrobial stewardship into formal healthcare professional education programs is more likely to prepare future healthcare professionals to reduce AMR and improve health outcomes (Langford et al., 2020; Majumder et al., 2020). An 'Expert Review of Anti-Infective Therapy' emphasized the importance of integrating AMS programs into healthcare professions education curricula (Majumder et al., 2020) such as nursing.

It is important to strengthen the science component of the nursing curriculum and practice to adapt to and manage the emerging threats to healthcare systems. Supporting students and nurses to apply science knowledge is more invaluable in this era of AMR and pandemics such as COVID-19. Since the antimicrobial stewardship practices are already integral to clinical nursing practice, nurses are perfectly positioned to enhance antibiotic optimization and contribute to antimicrobial stewardship (Kirby et al., 2020). Supporting

nurses to take on task-shifted roles through application of the underlying science may significantly contribute to reductions in resistance and improve health outcomes.

The Implications of Task-shifting for the Education of Preregistration Nurses in Uganda

Task shifting is "a process of delegation whereby tasks are moved, where appropriate, to less specialised workers" (Fulton et al., 2011; WHO, 2006, 2008). It has been promoted and implemented as an effective avenue through which health worker shortages can be addressed (WHO, 2007). In addition, task shifting has been noted to increase efficiency and cut healthcare costs around the world, especially in LMICs. Generally, task shifting from physicians to nurses is becoming more common globally, although differences have been observed across different health systems (Maier & Aiken, 2016). Evidence shows that among 35 countries including the USA, the European Union, Canada, New Zealand, and Australia, 69 percent had implemented task shifting, although large variations in scope were reported (Maier & Aiken, 2016). Policy and educational reforms are predicted to further shift the boundaries between the medical and nursing professions. These projected workforce changes are likely to further expand the nursing scope of practice.

Task shifting requires a higher level of autonomy. Modern nurses no longer work in silos dominated by doctors, but in collaboration as members of the healthcare team. Nurses therefore need a firmer understanding of the science behind illnesses to support their changing roles. The expanding role of nurses strategically places them in positions requiring greater involvement in antimicrobial stewardship, which could lead to better patient outcomes (ANA, 2019).

Task-shifting has been the main stay in Uganda, with the evidence as early as 1918 (Baine et al., 2018). Within the Ugandan context, task shifting takes on vertical and horizontal forms, and exceeds nurses and midwives. For example, general surgeons carry out hysterectomies[2] which is traditionally the domain of gynaecologists, midwives carrying out nursing work and vice versa, nurses dispensing medicines and medical officers managing healthcare facilities (Dambisya & Matinhure, 2012). Most of the dispensing in some private and public hospitals, but especially lower health centres are carried out by nurses. Nurses have been observed to undertake roles beyond their scope of practice such as putting up

[2] A surgical procedure to remove the womb (uterus).

intravenous lines, patient assessment, diagnosis and prescribing (Dambisya & Matinhure, 2012). In many instances, nurses and midwives are the workforce that is constantly present on the ground, even in larger healthcare units like hospitals. According to (Ackers et al., 2016; Tweheyo et al., 2019), midwives and nurses were most often the only cadre continuously present on the ground and the presence of other professionals such as senior doctors was infrequent, with the medical workload provided by the largely unsupervised intern doctors. This means that nurses and midwives spent more time with the patients than any other cadres of health care professionals and were therefore in the best position to monitor patients.

Prescription of morphine has been reportedly delegated to clinical officers and Diploma nurses in palliative care settings in Uganda, after additional training from Hospice Africa. Previously, morphine was strictly reserved for in-patients and only prescribed by doctors. Procedures such as manual vacuum extraction[3], manual removal of the placenta[4] and aspiration were the reserve of doctors, but trained midwives are currently performing them. In another study, nurses and midwives performed episiotomies in addition to prescribing medicines, roles which are the reserve of obstetricians and doctors respectively (Baine et al., 2018). Comprehensive enrolled nurses (certificate) manage health centre II level facilities, their duties ranging from diagnosis, prescription, and management on the outpatient basis, in addition to the nursing and midwifery duties. Many nurses and midwives who received single training are posted to healthcare facilities requiring both nursing and midwifery services (Dambisya & Matinhure, 2012). They find themselves carrying out roles across the two professions. Task-shifting goes as far as patients' attendants and family taking roles such as feeding and bathing in-patients, collecting medications from the pharmacy, delivering specimens to the laboratories, and collecting results.

Whereas the above examples depict an overall increase in delegated tasks and therefore inferring a reciprocal increase in remuneration, investments in professional development and career development, it is not the case in many LMICs (Ackers et al., 2020). Although task-shifting was primarily encouraged due to acute shortages of health workers, it does not appear to be the case today. Task-shifting is no longer entirely due to health worker shortages per se; literature suggests that there are many unemployed skilled health workers available in Uganda. The small wage bill prevented government from employing them, in

[3] A surgical procedure to remove the retained pregnancy tissue in the womb by using gentle suction.
[4] The removal of the placenta from the uterus by disconnecting it from the uterine wall using an inserted hand.

addition to the government veto on recruitment, a position held by both health workers and ministry of Health officials (Baine et al., 2018). The working conditions with unclear career development paths, poor working conditions and low benefit packages force many highly skilled healthcare professionals to seek employment from the private sector or migrate (Baine et al., 2018). Some health workers suspected that the Government of Uganda was using task-shifting as a pretext to hiring skilled professionals, with the local governments preferring to hire less qualified workers to save on the remuneration bills (Dambisya & Matinhure, 2012).

Although task-shifting has been the cradle of the Ugandan health services delivery for a long time (Baine et al., 2018), it was mostly done without any enabling policy, regulatory framework or legal protection for those to whom tasks were shifted (Dambisya & Matinhure, 2012). In fact, services such as HIV/AIDS care and support, anaesthetic services and psychiatry extremely rely on the task-shifting to thrive in Uganda (Lutalo et al., 2009; Ozgediz et al., 2008; Weaver et al., 2006). A few examples exist of when task-shifting appears to be supported by institutional frameworks. In such cases, the health workers received training and support such in institutions that managed HIV/AIDS and tuberculosis. Largely, task shifting is informal and not supported by any policy and a scope of practice. It is unregulated (Baine et al., 2018).

According to Ackers et al. (2020) nurses and midwives took on significant roles as advocates for antimicrobial stewardship in an informal task-shifting approach, despite being barely mentioned in the National Action Plan. This goes to show that nurses may be a bedrock of antimicrobial success if adequately educated, trained, supported, and remunerated. Such efforts have proved successful in HIV/AIDS care and management. Ackers et al. (2020) acknowledged the need to actively engage and empower nurses and midwives owing to their more sustained presence on the ground and involvement with patients.

To adequately empower nurses to take a central role in the global fight against antimicrobial resistance in an environment with extensive task-shifting, healthcare leaders need to pay attention to the nurses' scope of practice, especially in LMICs such as Uganda, where the regulation regarding the scope of practice is not existent amidst an evolving nursing profession (Feringa et al., 2018). The regulation in place appears to lag far behind the current nursing practice. Nurses also need to base their own clinical decisions and practice on a strong body of bioscience knowledge because their role has expanded. Empowering nurses through training and support is more likely support them to base their practice on evidence,

communicate better with colleagues, build confidence and trust from themselves and colleagues even on issues regarding Antimicrobial resistance (Govender et al., 2018). As explained above, they are the ones administering the antibiotics, they monitor patients, spending the most time with them. In some lower health facilities, they are the workforce mainly involved in assessing, diagnosing, treating, and referring patients. Nurses in Uganda currently perform roles way above their scope of practice. In times of outbreaks, nurses are at the forefront of fighting epidemics and pandemics such as cholera and Ebola and COVID-19 and HIV/AIDS. Nurses in Uganda are working more independently (usually not by choice) under challenging circumstances and need strong bioscience foundation to make clinical decisions leading to improved patient outcomes.

Whereas many tasks requiring strong bioscience knowledge on antibiotic resistance have been informally task-shifted to nurses in Uganda, they have received minimal training, assessment, and support before entrusting them with this responsibility. According to Ness et al. (2015), it is logical to shift such roles to nurses and midwives as both cadres are involved in roles such as antibiotic prescription (especially in lower health centres and private clinics), dispensing, administration and monitoring of antibiotics, collecting laboratory samples, infection prevention and control (such as hand washing, sterilization and disinfection). When such roles are shifted, it is vital for those to whom the new roles are entrusted to understand the science and implications of such roles, such as prescribing. Welsh (2019) reported suboptimal antibiotic prescribing practices among midwives in Uganda, a practice that may stem from assigning new roles to professionals without adequate support and formal education. Welsh (2019) further stressed that although the midwifery curriculum in Uganda includes pharmacology, antimicrobial resistance and stewardship were not explicitly included although they were informally expected to prescribe antibiotics in practice.

This study will examine the current levels of knowledge on biosciences using antibiotics resistance as an indicator of bioscience knowledge. It will identify the factors associated with this level of bioscience knowledge among preregistration nursing students in Uganda. The study will further assess how nursing students currently learn and apply bioscience knowledge to clinical practice.

Clinical Supervision in the Clinical Learning Environment

Universities rely on outside organizations to provide environments in which students get exposure to patient care experiences. These contexts are commonly termed clinical learning environments (CLEs) (Flott & Linden, 2016). These may include hospitals, clinics, and simulation laboratories, GP offices, health departments, hospice settings and other healthcare settings (Mugwanya, 2015). Given the importance of CLEs, nurse educators should ensure that they contain meaningful learning opportunities. For example, nurses in one study in Uganda perceived the practicum sites as having a high number of patients and an array of health conditions, with many healthcare professionals involved in clinical teaching. The setting was viewed as ideal, offering numerous learning interprofessional and extraprofessional learning opportunities for students (Drasiku et al., 2021). Similarly, Kamphinda and Chilemba (2019) supported the position that the CLE in Malawi was rich with clinical learning opportunities for nursing students. Indeed, Fell et al. (2016) maintained that the CLE was the optimal context to 'nursify' bioscience knowledge and apply it to deepen students' learning. Montayre et al. (2021) added that the integration of biosciences to nursing practice can be strengthened by embedding the practice to theory (classroom) and theory to practice (CLE) early on at the curriculum level.

An ideal CLE should promote supervision among learners through high-level peer interactions, staff support to promote confidence and motivation. In the recent past, nurse education has increasingly emphasised practice-based learning, which has increased the awareness of the vital position that clinical mentorship/supervision plays in nurse education and clinical placement student experiences (Eller et al., 2014; Foster et al., 2015). Clinical supervision is the process by which professional support and learning as required by the learner are provided in a non-judgemental manner within a CLE (Franklin, 2013). Through clinical supervision, nursing students can interact with experienced professionals to increase competence as well as confidence (Muthathi et al., 2017). This means that clinical supervisors have a dual role: (1) to provide patient care and (2) facilitate the learning of nursing students (Bwanga & Chanda, 2019). In theory, approved supervisors support preregistration nursing students to develop professional competency and confidence to promote safe and appropriate nursing care.

In addition, the general expectation is that nurse lecturers work hand in hand with clinical supervisors (mentors and preceptors) and brief them on the direction and information

about the students' theoretical learning and learning objectives prior to commencement of placements. All students should be introduced to their supervisor and be made aware of the expectations prior to commencing clinical placements. The supervisor should identify learning opportunities for students and call their attention to recall the theory and integrate nursing skills and bioscience practice during the clinical placements. Relatedly, effective clinical supervision was reported to be vital in ensuring positive CLE because supervisors offered learners opportunities to translate the theory into competencies (Rezaee & Ebrahimi, 2013). This may mean that effective clinical supervision is likely to result in positive learning experiences for nursing students.

Theory and practice share a reciprocal relationship: theory forms a basis on which practice is formed and without practice, theory is virtually meaningless. Nursing students generally spend at least 50% of their time in the clinical area, arriving with theoretical knowledge that they have largely not applied to nursing practice (Spouse, 2001), although this may be higher in some countries. They need the support of skilled and experienced professionals to make sense of that theory and relate it to their own practice in a safe manner. Connecting this theory and practice requires different teaching approaches to those used (Habimana et al., 2016; Mugwanya, 2015).

In the UK, the NMC published new standards for student supervision and assessment (Pearson & Wallymahmed, 2020). The new changes included phasing out of the term 'mentor', new roles such as 'Practice Assessor', 'Practice Supervisor', 'Nominated Person', and 'Academic Assessor' were introduced. The practice supervisors would support students in practice, give feedback to practice assessors on the competence of the learner to inform their decision. The practice and academic assessors will work-hand-in-hand to confirm the progress of the learner. In the new changes, all RNs will contribute to supervision and support of learners in practice. All registered healthcare professionals could act as clinical supervisors.

Within biosciences, the clinical supervisor is expected to have relevant bioscience knowledge and skills, be committed to supporting bioscience learning, and listen to the learners and meet their learning expectations. The final goal of clinical supervision within biosciences would be to enable the student to make appropriate and effective clinical decisions. It improves students' competence and provides a space for reflection and emotional support, support with professional development, and compliance with professional

and organizational treatment standards and practice. Clinical supervisors should provide learning opportunities, support, guidance, and feedback. It is an important element of learning in the clinical setting. Clinical supervision enhances the integration of theory to practice. Therefore, a study to investigate how students actually learn and apply bioscience knowledge to clinical practice will contribute to bridging the theory-practice gap currently existent in nursing education and practice. Literature suggests that the role of clinical supervisors is complex, mainly involving three major roles: management, education, and support (Bwanga & Chanda, 2019). According to the UK General Medical Council (GMC, 2015), a clinical supervisor is a professional trainer designated to oversee clinical work of a specific trainee and give valuable feedback during the placement.

The Managerial Function of Clinical Supervision

The managerial function of clinical supervisors sets the stage for creating a conducive CLE to enable the student to learn more effectively. The management role lends itself to the responsibility of ensuring that the learners recognize their roles and responsibilities within the CLE, they learn their professional boundaries and are aware of their professional scope of practice (University of Ottawa, 2011) as cited in (Bwanga & Chanda, 2019). The clinical supervisor ensures that students uphold and maintain the professional practice standards and ethics. The clinical supervisor plans the progress of the placement in addition to other tasks such as ensuring the availability of resources, staff, practice placement profiles[5], and workspaces (Bwanga & Chanda, 2019; Walsh, 2014).

A study assessing the factors affecting clinical supervision of nursing students in Uganda reported a coordination barrier between the HEI and the Hospital, where the university communicates to the hospital, but the clinical supervisors are not informed and until the morning students arrived on placements (Mugwanya, 2015). Similarly, Mulabiza (2018) reported poor working relations between the clinical placement site and training institution, a factor that was identified to hinder clinical skills development among the certificate and diploma nursing students. For example, the nursing school had no formal agreement with the hospital, no working policies for preceptorship were in place thereby limiting the effectiveness of the preceptorship program.

[5] A document which gives detailed information about the location, setting, philosophy, the health, and safety guidelines, learning opportunities and resources available in a particular clinical placement site.

In one study in Uganda, preregistration nursing students reported that induction to the placement sites was poorly done by their clinical supervisors (Mugwanya, 2015). They were asked to start working on arrival at the ward without familiarizing them to the personnel, working practices, expectations, and norms of the CLE. Another study in a larger regional referral hospital in Uganda revealed that the clinical preceptors did not orient students on the clinical routines, policies and practices of the placement sites (Mulabiza, 2018). A systematic review reported that although induction was important to nursing students, it was more so for international students who needed to be introduced to the culture of healthcare of the country (Bwanga & Chanda, 2019). This could have contributed to the failure to meet their learning needs that they reported (Mugwanya, 2015).

Clinical supervision was reported to be negatively affected by a lack of resources, especially in low resource settings, such as Uganda. Bwanga and Chanda (2019), Drasiku et al. (2021) and Mbakaya et al. (2020) reported inadequate supply of equipment and supplies, teaching materials, in addition to shortage of staff. The shortage of resources and personnel increased the workload of the clinical supervisors, to provide patient care and supervise students. This greatly limited the time available for teaching activities such as clinical teaching, assessment, and feedback. Bwanga and Chanda (2019) also reported that no protected time was set aside for clinical supervision, resulting into inconsistency and inequality in the teaching, where teaching times and durations were at the discretion of the clinical managers. According to Bwanga and Chanda (2019), CLEs suffered from shortage of staff was compound by the large number of students sent for clinical placements at the same time, further straining the limited resources and making supervision even more difficult. In contrast to Bwanga and Chanda (2019); (Mulabiza, 2018), Mugwanya (2015) reported an appropriate student to clinical supervisor ratio. However, the supervision was similarly limited by the big workload.

There is some evidence suggesting that some of the increased workload on the clinical supervisors was due to inadequate preparation of students for clinical placements by the HEIs. When students arrived on placements without the requisite knowledge, the supervisors were compelled to teach the theory as well as the practical components in the limited time available (Bwanga & Chanda, 2019), further overloading them. Adequate preparation prior to clinical placements supports the students' transition from classroom and simulation laboratory learning to the CLE. Students therefore need to arrive with the requisite knowledge and skills, given the limited time available for teaching in the CLE. According to

Habimana et al. (2016), students who join the clinical placements short of the requisite knowledge and skills are more likely to fall behind their peers and the supervisors and staff may be too busy to identify them and even follow them up .

The Educational Function of Clinical Supervision

The educational element of clinical supervision includes support rendered to learners to integrate knowledge, attitudes and skills to practice and become competent (Baker & Latham, 2012). The practice supervisor is expected to "role model safe and effective practice in keeping with the NMC Code" (NMC, 2018bc). The clinical supervisor should assist leaners to identify learning resources and learning strategies and stimulate them to create knowledge that will uniquely fit into the professional expectations of nurses. To achieve the learning objectives, supervisors create CLEs that stimulate reflection, critical thinking, teamworking, and responding appropriately to the needs of the patient (University of Ottawa, 2011). For example, in their systematic review of the nurses' experiences of clinical supervision of nursing students, Bwanga and Chanda (2019) identified four educational functions of clinical supervisors: clinical teaching, being role models, assessing leaners and giving valuable feedback. Within bioscience learning, nursing students equated a good clinical teacher as those who asked questions and tested their students' knowledge (Fell et al., 2016).

Clinical supervisors of bioscience learning should possess sufficient knowledge and skills in biosciences in addition to nursing knowledge and skills and adequate clinical education principles relating to clinical supervision. There is evidence within bioscience learning to suggest that good clinical supervisors should not only have adequate bioscience knowledge but also prioritize biosciences in their own teaching and nursing practice. It seems therefore that clinical supervisors who deliberately place biosciences at the forefront of their practice and teaching are more likely to meet the students' bioscience learning objectives whilst improving patient outcomes.

Although there is also a paucity of nursing research on learning of biosciences in clinical practice, literature suggests that the lack of bioscience knowledge may reduce the confidence and ability of a supervisor to effectively undertake their teaching role. For example, students in Australia viewed supervisors who lacked adequate bioscience knowledge as limiting their learning opportunities and as restrictive barriers to their need to

integrate bioscience theory and practice (Montayre et al., 2021). A study in the UK suggests that learning of biosciences in the clinical learning environment is persistently and consistently hindered by poor bioscience understanding and practice by practitioners (McVicar et al., 2010). There is a general consensus that clinical educators may not have adequate bioscience foundation to support students to apply bioscience knowledge within practice (Davis, 2010; Friedel & Treagust, 2005; Logan & Angel, 2011; McVicar et al., 2010). Although this evidence is from other contexts, the Ugandan context may similarly face the same problem. This study will support our understanding of the nature of clinical supervision that nursing students in Uganda currently receive while learning and applying bioscience to clinical practice.

Nursing students place great importance on clinical supervisors who can teach and support their learning. Literature suggests that effective clinical supervisors need to be competent in the principles and practices of clinical instruction. The common narrative in LMICs settings such as Uganda is that most of the clinical supervisors were not competent to undertake clinical teaching responsibilities, mainly citing lack of formal training. A case in point is a study in Uganda which investigated the factors affecting clinical supervision of nursing students. This study suggests that the clinical supervisors had limited training in the principles and skills of clinical supervision (Mugwanya, 2015). In addition, end of placement evaluations and formal placement appraisals were not done to assess the extents to which placement objectives were met on the side of learners and clinical supervisors.

As in many low-resource settings, most nurses in Uganda possess professional qualifications below degree level. Despite this, some evidence suggests that nurses viewed themselves as possessing invaluable experience and expertise (Mekgoe et al., 2019) to supervise nursing students on the degree program in spite of not having formal clinical teaching training (Drasiku et al., 2021). Literature stresses that a lack of formal training in clinical teaching erodes the value of the clinical experience and expertise that the teacher imparts on the learner (Mkony et al., 2012) and may affect the delivery of the content and communication of objectives and feedback. Another study of clinical preceptorship standards for nursing students in Uganda revealed that the clinical preceptors were not competent to support learning, with 80% lacking formal preceptorship training (Mulabiza, 2018). They also lacked skills in developing daily work-plans to identify appropriate patients for their students. A systematic review on clinical supervision in nursing reported that most of the clinical supervisors were not competent in the education principles of clinical supervision.

Conversely, those who were trained in clinical supervision were confident in the teaching and facilitation of practice-based learning (Bwanga & Chanda, 2019).

There is evidence, predominantly in the low-resource settings, to suggest that some nursing students were minimally supervised while on placements. A study in Malawi reported limited clinical supervision for nursing students. In this study, supervisory visits were "scanty" although the CLE was in the vicinity of the HEI. Their lecturers' visits were largely to checking their clinical placement attendance and not teaching or supporting their learning (Kamphinda & Chilemba, 2019). They reported feeling alone with ward nurses who were not interested in teaching them. The students indicated that they were left to work on their own, unsupervised, and expected to perform roles like those of staff nurses, without support (Kamphinda & Chilemba, 2019).

In Malawi, nursing students were not formatively assessed and given feedback; mistakes went uncorrected and bad practices may have been reinforced. This is not surprising because it is difficult for a supervisor who scarcely works alongside students and therefore lacks a point of reference to give objective feedback (Kamphinda & Chilemba, 2019). In another study in Malawi, the students were not satisfied with the how assessments and feedback were given during practice, partly because they were sometimes not done in time (Mbakaya et al., 2020) or that it was not given continuously as in (Kamphinda & Chilemba, 2019). The learners sometimes interpreted the lack of feedback to mean that their clinical supervisors were not interested in their work.

Although assessment and feedback are part of the roles of clinical supervisors, there is some evidence attesting to the contrary. A study in Uganda reported that preceptors did not give feedback on formative and summative assessments (Mulabiza, 2018). Although this was a study for certificate and diploma students and generally looked at learning in clinical placements, it gives a snapshot into what could be happening in biosciences. Our understanding of the kind of assessment and feedback that students currently receive while learning and applying biosciences is limited. Therefore, this study will add to the body of knowledge in this area and possibly suggest ways to improve nursing education in this context.

The Support Function of Clinical Supervision

The supportive function of clinical supervision aims at creating an atmosphere where the learner can calmly and safely discuss concerns and try out new things. This function contributes to a positive clinical learning environment, allowing the learner to adjust and cope with its stresses. In this role, the clinical supervisor supports students to socialize into the profession, building therapeutic relationships (University of Ottawa, 2011). In addition, the supportive function also entails the stakeholders supporting clinical supervisors in their role. For example, HEIs have the responsibility of ensuring that supervisors are qualified, trained and competent for their roles (Walsh, 2014).

A report from a systematic review on clinical supervision suggested that clinical supervisors were dissatisfied owing to the little supported given to them from the HEIs (Bwanga & Chanda, 2019). The HEIs did not communicate the students' placement learning outcomes in a timely manner and they were less involved in the supervision of their students. In the study by Mugwanya (2015), the clinical supervisors claimed that the university tutors and lecturers were largely uninvolved in the clinical placements of their students. They called on them to be more involved in clinical teaching alongside them and to also reduce on their teaching. In another study, nursing students expected their lecturers to accompany them on clinical placements and have some teaching sessions (Mbakaya et al., 2020). In this study, the students called for allocation more clinical teaching hours for their lecturers. In this study, the students felt more comfortable learning from the lecturers that taught them in the classroom because of the existing rapport and pursuit for continuity, more so given the disparity between the ideal taught in the university and what is in practice.

Similarly, students in a study by Kamphinda and Chilemba (2019) reported missing the supervisory relationship of their lecturers once they went on clinical placement. They perceived their lecturers to be in a better position to teach them than the ward nurses. Similarly, a study in Iran reported that nursing students lacked guidance due to the unsupportive relationships with staff nurses (Cheraghi et al., 2008). It is not uncommon for student nurses to report friction with their clinical supervisors. In one study, students preferred their lecturers to staff nurses and supervisors because of the negative relationships in addition to the staff nurses being too busy to teach them (Mbakaya et al., 2020). This is similar to study in Greece where staff nurses were reported to be hostile to nursing students (Papathanasiou et al., 2014).

Nursing can no longer ignore clinical supervision if it is to improve bioscience education and practice. It is not surprising that most nursing students are largely voicing discontent with clinical supervision while on placements. It seems that the practice settings have not stepped up to lead the way regarding bioscience practice despite evidence that the relevance of biosciences goes beyond the remit of the theoretical and practice applications (Montayre et al., 2021), enabling nurses to provide more holistic care. One of the hinderances to the attention on bioscience teaching within nursing practice education is the lack of explicit bioscience content in the placement documentation (Fell et al., 2016). For example, a lack of emphasis on specific biosciences components in observation charts and patients' notes offer little incentive for teachers and students to bring biosciences to the forefront in practice settings. In addition, incorporating clearer bioscience criteria in patients' assessments and supporting practice educators to link bioscience theory to clinical reasoning is likely to provide more systematic and deliberate education and support for nursing students (Fell et al., 2016). These issues increase the importance of biosciences in preregistration and post-registration nursing education.

In conclusion, the science component of nursing appears to be weak in education and clinical practice. This is a significant gap given the enhanced roles of nurses in low resource settings like Uganda, which are also struggling with the threat of AMR, which call for a stronger science basis for clinical decisions. This study will fill this gap by increasing our understanding of the level of science knowledge that nursing students currently enter practice with and the factors of that level of knowledge. Additionally, we will better understand how preregistration-nursing students learn and apply biosciences in clinical practice and the factors that affect their ability to apply science to practice.

Theoretical Framework for this Study

The review of literature has revealed that the science component of nursing appears to be weak in education and clinical practice. This is a significant gap given the enhanced roles of nurses in low resource settings like Uganda, which are also struggling with the threat of antimicrobial resistance, which call for a stronger science basis for clinical decisions. This study will fill this gap by increasing our understanding of the level of science knowledge that nursing students currently enter practice with and the factors of that level of knowledge. Additionally, we will better understand how preregistration-nursing students learn and apply biosciences in clinical practice and the factors that affect their ability to apply science in practice.

To locate the research problem within an existing theory, reduce it to understandable concepts, and specify the key variables, I adopted Biggs' 3-P Model of teaching and learning to inform the conceptual framework of this study. A conceptual framework is a representation of a researcher's synthesis of literature on how to explain a particular phenomenon (Regoniel, 2015). It identifies the variables within the research and demonstrates how they interact according to the researcher's understanding. Conceptual frameworks usually draw from tested theoretical frameworks or models that other researchers have used to test theories to explain how and why particular phenomena occur (Regoniel, 2015).

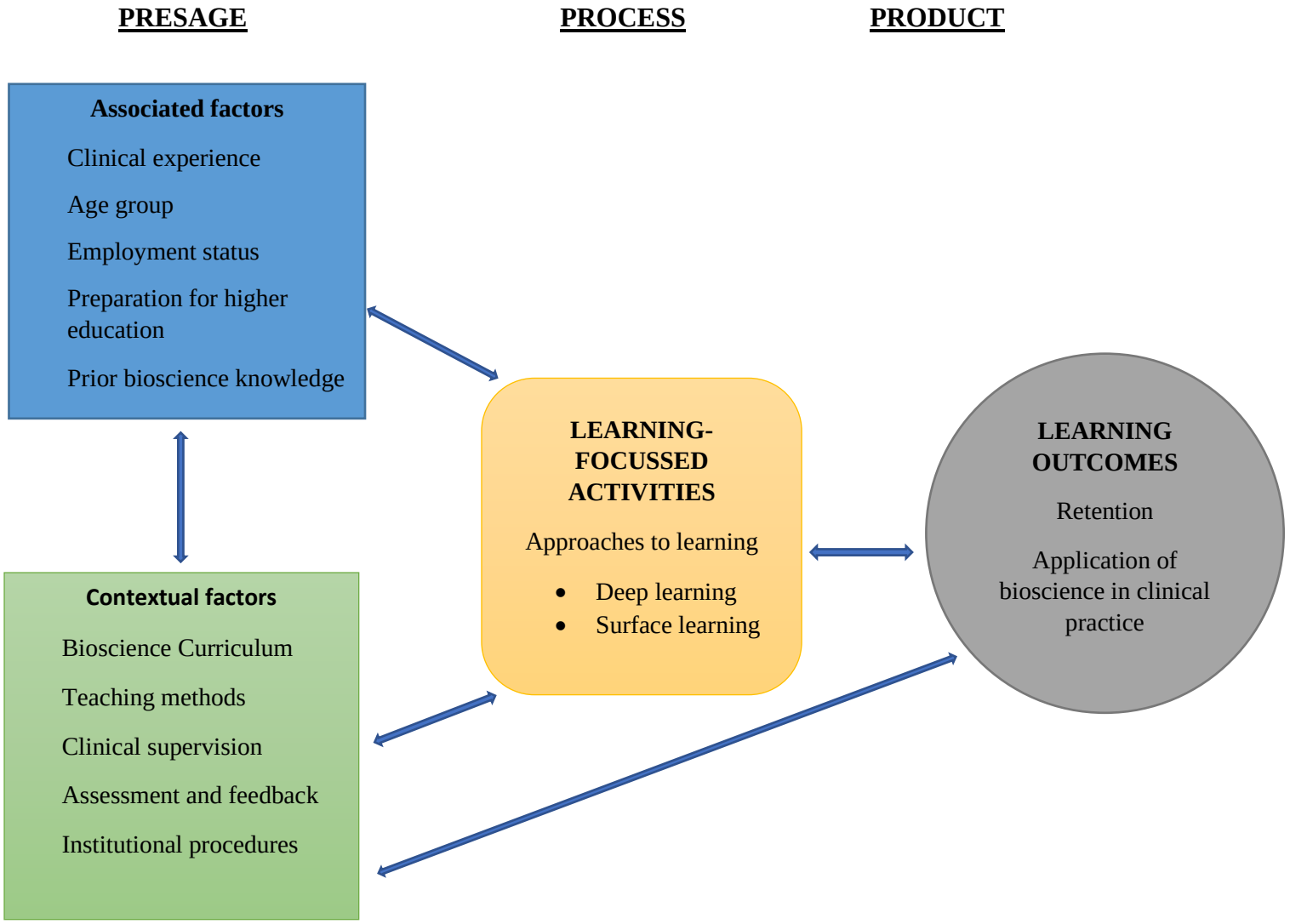
The aim of this study is to understand the level of bioscience knowledge and associated factors and how the students currently learn and apply that knowledge in clinical practice. It assesses the success of the bioscience curriculum, teaching, and learning processes that have occurred during the pre-registration nursing degree. In other words, this study sought to understand learning that has taken place, the learners, and their context. Learning is a complex process where learners assimilate knowledge using specific techniques within a complex environment. Biggs' 3P model was relevant to this study because it captures the complex process of learning and presents the relationships existing within the learning environment (Tynjälä, 2013). It shows how the factors inherent within learners and the teaching context interact during learning to lead to achievement or non-achievement of desired learning outcomes. Within this model, the teacher is responsible for designing and structuring the learning environment while the learners are responsible for appropriately engaging with the environment to achieve deep learning.

Biggs explains that learning is about interaction of the student and the teaching context to produce an approach to learning which affects the quality of the learning outcomes (Biggs, 1989). In other words, it is an interaction between what happens during teaching and learning and the approaches a student adopts to learning. Biggs' 3 Ps refer to the basic components of learning: presage, process, and product. Biggs theorizes that two presage factors, that is student-related and teaching context-related factors, interact to generate an approach that a student uses to learn (process), which produces characteristic learning outcomes (product). Input from the presage stage directly affects the student's approach to learning. For example, the teaching strategies employed by bioscience teachers will influence the approach the learner adopts to learn. Teaching strategies which do not adequately support learners will result in learners adopting surface approaches to learning. The aim of teaching in this case would be to ensure that learners are encouraged to apply deep approaches to learning and discourage learners from using surface approaches.

The process level is the heart of the 3P model, determining whether the activities learners pursue produce the desired learning outcomes. These activities depend on the students' perception of themselves, the learning tasks, their reflections, and the context in which all this takes place (de la Fuente et al., 2014). The assumption in this study is that students will appropriately engage with the bioscience course content using deep approaches to learning and achieve the desired learning outcomes. Bioscience concepts are complex in nature and often learners require an experience by doing or examples in clinical practice on which to build and refine new knowledge to appropriately engage with content. Nursing is a practice profession (Willis, 2015) and as such theoretical knowledge should be translated to the patients' bedside through doing. This means that students should be actively involved in their learning to develop bioscience competences through experiential learning.

Kolb's four-stage model of experiential learning suggests that learning is unique for each learner and is influenced by the students' knowledge and experience (Kolb, 1984). In this way, learning is cyclic rather than a rigid linear process, constructed on prior knowledge and experiences (Fry et al., 2008). They learn by doing, while experiencing, through hands-on practice and reflection (Fry et al., 2008; Kolb, 1984). Experiences support learners to gain a sense of belonging, being part of a culture and social context thereby creating memories of rich experiences of learning on which to build future learning (Wilson & Beard, 2013). In this case, a student who has prior clinical experiences of a bioscience concept will more likely engage better with new knowledge through reflecting on past experiences.

Figure 1: Applying the 3-P Model of Teaching and Learning to Biosciences in Nurse Education



Source: Adopted from Biggs (Biggs & Tang, 2011)

In this study, factors related to the students such as clinical experience, employment, preparation for higher education and prior bioscience knowledge will affect how well they engage with new bioscience knowledge. In addition, contextual factors such as curricula, teaching methods, clinical supervision, assessment and feedback and institutional procedures will also affect the learning process. The product of the learning process includes the knowledge, skills, and attitudes that learners retain and apply in clinical practice. This considers the quantity and quality of learning, critical thinking, values, attitudes, the competences gained and transferred to new clinical problems.

Although Biggs' 3P model is generally well regarded in higher education, some criticism around its underdevelopment has arisen. It is thought that this model was not

allowed adequate time to be explained and examined before readily taking it up (Howie & Bagnall, 2013). Not enough research has been undertaken into its "underlying structure and meaning" and as such it did not "earn its due" (Howie & Bagnall, 2013, p. 392). Following from this is the lack of explicit understanding of what exactly surface and deep learning mean and constitute in practical terms. We still have insufficient supporting evidence on how effective this model is when applied to real practice settings in higher education (Howie & Bagnall, 2013).

I expect this study to contribute to the 3P model. First, the mixed methods approach will provide data from more than one source using quantitative and qualitative methods thus increase validity. It will identify the personal factors associated with bioscience success and attempt to explain these as well as those within the learning context. The qualitative results will be useful in putting a voice to the contextual factors within the 3P model as applied to nurse education thereby improving its applicability to real-life situations.

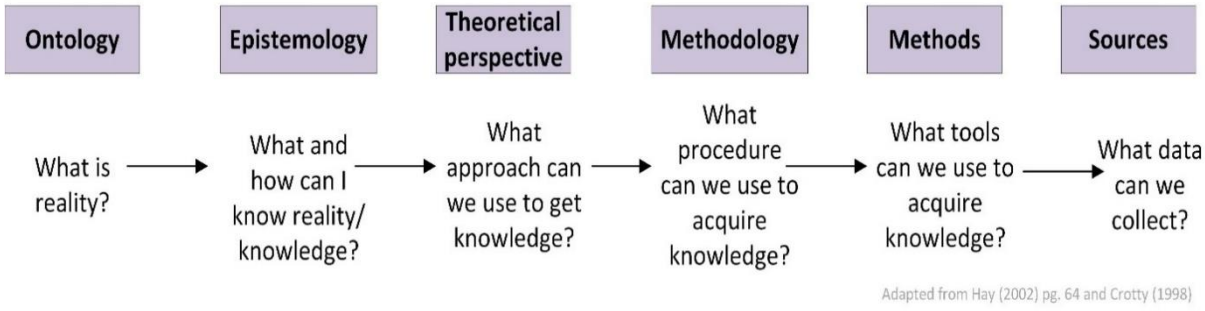
Chapter 3: Methodology

Introduction

Research can be described as a systematic way of obtaining information or a methodical way to answer questions (Gliner et al., 2011, p. 3) on a particular phenomenon. It is a systematic and controlled enquiry through which data are collected, analysed, and interpreted to serve purposes such as elimination of difficulties or improvement of conditions (Cohen et al., 2013; Mackenzie & Knipe, 2006). This definition adds the steps and purpose to the definition. Research, therefore, must be systematic, following a series of elaborate steps, and purposeful for it to be meaningful. This does not mean that the process is always linear, because research is often iterative. Being clear about the research process is important in interrogating the methods used, reusing and or building on previous research and assessing the research for quality.

Systematic enquiry has generated various methodologies collectively called paradigms. A paradigm is a set of assumptions about how things work, a shared acceptance of reality (Rossman & Rallis, 2003). A reality can be viewed differently by people because paradigms are like lenses that govern how we structure our thoughts about observed phenomena. A research paradigm is a set of beliefs and prescriptions shared between scientists about what should be studied, how problems should be understood, and addressed (Bryman, 2003). It denotes the philosophical positions of researchers about the nature of reality, what can be known, and how that knowledge can be obtained (Clark, 1998). Guba (1990) explained research paradigms as characterized through their ontology (what is reality), epistemology (how do you know something), and methodology (how do you go about finding it out). Figure 2 illustrates the relationship between them.

Figure 2: Relationship between ontology, epistemology, and methodology.



A paradigmatic stance would prompt the researcher to think about the being of phenomena or the ontology. Ontology is the study of being or the nature of reality. It denotes the way things are. For example, the nature of a parameter like weight may be objectively measured and would give a similar result regardless of who is doing the measurement and the machine used if it is standardized. In contrast, a feeling such as hopelessness would be very subjective and could be interpreted differently depending on who is interpreting it. So in this case, epistemology is the view of how knowledge about the weight and despair can be taught or studied (Bryman, 2003). It is the way researchers believe they know things. Epistemology focuses on the origins and nature of knowledge, how knowledge is constructed, and the relationship between the "knower and the known, and what role values play in understanding" (Maykut et al., 1994, p. 4). It deals with the means of production and dissemination of knowledge, asking questions such as: Is there truth and/or an absolute truth, is there one way or many ways to obtain knowledge, and how do we know what we know? Epistemology will then determine the theoretical perspectives, methodology, methods of seeking knowledge, and sources of knowledge. Methodology is the study of the epistemological assumptions contained in specific methods which encompass our entire approach to research, assumptions about the nature of knowledge, and the methods of data collection and analysis (DeMarrais & Lapan, 2003, pp. 4-5).

In summary, a paradigm consists of three elements: ontology (the nature of reality), epistemology (the belief about the nature of knowledge), and methodology. The hypothesis of each paradigm has different connotations depending on the underpinning theoretical framework (Assalahi, 2015). There are two major research paradigms: positivism and constructivism.

The positivist paradigm of research

Positivism is based on the universality of laws and emphasizes the existence of universal reality on which people can agree (Newman & Benz, 1998). It contends that these shared truths are significant provided they are observable, replicable, and verifiable (Anderson & Anderson, 1998). Positivists believe that there is a single reality which can be measured, it is universal rather than embedded, working with a unitary and invariant set of methods (Scott & Robin, 2011).

The ontological assumption supporting the positivist paradigm pertains to the independent realities outside the mind. Objectivism is used to describe the ontological stance

of positivism. To call anything real means that it is essentially out there and detached from the individual. The positivist paradigm posits that there is an external world out there that needs to be discovered. The answers are out there and only need to be sought with the right methods. Positivists claim that for concepts to be deemed real, they should be objectively verified (Cohen et al., 2013) and proved using scientific means through measurement and/or observation.

The epistemological assumption of positivism is realism. It posits that the truth resides within objective entities and resides independently of the human mind (Crotty, 1998). In other words, the world is objective, existing independently of those who seek to know it. There is a clear separation between the subjects (knowers) and the objects (the world) (Scott & Usher, 2010), and researchers should attempt to detach themselves from the reality under investigation, distancing themselves from those or what is under study in order to prevent or reduce bias (Assalahi, 2015). The facts are to do with the world and are therefore objective, and values and concerns are to do with the subjective which must not be allowed to interfere with the discovery (Scott & Usher, 2010). Positivists "bracket out their value systems" in order to discover what is, thereby reporting what matches to the reality is in a direct way (Scott & Robin, 2011). The researcher therefore, seeks to explain reality by objective observation, authentication, and measurement (Anderson & Anderson, 1998; Clark, 1998). The positivist philosophical stance of objectivity during discovery informs the associated methodologies as part of the overall design in the process of inquiry.

The constructivist (interpretive) paradigm of research

This constructivist philosophical stance largely came to prominence in response to criticisms of the positivist stance. The main criticism of the positivist school of thought was their ignorance and departure from the social factors that make researchers and respondents uniquely human (Assalahi, 2015). Unlike positivists, the constructivists are concerned with understanding the subjective world of human experience (Cohen et al., 2013). They argue that human behaviour can neither be governed by general universal rules, characterized by underlying uniformities nor explained by implementing natural science methods such as measurement and observation (Cohen et al., 2013). They posit that the social world can only be understood from the viewpoint of those who are part the ongoing phenomena under study. Therefore, human behaviour can be understood by researchers by way of those who perform

them and in the context in which they happen. This is due to the complex nature of our environment and the interactions humans have with the world. They reject the view of the detached, objective observer, choosing one where the researcher shares the frame of reference of the participants to understand their behaviour. Constructivists model individuals under study as autonomous, not the plastic version hypothesized by positivists (Cohen et al., 2013). Therefore, constructivists concentrate on the qualitative aspects of human relationships (Wallen & Fraenkel, 2001).

The ontological stance of constructivism is relativist (subjectivism). For them, realities are multiple and relative, "a social construct that embraces multiple interpretations of reality" (Newman & Benz, 1998, p. 2). Interpretivism views reality as part of the human mind, although entities are external because their meanings are given from human perceptions. The epistemological stance of constructivists is constructionism, believing that knowledge is constructed via participants (Assalahi, 2015). Researchers are active knowers who understand and reflect on the phenomena under investigation. The researcher can mutually attain that understanding by interpreting the meanings of those involved. Also, researchers work as part of rather than detached from the knowledge they seek (Dunne et al., 2005, p. 15).

Qualitative research designs typically aim to understand and unearth what is happening in a social context. They are concerned with observing and interpreting phenomena with the aim of constructing theory to explain what is experienced (Newman & Benz, 1998). Qualitative research has no specific structure and may change over time depending on the merging phenomena. Wallen and Fraenkel (2001) summarized the central features of interpretive research as: interested in exploring and describing contextualized reality through the eyes of participants; gain deeper understanding through collecting, categorizing of data rather than making overarching generalizations; they construct questions and designs depending on the purposive sample; the results are described in detail, uncovering underlying patterns; they establish validity and reliability.

The pragmatic paradigm of research

The tensions between the positivist and constructivist points of view resulted in the 'paradigm wars' whose central debate was the perceived difference in philosophical assumptions. The "wars" ranged from the 1970s to 1990s (Teddlie & Tashakkori, 2003). The

hypothesis that the constructivist and positivist paradigms could never be mixed was founded on the belief that that two ontologically, epistemologically, and methodologically different paradigms could not be integrated.

Other schools of thought came up to support the mixing of the two paradigms. For example, critical realism supported the belief that qualitative and quantitative research can actually work together to address each other's' limitations (Shannon-Baker, 2016). Pragmatism, the most prominently accepted alternative to the two old paradigms, supports mixed methods research (Feilzer, 2010). One of the most important utilities of the pragmatic paradigm is that it aims to find a middle ground between the first two paradigms (Johnson & Onwuegbuzie, 2004). Pragmatists believe that reality is continually negotiated, debated, and interpreted and therefore the best method to use is the one that solves the problem. It offers researchers the freedom to choose the best approach for specific research questions at hand (Yardley & Bishop, 2015), and advocates for a balance between objectivity and subjectivity throughout the research (Shannon-Baker, 2016). It recognizes that while positivist and interpretivist views are distinct, they are commensurate as well since they both advance knowledge production (Yardley & Bishop, 2015) and construct shared meaning (Yardley & Bishop, 2015).

Pragmatism as the paradigm position for this study

Philosophy shapes the way we formulate research problems, the questions we study, and the methods we apply to obtain the answers (Theiss, 2019). They reveal what assumptions researchers make about their research, which leads to their choice of research design and methods, data analysis and interpretation (Moon & Blackman, 2017). Researchers bring with them assumptions, ideas, and positions, often developed over years of personal experiences, convictions, and motivations to their research. This is emphasized by Theiss (2019) who suggests that philosophical assumptions are embedded in our training and reinforced by the cultures within our disciplines. Often, researchers' assumptions change over time such as when they leave their discipline and work in multidisciplinary teams.

Making personal philosophical stances explicit is important in validating the truth because the researcher's assumptions tend to steer research in a certain direction. One could argue that researchers' ontology and epistemology play a vital role in how they view knowledge and relate with it, and the methodology they will use to study that knowledge. Awareness of the philosophical assumptions of the researcher fosters the quality of research

and can contribute to creativity. As a nurse educator, my experiences in clinical nursing practice and nurse education have shaped my view of reality. They affect the kind of problems I investigate; whether I seek to solve problems in the real-world, discover a hidden truth, or extend my knowledge of a particular phenomenon. Furthermore, my experiences affect the methodology I chose to apply to this study, my beliefs and assumptions about nursing education research such as the nature of truth, origin of knowledge, the goals, and best means of achieving those objectives (Fraenkel et al., 2015).

I initially came to nursing with a "textbook version" of health and illness. I was trained to look out for classic signs, symptoms, read results and interpret them from standardized measures and use protocols to achieve the desired goals. My general view of health and illness was skewed towards positivism and hard science. As I progressed through my career, I realized that whereas the numbers and science were good indicators of health/illness, predictors of improvement or deterioration, they were not the only source of truth. There were other 'softer' realities that affected health, although they could not be necessarily measured or quantified. I recall stories of patients' experiences of health and illness constructed from the contexts where I worked. No two individuals had the same experience, even when they had similar health problems. I realized that health knowledge is both objective and subjective. It is a continuum, a spectrum of colours.

My transition from clinical nursing to nurse education further cemented my views of reality. In the six years of teaching, I was often assigned to teach bioscience courses and support supervise students on clinical placements. First, I noticed that the students' scores in the bioscience courses were consistently lower than the non-bioscience courses. I recall several incidents when my colleagues and I discussed these problems informally. Whereas this was the case for many years, we did not formally raise this with management or collectively seek for possible solutions. For some reason, we appeared to view this as normal. As I took on more responsibility, several students came up to me seeking support with bioscience courses, with many of them failing individual courses and a few repeating the year. This was similar in two HEIs where I worked. It became common that most of the retake assessments were in bioscience courses. Many students appeared to either be on the borderline or fail bioscience courses. I initially believed that the problem was just due to the complexity of the bioscience content. I set out to find innovative ways to support my students. For example, I showed my class how to recall the names, locations, and functions of the twelve cranial nerves. I also took time off to teach struggling students how to use mind

mapping to understand complex bioscience concepts. Later, I understood that although students recalled the science it did not automatically translate to transfer of that knowledge to clinical practice. The knowledge somehow remained with the learner and did not trickle down to the patient.

During clinical support supervision, I noted that whereas students learned the clinical skills, most of them could not explain the science behind their own actions. Most of the students could not explain the scientific rationale of their clinical decisions and why they recommended certain courses of action such as certain medications. Their answers were often down to protocol rather than logic. Students often fell silent when I asked science questions related to their case presentations. I noted that although they learned biosciences well into their third year, many found it difficult to apply that knowledge to clinical practice. The bioscience problem appeared to be more complex, more widespread, traversing the classroom to clinical practice. This problem could not be understood through scores alone. I needed to understand what exactly the students were experiencing. What was happening in their classrooms and clinical placements that promoted or prevented the retention and application of biosciences in clinical nursing practice. I needed to explore the factors associated with retention and application of science from multiple angles. Looking back to my days as a preregistration nursing student, it was not uncommon for large numbers of students in the faculty of Medicine to fail and retake bioscience courses. It was the same, year after year.

I decided to dedicate time to understand the bioscience problem in Uganda. As a pragmatist, I am free to choose the methods I employ to answer the research questions. The bioscience problem is complex and requires both subjective and objective methods to study it. Whereas I was aware that students were struggling to retain and apply biosciences, there was no research evidence to back up my observations and convictions. There were many methodological possibilities at my disposal to open this up to further exploration. However, given the lack of literature in Uganda, I had to start from somewhere easier and work my way up to build more evidence. First, I needed evidence that students struggled more with biosciences than non-bioscience courses. Then, understand how widespread these difficulties were across the country, which section of learners were more affected, and the factors that were associated with these difficulties. Lastly, I would explore how students learn biosciences in the classroom and clinical area, what support they receive to learn and apply science, and the factors that affect the application of bioscience knowledge to clinical practice.

According to Andrew and Halcomb (2009, p. 45), pragmatism is a philosophical stance that embraces several viewpoints of a research problem, and therefore underpins most mixed methods research. It is a problem-solving philosophy where "the best research methods are those that help to most effectively answer the research question" (Andrew & Halcomb, 2009). In this research, a mixed methods approach was appropriate because we had limited understanding of this complex problem in Uganda. This approach will provide a better understanding of this less-known problem, than if qualitative or quantitative methods were used alone (Creswell & Clark, 2017). Greene (2007, p. 20) added that a mixed methods approach provides multiple ways of "seeing and hearing", thus becoming a natural outlet of conducting research that is "constantly being displayed through our everyday lives" (Creswell & Clark, 2017, p. 2). Mixed methods enabled the study of the bioscience problem from multiple angles. Greene et al. (1989) as cited in Molina-Azorin (2016) explained that mixed methods research can be used to develop and expand findings from one method with another method. This study had separate but related quantitative and qualitative research questions, meaning both methods were necessary.

In this study, the quantitative and qualitative strands have a "symbiotic relationship". The quantitative results identified the extent of the problem and uncovered the relationships between the variables, while the qualitative results revealed the meanings behind the problem thus explaining the quantitative results. The quantitative strand was important in two ways:

1. Prior to this research, most of what was known about bioscience education in Uganda was anecdotal. First, I had to establish that nursing students experienced significant problems with bioscience courses than with other disciplines. To answer this question, I collected and analysed secondary data which included scores of bioscience courses and non-biosciences. I compared bioscience scores with non-bioscience scores originally collected over years. It provided baseline data on which a wider quantitative study and later a more in-depth qualitative study would be done.
2. The major quantitative study established the extent of the difficulties in biosciences in Uganda. Although the secondary results suggested that students experienced significantly more problems with the biosciences than non-biosciences, this was not sufficient to measure the level of explicit bioscience knowledge and associated factors among nursing students as they prepared to enter practice. In addition, more data were needed to further understand the scope of the problem to

allow for generalizations. It identified the factors associated with the different levels of bioscience knowledge. The results from this phase could therefore be generalized to the preregistration nursing students in Uganda. Importantly to the qualitative strand, the quantitative strand supported the selection of the participants in the qualitative strand of this study, where deeper exploration of these relationships was explored.

The qualitative strand added quality to the dry quantitative results. It explained the results from Phase 1: why students in Uganda experience difficulties in retaining and applying bioscience knowledge to clinical practice. It further expanded our understanding and explained the difficulties that nursing students experienced with biosciences. It explained why how and what they learn affect their retention and application of biosciences. It described the level and kind of support they receive to learn and apply their bioscience knowledge and identified the factors which affect their application of bioscience knowledge to clinical practice. Creswell and Clark (2017) noted that whereas quantitative methods provide a general understanding of a research problem, qualitative data provides a detailed understanding of a problem. One approach could not paint the complete picture of the bioscience problem in Uganda and employing mixed offset the weaknesses of each approach and drew on the strength of each.

Reflexivity

The interaction between researchers and the researched and resultant data collected can greatly impact on qualitative findings (Breuer et al., 2002). First, the 'self' of a researcher contributes to the conception and development of qualitative questions such as choosing to research what interests or affects them. Second, it may affect how results are interpreted. This means that they bring their personal experiences, preconceptions, backgrounds, and beliefs about the likely findings before they even set out to conduct the study (Drake, 2010). Whereas this may be useful in some ways such as when they need to interpret their participants' reality, it can greatly bias the findings if not recognized and kept in check through reflexivity.

Reflexivity generally refers to examination of the beliefs, preconceptions, judgements, and practices of oneself throughout the research process and how these may have influenced the study. It is a deliberate process where researchers maintain a conscious awareness of their

potential impact on the study (Bondi, 2009; Lynch, 2008) and it involves repeatedly questioning the 'taken for granted' assumptions thereby shedding light on the researcher as a part of the research (Finlay, 1998) and rather than entirely ignoring their impact. Reflexivity promotes transparency at each stage of the research process (Lynch, 2008) and demonstrates that the findings are valid (Koshy et al., 2010).

Reflexivity is considered differently across research traditions with positivists choosing to adopt a value free position mimicking the natural sciences and therefore use the third person narrative. In contrast, interpretive approaches encourage discussions on reflexivity, choosing to use the first person (Webb, 1992). Part of my reflexivity was in locating my position within this research. Whereas I was valuable in accessing and interpreting the realities of the research participants, my position as an insider being a Ugandan Nurse educator who taught some bioscience courses on the curriculum could potentially bias the interpretation of the participants' reality. My own experiences and frustrations on seeing students failing to understand and apply bioscience in clinical practice were understandably likely to get in the way of impartiality. I knew the hurdles in accessing learning opportunities and achieving learning objectives, given the competing demands between clinical roles and students supervision and teaching. I witnessed first-hand, the inadequacy in clinical supervision in many clinical contexts in Uganda having been a student myself and a clinical support supervisor for years. I was genuinely interested in improving the science educational preparation of the students.

Whereas this was the case, I was not a member of staff of the University where I collected qualitative data which helped me to step back from my own preconceptions and seek to understand the students' reality. I sought to understand their experiences of learning and applying biosciences through their lenses, constantly bracketing my own biases, and checking to ensure that my interpretations were consistent with their shared meaning. In addition, even though I joined nursing through a similar route (A-levels), I undertook my studies in a public university which was better equipped and funded and therefore my own experiences may have been different in this respect.

Whereas I could relate with these participants and the general culture in Uganda, I was an outsider in this university and the hospital where they went for clinical practice. My position within this study constantly shifted between being an insider and outsider. This gave me insight into the inner workings of the students' experiences while also keeping me

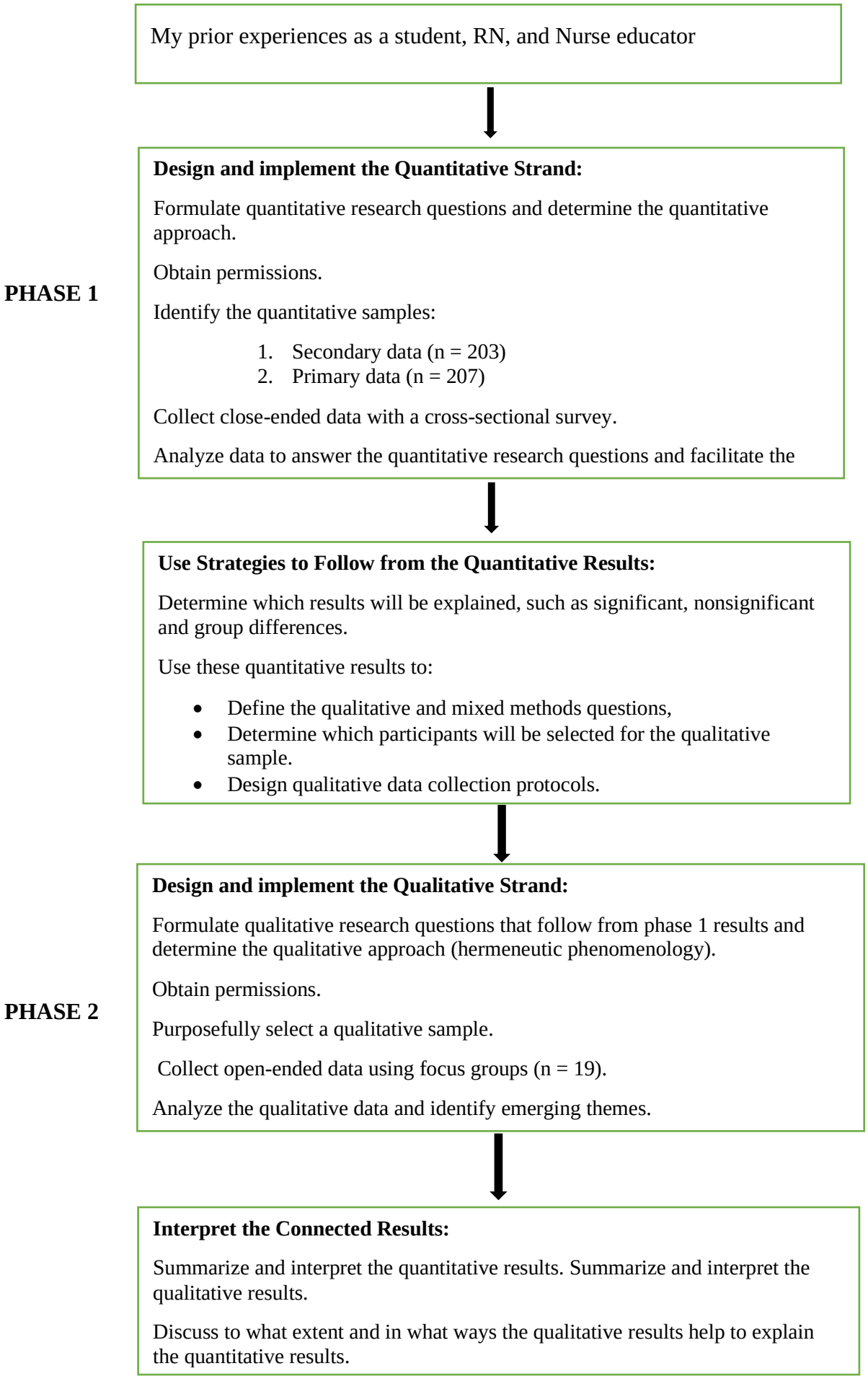
objective especially in my questions and interpretations. I remember my surprise when I learned that most of the students' clinical assessments took place in the side rooms with many lasting only a few minutes. In such incidences, I allowed myself to be the outsider in this context allowed myself to depend on them to understand why they felt the way they felt thus enriching the data collected and resultant interpretations.

Research Design

According to Andrew and Halcomb (2009), a research design is the general approach to a research study which encompasses the aims, methods and expected outcomes. In this research, quantitative and qualitative data were collected and analysed, and the findings were integrated, and conclusions drawn from the two data sources. A sequential explanatory design consisting of two phases was conducted. First, background secondary quantitative data was collected and analysed, followed by a larger quantitative survey, followed by a qualitative study. In this design, a researcher examines a research problem using connected quantitative and qualitative studies that are sequentially aligned (Creswell & Clark, 2017). In this study, first, preliminary numerical data in form of scores were collected and analysed. The first data set informed the design of the first phase, where more numerical data were collected via a quantitative survey. The results from the survey informed the research questions, sampling, and data collection in the qualitative phase.

The research questions iteratively influenced the overall design of this study. According to Creswell and Clark (2017, p. 60), mixed methods research designs are principally determined by the research questions. This as they explained, stems from the central tenet of pragmatism where the researcher selects what works to decide on the methods that work best to answer the research questions. As explained above, the research problem could not be sufficiently answered with quantitative or qualitative methods alone. In this case, for example, the quantitative results provided an overall understanding of the research problem, the qualitative results were needed develop a deeper understanding of the problem, thus explaining the quantitative results. The quantitative and qualitative strands were connected at the data collection. Figure 2 below illustrates the overall research design for this study.

Figure 3:Flowchart of the overall research design



According to Creswell and Clark (2017), four key points can be used to determine research design decisions. The level of interaction of the strands, the relative importance of the strands, the timing, and procedures of mixing the strands.

The level of interaction, as elaborated by Creswell and Clark (2017), is the extent to which each of the strands is separate or interacts with the other. In this study, the two strands interacted directly, thus adopting an interactive approach. The two strands were combined before the final interpretation of the results. The quantitative and qualitative strands were connected at the data collection. More precisely, the design and conduct of the qualitative phase depended on the results from the quantitative phases.

The two strands were of equal priority in this study. The quantitative and qualitative approaches added valuable insights of approximately equal proportions to answering the research questions as supported by (Johnson et al., 2007). In this study, the quantitative method supported the qualitative component by first, bringing the problem in the limelight. It illuminated our way into this less known problem of biosciences in Uganda, by suggesting that nursing students experience some difficulty with bioscience courses as portrayed by the course scores. In addition, it measured the level of explicit bioscience knowledge that nursing students had as they prepared to enter practice. It also identified the students who most likely struggled to retain and apply bioscience knowledge to clinical practice and the associated factors. It provided preliminary information on the bioscience problem, thereby providing baseline evidence on participants to select in the qualitative phase of the study. Equally, the qualitative phase clarified the quantitative results. It explained the difficulties the students faced in the acquisition and application of biosciences in the classroom and clinical practice contexts. It identified and explained the barriers to retention and application of biosciences, thereby clarifying the quantitative results. It went beyond explaining the significant quantitative results to identifying and explaining other factors that affected the retention and application of biosciences within the wider social context of higher education. It extended our understanding of the bioscience problem beyond the bounds of the quantitative results to include the students' perceptions about the support the students get to apply biosciences in clinical practice.

In terms of timing, the relationship between the quantitative and qualitative strands influenced the kind of data collected and the order in which the results from the two sets were used. The two forms of data were linked in a sequential manner by having one phase build on

the other, forming the research design which directed how the next phase was conducted. In each case the preceding phase was necessary for the planning of the next phase (Doorenbos, 2014). First, secondary data from one university was collected and analysed. The results from this preliminary dataset fed into the main quantitative study among nursing students from four universities. Then, the results from the quantitative strand were used to conduct a qualitative study involving focus group interviews in one university. In this sequential design, data collection and analysis of the preceding component took place before the data collection and analysis of the next phase because the next components depended on the outcomes of the previous phase (Schoonenboom & Johnson, 2017).

The point of interface, the point where the two strands were mixed, was from the point of quantitative data analysis to qualitative data collection. This is because the results obtained from the quantitative strand were used to make decisions about the qualitative strand. The mixing in this case occurred through connection by using the results from the first strand to shape the design of the qualitative strand. In addition, the quantitative phase informed the inclusion and exclusion criteria and resultant sampling and data collection of the qualitative strand of the study. This is supported by Creswell and Clark (2017) who argue that mixing the two strands at the point of data collection is a strategy of connecting where the results from one strand build on the data collection of the other strand.

Therefore, the overall research design for this research was a sequential explanatory design examining the bioscience problem in Uganda by connecting one quantitative phase and one qualitative phase in a sequential manner. Each phase used what was learned in the previous phase to address the central research aim (Creswell & Clark, 2017). Within the sequential explanatory design, the quantitative strand informed the group of nursing students who would participate in the qualitative strand. The quantitative strand supported the development of the research questions for the qualitative strand. It guided the qualitative strand by identifying the characteristics of the purposive sample for the qualitative strand. It was suitable because the research questions aimed to assess the knowledge of ABR and the associated relationships but also used qualitative results to explain the reasons for the quantitative results. It also extended our understanding of the deep-seated problems existent in the academic and clinical contexts in Uganda. It was suitable because the researcher was able to return to the participants for a second time to collect qualitive data.

Methods

Before deciding and embarking on the quantitative phase, my biographical and autobiographical experiences and background data were used to support the design of this phase. As discussed in the literature review, it appears that a student nurses generally struggled to retain and apply bioscience subjects, although no research evidence existed to support this claim. I collected background secondary data to verify this claim: to analyse the differences in the students' scores in the bioscience and non-bioscience subjects. I collected this data to study the trends in performance in biosciences within the two nursing programs. In addition, this background step explored any variations or similarities in scores within and between the two nursing programs and courses. The outcomes of this secondary data analysis generated the initial empirical evidence suggesting that nursing students experienced significant difficulties when learning biosciences.

The data were collected from a private, non-denominational urban university in Uganda. This university currently has six university campuses in six countries. Its nursing program operates on a work-study model, where students continue to study alongside their work, allowing them to continue clinical practice as they learn. It offers two nursing programs: (1) a diploma of nursing, where students who have a certificate of nursing upgrade to the diploma; and (2) a nursing degree, which enrols diploma holders intending to upgrade to the degree level.

Initial Research Questions

Before embarking on secondary data analysis, Johnston (2017) recommends that the researcher should first develop a research question to guide the dataset to use and the analyses to apply. The aim of this phase was to assess the overall level of knowledge of biosciences among nursing students in the university. The research question focused on examining the relationships between biosciences and nursing courses whilst also contributing to the overall aim of the study. An analysis of bioscience scores appeared to be a feasible option, at least to identify the relationships between bioscience courses and social science, nursing science, and behavioural science courses. It also provided preliminary evidence on the bioscience problem in Uganda, given that this area had not been explored prior to this study. The research question for this secondary data analysis was:

How effective is bioscience teaching? Specifically, this secondary data analysis sought to answer the following questions:

a. What proportion of pre-registration nursing students passed bioscience courses in the university in Uganda?
b. What proportion of pre-registration nursing students barely passed bioscience courses in the university in Uganda?
c. What proportion of pre-registration nursing students failed bioscience courses in the university in Uganda?
d. What is the difference between assessment outcomes in biosciences and non-bioscience subjects among nursing students in the university?

Identifying the dataset

I identified a university in Uganda that specializes in nursing education. I chose this university because I understood the organizational culture of teaching and learning in that context and the dataset would be accessible in a short time. My understanding of the context was important because it directly affected by the teaching and learning of biosciences in that context. This made this research practically relevant to my workplace. Also, understanding this context gave more meaning to this research because the results would directly relevant and useful to my work and contribute to improvement of teaching and learning in the university. The university kept records of students' performance, although data was not primarily archived to answer the research question at hand.

Johnston (2017) recommended that a researcher should evaluate the dataset after identifying it. Evaluation of a dataset is important for the researcher to ensure that it is appropriate for the research question (Dale et al., 1988; Smith & Smith Jr, 2008; Stewart & Kamins, 1993). This is an beneficial for secondary data analysis because having the data available made it easier to evaluate it for appropriateness before considering it for use (Stewart & Kamins, 1993, p. 18). Johnston (2017) recommends the following steps in evaluating the appropriateness of a dataset:

a) The original purpose of the study
b) Who was responsible for collecting the data?
c) How was the data collected?
d) When was the data collected?

e) What data was collected?

f) How consistent are the data?

This data was originally collected to report and archive examination scores of all nursing students in university. This data would be used to make decisions on the academic progress of the learners. These would be reflected in the transcripts of the students at the end of the academic program. In other words, the assessments sought to measure students' knowledge in respective areas of the approved nursing curriculum. Data were collected using standardized theory and practical assessments by lecturers and course leaders in the university. The quality of examinations was internally evaluated by subject experts followed by external appraisal. University policy ensures that this data is first checked by an examinations officer before submitting it to the academic registrar. Thereafter, the assessments were marked using standardized rubrics, and scores awarded as percentages.

The time when the data was collected is important (Boslaugh, 2007) because older data may not be as useful as newer data in some disciplines (such as technology), whereas it may not be the case in others. The data were originally collected between 2015 and 2017, and at several points along the nursing programs. This was the most current data available to the researcher to confirm what was currently taking place. This is data was also important because it covered seven cohorts of students. Three of the cohorts were nursing students on the diploma in nursing program, four groups were on the pre-registration degree. It was useful in demonstrating what was presently happening in biosciences in nurse education in Uganda and set a yardstick on which future analyses would be conducted. The data collected included the following: scores, grades, course, year of study, and cohort. This data was enough to answer the research questions at hand. The data were consistent because they were collected and compiled in a uniform format due to standardization of assessments, data collection, checking, grading, and reporting.

Preparation for data analysis

In preparation for data analysis, I evaluated how relevant and closely the data answered my research question. Although the purpose of the present study differed from those of the primary data collectors, most of the variables I required to answer my research question matched with those already included in the primary data. No scores were missing for any group of students. Although the assessments differed by cohort, program, and year of study, they were standardized to ensure that they met the quality standards of the university.

The secondary data were already compiled and stored in Microsoft excel format and therefore did not require extensive cleaning. I only retrieved the variables that were of interest to my research question. These included the final score, course, group, and program of study. Program of study refers to whether the student is on the pre-registration nursing degree, preregistration midwifery, or diploma in nursing program.

I created and coded new variables: grade per course and overall grade. I made these with the guidance of the university grading system. The overall pass mark in this university was sixty percent, but students who scored from 60% to 64% were graded as borderline. Therefore, in this analysis, any course score from 60% to 64% were coded as "barely pass" and these learners were likely to be struggling to pass the course. Students who scored below 60% automatically failed the course, therefore a code of "fail" was assigned. Any score greater or equal to 65% was regarded as a good pass, so it was coded as "pass". Other pre-existing variables such as course score, program of study, course was recorded and coded.

Data analysis

The bioscience courses analysed included anatomy and physiology, biochemistry, pathophysiology, pharmacology, microbiology, and life sciences. The non-bioscience courses included health assessment, adult health nursing, advanced nursing concepts, normal childbearing, HIV/AIDS care and support, developmental psychology, sociology of nursing, and trends and issues in nursing. The cleaned data were exported all data into SPSS software version 25 and analysed using descriptive statistics.

The main quantitative part of the study was designed following the secondary data analysis and sought to answer the following research questions:

a) What level of explicit knowledge on Antibiotic Resistance do nursing students currently have as they complete their degree program and enter practice?
b) What factors are associated with the levels of bioscience knowledge among nursing students completing their preregistration nursing degree in Uganda?

I used a quantitative cross-sectional descriptive survey to measure the current level of knowledge on antibiotic resistance, a bioscience concept, among nursing students in Uganda and identify the factors associated with that knowledge. A quantitative descriptive survey was appropriate to answer the research questions because there was no baseline data on the level

of biosciences knowledge that nursing students in Uganda had at the completion of the preregistration nursing program.

It would support our understanding of the factors associated with learning of biosciences among nursing students in Uganda. In addition, our understanding of the success of the current teaching methods used to deliver bioscience knowledge to nursing students in Uganda was limited. Creswell (2013) explains that a quantitative descriptive study is ideal when very little is known about a phenomenon in the given context. To our knowledge, no study had been undertaken to measure explicit bioscience knowledge among nursing students. This phase measured and described the level of explicit knowledge of ABR among nursing students. It also identified the relationships between demographic variables and determined causal relationships are determined using appropriate statistical tests.

Data were collected using a self-administered survey on ABR (see appendix A7). Response rate for this survey was 86% (N = 241, n = 207). The response rate was high because the researcher collected data while the students were in class and the instrument was collected immediately after completion. Subjects spent about between 15-30 minutes completing the survey.

This phase used a large sample of 3rd and 4th year pre-registration nursing students in Uganda, and assessed their level of explicit knowledge on ABR. The subjects selected were 3rd and 4th year preregistration nursing students because they had completed the mandatory bioscience content on the preregistration nursing curriculum. It was assumed that at that stage of their studies, they had acquired the basic and applied bioscience knowledge and were in the best position to provide information on their knowledge of ABR as they prepared to exit their nursing program and enter practice.

A full list of all university nursing schools/departments in Uganda, offering a Bachelor of Nursing degree was obtained. I conveniently selected four universities based on geography and type of university (private/public). Two public and two private universities were selected. All 3rd and 4th year nursing students from the invited institutions were invited to take part. All consenting subjects were recruited to participate in the study. Descriptive statistics were used to describe the phenomenon and inferential statistical tests were used to predict relationships between variables and generalise findings to the entire population. The survey was piloted on a section of nursing students in Uganda.

The study area

This study took place in four universities in Uganda because they were representative of the student population and characteristics of the universities in this context. Amongst them were two public universities (Universities B and D). They enrol students direct from A-levels and from the diploma route for those wishing to upgrade to the preregistration nursing degree. The two private universities were in the capital (University A) and a rural district in central Uganda (University C). University A runs a work-study program, where nurses upgrading to the Bachelor of Science in Nursing (BSN) degree continue to work while studying. University C is a private religious-based not-for-profit university in the rural central part of Uganda offering nursing degree programs for candidates direct from A-levels and those from the diploma in nursing.

Some of the above-mentioned characteristics such as ownership (private/public) and model of delivery of the degree programs (e.g., work-study program and full-time programs) were likely to impact on the findings of this phase. In Uganda, most students entering nursing programs directly from A-levels prefer to enrol in public universities largely because of their reputation as well-established universities, but also because of the opportunity to get government scholarships to pursue their degrees (these are given on merit to the best performing students at A-levels). This means that the quality of students that public and private universities attract may vary. Usually, public universities take on the best performing students from A-levels and those who were unsuccessful in winning government financial support either study on private basis in the public universities or opt to enrol in privately owned universities.

The mode of delivery of the study program also varies from university to university and this may affect the class size and learning environment of the students. Among the four universities selected, University A operates a work-study program for all students, where qualified nurses wishing to upgrade their qualifications are offered an opportunity to work full time or part-time and study for two days each week. This means that their students were not pulled from their work to study, but the study program gave them opportunities to remain in active employment whilst they studied. No students directly from A-levels enrol on such a program. This model attracts mature and highly experienced nurses in the country. These students appeared to have their bioscience instruction integrated to nursing practice, given their clinical experience. They were in active employment and therefore more likely to have more opportunities to practice what they learnt in class because they spent most of their time

in clinical practice, connecting what they learn to clinical practice. Class sizes within nursing degree programs in Uganda tend to be smaller (less than 30 students) and relatively uniform (age, profession, and working experience), the methods of instruction were more likely to be practice oriented.

This was in sharp contrast to the universities that ran traditional nursing programs where all students studied all full-time. These universities tended to attract a mixture of A-level leavers and diploma holders. Diploma holders who wished to enrol on these programs opted to work over the holidays and weekends or left work to concentrate on their studies. Other universities which enrolled students from both routes offered to teach their top-up students on some weekdays and over the weekend. This means that class sizes are likely to be larger and diverse in terms of science background, age, and clinical work experience.

The nursing program in University B is part of the School of Medicine and Health Sciences. This means that within a typical bioscience classroom, the nursing students (from A-levels and Diploma routes) also study with students from the faculty of medicine. The other students include Medical, medical laboratory, and pharmacy students. This means that the class size could reach over 200 and is so varied thus affecting the methods of instruction, support for learners, integration of biosciences to practice, and opportunities to practice.

Generally, it was highly likely that students with clinical experience, had more opportunities to practice what they learned in the classroom, and came from more uniform and smaller class sizes and therefore appeared to be more likely to have higher levels of bioscience knowledge as they completed their studies. I also expected that the students who enrolled directly from A-levels found bioscience learning easier in the classroom, owing to their strong science background. These students appeared to find integration more challenging owing to their limited clinical experience.

Sample size calculation

Sample size calculation

The sample size needed for the survey was calculated basing on a confidence interval (CI) of 95% and expected prevalence/coverage of 50% and a desired margin of error of 5% and an estimated design effect of one. The class size of preregistration nursing students is small compared to other programs ranging from 10-30 students. Using conventional formulae which assume an infinite population would yield a sample size too big for the size of the

population. By estimation, each class size is about 20 students in 10 universities. Since the study was targeting 3rd and 4th year students, each university would have an estimated 40 students to give a total population of 3rd and 4th year nursing students to be 400.

- Estimated population (N) was 400 students
- Confidence level of 95% with a corresponding Z-score of 1.96 (z)
- Margin of error of 5%, which is 0.05 (e)
- Expected coverage is 50% which is 0.5 (p)

Using the formula below, the estimated sample size calculated was 196 students.

Sample size (n) = $\frac{Z^2XP(1-P)}{e^2} \div 1 + (\frac{Z^2XP(1-P)}{e^2N})$

If a few students may withdraw participation or may not be on campus at the time of data collection, the target was revised to 200 students. A sample of 200 students was thought to be representative of a significant percentage of nursing students in Uganda. A number as large as possible was be needed to confidently establish their level of knowledge on antibiotic resistance, calculate the levels of significance, and associated factors. This sample was maintained given that the students were easily accessible since they would be found in their universities.

Participant selection

I obtained a representative sample from the target population using two-stage cluster sampling. First, I obtained a list of all universities in Uganda offering pre-registration nursing degrees. The universities were divided into public and private universities. Then four universities (clusters) were randomly selected from the list (two public and two private universities) using simple random sampling without replacement. Lastly, entire classes of 3rd and 4th year nursing students in the selected universities were conveniently selected to participate in the study. Convenience sampling was used here because nursing classes are typically small and employing random sampling may mean that a smaller sample size would be obtained. This technique was used to reduce the research costs. In addition, students from the same class were more likely to be homogeneous as there was more uniformity of subjects and learning context within the cluster than between clusters. It also made comparisons between universities possible.

Recruitment strategy

All 3rd and 4th year pre-registration nursing students in the selected universities were invited to participate in the study. After obtaining ethics permission from the universities, entire 3rd and 4th year cohorts of pre-registration nursing students were considered to participate in the study. The recruitment letters and information sheets were distributed by the course leader or another faculty member on the morning of the intended date of data collection. This was to avoid prior revision, cheating, and conferring by the study subjects, which would contaminate the results of the study. The potential subjects were given time to consider whether they wished to participate. I obtained a written agreement from the university allowing me to collect data. The module leader was contacted for permission to collect data. I sought permission to recruit participants during class time, although they had an option of not completing the survey in the class.

Participants were fully informed of what the study entailed, what their role in the study was, how long the data collection would take, what benefit they would gain, and the potential risks involved. Students were presented with a letter asking for their participation in the study. The research was explained to the whole class, but each student was invited to participate in the study individually and provided with the participant information sheet.

They were informed that participation was voluntary, and no penalty would be given for non-participation. Thereafter, they were asked to independently consent to participate in the study by signing the consent form, prior to completion of the survey. Each subject who consented to participate in the study was asked to put the signed consent form and completed survey in the envelope provided and seal them. The sealed envelopes were collected and stored safely by the researcher.

Anonymity was ensured throughout the study. Each survey tool was anonymized using a unique code which the subject was instructed to take a note for purposes of identifying the survey they completed in case they wished to withdraw from the study within 14 days after data collection. No name or initials of the participant was used on the form. The survey questions were completed independently and privately by each participant such that no participant could be traced back by use of their responses. The subjects were informed that the survey scores would not be used in any way for their progressive assessments to reduce the chances of cheating or conferring with each other. Participants were informed that only the researcher will have access to the data.

Inclusion criteria

Grove et al. (2012) define sampling criteria (eligibility criteria) as the list of features required for membership in the target population. Sampling criteria reduces the effect of the extraneous variables and ensures a large target population of potential subjects. To reduce sampling errors, the sampling criteria was as strict as possible (Grove et al., 2012). This would maximize the effect of the independent variables and reduce the effect that extraneous variables had on the dependent variables.

Only 3rd and 4th year pre-registration nursing students from the selected universities were included in this study. Top-up nursing students at the same level as 3rd and 4th year preregistration nursing students were also included in the study. Third and fourth-year nursing students and top-up students at the same level who consented to participate were included in the study. Only students who were present on the day of data collection participated in the study.

Exclusion criteria

Students registered on other programs other than the Bachelor of Nursing degree were excluded from the study. Students in the 1st and 2nd year of the nursing degree and top-up nursing students at the same level were excluded. Any eligible students that declined to consent were excluded. All absent students were automatically excluded from the study. All pre-registration nursing students from other universities other than the four selected ones were excluded from the study.

Data analysis

A total of 207 students completed and returned the survey, exceeding the original projection of 200 students. Quantitative data were prepared by inspecting for completeness and consistency. They were entered into SPSS version 25 and coded. Descriptive statistics were used to summarize the data using measures of spread and dispersion. For example, frequencies and percentages were used for dichotomous variables, and means and standard deviations were used for continuous variables. Outcomes on knowledge on antibiotics and antibiotic resistance were described using absolute numbers and percentages. Responses were dichotomized as correct or incorrect or as Likert scale answers where applicable. The percentages of correct answers were calculated.

Data were grouped in the following ways: demographic characteristics, general knowledge of antibiotics, specific knowledge of antibiotics use for specific infections, use of

antibiotics in the treatment of bacterial infections in the clinical area, personal practice and use of antibiotics, knowledge of the mechanism of action and contributing factors to antibiotic resistance. Inferential statistics were used to uncover any relationships and correlations between variables and generalize them to the entire population.

Data collection tools

Data were collected using a self-administered survey questionnaire consisting of 46 questions (see Appendix five attached). The survey was developed from extensive literature review on ABR, and some questions were adopted from previous surveys but modified to suit the level and context of the participants in Uganda. This was done because the surveys that were available were not suitable for the context of Uganda and the level of 3rd and 4th year students.

Questionnaire development

The questionnaire was developed in stages:

I undertook a literature review on the knowledge of antibiotics resistance among preregistration nursing students and other cadres of healthcare practitioners and students (e.g. Crombie, 2012; Erku, 2016; Kiguba et al., 2016; Nambatya et al., 2011; Weier et al., 2017). The literature review was done to define the concept of ABR and determine if other questionnaires or survey instruments existed on this topic. Artino Jr et al. (2014) pointed to this as the importance of conducting a literature review prior to developing the questionnaire. Gehlbach et al. (2010) supported this by emphasizing that the first step in survey development is the literature review which guarantees that the idea aligns with the related theory and research in the same field. It aligns the instrument with those already in existence.

A thorough literature review also helps the researcher to identify existent surveys that could potentially be used or adapted for the present study (Artino Jr et al., 2014). A pool of 50 survey questions was generated based on the already available tools in the literature (e.g. Asante et al., 2017; Inácio et al., 2017). These studies were selected because they resonated with the aims of the study and the level of students that I included in the study.

During the development of the items, the goal was to ensure that the items of the survey adequately presented antibiotic resistance in the language that preregistration nursing students in Uganda would understand (Artino Jr et al., 2014) and relate to. The number of questions included depended on the degree of complexity required and the level at which I was to assess knowledge on ABR. For example, I ensured that the simple and general questions

came at the beginning and arranged the questions to flow from general to specific. The more complex and specific questions came later in the survey also because the preceding simpler questions were prerequisites to understanding the more complex ones.

I assessed the suitability of the 50 questions to my research context. Most of the questions were appropriate but some had to be revised to reflect the context in which they were to be used. The revisions to the content of the questions were guided by the preregistration nursing curriculum currently in use in Uganda (see appendix A6 attached).

Since the study tool was also to be used to assess the factors associated with the level of bioscience knowledge, a section on demographic factors and aspects related to their study and employment were added to the questionnaire. In addition, the response options were checked to ensure that they were appropriate. The survey-questionnaire consisted of six sections.

Section 1: Demographic characteristics of the subjects

From the extensive literature review demographic factors were characterized as independent variables. Initially, ten demographic factors were included to in the survey, but after the literature review, employment status was added because some nursing programs in Uganda offer a work-study program. It was not apparently clear whether employment status would affect the learning of biosciences, but this factor was added to avoid it becoming a confounder. The other demographic factors included were gender, age, nationality, marital status, religion, tribe, program of study, route of entry onto nursing the program, year of study, and university.

Section 2: Knowledge on antibiotics

This section consisted of ten statements about antibiotics to which students would give answers. After undertaking the first pilot, the alternatives offered in the 10 questions of this section were revised from two (agree and disagree) to three (agree, disagree, and do not know). This was to reduce the chance of using guesswork or chance in answering the questions. It eliminated the chances of students randomly choosing answers thereby clouding the real picture in their knowledge on antibiotics.

The wording in questions 3, and 4 were revised. Question 3 was changed from “antibiotics are useful for bacterial infections’ to “antibiotics are used to treat bacterial infections”. Question 4 was changed from “Antibiotics are useful for viral infections” to

"Antibiotics are used to treat viral infections". This was to avoid any confusion as to the indications of antibiotics.

Section 3: Questions on antibiotics and bacteria

Initially, the instructions for this section of the questionnaire were not very clear. There was no instruction on how the student would indicate their choice. After the first pilot, an instruction was added: Please tick against or circle the best answer to the following questions on antibiotics and bacteria. In addition, option D in question 14 was changed from E. coli to Escherichia coli to give the bacteria its full name.

Section 4: Knowledge on the use of antibiotics in the treatment of bacterial infections in the clinical area.

This section had 10 questions on the prescription practices and use of antibiotics. Questions 20-24 were modified to have possible answers from "Yes and No" to "Yes, No, and Don't know".

Section 5: The professional role of nurses in reducing antibiotic resistance.

Before the first pilot, this section had six questions involving the knowledge of antibiotic stewardship and the professional role of nurses in reducing antibiotic resistance. Revision of this section was done after the pilot when only one student out of the 15 had heard of antibiotic stewardship. It seemed that this concept was new and not directly taught on the curriculum. Two questions on the professional role of nurses in reducing antibiotic resistance, which is stewardship were left.

6. Mode of action and contributing factors to antibiotic resistance

Initially, these 10 questions had two alternative responses (Yes and No). After the first pilot, a third option (I don't know) was added. The 'I don't know' option was added to avoid forcing the students to make a choice between Yes/No or Agree/Disagree on an aspect of biosciences they did not know. Students would be more motivated to generate answers or guess because they interpret the answers to impact on their final grade unlike the general population (Gideon, 2012; Rossi et al., 2013), therefore an 'I don't know' answer would filter out more false positive answers. In addition, since close ended questions are more likely to suffer from correct guessing than open ended questions (Rossi et al., 2013), adding an I don't know option would be an answer in its own right and therefore students who actually do not

know would be more likely to choose it because they would view it as an acceptable choice. The questions were further organized to flow more logically.

Pre-testing the questionnaire

The survey was piloted on fifteen 3rd and 4th year nursing students in two universities. Respondents were asked to comment on the clarity, order, relevance, and the time taken to answer the questions. They were asked to comment on whether the questions and instructions were understood. The pretesting process also helped to determine whether the response categories in the close ended questions were enough and whether certain questions were systematically missed by respondents. The pilot was administered in the same procedure as it was used in the main study to highlight any potential problems.

Modifications were made considering the responses from the pilot. All double-barrelled questions and double negatives were removed. Ambiguous questions were either modified or discarded. The questions were more clearly written and better presented. They were clearly numbered and grouped according to subject matter. Clear instructions were written for the respondents and headings made it clear to follow. A second pilot was done on the same students to seek additional comments on the questionnaire. Feedback was that the questions were more precise, direct and instructions were clear. The response time for the questionnaire was between 10-20 minutes.

The responses were used to test data entry and analysis procedures. The data was entered SPSS software version 24 and statistical tests were run to test the accuracy and viability of the project design (Ruel et al., 2015) . I modified the questionnaire based on the feedback from the pre-test. The reliability of the questionnaire was checked, and Cronbach Alpha value was 0.82.

This study received ethics approval from the University of Salford, an accredited research ethics committee in Uganda, and the Uganda National Council of Science and Technology, which is the national regulator of research in Uganda (see appendices E1, E2, and E3 attached).

The qualitative strand of this study followed the preliminary analysis of phase 1. The findings from phase 1 refined the qualitative research questions. The aim of Phase 2 was to explore students' experiences of learning, the teaching, and application of biosciences within university and clinical practice settings. Preregistration nursing students were the recipients of teaching in the academic and practice settings. They are the future of nursing and the

quality of their learning and practice of biosciences will ultimately affect the overall patient care. Exploration of their experiences and the factors that affect their learning would provide a benchmark upon which to improve retention and transfer of biosciences in nursing practice. The results from this phase would add to the body of knowledge and provide preliminary guidance to Higher Education Institutions and practice settings in to how to support nursing students better. The research questions were:

1. How do nursing students learn biosciences in the classroom and on clinical placements?

2. What are the students' perceptions about the support they receive to learn and apply biosciences?

3. What factors affect the application of bioscience knowledge to clinical practice among nursing students in Uganda?

In order the answer the research questions and meet the overall aim of this study, Phase 2 was conducted using a qualitative approach. Qualitative research is best suited for in depth exploration of lived experiences. It supports the researcher to be immersed in the researched, thus providing a rich and detailed picture of the phenomenon (Punch, 2013; Taylor et al., 2011). Furthermore, qualitative studies explore and unlock the meaning participants attach to their experiences (Creswell & Poth, 2016; Hennink et al., 2020), thus shedding light on the meanings that are less visible . They tend to seek to understand the complexities of social relationships and inductively explore the 'what, why and how' questions of the human experience (Tuffour, 2017). They describe, interpret, understand phenomena as experienced by the participants (Finlay, 2011). Qualitative inquiry is ideally placed to understand complex relationships among phenomena and interpret these meanings through exploring anticipated and unanticipated patterns (Braun & Clarke, 2013). Qualitative researchers exercise subjectivity whist acknowledging how their personal preconceptions shape the knowledge through reflexivity (Braun & Clarke, 2013; Willig, 2013).

I chose qualitative methods to understand the experiences of nursing students when learning and applying bioscience knowledge. It would help me to understand and interpret the meanings behind the participants' perceptions thereby giving more accurate account of the phenomenon under study. These unique characteristics of qualitative data link with the constructivist phenomenological approach adopted for this phase. It did not attempt to predict the outcome of the phenomenon, rather, it explored the details of the subjective experience

and interpreted meanings as they emerged. This added to the robustness of the study because I collected real data on the experiences of the students linking into the phenomenological approach discussed next.

Phenomenology

According to Teherani et al. (2015), phenomenology is the approach to research that aims to describe the 'real' phenomenon by exploring it from the standpoint of those who experienced it. Phenomenology describes the experience in terms of what was experienced and how it was experienced (Teherani et al., 2015). I wanted to understand the experiences of learning and applying biosciences and make meaningful conclusions that reflected the participants' experiences, hence employing phenomenology. The theoretical basis of this phase is constructivism, which correlated with phenomenology because the emphasis of this phase was on the meanings and interpretations of the experiences. According to Neubauer et al. (2019), phenomenology requires the researcher to reflect on the philosophy they embrace before choosing the phenomenological tradition to use.

Phenomenology has its roots in philosophical traditions that evolved over centuries; but modern phenomenology is credited to Husserl who defined phenomenology in the early 20th century (Kafle, 2011). His approach valued objective and subjective experiences equally, believing phenomenology to be a science of 'pure phenomena' (Eagleton, 2011, p. 55; Laverty, 2003). He rejected the positivists' belief in absolute objectivism opting instead to hold that the object of scientific study should be the phenomena as perceived by the individual's consciousness. Husserl's stance was that the assumptions, philosophical theory, deductive logic, and other empirical science or speculations held by the researcher should not inform phenomenological inquiry (Moran, 2002). To Husserl, the subjective and objective knowledge is deeply interwoven (Neubauer et al., 2019) and attempting to disconnect one form the other is diluting the experience as it is lived by the person. This school of thought pushed phenomenology beyond sensory perception to experiences of thoughts, emotions, and memory (Reiners, 2012).

Husserl's developed transcendental subjectivity (descriptive phenomenology) as a new field of inquiry still in use today (Staiti, 2012). The goal of descriptive phenomenology is to attain transcendental subjectivity, where the biases of the researcher on the study are constantly assessed and presuppositions neutralized to maintain the 'purity' of the experience (Lopez & Willis, 2004). The researcher steps aside and allows the data to emerge without

their subjectivity influencing the descriptions. The researcher therefore should reflectively access the participants' experiences without bringing categorizations, assumptions, expectations or hypotheses to the study (Laverty, 2003). This approach therefore follows rigorous descriptions of the participants' experience without external theory through bracketing (Laverty, 2003). Tufford and Newman (2012) is used to reduce the negative effects of introducing preconceptions into the research process. While the aim of the research is to present the feelings, views, attitudes, and lived experiences of research of participants, researchers are the instruments for analysis and interpretation of the data collected.

The subjective nature of qualitative research means that researchers may inevitably transmit their own preconceptions which ultimately influence how data is collected, interpreted and presented (Tufford & Newman, 2012). Bracketing also helps the collective effects of research material which may be emotionally challenging and facilitate deeper reflection at all stages of the research process. Descriptive phenomenology did not fit well with my personal philosophy, where this study was not entirely independent of my background and experiences of the phenomenon.

Away from the descriptive approach to phenomenology, the hermeneutic (interpretive) phenomenological approach assumes that reduction is impossible. The researcher cannot suspend personal opinions to just describe the experiences. Hermeneutics stress that philosophies, theories, and interpretations all permeate the research findings and contribute to the understanding of experiences in different ways (Finlay, 2011; Smith & Shinebourne, 2012; Tuffour, 2017). The resulting human experience is grounded on unrestricted imagination. Hermeneutic phenomenology traces its roots to Martin Heidegger. Heidegger breaks away from Husserl on the 'focus of phenomenological inquiry'(Neubauer et al., 2019). Husserl focused on the nature of knowledge (epistemology) while Heidegger was interested in the 'nature of being' (ontology) (Reiners, 2012). He focused on the human experience and how it is lived (Laverty, 2003) i.e. the relationship between the human being and his context. This school of thought holds that a person's conscious experience is not separate from their world or their history. Instead, the historically lived experiences, culture, and other experiences play a part in present experiences. We cannot step out of our world; we cannot experience phenomena without looking back to our background experiences (Lopez & Willis, 2004).

First, this tradition pushes beyond the boundaries of the descriptive tradition to interpret the experiences and phenomena via the person's world. In hermeneutic phenomenology, the researcher interprets the narratives of the participants in relation to their context to describe the underlying understanding of being and how that shaped their decisions. It holds that there is phenomena out there to be explored, requiring an investigator to meticulously bring it to light using their prior experience, beliefs, or notions to make sense of the experience once it is revealed (Smith & Shinebourne, 2012).

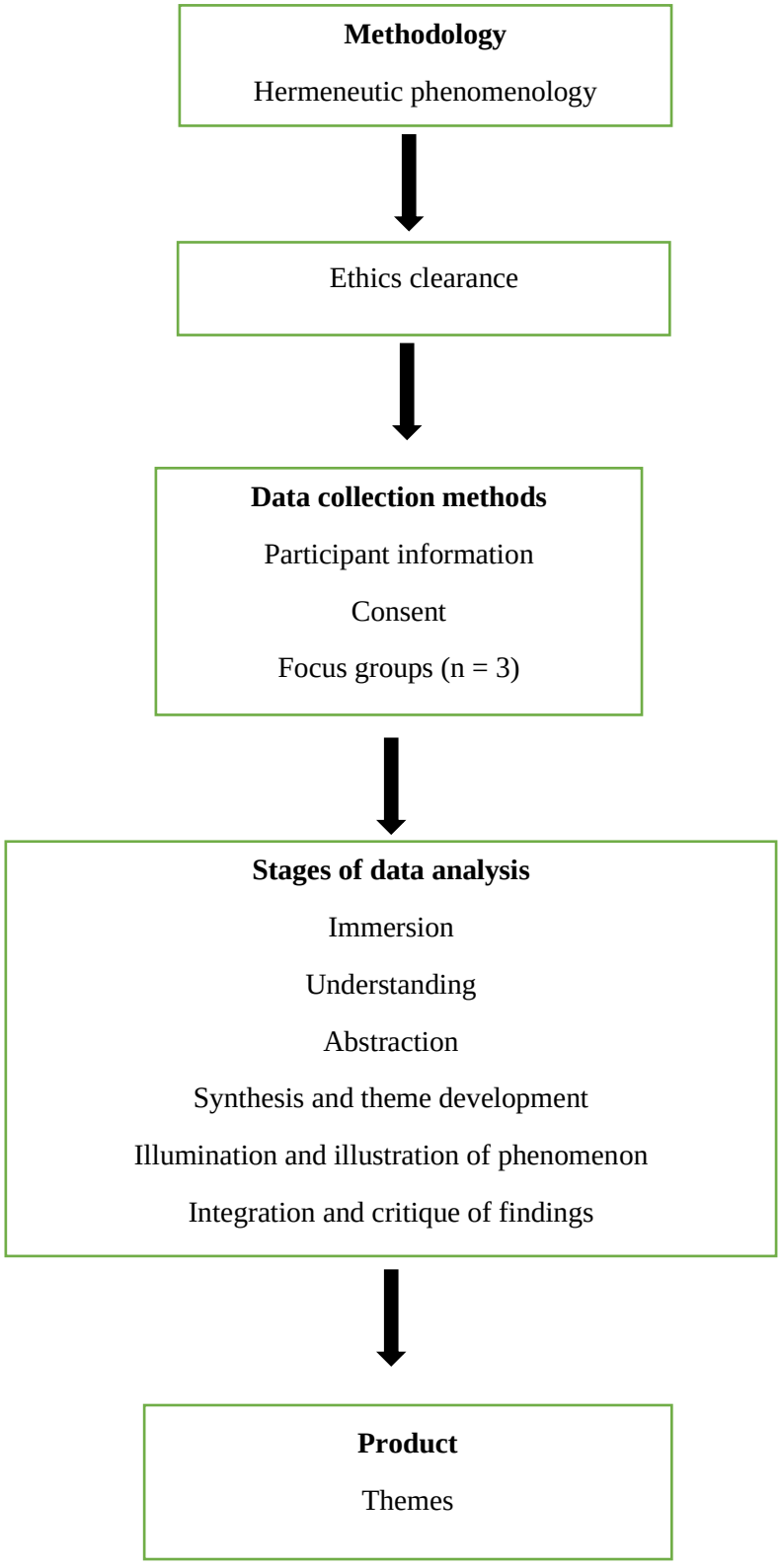
Secondly, hermeneutic phenomenology recognizes that just like the participants, the researcher cannot fully bracket or get rid of their lifeworld. Instead, the researcher's past experiences are viewed as valuable contributions to the inquiry. For example, my own experiences as a student nurse and nurse educator led to my interest in investigating this phenomenon. My position is that my interpretations of the students' experiences and personal reflections will shed light on the overall understanding of their experiences. My knowledge and experiences of the research context are valuable contributions to this research and bracketing them would dilute our understanding of the whole experience. Moran (2002) supports this view and contends that to ask a researcher to take a purely unbiased approach to an inquiry in which they have a subjective vested interest is inconsistent with the roots of hermeneutic phenomenology. The researcher should instead openly acknowledge his/her preconceptions and reflect on how this contributes to the analysis process. The researcher plays a central role in analyzing and interpreting the participants' experiences.

My aim was to intuitively seek to understand the surface meaning of the students' experiences of learning biosciences and reflect on my understanding of the context and past experiences to explain the deeper interpretation of that experience. The cycle of interpretation and reflection within hermeneutic phenomenology resonates with the hermeneutic circle where the encounter with the participants and the researcher's knowledge and experiences enrich the inquiry (Smith & Shinebourne, 2012). The other advantage of this approach is heavy reliance on inductive data collection which may unveil information that was not part of the original focus (Gray, 2013). This however may weaken the original aim and cloud the findings.

I selected hermeneutic phenomenology over descriptive phenomenology as the approach for this study because it considers the meaning of the lived experiences as well as the contextual forces that shapes that experience (Heidegger, 2010; Lopez & Willis, 2004).

Bioscience retention and application takes place within academic and clinical contexts. Hermeneutics recognizes the importance that academic and clinical learning contexts, and the players therein have on the overall retention and transfer of knowledge. The hermeneutic approach would open the space for me to fully explore and uncover potentially hidden layers of the experiences without having to bracket off my personal experiences (Heidegger, 2010).

Figure 4:Overview of the research approach adapted for Phase 2.



The qualitative strand of this study focused on a case study of a Ugandan university: University D. Although the phase 1 yielded useful results which pointed to the general difficulties nursing students experienced and the associated factors affecting their learning, it could not provide an in-depth exploration of the experiences of teaching and learning of biosciences among preregistration nursing students. Hermeneutic phenomenology was suitable for this phase because it gave me the freedom to explore the participants' interpretation and add my own interpretations. This was useful because the interpretive element of hermeneutic approach clarified the meanings and assumptions that the participants themselves had difficulty articulating (Crotty, 1996), especially the implicit practice knowledge. Furthermore, the participants often used statements that carried unique meanings in their context which an outsider would not clearly understand. My unique experience and position within the Ugandan context were useful to reflectively disentangle these experiences and interpret their meanings in an understandable way.

A more in-depth study was required, one which could explore the bioscience problem more thoroughly in the time and resources available. The bioscience problem among nursing students was multifaceted and it would be more suitable to examine it from different viewpoints. For example, exploring the socio-economic pressures that drive the bioscience problem in the real-life practice settings would enrich our understanding of this problem within the Ugandan context. A retrospective study enabled me to explore the experiences of teaching and learning biosciences from the students' perspective in their own context.

Study context

University D was selected following analysis of the data from Phase 1. University D currently runs Diploma of Nursing and Bachelor of Nursing degree programs. The students on the degree program are enrolled via two routes: (1) the direct route, where students were registered directly from A-levels on to the degree program lasting four years; (2) qualified nurses already holding a diploma of nursing were registered on a nursing degree program lasting three years. Unlike University B which operates a nursing program as part of a better resourced large medical school, University D did not seem to be well resourced. Students in B have more access, in terms of proximity, to a large regional referral hospital to which the university is affiliated. Their students had could spend extra time on the wards outside of the normal teaching times whereas students from D, for example, had to be transported by the university to their clinical placements only during term time. Relatedly, the medical school in University B boasts of fully functional and separate departments headed by experienced

personnel. For example, it has an anatomy and physiology department, microbiology department, biochemistry department and pathology department, all of which have separate laboratories. For example, the pathology department is housed within the hospital and was operated by clinically experienced pathologists. This implies that the preregistration nursing students in university B had access to more resources than those University D students.

The results from phase 1 suggested that among the four universities surveyed, D had the largest proportion of participants with a low level of knowledge on antibiotics and bacteria. Exploring the difficulties existent within the students' context would highlight the challenges students in University D face in learning and applying biosciences to clinical practice. In addition, University D enrols direct students who were identified in Phase 1 as associated with lower bioscience scores. The characteristics described above appeared to have contributed to the low level of bioscience knowledge among the students in D in addition to other factors.

It was therefore important to hear the voices of this demographic group and understand and interpret their experiences. Phase 2 was important in exploring and explaining the quantitative results, in addition to uncovering any contributors to this phenomenon in their context. Exploration of what happens in the academic and practice settings in D provided insight into how the students' learning experiences and other stakeholders in their context shaped their retention and application of biosciences. This study opened the doors to unlock our understanding of the bioscience problem in Uganda.

Sample selection and recruitment

Creswell and Poth (2016) recommend that finding and accessing the right participants and place to study and establishing rapport is an important step in qualitative data collection. Following the results from Phase 1, the levels of biosciences were not significantly different between the students by year of study, suggesting that the difficulties with biosciences did not improve or worsen as the learners progressed within the nursing degree. I relied on this result to select all the students in University D who had had at least one clinical placement as they had experienced the teaching in the academic and clinical contexts. Furthermore, these students could reflect on their experiences with biosciences. I was keen to explore any differences in experiences as the learners progressed through the nursing program.

These students had participated in the first phase, and they knew me from our previous encounter. I approached the Dean of the school to ask for permission to collect data

from the students. Then the Head of the nursing department offered to introduce me to the students and connected me to their class leaders. I held three meetings with three cohorts of students, introduced my study and asked them for voluntary participation. All the students in the three classes (n = 19) consented to participate. During our face-to-face meeting, I explained the study and its purpose. Each group selected the time they wished to have their data collected and I maintained communication with their leaders throughout the process.

Closely related to this step is the sampling strategy. Purposive sampling technique was used to select the participants. I used criterion sampling; a type of purposive sampling commonly used in phenomenological approaches where all cases that meet the criteria useful for quality assurance are used. Criterion sampling has been shown to work well when the researcher aims to study all individuals who represent the population who have experienced the phenomenon (Creswell & Clark, 2017). This technique was suitable to access the students who had first-hand knowledge and experiences of interest for this study. I aimed to access participants who would provide in-depth data with rich experiences (Creswell & Clark, 2017) of learning and applying biosciences the Ugandan context. I did not consider any other demographic characteristics. It was essential to select the students who had these experiences to obtain rich information associated with hermeneutic phenomenology. I was cognisant of the need to obtain a homogeneous group of participants to increase the chances of obtaining rich and accurate data. Creswell and Poth (2016) emphasize that phenomenological studies need to have more homogeneous characteristics because more diversity in the group makes it more difficult for the researcher to find common experiences, themes, and overall essence of the experience of the whole group. According to Creswell and Poth (2016), research participants in a phenomenological approach should be carefully selected to ensure that they are all experienced in the phenomenon under investigation to enable the researcher to condense the information into a common understanding.

Inclusion and exclusion criteria

All students on the preregistration nursing degree program in University D were included. The students from University D who were on the top-up program were excluded, leaving only those direct from A-levels. Entire cohorts of 2nd, 3rd, and 4th year students were included. First year students were excluded because they had covered a small portion of the bioscience curriculum and had not had any clinical placements. They had limited experience

of the phenomena under investigation. None of the students recruited withdrew before, during, or after the data collection.

Sample size

University D typically had small class sizes. Nineteen participants were recruited for this phase, from the 2nd, 3rd, and 4th year. In this study, all (n = 19, 100%) of the students in the three classes consented to participate in this study. This means that the data collected from this phase represented the experiences of all students on the degree program, who enrolled on the nursing degree straight from A-levels. According to Creswell and Poth (2016), qualitative samples are usually small, but the data collected is in depth and rich. I then focused on the quality of the sample which would give me thick descriptions of the experiences. My guiding principle in ensuring data quality at this point was ensuring that all the participants had lived the experience (Polit & Beck, 2009). This was the case because it was university policy for all students to attend at least 75% of the classroom teaching and 100% of the clinical placements. Nineteen students were recruited, including six, seven and six 2nd, 3rd, and 4th year students, nine of whom were female.

Ethical Considerations

The aim of research was to answer research questions and improve our understanding of the world and those who live in it. Obtaining meaningful evidence requires ensuring the design and execution of research adheres to research ethical principles (Doody & Noonan, 2016). Part of this is in anticipation of potential or actual risks that may arise and clearly planning how to address ethics arising within research studies (Doody & Noonan, 2016). Ethics in research refers to observing the principles of informed consent, beneficence, confidentiality, and justice (WMA, 2014). Research ethics refers to the system of approved moral values focusing on the professional, legal, and social obligations to the participants (Polit & Beck, 2020). The ethics were an important aspect of this study to merit adherence to the standard of conduct expected of a researcher. In keeping with ethical principles, this study was subjected to scrutiny by ethics committees in the UK and Uganda. In addition, the entire project was supervised by researchers with adequate experience.

General ethical considerations for this project

This study was approved by the Research Ethics committee of the University of Salford (protocol number HSR1718-097). Then, it was further approved in Uganda by two

ethics committees to ensure that the project conformed to the acceptable standard in Uganda: (1) Clarke International University Research Ethics Committee (UG-REC-015 number IHSU-REC/0118) and (2) the Uganda National Council of Science and Technology (study reference number HS 313ES). These and other approvals obtained from the respective universities are attached in Appendix One and Appendix Two.

Ethical considerations for Phase 1 of the study

Consent

Several steps were taken to ensure that the nursing students participating in this study fully understood and were aware of the expectations placed on them as participants. First, I obtained permission letters from the four universities indicating their willingness to have their students participating in this study subject to meeting the required ethical clearances. Then, I obtained ethical approval from the University of Salford. Then, I obtained ethical approval from an accredited research ethics committee in Uganda, and the Uganda National Council of Science and Technology, which is the national regulator of research in Uganda.

I approached the students in through the help of their lecturers and invited them to participate in the study. I explained the purpose of the study, how they could participate and what my role was in ensuring that the study is conducted in an ethical manner. Then, I provided them with a participant information sheet (see Appendix Three) and answered any questions they had pertaining to the study prior to consenting to take part in the study.

Confidentiality and anonymity

In keeping with the ethical principle of confidentiality, I anonymized each survey. Each survey was assigned a number and uploaded on the University of Salford password protected F-drive in line with the University guidelines.

Voluntary participation and right to withdrawal from the study

The participants were informed that participation was voluntary, and they could decline to participate or withdraw from the study at any time without penalty. The participant information sheet contained the contact details of my main supervisor and the chairperson of the research ethics committee of the University of Salford. Any participant who had a complaint about the researcher or the research could use these to raise a complaint through any of these channels.

The process of gaining ethical approval to conduct focus group interviews

Creswell and Poth (2016) emphasize that a qualitative researcher deals with ethical issues throughout the study, even in the field, during analysis and dissemination. The ethical issues in this study included: informed consent procedures, confidentiality toward the participants, and benefits to the participation outweighing the risks. I accessed the participants in a university setting. This meant that I had to obtain ethical approval in steps: first from the University of Salford, then through an approved Uganda Ethics committee and a national committee and lastly University D. I applied for ethical approval for the second phase and permission was granted by the University of Salford ethics committee. Then I applied for permission from an approved ethics committee in Uganda, International Health Sciences University research ethics committee. Then permission was sought from the Vice-chancellor's office and Dean of Students of University D.

In this study, there was minimal potential for harm due to discomfort, distress, inconvenience, and change in lifestyle for the participants. I was cognizant of the need for safety of the participants and myself. There were no specific requirements for abstentions from the participants to participate in this study. None of the participants was classified as vulnerable or lacking capacity to participate on their own behalf. All the participants were adults, at least 18 years old because nursing programs only accept students who are at least 18 years to register on the nursing degree, a requirement congruent with similar studies that investigate student nurses' lived experiences (Fell et al., 2016; Mbakaya et al., 2020; Molesworth & Lewitt, 2016; Morrell-Scott, 2017).

I was cognizant of the power dynamic that could have existed between the participants and myself. Whereas I was not a member of staff of the university, the participants were aware that I was a nurse educator and a doctoral student. This could have had potential power issues due to the natural power dynamics between students and nurse educators. Such feelings could make the participants feel pressured, manipulated, or coerced into participating (Gerrish & Lacey, 2010), even when they did not wish to. In addition, the participants could potentially skew the results to produce data which is not a reflection of their experience. This Hawthorn effect was at the forefront of my mind during this process (McCambridge et al., 2014).

First, I built on the rapport already established from Phase 1. I identified with the participants as a student myself and as someone who is genuinely interested in understanding their experience and committed to interpreting and reporting it in the way they expressed it without watering down the spirit of the narrative. After lengthy discussions with the participants, they viewed me as someone who was interested in voicing their experiences, some of which were negative, in a neutral sense. They had raised some of the negative issues with the university administration but with limited success. I assured them that I would share a copy of the findings with their university, although it would take some time.

Consistent with the ethical principles, I explained to the participants that they could withdrew from the study anytime, without explanation or penalty for doing so. One of their concerns was anonymity, as some thought that their opinions would not be anonymous to their lecturers. To ensure anonymity, no names were used during data collection. Each student assigned a random number to him or herself. To increase confidentiality and anonymity, the participants decided the venue and time for data collection. I ensured that it was safe and conducive for the participants. Each recording and transcript of the focus group was securely stored on a password protected F-drive in line with the University guidelines.

This research could have been viewed as potentially damaging to the reputation of the university if students criticized the nursing program. The university might have been concerned if participants raised questions pertaining to the university's ability to prepare them for RN status. I assured the Dean and Head of the nursing department that any publications resulting from this study would not identify them. In addition, they viewed this research in a positive light, stating that it was an opportunity to identify weaknesses, strengths, and areas of improvement. It would provide an unbiased view of their context from an outsider's perspective. No ethical issues arose in the process of carrying out this study.

Data collection

According to Creswell and Poth (2016), the approach to research guides researchers to the most appropriate approach to data collection, although this is not a rigid requirement. They further note that phenomenological studies primarily collect data using in-depth interviews with about 10 individuals. The emphasis in phenomenology is on describing the meaning of the experiences with a small number of participants who have experienced it. I chose to collect data using focus group interviews. De Chesnay (2014) defines focus group interviews as conversations in which individuals from a targeted population discuss and share

experiences or opinions of specific interest, conducted by a facilitator. The three focus groups were influenced by the group compositions. The students' groups were already in place and there was no need for me to create new ones.

I facilitated all the focus group discussions, and my role was to organize and guide the discussion. I opted to facilitate the focus groups because I understood the context and language used by the group members. I was conversant with the language, slang, and expressions as supported by (Carey & Asbury, 2016; Krueger, 2014). I was aware of the need to actively listen and encourage discussion, manage time and conflict, while also redirecting the group back to the purpose of the study. My background as a nurse and nurse educator was important in facilitating these focus group discussions. In addition, I took note of any salient non-verbal information during the process which were important in data analysis (Carey & Asbury, 2016). The three Focus discussion groups lasted between 1½ and 2 hours as recommended by De Chesnay (2014), which time was adequate to discuss the process, conduct the group interview and bring each to a close. I worked with the class leaders to organize the meeting rooms. The venue was well ventilated and comfortable, quiet, and private. We sat in a circle, to be able to interact better.

Data was collected using a predetermined discussion guide (Hennink et al., 2020), consisting of five broad questions. The questions were open ended, and each consisted of a few more specific questions to obtain more in-depth information. I used probes and clarifiers to help elucidate the participants' responses to gain deeper information (De Chesnay, 2014). Some clarifiers asked for examples to illustrate what the participant meant. The process of focus group interviewing followed the three recommended phases: rapport building, questioning, and closure (De Chesnay, 2014). During the rapport building, I introduced myself, reviewed the purpose of the research study and answered the questions from the participants. We laid down the ground rules as follows:

1. Everyone's opinion is important. We would treat each other and each other's opinion with respect.
2. One person speaks at a time.
3. Whatever is said discussion remains confidential and should not be shared outside of the group.

During this phase, I reassured the participants that their responses would remain anonymous. The information was confidential and would only be used for the purpose of this

study. During the question phase, I asked specific predetermined questions related to the phenomenon under study. Although the questions were predetermined, I was flexible, often creating new questions depending on the responses of the participants but keeping in mind the research questions of this study. I noted non-verbal ques and sought clarifications on non-obvious phrases. Lastly, at closure, I checked to ensure that nothing was missed during the discussion. I asked the participants to bring up anything they felt was missed out but needed to be discussed. For this phase, I did not need to predetermine the number of participants because the classes were typically small but fitting into the qualitative philosophy whilst also being representative of 100% of the students. The focus groups were conducted between late February to early March 2020. Participants were given a lunch snack, refreshments, and transport refund to compensate for their time.

The five questions were developed from literature review but were flexible depending on the need for depth, clarity, and uniqueness of each group. For example, 3rd and 4th year students had a more comprehensive experience of learning biosciences because they had completed formal tuition in biosciences and had had more clinical placements than 2nd year students. Furthermore, the 4th year students were nearing completion of their studies and were more likely to reflect more on their experiences in relation to their future role as RNs. Data was audio recorded, with consent from the participants, using a digital voice recorder. The audio recordings were downloaded and stored on a password protected computer.

Data analysis

Data analysis for this study started during data collection, when ideas and themes started developing in my mind as I interacted with the participants. Data collection, analysis and report writing were interrelated as De Chesnay (2014) supported. I engaged the data several times, moving in circles back and forth rather than in a liner manner. Smith (2007) agrees noting that qualitative data analysis was ‘an interactive and inductive cycle’. I transcribed the data immediately following data collection and reflective notes were written about the experience. The transcription was verbatim and exported the transcripts into NVivo software version 12.

During data analysis, I followed the hermeneutic phenomenological data analysis techniques where recurring themes were identified to provide thick descriptions of the participants’ experiences (Van Manen, 2016). The data analysis for this phase was informed by the six stages of hermeneutics as described by Ajjawi and Higgs (2007); (Ajjawi & Higgs,

2008). This approach follows a "systematic identification of participants' interpretations and constructs" referred to as first-order constructs. Then constructs are the are "layered with the researcher's own understanding, interpretations and constructs" called the second order" (Ajjawi & Higgs, 2007). These stages include immersion, understanding, abstraction, synthesis and theme development, illumination and illustration of phenomena, and interrogation and critique.

I relied on two key hermeneutic strategies (hermeneutic circle and dialogue of question and answer) from literature to incorporate into this phase. The hermeneutic circle helps us to understand and interpret data. It is a metaphor that denotes a kind of movement between parts (data) and the whole, with each giving meaning to the other such that understanding is circular and interactive. As I conducted data analysis, I was open to questions emerging from the data and allowed the data to speak. I found the answers by digging up more information from the data to gain understanding and creating texts of my interpretations of the data from the participants. I continuously held a dialogue with the data, thereby forming a convergence between my insights and the text (Bontekoe, 1996).

First, I repeatedly listened to audio recordings. Then I read and re-read the transcripts to familiarize myself with them, a process called immersion (Van Manen, 2016). Immersion supported me to engage with the meaning of the texts to gain preliminary sense or interpretation of what the participants said. According to Van Manen (2016), immersion aids coding. I constantly recreated the participants' context relating it to what was said to understand the reasoning behind what was communicated. I took note of my thoughts, interpretations, contradictions and continuously interrogated the text for emerging meanings (Barbour, 2001) storing them as memos in NVivo software.

Stage two involved understanding or identifying the first order constructs. First order constructs were the participants' ideas in their own words which capture the precise detail of what the person was saying (Ajjawi & Higgs, 2007; Titchen & McIntyre, 1993). These constructs were related to the participants' experiences of learning and applying biosciences. These constructs were coded using NVivo software. I identified overlaps and relationships between the first order constructs, constantly checking for meanings. This cyclic interrogation of the data led to richer and deeper understanding of the participants' experiences, a central part in the creation of the second order constructs.

In the abstraction stage, I identified the second order constructs and created themes and subthemes. The second order constructs were my interpretations of the participants'

verbal and non-verbal statements. They were a 'layer' of meanings constructed using my theoretical and personal knowledge. Using NVivo software, similar codes created in the previous stage were condensed under the new node (second order construct). This process was not straight forward as I had to constantly move back and forth between the first and second order constructs to ensure that all the themes have relevant codes under them. At the end of this stage, all the relevant texts were grouped under the relevant construct relating to the research questions.

In stage four, I refined the themes created in stage three. I studied these themes and subthemes to identify connections, relationships and thought about the meanings behind these connections. I moved back and forth, building, and breaking the parts apart and constructing newer meanings and connections. I searched literature to try and understand some findings that were emerging and moving from texts to second order constructs to literature in an iterative manner informed by the hermeneutic circle. I devoted myself to interpret the meanings of the participants' experiences of learning and applying biosciences. This helped me to identify some of the meanings that the participants could not articulate. I continually reflected on the emerging meanings of the interpretations in the process of writing the results.

During the stage of illumination and illustration, I examined the literature for relationships between my findings (themes and subthemes). My aim was to support further development of my interpretation of meanings and build up a theory of the overall experience of learning and applying biosciences for nursing students in Uganda. I revised the themes by creating some and condensing others. Finally, during integration, I tested and refined the themes. Further critique took place as I presented my findings and described the experiences of learning and applying biosciences. I used the comments from the supervisory team to clarify and explain narratives that were unclear. I also elaborated on those statements that were less obvious to an outsider. Adjustments were done as needed throughout the process of report writing.

I maintained rigour by stepping back to question the responses of the participants, trying to understand the deep-seated meanings by examining the context and cross checking with some participants to understand what was said (Van Manen, 2016). I stepped back to reflect on the meaning of what was said rather than taking responses at face value. The reflective notes were useful in recording and justifying the decisions I made throughout. According to Creswell and Clark (2017), reflective notes influence dependability and authenticity of study findings. Furthermore, I maintained closeness to the participants'

constructs through cross-checking with the original audio recording and transcripts as I reflected and wrote my findings.

In conclusion, this chapter presented a thorough description of how I conducted this study and justified my decisions. I explained how my experiences and research questions shaped the approaches to this research. I described the designs used, the sampling, data collection, and analyses. I will present the findings in the next chapter.

Chapter 4: Phase 1 results

Introduction

This chapter will present results from Phase 1. The quantitative data were collected from four universities, with one also providing secondary data on which the main quantitative study was built. Cumulatively, data were collected from 410 nursing students in four universities.

Descriptive statistics

Data from of 203 students was analysed, with 104 students studying at the diploma level and 99 students at the pre-registration nursing degree level. Fourteen courses were analysed and a total of 971 course scores. Each group of students studied different bioscience and non-bioscience courses at a specific stage of their respective program. The students on the degree program were exposed to more biosciences content (number courses and depth of content) compared to their diploma counterparts. That is, biochemistry, pathophysiology, and life sciences were only present on the preregistration degree level. Pharmacology, anatomy and physiology, and microbiology were taught at both levels, although the course content and depth differed. A summary is presented in Table 2 below.

Table 2: Courses Included by Group of Students.

Group	Level	Number	Bioscience courses taken	Non-bioscience courses taken
1	Diploma	31	Pharmacology, physiology, anatomy, and microbiology,	Development psychology, Health assessment, HIV/AIDS Care and Support.
2	Diploma	40	Pharmacology, anatomy, and physiology	Health assessment, adult health nursing.
3	Diploma	33	Pharmacology, anatomy, and physiology	Health assessment, adult health nursing
4	Degree	33	Pharmacology, Microbiology, biochemistry.	HIV/AIDS care and support, advanced nursing concepts, trends, and issues in nursing.
5	Degree	31	Microbiology and life sciences.	HIV/AIDS care and support, trends and issues in nursing
6	Degree	12	Anatomy and physiology, life sciences	Normal childbearing, management, and leadership
7	Degree	23	Anatomy and physiology, life sciences.	Normal childbearing, Management and leadership.
Total		203		

Overall performance

The scores in bioscience and non-bioscience courses were coded using the university guidelines, where a score below 60% was coded as "fail", a score from 60 to 64% was coded as "barely pass", and a score greater than or equal to 65% was coded as "pass". Table 3 below summarizes the results. About half of the students barely passed at least one bioscience course, while 14.8% failed at least one bioscience course (N=203). Overall, 61.6% of the students experienced some form of difficulty (failed or barely passed) in passing bioscience courses, while only 10% experienced some form of difficulty in passing non-bioscience courses. Compared to the 90% who passed all non-biosciences, 38.4% of the students passed all bioscience courses.

Table 3:Overall Performance in Bioscience and Non-bioscience Courses.

Course outcome	**Biosciences**	**Non-biosciences**
Failed two courses	1%	0%
Failed one course	13.8%	0.5%
Barely passed at least one course	46.8%	9.5%
Failed or barely passed at least one course	61.6%	10%
Passed all courses	38.4%	90%

Performance by course

Table 4 shows the courses analysed by group. It shows the minimum (Min) and maximum (Max) score, mean score, and standard deviation per course. The performance of students was analysed in fourteen courses, consisting of six bioscience and eight non-bioscience courses. From the table below, the mean score in biosciences ranged from 63.06 to 77.19 percent. The best scores were achieved in microbiology and the worst in life sciences. The mean score in non-bioscience courses ranged from 71.69 to 79.92 percent. The best and worst non-bioscience scores were in Health Assessment and Adult Health Nursing, respectively.

Table 4: Overall Performance by Course, Showing Minimum, Maximum, and Mean Scores per Group of Students.

Courses	Group of students								Course scores			
	1	2	3	4	5	6	7	N	Min	Max	Mean score	SD
Biosciences												
Pharmacology								137	39	88	65.23	9.53
Microbiology								93	60	90	77.19	7.09
AP								139	60	88	68.50	7.37
Path								33	44	87	70.94	8.82
Biochemistry								64	44	84	66.55	8.05
Lifesciences								35	49	78	63.06	7.19
Non-biosciences												
Dev								31	63	93	78.32	6.62
HA								104	60	93	79.92	7.61
AHN								104	52	87	71.69	5.92
HIV								64	58	83	72.27	5.45
ANC								33	60	83	72.36	6.70
Trends								64	64	91	78.73	6.23
NCB								35	63	86	74.83	5.65
MWH								35	61	84	76.03	4.56

AP: Anatomy and Physiology

Path: Pathophysiology

Dev: Developmental psychology

HA: Health Assessment

AHN: Adult Health Nursing

HIV: HIV/AIDS Care and Support

ANC: Advanced Nursing Concepts

Trends: Trends and Issues in Nursing

NCB: Normal Childbearing

MWH: Midwifery and Women's Health

Performance in biosciences

Each student's mean bioscience and non-bioscience scores were computed to permit further comparisons between groups, levels, and between bioscience and non-bioscience courses.

(a) Performance by group

A one-way ANOVA test was performed to identify differences in the mean scores in bioscience courses broken into groups (group 1-7). There was a significant difference in the mean performance in biosciences among different groups (p=0.000, alpha=0.05). This result, however, did not distinguish whether these differences were between only two, three, four, five, six, or seven groups, as there were seven groups of students. Therefore, the mean score for each cohort was computed.

Table 5: Mean Bioscience Scores by Group.

What group does the student belong?	Mean bioscience score	N	Std. Deviation
Group 1	73.91	31	5.46
Group 2	64.49	40	7.46
Group 3	62.68	33	6.34
Group 4	70.26	33	6.32
Group 5	70.97	31	7.56
Group 6	71.67	12	5.33
Group 7	65.96	23	6.46
Total	68.15	203	7.64

Table 5 shows that Group 2 and Group 3 had the lowest mean bioscience scores (64.49 and 62.68 respectively), and Group 1 had the highest mean bioscience score (73.91). A one-way analysis of variance (ANOVA) was used to further understand if the differences in bioscience performance by group were statistically significant. The results suggested a statistically significant difference in the performance of biosciences (p = 0.000).

Group 1, 2 and 3 were on the same nursing program and therefore had similar teaching and learning context. Group 1 was admitted on the nursing program in 2016, while 2

and 3 were enrolled in 2017. The 2017 group was too big to fit in one class, so they were split into two. On average, groups 2 and 3 seemed to struggle to pass bioscience courses owing to the below 65% mean score. In contrast, Group 1 had the highest average score. Group 1 performed better than group 2 and 3, with a mean difference of 9.42% and 11.23% respectively. Other factors that cannot be explained by this study may have played a role in these differences. The year 2017 was the first time the university admitted such a big number of students (73) compared to the previous years which had about 30 nursing students per group. The big number of nursing students in 2017 probably overwhelmed the teachers and they could not apportion significant support to the learners. In addition, the cognitive ability of the learners in the 2016 and 2017 groups may have been significantly different resulting into the differences in mean bioscience scores.

(b) Performance by level of study

An Independent Samples T-test was used to compare the means of the normally distributed bioscience scores for the two independent groups (Diploma and Bachelor level students). The mean bioscience scores of diplomas and degree level students were 66.72 and 69.65, respectively. Although the degree students' mean score was higher than that of diploma students, an independent samples t-test revealed that performance in bioscience courses did not significantly differ between diploma and bachelor's students ($t= -2.775$, $p=0.066$). Nursing students, whether on the diploma or degree program, did not seem to significantly differ in their performance in bioscience courses. With only 38.4% (N=203) passing all bioscience courses, the results suggest that most nursing students regardless of level of training (diploma or degree) experienced difficulties in learning and passing bioscience courses.

Comparison between scores in bioscience and non-bioscience courses

(a) Comparison by group

Both bioscience and non-bioscience scores were normally distributed by group (cohort). A Pearson correlation was performed to see if a relationship existed between bioscience and non-bioscience scores. The results in table 6 show a statistically significant linear relationship between bioscience and non-bioscience scores ($p = 0.000$). The direction of their relationship is positive, implying that the scores tended to increase together. The strength of their relationship is approximately moderate ($r = 0.583$). By squaring 0.583 and multiplying it by 100, the percentage of variability shared between the

bioscience and non-bioscience scores was 34%. Hence, bioscience scores shared 34% of its variability (spread or dispersion) with non-bioscience scores.

Table 6:Pearson Correlation Between Bioscience and Non-bioscience Scores.

Correlations

		Average_BSC	Average_NBSC
Average BSC	Pearson Correlation	1	.538**
	Sig. (2-tailed)		.000
	N	203	203
Average NBSC	Pearson Correlation	.538**	1
	Sig. (2-tailed)	.000	
	N	203	203

***. Correlation is significant at the 0.01 level (2-tailed).*

BSC-Biosciences; NBSC-Non-biosciences

(b) Comparison by level of learning

After testing for normality (using Shapiro-Wilk test) in the non-bioscience scores, the p-value for scores in non-bioscience courses by level (diploma and degree) was 0.002, meaning that it was not normally distributed, and therefore parametric tests are not suitable to make comparisons between bioscience and non-bioscience scores. A Wilcoxon signed rank sum test was used to compare two related observations (bioscience and non-bioscience scores) for each student. In this case, each student's bioscience and non-bioscience scores were compared to see if there was any significant difference.

The results suggested a statistically significant difference between bioscience and non-bioscience scores for each student (Z= -11.203, p = 0.000). This suggests that generally, nursing students found it more difficult to pass bioscience courses than non-biosciences. It suggested that individual students and entire cohorts of nursing students found biosciences more difficult to learn that non-bioscience courses.

The results above suggested that performance in biosciences was significantly different from non-biosciences. The students experienced difficulties in learning and passing bioscience courses regardless of their group or level of training. There could be several

factors that predict the bioscience course pass rate among nursing students. These were explored in the qualitative phase (Phase 2) of this project.

Survey results

Data processing and analysis

Data were collected on the current knowledge of ABR, and the factors associated with acquisition of that knowledge. A total of 207 students managed to complete the survey. Data were collected over of six weeks, across eight classes in four universities. The collected data were checked for completeness and consistency. Those that did not meet the criteria were automatically excluded. All completed tests were entered in SPSS software version 25 for analysis. The demographic characteristics were coded. They included gender, age, nationality, marital status, employment status, route of entry onto nursing program, year of study, and university of study. New codes were created such as age group and score. A score of 1 was coded for the correct answer and 0 for the incorrect answer. For questions which had an option of 'I don't know' the code of 0 was assigned if the student chose that option. The total score for each subject was computed to a percentage and coded under the new variable 'Score'.

Similar grading and codes, like those used in the preliminary data were used. A score below 60% was coded as "fail", a score between 60 and 64% was coded as "barely pass", and a score greater than or equal to 65% was coded as "pass". This was for two reasons: (1) Uniformity with the preliminary phase and (2) The standard of the test (survey) was much lower than a university set assessment. The questions were set to a standard lower than the typical bioscience assessment for preregistration nursing students in Uganda. I was however cognisant of the fact that the students did not revise for this test. As mentioned earlier, the questionnaire was divided into six sections, namely:

a. Demographic characteristics.
b. General knowledge on antibiotics.
c. Knowledge on antibiotics and bacteria.
d. Knowledge on the use of antibiotics in the treatment of bacterial infections in the clinical area.
e. Personal use of antibiotics
f. Knowledge of mechanisms of antibiotic resistance and contributing factors to antibiotic resistance.

The results will be presented according to these six sections.

Section A: Characteristics of study participants

Descriptive statistics were summarised in tables. Table 7 shows the distribution of the nursing students by route of entry, nationality, and gender. Eighty six percent were Ugandans and 13% were foreign students. The foreign students were from Kenya, Tanzania, Democratic Republic of the Congo, Zambia, Rwanda, South Sudan, and Nigeria. Of the 207 students, 50.7% were enrolled onto the preregistration nursing program directly from A-levels and 49.3% were from the Diploma in nursing route. Over half of the students enrolled directly from A-levels were male while less than a quarter (22.5%) of those enrolled via the diploma in nursing route were male. Over 77% of the students enrolled via the diploma route were female, whereas those enrolled directly from A-levels were about 49%.

Table 7: Number of Students by Route of Entry, Gender, and Nationality.

Route of entry onto the nursing program	**Nationality**	**Gender**		Total
		Male	Female	
Direct from A-levels	Ugandan	46	41	87
	Foreign	8	10	18
	Total	**54**	**51**	**105**
From a Diploma in Nursing	Ugandan	21	72	93
	Foreign	2	7	9
	Total	**23**	**79**	**102**
Overall total		**77**	**130**	**207**

Table 8 below shows the number of nursing students by year of study (3rd and 4th), employment status, university, gender, and age group. Thirty-seven percent (N=207) of the nursing students were male, and 62.6 percent were females. About 58% of the students were in their 3rd year, while 42% were in the final year of study. The mean age of the participants was 27.68 (SD 5.15), ranging from 20 to 40 years. Most (70.5%) of the nursing students were in the 20-30 years age group while the rest (29.4%) were between 31 and 40 years of age. About 35% of the nursing students were in full-time nursing employment, 9.1% were working part-time, 53.1% were not employed, and 2.8% were employed elsewhere other than

in the nursing profession. All students in University A were employed at the time of data collection because their degree operates on a work-study program model.

Table 8:Distribution of Nursing Students by Year of Study, Employment Status, University, Gender, and Age-group.

Year of study	**Employment status**	**University of study**	**Gender**		**Age group**	
			Male	**Female**	**20-30**	**31-40**
3	Employed	A	4	22	17	9
		B	0	2	1	1
		C	2	0	1	1
		D	3	21	5	19
	Unemployed	B	19	17	36	0
		C	11	16	26	1
		D	0	3	3	0
4	Employed	A	5	19	0	24
		B	2	5	6	1
		D	6	6	9	3
	Unemployed	B	8	8	15	1
		C	12	10	22	0
		D	5	1	5	1
Total			77	130	146	61

Overall Knowledge of Biosciences

The median score was 68%, ranging from 40-91%. The mean bioscience score was 66.5% (SD 9.728). Overall, 21.2% of the pre-registration students failed, 20.8% barely passed, and 58% passed biosciences. The histogram below shows the overall frequency distribution of bioscience scores. This implies that whereas over half of the nursing students passed biosciences, a significant proportion (42%) either failed or struggled to pass biosciences.

Figure 5: Overall Bioscience Scores Among Preregistration Nursing Students in Uganda.

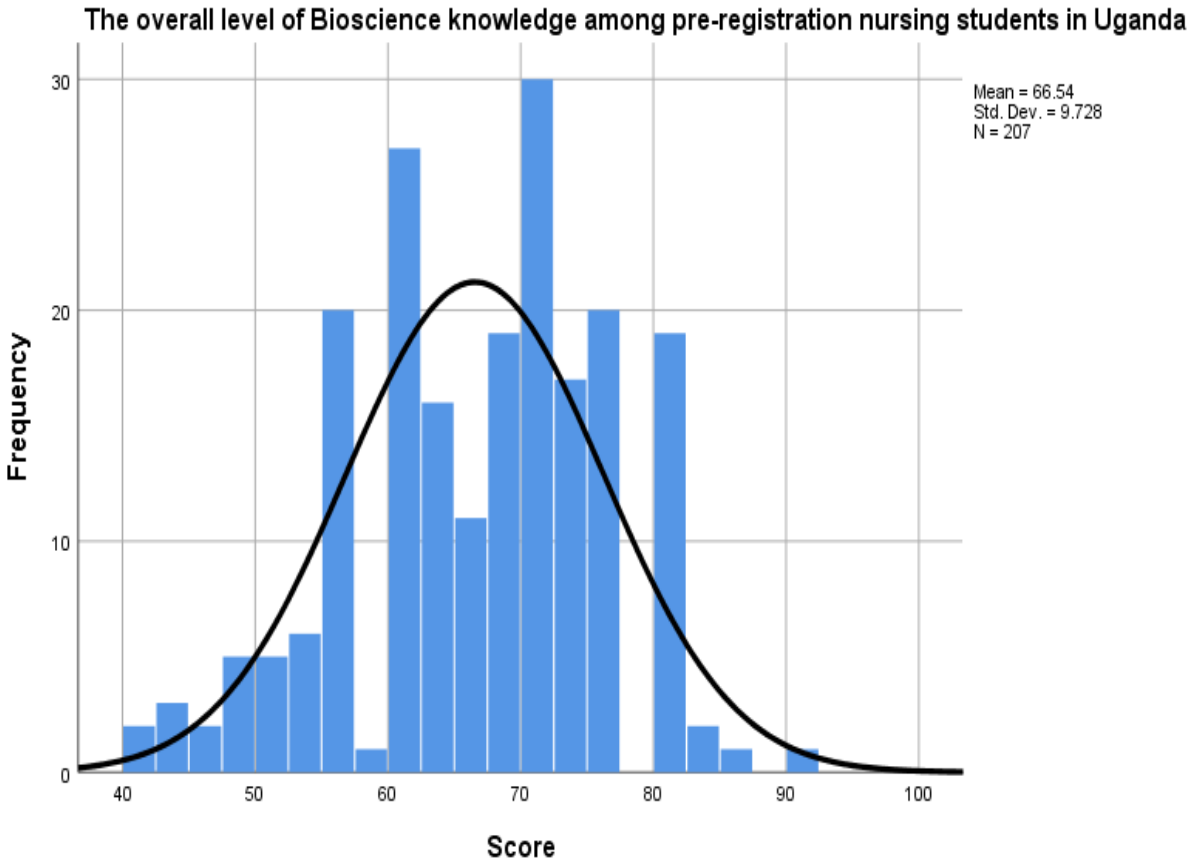


Table 9 below shows the performance of preregistration nursing students in Biosciences by university and year of study. University B had the highest percentage of students with who failed (29.5%) and barely passed (24.5%) and had the lowest proportion of students coded as pass (46%) in biosciences. University A had the highest percentage of students with pass (74%). These differences could be attributed to factors such as how hard the students found the test in each university, the quality of teaching, or the differences in the learning environments and personal characteristics. A larger proportion of unemployed nursing students failed and struggled to pass biosciences than their employed counterparts. Among the 3rd year students, 24.4% failed biosciences while 17.2% of 4th year students failed. A significant proportion (46.7%) of 3rd year nursing students struggled or failed to pass biosciences.

Table 9: Performance of Students by University, Year of Study, and Employment Status.

University	**Failed (%)**	**Barely passed (%)**	**Passed (%)**
A	10	16	74
B	29.5	24.5	46
C	22.2	19	58.8
D	21.2	24.2	54.6
Year of study			
3rd year	24.2	22.5	53.3
4th year	17.2	18.4	64.4
Employment status			
Employed	14.4	16.5	69.1
Unemployed	27.3	24.5	48.2

Section B: General knowledge on antibiotics

The ten questions focused on the general knowledge on antibiotics. Such as what antibiotics are and what they are not, when antibiotics should be used and when not to use them, some of the side effects of antibiotics and what they are used for and not used for. A score below 6 was coded as fail, one of 6 and 7 was coded as barely pass and 8 to 10 as pass.

Generally, 7.3% of the nursing students had failed, 22.2% barely passed, and 70.5% passed general knowledge questions on antibiotics. Table 10 below summarises the results. Of the 207 nursing students, 51 (24.6%) understood that antibiotics could be used as analgesics and anti-inflammatories, 59 (28.5%) thought that colds and coughs should always be treated with antibiotics to quicken recovery. In addition, 43% of the students thought that antibiotics should be prescribed prophylactically in patients. Among the employed Nursing students, 82.5% had passed questions on antibiotics compared to 60% of the unemployed students. Ten of the fifteen students who failed questions on antibiotics came from University B, while 94% of the students from University A passed questions on antibiotics.

Table 10: Participants' Knowledge About Antibiotics.

Statement	Correct answer	Incorrect answer
1. Amoxicillin is an antibiotic	206(99.5%)	1 (0.5%)
2. Aspirin is an antibiotic	177(85.5%)	30(14.5%)
3. Antibiotics are used to treat bacterial infections	201(97.1%)	6 (2.9%)
4. Antibiotics are used to treat viral infections	175(84.5%)	32 (15.5%)
5. Antibiotics are indicated to reduce any kind of pain and inflammation	156(75.4%)	51 (24.6%)
6. Antibiotics can cause secondary infections after killing good bacteria present in our organism	160(77.3%)	47 (22.7%)
7. Antibiotics can cause allergic reactions	194(93.7%)	13(6.35)
8. Colds and coughs should always be treated with antibiotics as patients will recover more quickly	147(71.4%)	59(28.6%)
9. Antibiotics should always be prescribed as preventive measures to fight against future infections	118(57.0%)	89 (43.0%)
10. Antibiotics can treat flu	151(72.9%)	56 (27.1%)

Section C: Knowledge on antibiotics and bacteria

The four questions in this section focused on the classification of antibiotics and classes of bacteria. Two questions asked about classification of antibiotics (macrolide and fluroquinolone antibiotics), one asked about classification of bacteria (Gram Positive and Gram negatives), and the last one asked about gram negative bacteria that cause nosocomial infections. A score of 2 or below was coded as fail, and scores of 3 and 4 were coded as pass.

Generally, 60% (n=207) of the nursing students failed questions on antibiotics and bacteria while the rest (40%) had passed. Among the four universities, B had the highest proportion (68.8%) of passes on questions about antibitics and bacteria. These questions asked about core bioscience content. Over 90% of the students in University C, 66.6% of students from D, and half of A failed these core bioscience questions. It seems that students from University B were more knowledgeable on core bioscience content than all the other

universities. This could be attributed to the fact that it is the only university whose nursing students learn with other groups of students (medical, pharmacy, and medical laboratory students) and peharps the method of teaching of the core bioscience content is more appropriate than those employed in the other three universities.

Most (77%) of the students from University B had a strong science background because they were enrolled from A-levels, so they came to the program with strong biology and chemistry grades. A strong science background combined with appropriate methods of instruction for core bioscience content could have supported these students to retain core bioscience knowledge than all the other students. Further analysis reveals that 70% of the A-level enrolled students and 64% of top-up students in this university passed core biosciece content on bacteria and antibiotics. Although University C also had a signifiacnt number of A-level entrants (73%), about 90% of them failed these core bioscience questions and all their topup students failed the core bioscicne questions. It seems that the factors that improved retention of knowledge on antibiotics and bacteria was context-based. Similarly, a significant number (64%) of nursing students from University D enrolled from the Diploma route, 71% of them failed core bioscience content while 58% of their A-level enrolled counterparts failed. University A did not enrol students from A-levels and about half of their students failed the core bioscience content.

Almost all (99.5%) of the nursing students correctly identified amoxicillin as an antibiotic. In addition, 65.2% of the students correctly classified ciprofloxacin as a fluoroquinolone antibiotic from other antibiotics Clarithromycin, Cephalexin, and Erythromycin. Of interest, 75% of the students in university C failed this question while 24%, 15%, and 12% of the students in universities A, B, and C failed this question respectively. About half (47.3%) of the nursing students failed to correctly differentiate between gram positive and gram-negative bacteria, over half (55%) of whom are from university C.

Over ¾ (75.8%) of all students (N = 207) failed to correctly link a common gram-negative bacterium to a bloodstream nosocomial infection. Particularly, universities C and D had very high proportions of failures on this question (84% and 88% respectively) compared to Universities A (68%) and B (67%). It seems that nursing students experience some difficulty in linking/integrating different concepts of bioscience knowledge.

Table 11: Overall Knowledge of Antibiotics and Bacteria by University and Route of Entry.

Outcome	A		B			C			D		
	All	Diploma	All	A-levels	Diploma	All	A-levels	Diploma	All	A-levels	Diploma
Fail (%)	48	48	31.2	30	36	92	89	100	66.6	58	71
Pass (%)	52	52	68.8	70	64	8	11	0	33.4	42	29

Section D: Knowledge on the use of antibiotics in the treatment of bacterial infections in the clinical area.

This section had a total of ten questions, five of which asked about how antibiotics should be used to treat bacterial infections. The five questions were on the use of antibiotics in children with diarrhoea, antibiotic use in patients with throat infections, pregnancy, and among individuals of different ages. They were also asked about bacterial sensitivity to antibiotics and resistant strains of bacteria. Questions tested the ability of nursing students to make informed choices about antibiotic use in different clinical situations. Five other questions in this section tested the choices of nursing students under circumstances such as when a patient is a child below 5 years, when a patient asks for antibiotics, when a patient can afford to pay for antibiotics, when laboratory facilities are unavailable, and when there is a throat infection. A score of 10 was given if the nursing student answered all the questions correctly and zero if they had no correct answer. Scores of 6 and below were coded as fail, 7 as barely pass and 8 to 10 as pass.

Of the 207 students, 40 percent and 48.3 percent barely passed the bioscience knowledge transfer questions on the use of antibiotics in the treatment of bacterial infections in the clinical area. Of the students who passed the knowledge transfer questions, 75% were enrolled directly from the Diploma in nursing and 71% were employed.

Although University B students performed best on core bioscience content questions (in section C), over half of them (51%) failed and 42% barely passed the questions on the use of antibiotics in the treatment of bacterial infections in the clinical area. University D students were almost equally distributed along the outcome continuum (fail, barely pass and pass) and had the highest proportion of students that passed these transfer questions. All their students who passed the bioscience transfer questions were enrolled from the Diploma in nursing. Like in University B, 92% of the C students either failed or barely passed these transfer questions. Most of the students from University A barely passed the knowledge transfer

questions. The number of those who failed was twice the number of those who passed. It seems that when it comes to knowledge transfer, preregistration students need other methods of teaching different from those that were used supporting retention of core bioscience knowledge.

As shown in Table 12, about 35% of the nursing students (N=207) would give or recommend an antibiotic for a child (under 5 years) with a normal temperature and diarrhoea. 95.2% (N=207) of the nursing students recommended to give an antibiotic to a child with a sore throat, fever, and rhinitis, even without visible presence of purulent formations in the throat. According to MoH (2016) Uganda clinical guidelines (UCG), antibiotics are indicated for a child with signs of dysentery or cholera and severe respiratory disease or pneumonia. The UCG recommends giving a soothing or cough remedy because it is likely to be a viral disease. In addition, no antibiotic is recommended for a child with diarrhoea. If the child presents with signs of dehydration, oral half-strength Darrow's solution in glucose or normal saline is recommended if the child can drink or intravenous Ringer's lactate. The majority (82.1%, N=207) of nursing students agreed that amoxicillin was the safest antibiotic in pregnancy when presented with ciprofloxacin and gentamycin as alternatives. 58.4% of the students correctly identified the antibiotics that have the best activity against anaerobic bacteria. About 84% (N=207) of the nursing students failed to identify the antibiotics that Methicillin resistant - Staphylococcus aureus is susceptible to.

About 41% (N=206) of the nursing students would recommend or prescribe an antibiotic for a cold or sore throat, 45% (N=207) would recommend or prescribe an antibiotic to a febrile child below five years. Over 53% of the nursing students would recommend or prescribe an antibiotic when there are no laboratory facilities to test for the causative organism. Over 92% of the nursing students (N=207) were not likely to recommend or prescribe an antibiotic when a patient asks for it, while 89% would not recommend or give antibiotics even when the patient can afford them.

As shown in Table 12, over 95% of the nursing students recommended an antibiotic for a child with a sore throat and a rhinitis (question 16), even though about 73% of them had earlier stated that antibiotics should not be given to patients with flu (question 10), or patients with a viral infection (84.5% in question 4), and that antibiotics should not be used to treat colds and coughs (71.4%, question 8). In addition, 173 (83.6%) of the students could not identify the antibiotics commonly used to treat infections caused by methicillin resistant

staphylococcus aureus (MRSA). Over 40 % of them did not clearly identify the antibiotics that have the best activity against anaerobic bacteria (question 18).

Table 12:Knowledge on the use of Antibiotics in the Treatment of Bacterial Infections in the Clinical Area.

Question	**Correct answer**	**Incorrect answer**
	overall	**overall**
15. A 4-year-old girl has a history of diarrhoea for 4 days (3 stools/day). She has no history of fever, and the temperature is 36.8 degrees Celsius. Which treatment do you propose?	134(64.7%)	73(35.3%)
16. A 6-year-old child has a fever of 38 degrees Celsius, purulent rhinitis, and angina for two days. On inspection, the throat is reddish but there are no purulent formations. Which treatment do you recommend?	10(4.8%)	197(95.25%)
17. Which one of the following antibiotics is safe during pregnancy?	170(82.1%)	37(17.9%)
18. Which one of the following antibiotics has the best activity against anaerobes?	122(58.9%)	85(41.1%)
19. Methicillin resistant - Staphylococcus aureus is susceptible to	34(16.4%)	173(83.6%)
When are you more likely to recommend or prescribe antibiotics?		
20. When the patient has a cold or sore throat	122(58.9%)	85(40.1)
21. When the patient is a child below five years with fever	114(55.1%)	93(44.9%)
22. When there are no laboratory facilities to test for the causative organism	97(46.8%)	110(53.2%)
23. When the patient asks for an antibiotic	191(92.2%)	16(7.8%)
24. When the patient can afford to pay for the medications	184(88.9%)	23(11.1%)

Section E: Personal use of antibiotics

Five questions asked about the students' own practices regarding antibiotics use. Questions were on when they use antibiotics, who prescribes their antibiotics, and what they do with left over or unused antibiotics. A score of 3 and below was coded as 'poor use' while a score of 4 to 5 was coded as 'good use'.

About 35% of the students (N=207) responded that they usually stop taking antibiotics when they start feeling better, yet a full dose is recommended. About 60% of them take antibiotics only when prescribed by the doctor, about half of the students kept leftover antibiotics at home for future use, and 37.7% shared antibiotics with sick friends or family members. Only 2.4% (N=207) correctly disposed of unused antibiotics. About 70% of the

students had poor personal use of antibiotics and the rest (30%) reported good use. There was not much difference in the personal use of antibiotics by gender, age group, employment status, marital status, year of study, university, or nationality.

Of the 207 students, 90.3% felt that nurses have a professional role in reducing antibiotic resistance. However, when asked about what the professional role of nurses is regarding antibiotic resistance, 70% mentioned patient education on the use of antibiotics (use timely, for the right duration), and 20.3% talked about the nurses' responsibility while handling antibiotics such as administering the right antibiotic, at the right time, to the right patient, right route, and right dose. None of the students mentioned infection prevention activities such as handwashing, sterilization, and disinfection as ways nurses can contribute to the reduction or spread of antibiotic resistance. In addition, none mentioned monitoring of antibiotics, surgical prophylaxis, surveillance of resistance, or taking off swabs for culture and sensitivity in determining the appropriate antibiotics to use. This may show that pre-registration nursing students were not sensitized on the threat of antibiotic resistance, even though they are routinely exposed to clinical problems requiring that knowledge.

Section F: Knowledge of mechanisms of antibiotic resistance and contributing factors to antibiotic resistance

Fifteen questions were asked in this section of the survey. Eight questions focused on antibiotic resistance. They were tested on their knowledge of the different mechanisms through which bacteria become resistant to antibiotics. Seven questions looked at the contributing factors to antibiotic resistance. A score of 0 to 9 was coded as fail, 10-11 was coded as barely pass, and 12-15 was coded as pass.

About half (46.9%) of the students passed questions on antibiotic resistance while 40.6% and 12.5% barely passed and failed, respectively. Almost all (95.2%) of the nursing students correctly stated that antibiotic resistance happens when a bacterium loses sensitivity to an antibiotic. About 59% of the nursing students failed to correctly state that bacteria can acquire resistant traits from another bacteria by way of viruses. Over 80% correctly pointed out that poor infection control practices by nurses contribute to antibiotic resistance. 63.3% of the nursing students correctly stated that people can pass on resistant bacteria to others through coughing and unwashed hands.

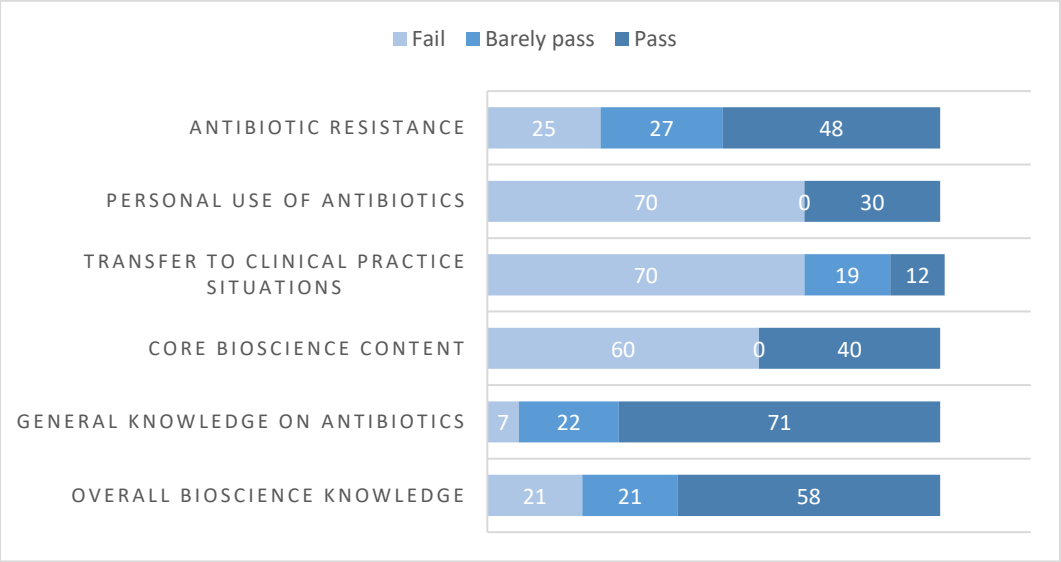
Table 13: Knowledge of Mechanisms of Antibiotic Resistance and Contributing Factors to Antibiotic Resistance.

Question	Correct answer			Incorrect answer		
	Overall	3	4	Overall	3	4
32. Antibiotic resistance happens when a bacterium loses sensitivity to an antibiotic.	197(95.2%)	111	86	10(4.8%)	1	10
33. Some bacteria are naturally resistant to certain types of antibiotics.	162(78.3%)	92	70	45(21.7%)	28	17
34. Bacteria can acquire antibiotic resistance through genetic mutation.	173(83.6%)	101	72	32(16.4%)	18	14
35. Bacteria can acquire resistance from other bacteria through conjugation.	133(64.3%)	80	53	74(35.7%)	40	34
36. Bacteria can acquire resistant traits from another bacteria by way of viruses.	85(41.1%)	55	30	122(58.9%)	65	57
37. Bacteria can acquire resistance from bacteria DNA existing freely in the environment.	112(54.1%)	62	50	95(45.9%)	58	37
38. Bacteria may acquire efflux pumps that expel antibiotics from the cell.	159(76.8%)	97	62	48(23.2%)	23	25
39. A single bacterium can acquire resistance to multiple antibiotics using different mechanisms.	178(86%)	106	72	29(14%)	14	15
40. People can pass on resistant bacteria to others through coughing and unwashed hands.	131(63.3%)	77	54	76(36.7%)	43	33
41. Prescribing broad-spectrum antibiotics increases antibiotics resistance.	152(73.4%)	88	64	55(26.6%)	32	23
42. Antibiotic Polypharmacy (the practice of concurrently administering many different antibiotics for the treatment of a single disease) can increase antibiotic resistance.	173(83.6%)	97	76	34(16.4%)	23	11
43. Poor infection control practices by nurses contribute to or cause the spread of antibiotic resistance.	167(80.7%)	96	71	40(19.3%)	24	16
44. Use of antibiotics in livestock production and agriculture contributes to antibiotic resistance.	122(58.9%)	63	59	85(41.1%)	57	28
45. Exposure to antibiotics appears to be the principal risk factor of antibiotic-resistant bacteria.	179(86.5%)	104	75	28(13.2%)	16	12
46. Antibiotic resistance can be minimized by using narrow-spectrum therapy after identification and susceptibility testing of infectious bacteria.	177(85.5%)	98	79	30(14.5%)	22	8

Summary of level of bioscience knowledge among preregistration nursing students

Nursing students generally passed questions on antibiotic resistance (48%), although some failed questions on transmission of resistant bacteria between humans (36.7%), the risks involved in indiscriminate use of antibiotics in poultry and livestock (41%), and how bacteria become resistant to antibiotics (14.6%). Only 30% of the students reported to have good personal use of antibiotics, with the bigger bulk (70%) reporting poor use. This aspect of antibiotic use is antibiotic stewardship. The majority (60%) of the nursing students failed questions on core bioscience content which may translate to poor transfer of knowledge because majority retained little core knowledge. These percentages represent the students who failed to attain the minimum required score to pass questions in the respective aspects of bioscience. In the core bioscience content section, some nursing students failed to classify bacteria (47%) and antibiotics (35%). The majority (75%) of them failed to link common resistant bacteria to the commonly used classes of antibiotics.

Figure 6: Levels of Bioscience Knowledge Among Preregistration Nursing Students.



The staked bar chart above (Figure 6) shows a summary of performance of nursing students in different aspects of biosciences.

A large proportion (about 70%) of them scored poorly on questions about bioscience knowledge transfer to clinical situations. Many wrongly recommended the use of antibiotics to manage colds and coughs (40%), and when laboratory services were not available (53%). The aspects they found difficulties in include the use of antibiotics to treat children with a combination of symptoms such an afebrile child with a diarrhoea (35%), a febrile child with a

throat infection (95.3%), and the use of antibiotics in the treatment of anaerobic bacterial infections (41%) and MRSA (83.6%).

Factors associated with the level of knowledge in biosciences among nursing students in Uganda

All independent variables were tested against bioscience scores obtained to find out if the bioscience scores were normally distributed for each predictor variable. Using the Shapiro-Wilk test for normality, the overall bioscience scores were found to be normally distributed by Employment status, age and age-group, route of entry, and university of study with P values for employment status (0.184, 0.137), age group (0.09, 0.223), route of entry (0.142, 0.224), and university (0.573, 0.291, 0.045, 0.483). So parametric tests were computed on these variables.

Age of the nursing students

A simple logistic regression was computed to determine if age is associated with passing or failing biosciences among pre-registration nursing students in Uganda. A binary outcome variable (outcome of biosciences) with fail/pass (0,1) and continuous (age) and dichotomous predictor variables (age group) were used.

The results indicate that age is a statistically significant predictor of biosciences outcome among nursing students in Uganda, Wald =4.567, p=0.033. Likewise, the test for the overall model is statistically significant, LR chi-squared 5.098, p= 0.024. That is, being older or younger may be associated with whether a pre-registration nursing student passes or fails biosciences.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	What is your age?	.081	.038	4.567	1	.033	1.085
	Constant	-.893	1.023	.762	1	.383	.410

a. Variable(s) entered on step 1: What is your age?

The odds ratio (OR) is 1.085, meaning that as age increases, the odds of passing (passing=1) increase by 1.085 times. Therefore, older students were associated with better bioscience outcomes, and the relationship was statistically significant.

Route of entry onto the nursing program

(a) Route of entry and bioscience outcome (pass/fail)

The route of entry on to the nursing program was tested for statistical significance. The route of entry in this case means the level at which the nursing student was enrolled on the nursing program. They can be enrolled through the direct route (from A-levels) or from the completion from a diploma in nursing.

The outcome variable is ordinal and therefore a Wilcoxon-Mann-Whitney test was used to test for any association between route of entry and bioscience outcome. The results suggest a statistically significant difference in the underlying distributions of the bioscience outcomes for those that had a diploma and those enrolled directly from A-levels ($z = -2.94$, $p = 0.003$).

(b) Route of entry and overall bioscience score

An independent samples t-test was done to compare the means of the normally distributed interval dependent variable (score) for the two independent groups (diploma/A-levels). The results indicate that Preregistration nursing students enrolled via the diploma route have a higher bioscience score (68.84) than those enrolled directly from A-levels (64.31). The difference in bioscience scores between both groups is statistically significant ($t = 13.438$, $p = .001$) as summarized in Table 14.

On performing the Mann-Whitney Test, nursing students who were enrolled through the diploma route had higher mean rank (116.96) than those enrolled directly from A- levels (91.42). This suggests that nursing students enrolled on the pre-registration nursing program and had a diploma in nursing were associated with higher bioscience scores than those enrolled directly from A-levels.

Table 14: Independent Samples T-test for Bioscience Scores, Route of Entry, and Employment Status.

Independent variable	**Group statistics**			**Independent samples T-test**	
		Mean	Std. Dev	Sig. (2-tailed)	t
Route of entry	Direct from A-levels	64.31	10.317	.001	-3.438
	From a Diploma in nursing	68.84	8.538		
Employment status	Employed	68.82	8.698	.001	3.239
	Unemployed	64.53	10.174		

Employment status

Employment status and bioscience scores

An independent samples t-test was done to compare the means of the normally distributed interval dependent variable (score) for the two independent groups (employed/unemployed) of nursing students. The results summarized in Table 14 above indicate that employed nursing students have higher bioscience scores (68.82) than their unemployed counterparts (64.53). The differences between the mean bioscience scores for both groups are statistically significant ($t = 3.239$, $p = 0.001$).

On using the Mann-Whitney Test, employed nursing students had a higher mean rank (117.01) than those who were unemployed (92.53) ($p = 0.003$).

The employment status of the students was further categorized into four groups and a one-way ANOVA was used to test the differences in the bioscience mean scores broken down by the four categories of employment status. As shown in Table 15 below, the mean scores differed significantly among the different employment categories ($p = 0.003$). Furthermore, the nursing students in part-time nursing employment had the highest mean score (69.47), followed by those in full-time nursing employment (69.25). Interestingly, nursing students who were unemployed had a higher mean score (64.53) than those employed in other disciplines other than nursing (61.67).

Table 15: Summary of SPSS Output for ANOVA and Report of Employment Status and University of Study.

Independent variable	**Report**				**ANOVA**
		Mean	N	Std. Dev	Sig.
Employment status	Employed in nursing FT	69.25	72	8.33	.003
	Employed in nursing PT	69.47	19	9.79	
	Employed other	61.67	6	7.58	
	Unemployed	64.53	110	10.17	
Total		66.54	207	9.73	
University	A	69.38	50	8.50	.025
	B	63.79	61	10.09	
	C	66.71	63	9.45	
	D	67.00	33	10.37	
Total		66.54	207	9.73	

It appears that being in part-time employment within the nursing profession was associated with better bioscience scores than being employed on full-time basis in the nursing profession, being unemployed or being employed in another discipline other than nursing.

Bioscience scores by university of study

A one-way ANOVA was done to determine if there is a difference in the mean bioscience scores among the nursing students from the four different universities. The mean of the bioscience scores differs significantly among the four universities ($p = 0.025$) as summarized in table F2 above. The report above indicates that the nursing students from university A had the highest mean bioscience score, while those from B had the lowest.

Transfer of bioscience knowledge to clinical practice and employment status

A Wilcoxon-Mann-Whitney test was performed to test for any significant association between the employment status and the bioscience knowledge transfer scores among the nursing students. The results are summarized in Table 16 below suggest a statistically significant association between bioscience knowledge transfer and employment status ($z = -$

3.277, p = 0.001). The employed nursing students had a higher bioscience knowledge transfer rank (118.23) than the unemployed students (91.45).

Table 16: Summary of SPSS Output for Wilcoxon-Mann-Whitney Test for Knowledge Transfer Score.

Independent variable	**Wilcoxon-Mann-Whitney test Knowledge transfer score**		**Mean rank**		**N**
	Z	Sig. (2-tailed)			
Employment status	-3.277	.001	Employed	118.23	97
			Unemployed	91.45	110
Route of entry	-3.307	.001	Direct from A-levels	90.70	105
			From a Diploma in nursing	117.69	102

When employment status was further broken down into 4 categories, the nursing students in full-time nursing employment had a higher mean rank for bioscience knowledge transfer (124.33) than their counterparts in part-time employment (97.97), those who were employed in other disciplines (109.25) and those who were unemployed (91.45). The unemployed nursing students still had the lowest knowledge transfer score. This association was also statistically significant (p = 0.003) on running a Kruskal-Wallis Test.

Similarly, nursing students who were enrolled via the diploma route had a higher bioscience knowledge transfer rank (117.69) than those enrolled directly from A-levels (90.70) as shown in Table 14 above. the difference in the underlying distribution of the knowledge transfer scores for diploma and A-level enrolled students was statistically significant (z = -3.307, p = 0.001).

Transfer of bioscience knowledge to clinical practice and route of entry on the preregistration nursing program

A Wilcoxon-Mann-Whitney test was performed to test for any significant association between the route of entry and knowledge transfer scores. The results suggest a statistically significant association between bioscience knowledge transfer and route of entry (z = -3.307, p = 0.001). Nursing students who enrolled from the diploma route had a higher knowledge transfer rank (117.69) than those who were enrolled from A-levels (90.70). Similarly, the same group of students had a higher rank for general knowledge on antibiotics (119.61) than those enrolled directly from A-levels (88.83), and the difference was statistically significant

($z = -3.777$, $p = .000$). The results above suggest that nursing students who already have a diploma in nursing and are actively employed in the nursing profession are associated with higher bioscience knowledge transfer than their A-level enrolled and unemployed counterparts.

This chapter had presented the quantitative results from this study. The data suggests that first student nurses currently struggle to understand, retain, and apply bioscience knowledge on ABR to clinical practice. Secondly, it identified the factors associated with the acquisition of this knowledge. The next chapter will present the qualitative results, which will expand and explain the quantitative results.

Chapter 5: Phase 2 findings

The aim of Phase 2 was to explore students' experiences of learning, the teaching, and application of biosciences within university and clinical practice settings. It explained and expanded the quantitative findings. Four themes relevant to the students' experiences with biosciences emerged. They include bioscience curricula; teaching methods; clinical supervision; and assessment and feedback. Each theme will be presented, followed by quotes from participants to demonstrate the grounding of the interpretations from the data. The qualitative data was collected from university D.

Theme 1: The bioscience curriculum

The students' experiences of the curriculum focussed on their classroom and clinical experiences, and impact of the curriculum on their overall bioscience competences upon graduation. The students' views of the bioscience curriculum appeared to evolve as they spent more time interacting with the bioscience courses and the clinical context. The second-year students described the curriculum as too crowded resulting in a heavy workload for both learners and teachers. As documented in the literature review, the nursing students learn seven bioscience courses, predominantly in year 1 and 2. The curriculum is prescribed by a national regulatory body meaning that the university had limited room to alter it. Learners also had to contend with non-bioscience courses in addition to biosciences in a limited period. In trying to implement the prescribed curriculum, the quality of teaching may have been compromised. They felt that this was not a matter the university could resolve given that the curriculum was externally prescribed:

> *"They squash a lot of content in a short time, in addition to non-bioscience courses. It makes it very difficult for us." (Second year student)*

> *"Bioscience courses are given a short period of time. The school tries to create time for you to cover the courses. The lecturer tries his level best, so while covering it, they do not teach well." (Second year student)*

> *"You have more than 8 hours a week to cover pharmacology, at the same time you have physiology, which is another bulk. You also have other bioscience courses and the non-bioscience courses are also weighing you down. The load is too big for the*

student to have all that content. For sure it is a big load to carry." (Second year student)

The students in this study explained that the crowded curriculum forced their teachers to teach at a faster pace to cover as much as they could in the time available, further leading to reduced understanding. The decreased understanding and increased demand placed on the students' time overwhelmed them and they adopted surface learning strategies to obtain the required scores to progress to the next level. The experience of having to cram to progress to the next level appeared to be similar across the three groups. Some felt that cramming was the only way to pass biosciences given the circumstances. They however understood that although they crammed to pass, it was not an effective way to retain bioscience knowledge in the long term:

"They must teach faster otherwise we will not cover all the systems. You must cover pharmacology, at the same time you have physiology, which is another bulk. At the same time, you have other bioscience courses, even these non-bioscience courses they are also weighing you down." (Second year student)

"In the first years we were not understanding anything. We were just there sitting for lectures and cramming things to pass. We were just cramming. If you ask us those things now, the things we read, I don't remember." (Second year student)

"We just repeat it over and over again. You can keep writing it down, singing it or keep saying it. At times I cram and when you ask me, even immediately, I don't actually remember." (Third year student)

"We do anything to ensure that we pass, even if it means cramming. Sorry for speaking it out, but there is no other way I can learn in my circumstances. It is the only way I can learn." (Fourth year student)

It appears that although the teachers tried to teach faster to complete the curriculum, they were not successful, yet they were required to assess learning of the whole syllabus. This placed an additional burden on the students because they had to understand what was not well taught and complete the rest of the content on their own:

"Sometimes, they set exams following the curriculum, but they manage to cover about one third of the content. But when they are setting, they set what they are supposed to cover but did not teach." (Second year student)

"Many do not complete the syllabus but even the small bits that they manage to teach are still not taught very well. You as the student are burdened because you must search for what they have not taught and teach yourself, and then revise what they have taught in real depth because it was not well taught." (Third year student)

In their discussion, third-year students noted that the time allocated to their clinical practice was insufficient for high school leavers without prior clinical experience. Their clinical week lasted four days, rotating across three departments in one month, an average of one week per department. The lack of clinical experience meant that they started from the basic skills and moved on to other departments before cementing their learning. Given their limited clinical experience, the students felt that one month of clinical placement was inadequate to learn clinical skills, and biosciences as well as other aspects of care:

"One month is too short, considering the amount of practice we need as direct students who don't have clinical experience. You must use that one month to rotate in three departments. Our clinical week runs from Monday to Thursday. You roughly work on a department for one week and move to the next one." (Third year student)

"You find that the patients are many, they have various conditions, and the opportunities are there but it is practically impossible to learn about the conditions of say, 80 patients in 4 days!" (Third year student)

Unlike the university learning, which was planned with specific personnel responsible for teaching, the placements appeared to be less structured in terms of what students were expected to do and who was to support their learning. The university did not seem to regulate, control, or significantly contribute to the learning that happens in the CLE. The students felt that they merely rushed through things and before they could acclimatize to the context, they moved to the next unit. This study suggests that not only is the time allocated for clinical placements insufficient for learning and applying biosciences in practice, but it was also not well utilized:

"I am on my feet all day doing the same things, getting exhausted from the walking. I keep taking off blood samples. By the time I start focusing on my learning objectives, it is too late in the day, or the clinical rotation has ended, and I move to another department, and the same thing happens all over again." (Third year student)

"Our lecturers don't really be with us right from the start to the end. We are left with some objectives, but it is up to the student to figure out how to meet them. For example, you may have to tie yourself on someone (shadowing staff)." (Second year student)

"The school does not seem to take a keen interest in the practical part of our learning. They are not taking much interest in what is happening in the clinical areas." (Third year student)

"They don't teach you; they don't supervise you or check on you. They even know we are direct students, but they just don't care. I can't tell if they just don't care, or they also don't know what to do." (Fourth year student)

Although it was unlikely to allocate more time clinical practice during the regular academic year, the students expressed willingness to spend part of their recess term honing their practical skills, especially the biosciences if the opportunity arose. Some suggested that the university could utilize the recess term, of about ten weeks each academic year, to avail direct students more time for clinical placements. When asked about how they compensated for the limited time, the students sought for placement opportunities elsewhere over the holidays which was usually difficult because of the red tape and administrative costs attached. They suggested that this arrangement should be compulsory for students with limited clinical experience. At the time of data collection, clinical placements during recess term were optional and the entire cost was borne by the learners, with limited support from the university. This support was in the form of letters of introduction which learners could use to gain access to placement sites of their choice. The students complained about the heavy financial costs attached to getting placements privately which required them to pay out of pocket for transport, meals, sundries, and placement fees for some places. In addition, the students received no supervision in the hospitals where they practiced. They recommended that the university creates protected time for clinical placements during the ten weeks of recess term and make it compulsory for all students enrolled directly from A-levels.

If protected time is made mandatory for this group of learners and charged on tuition, it may support them to improve their knowledge and application of science. This recommendation is feasible and mutually beneficial for the clinical staff who rely on students to contribute supervised labor. In addition, the placement sites are usually not crowded with students during recess term because most students break off for holidays. The staff would

therefore have more time to support students as the students assist them. Staying back to hone bioscience and clinical skills during recess term may give the direct students more opportunities to learn and apply biosciences:

> *"The university could say let us give them two more months to practice in the hospital during the recess term. If they feel that they cannot afford that extra transport, then let them include it on the tuition but not leave us to get that transport out of pocket." (Third year student)*

> *"Yes, let them make it compulsory for direct students to stay back during recess term to perfect their skills and include that additional fee on the tuition." (Third year student)*

> *"During holidays, the staff lack support and help from students. When you go there over the holidays, they get that attitude to teach you with the hope that they will benefit from your labour." (Second year student)*

Despite the short time allocated for clinical placements, participants noted that learning opportunities were abundant in the clinical areas had they had more time and support. Supporting the students to practice during recess term would tap into these learning opportunities in the times when the placement sites are less crowded, but in need of more student support due to the many patients:

> *"So, we found it not easy to learn from the ward during the semester. I go there on holidays. If you go to the ward on holidays, and the ward is not very busy, you are given tasks to complete and you can consult with the staff, and they teach you." (Second year student)*

> *"Yes, during holidays, the staff lack help from students, they get tired. When you go over there, they are forced to consider you because you are also helping with the work. They get that attitude to teach you." (Second year student)*

> *"I use the two months of recess. The only advantage is that the hospital is not too crowded with students, and I can get some time to interact with the patients. The challenge is that it is the same place where I go during the school calendar. So, I face the same challenge and do the same things." (Third year student)*

"There are more learning opportunities during the holiday because the patients are many but the students available to help with the work are few." (Fourth year student)

The students acknowledged that biosciences were complex in nature and understanding them was difficult. They, however, found integrating real life examples of clinical problems into their teaching motivating. Real life examples supported them to connect the theory to the practice, made learning more interesting, and possibly increased lecture attendance. Lecturers who had vast clinical experiences often drew from their vast pool of clinical examples and demonstrated how the bioscience concepts they were learning in the classroom applied to clinical practice:

"The course was hard, but he put the interest in us (motivated us). We knew the course was hard, but the person who taught us was very knowledgeable and confident. He brought in real life examples of scenarios between a patient and a health worker. We said this was it and we would never miss his classes." (Third year student)

"There were times when you could actually understand, especially when the concept is related to the patient. When real life examples were used, we made connections easily" (Fourth year student).

"They should focus more on the relevance of biosciences to clinical practice right from the start. For example, someone is teaching you lipid metabolism in biochemistry, they should show you how those chemical pathways relate to a patient's problem and how I can recognize and solve it as a nurse" (Fourth year student).

The need to link theory was apparent in this study. Contextual integration of biosciences to nursing practice was an important factor in supporting learning and application of biosciences in clinical practice. The respondents stressed that interweaving biosciences within the teaching was vital in establishing and maintaining the retention of bioscience knowledge. For example, retaining and applying bioscience knowledge among nursing students was more successful when teachers incorporated real life examples in their teaching. Using relevant clinical examples was useful, especially given that many of the students appeared to need visual aids to understand what they were learning. In addition, linking theory to practice during bioscience teaching was important in supporting them to identify and differentiate clinical problems during their clinical placements and assessments. For example, when teaching about chest pathophysiology, a teacher would use real-life x-ray

films, to support students to differentiate between a patient suffering from asthma, lung cancer, and tuberculosis (TB). This study suggests that biosciences could be linked to clinical practice by using relevant clinical examples in classroom teaching, recapping bioscience theory before performing nursing procedures and learning biosciences at the patients' bedside. For these learners, bioscience learning should be practically linked through demonstrating clinical relevance, using real-life examples, and hands-on:

> *"Teaching me about a drug without showing it to me is not useful. Some of us learn by seeing and touching. If I see something it is hard to forget. But if they just tell me without showing me, the information will remain with the lecturer. These biosciences should be conveyed in a practical way such that we don't forget." (Second year student)*

> *"The teaching should be more practical. For example, if I am studying heart rhythms, they should really have an angiogram or cardiogram or at least an image for the students to see. By the way when you learn practically, see and touch, you never lose it." (Third year student)*

> *"I will not see the bronchial constriction but can see the chest x-ray and it will show me. But if the lecturer only tells me about the chest x-ray without showing me, do I even know what it looks like? If you give me that chest x-ray tomorrow, can I tell the difference between a patient who has asthma, lung cancer, or TB? I will not because it was just theory and no practical." (Second year student)*

> *"I think that the other way to improve how we learn bioscience is, since at the end of it all, it applies to the patient, I would suggest that instead of only being theoretical we should have the opportunity to have hands on learning." (Fourth year student)*

> *"It should be hands-on. If you tell me to do head to toe exam, you can show me the video of how it is supposed to be done, but let's go to the ward, do it as I watch. Tell me this is how we percuss. This is the normal percussion note and this is the abnormal one. This is what we are looking for." (Fourth year student)*

It appears that linking bioscience teaching to clinical practice did not only support students to understand, remember, and apply what they learned in practice, it also helped them to further understand bioscience theory during revision. It motivated them to explore

clinical problems further on their own initiative. It therefore appears that teaching biosciences in this way supports nursing students to transfer learning to new clinical problems:

> *"We want them to show us how what they are teaching us is related to patients so that when I am reading, I easily relate the patients' symptoms to what I am reading." (Fourth year student)*

> *"I can sit down on my own and read most of the theory the lecturer teaches, but I need to see and touch to understand better. It would help me to think outside the box and give me more zeal to further research and explore." (Third year student)*

In addition to using relevant clinical examples, learning biosciences from the patients' bedside afforded the students the opportunity to recap the theory prior to linking it to practice. Recapping theory prior to the practice of biosciences appeared to form a link between classroom and clinical practice settings. It may support learners to make rational clinical decisions and improve confidence to apply theory to practice further reinforcing their learning. Learning biosciences from the patients' bedside appeared to provide the best context to link biosciences to practice. They were able to integrate the abstract and intangible concepts of biosciences in the real world. It meant that abstract bioscience concepts became tangible and observable. The patients' bedside presented the experiences of how bioscience problems present in the real world. They got firsthand experiences of the value of biosciences to clinical decision-making and how these decisions could affect individuals and families. The bioscience learning could then be extended to the nursing interventions and other clinical problems:

> *"When the teachers recap the theory, we learnt in the class at the patients' bedside, I am sure we would understand biosciences. We would be more confident." (Fourth year student)*

> *"We want to learn bioscience problems in the clinical area, with real patients, with real problems. What I mean is that since the patients are the ones with the problems we seek to understand and manage them in the real world under supervision" (Third year student).*

> *"The best way of learning in the clinical area would be performing tasks like taking temperature. When it comes to interpretation, the supervisor can initiate a discussion on what bioscience rationale is behind the patients' temperature reading (possible*

causes, management, alternative care). Then, we can take it down to the nursing procedures such as tepid sponging." (Second year student)

In addition to linking theory to practice, the students pointed out the importance of linking bioscience courses to each other. They appeared to understand that the courses were related and complementary and that teaching them in total isolation of each other was detrimental to learning. If bioscience concepts are linked to each other during theory and clinical teaching, the student will most likely manage bioscience problems more holistically and transfer that knowledge to solve new clinical problems. Linking bioscience courses may require teaching particular complementary courses in a coordinated manner:

"All bioscience courses work hand in hand. Each course compliments the other. The biosciences are mainly taught theoretically and in isolation, so we find it troublesome to relate the theory to the practical aspects." (Second year student)

"For biochemistry, it is difficult to pull those things together when you taught them a long time ago. It needs to be taught close to pathophysiology, pharmacology, and microbiology. These biosciences are complementary, but when you teach them in isolation of each other, it becomes difficult to comprehend." (Third year student)

In addition, the students preferred to have bioscience courses taught close to each other and close to when they have clinical placements to make the links easier. They found it difficult to draw knowledge from courses they learnt long ago. It appears that the students' understanding of relevance of biosciences to clinical practice happened later in the program. They stated that they did not realize why they were learning some courses in the first years until they went for practice. It could be that the relevance of bioscience theory to practice was not explicitly emphasised in the teaching, the methods were not supportive in linking theory to practice, or they had not yet intellectually developed to link the theory to the practice. What is clear in this study is that many of the students realized the importance of theory to practice much later, sometimes when opportunities to make the connections were gone. They recommended to teach the courses closer to when they are due to go for practice and closer to each other. For example, they thought that biochemistry should be taught close to pathophysiology and pharmacology such that the student comprehends the links these have on each other at the point of teaching and clinical practice:

"I am confident in some courses but not biochemistry. The teaching of biochemistry is problematic. I think they should change the way it is done. We learn it in first year

and we cannot see the relevance of it at that point. They should teach it close to when we go for placements not in first year when we don't even understand what it is for." (Third year student)

"Learning bioscience courses very early is not good because we only appreciated the practical things later, when the chance to integrate it is gone." (Fourth year student)

"We should learn biochemistry later when we have had some other courses because then we will be able to apply it. These biosciences are complementary, but when you teach them in isolation of each other, it becomes difficult to comprehend." (Third year student)

"You meet a patient now and you say, Oh, biochemistry was required for me to understand this condition! Back then we were not understanding anything." (Third year student)

The participants were keen to point out the importance of linking clinical skills teaching to biosciences to improve application. They recognized that all nursing skills were founded on bioscience principles although this linkage was not always apparent during teaching. They reasoned that they applied biosciences better when a clinical skill was taught together with its underlying bioscience, and possibly extending the learning to other potential clinical problems. For example, when teaching a skill like chest percussion[6], students would learn the normal and abnormal percussion notes. A normal percussion sound over the lungs would be a resonant sound in contrast to a dull or hyper resonant sound indicative of pleural effusion or pneumothorax. When such skills are taught and possible bioscience explanations for abnormality, signs and symptoms and nursing management discussed, the student would apply the science to practice better than when the skill is taught separately from the science. The students in this study maintained that although linkage of the skills to bioscience was limited in practice, retention and application was easy when it was done that way:

[6] Chest percussion is a physical assessment technique which produces audible sounds by tapping on the patient's chest wall. The sounds can be interpreted by a skilled examiner to detect fluid, air, or solid.

"We need more hands-on opportunities for both the skills and biosciences in order to connect and cement what we have learnt." (Third year student)

"Let us go to the patient's bedside. Tell me this is how we percuss. This is the normal percussion note and this is the abnormal one. This is auscultation and these are the normal breath sounds. Let us explore the possible causes of the abnormal percussion notes and auscultation sounds and I will always look out for it in the future." (Fourth year student)

This theme expressed the participants' awareness of the opportunities and barriers within the curriculum. They were also cognisant of their unique need to retain and apply biosciences and the importance of more practice given their limited experience. They emphasised the importance of structuring the bioscience courses in a way that connects them to practice, to each other and to the clinical skills. They were willing to dedicate more time to their clinical bioscience practice during recess term if they received support from the university.

Theme 2: Teaching methods

Lecture Method

According to the respondents, bioscience content was predominantly delivered using the lecture method. Respondents said that during the teaching, lecturers explained some of the most vital concepts summarized in the PowerPoint presentations and used the blackboard to further illustrate the concepts. All respondents, regardless of the year of study agreed that lectures were the principal method used in teaching biosciences in their university. They however differed in their perception of the importance of lectures as a method of teaching bioscience concepts. The 2nd year students focused on the nature of lectures as a method in conveying bioscience content while the 3rd year students looked at how effective lectures were in understanding the content.

The 2nd year students perceived lectures to be passive, contributing to the difficulty in learning. First, their lecturers appeared to overrate the benefit lectures had on bioscience knowledge retention and understanding. Then, the passive nature in which the lectures were delivered further amplified the difficulty to understand the already complex bioscience concepts. It appears that there was a disconnect between what the teachers thought was the

useful way to teach from what students found useful practically. For the students, the way lectures were conducted did not adequately support them to understand biosciences and motivate them to learn:

> *"Some lecturers, (whispers, group laughs), the way they put forward themselves, it has some loopholes somehow. It sometimes does not motivate the students. Sometimes the way they do their things (deliver bioscience content) they don't prompt or encourage you to participate and think." (Second year student)*

> *"Most times, these lecturers think that we think the way they think. Someone comes, teaches something the way he (lecturer) understands it, and he assumes that you (student) have understood it." (Second year student)*

Indeed, lectures have dominated bioscience teaching in higher education and these teachers may have formed these experiences along the way and used them in their own teaching and assumed they would work for their students. It appears that the lecturers in this context understood the challenges related to delivering bioscience courses from their own experiences as students. The participants reported that one lecturer acknowledged this and tried to improve his teaching, only that he did not meet the students' expectations. This study suggests that the challenges inherent in teaching biosciences for nursing students have been the mainstay in this context. This may explain why the students perceived their lecturers as over relying on lectures and overrating them as effective in supporting learning. Evidently, there was a disconnect between what the students perceived lectures to be and what their teachers were doing. For these students, lectures were demotivating, shallow and dry. They felt less encouraged and prompted to learn and participate in their learning:

> *"The lecturer should work hand in hand with the student. But most times, some lecturers think that we think the way they think. Someone comes, teaches something the way he/she would understand it and then assumes that you have understood it." (Second year student)*

> *"They opt to use lectures which are easier and faster, but they do not help us to understand. Maybe it is the only way they know how to teach in these circumstances. (Fourth year student)*

"I am wondering, we are taught by nursing degree holders, and I think they faced similar problems. If he also passed through the same system, I expected him to make some changes to his teaching from the experience he had as a student. He would try to make things easier, but he made things worse." (Third year student)

"The lecturer told us that his own experience as a student was worse. That he would see his lecturer only occasionally when he was a student. He said that he had to do things on his own. That he had to google for a lot of the information. For our case, he said that things were better because he at least comes and teaches us." (Third year student)

This was not to mean that they did not recognize that they had an active role to play in their own learning or that those biosciences were relevant. Rather, some admitted to possessing a laid-back attitude, predominantly looking up to the teacher to provide most of the required bioscience content. They cited two reasons for this lazy attitude: (1) the complexity of biosciences and (2) the lack of enough preparation for higher education. They found themselves learning complex bioscience concepts in an unfamiliar learning environment for which they were not prepared:

"On the other hand, we students also have a problem. Now sometimes it is negligence. We are lazy at times. We know that the content is relevant, but biosciences are complicated." (Second year student)

This study suggests that most of these students were not consciously aware of the academic demands of higher education. They admitted to coming to the nursing program with an attitude that learning at this level was easier than high school level. To them, coming to higher education was a time to relax and rest from the stresses of learning science subjects in high school. They were not prepared for the massive transition from a predominantly teacher centred high school science learning to higher education where they were expected to actively seek knowledge and contribute significantly to their learning. They expressed shock at the amount of time, commitment, and intensity of learning required at the higher education level which was very different from their experiences of high school. They found it difficult to cope especially with the complex science content. In addition, the relevance of bioscience courses was never emphasized to them right from the start of the nursing program. It should be noted that bioscience courses are taught throughout the first two years, at a time when learners are still adjusting to learning at higher education level. At the time of data collection,

the university did not have a program to prepare students for higher education and support them through this transition. The passive nature of lectures further compounded or prolonged the process of adjustment:

> *"We came thinking that we can rest while here. So, when we joined university, we found it difficult to cope." (Second year student).*

> *"We are not prepared. The brain must shift from the old methods to this new one. So, the brain is kind of resistant to this new way. It takes some personal bit of devotion to what you are doing. To overcome this problem, you must be highly motivated but because we are not motivated, you just have to find a way of helping yourself to learn." (Second year student)*

The participants maintained that the mature students already had a foundation for bioscience obtained at diploma level upon which they built the new knowledge. They had been to university and were used to how things are done, especially in the clinical area. They maintained that they did not know what was happening at the beginning of their studies. This means that they were unfamiliar with learning in higher education. They did not appear to be consciously aware of the workings of the new context and had not adjusted to the new system of learning. This may explain why they sought assistance from more senior students to support them with transitioning to the new context. In contrast to their counterparts who had prior biosciences, the direct students found it difficult to link what they were learning to clinical practice. They had limited science knowledge to work with whereas their colleagues already had a foundation on which they continued to build. Their limited experiences with higher education and biosciences meant that they needed more support:

> *"The extensors have already been in that environment of medicine; they have seen the practical aspect but for us we are just from senior six (A-levels). We do not know these things. They know these medicines and how they work, so the lecturer just teaches quickly and leaves us behind. They assume we know, yet we do not know anything, and the lecturer just continues like that. I found myself lost." (Second year student)*

> *"We do not know because we are fresh from high school. It is our first time to learn this way. We are just beginning but the lecturers do not seem to notice that we are different from the extensors who learnt some biosciences at diploma level and have been doing these things for years." (Third year student)*

"When you have not understood something, the senior students can help you." (Third year student)

Fourth year students appeared to view lectures as a non-essential tool for overall bioscience success. In fact, they laughed when they were asked about how lecturers teach biosciences. They seemed displeased with the whole idea of using lectures to convey bioscience content. Some openly stated that lectures were a 'waste of their time': they could read on their own and still understand the content. Some claimed to have read the notes and understood the content without having to attend the lectures. They also agreed with the others that the theoretical way biosciences were taught made connection of bioscience concepts to clinical practice difficult. They too reiterated that teaching biosciences in the classroom was passive and teacher centred, and their learning needs were largely unmet:

"They just come and project whatever notes they have and expect us to assimilate whatever they are saying at a go as they are there talking. I personally hate lectures. It is a waste of a lot of time, but I force myself to come. But those things, I can always sit and read on my own." (Fourth year student)

"Yes, I agree: When I dedicated myself to read on my own, I realized that my teacher did not do a good job. (Fourth year student)

One of the major reasons that diminished the effectiveness of lectures in conveying biosciences was the practice of mixing of A-level leavers with students who already have a diploma in nursing. They clearly pointed out that although it was not official university policy to teach A-level leavers together with top-up students who hold a diploma of nursing, it was often the case in practice. The extensor students had classes scheduled over the weekend while the direct students studied during the week. While this practice may have reduced the number of lectures delivered, saved on the time, and encouraged knowledge exchange between the two groups, it placed the A-level leavers at a disadvantage:

"The classes are not even meant to be mixed up, but the lecturers tell us that they do not have time, so they tell us to come during the weekend when the extensors come to learn." (Third year student)

They expressed concern that their learning needs were not addressed by their lecturers when they were taught together. They felt that their teachers failed to recognize that they lacked clinical experience and as such needed more time to learn even the basic concepts and

later get support to relate them to clinical problems. The lecturers did not seem to recognize that they taught two distinct groups of learners with diverse learning needs. Mixing them put the less dominant group at a disadvantage:

> *"The lecturers don't have the intuition that we are two different groups. They just see us like we are all the same. They don't differentiate between direct students and extensors." (Third year student)*

> *"If you the direct students are learning together with the extensors, the lecturers do not mind you. I just noticed just recently that during a dermatology lecture, when we still ask a question about something we are not aware of, the lecturer does not seem to mind. Forgetting that we don't know because we are fresh from high school." (Third year student)*

Mixing the groups appeared to hide the bioscience challenges intrinsic among the direct students. Their clinically experienced counterparts were more in number and in active employment and could more easily relate their learning to their own practice:

> *"All of us have experienced this problem. When it comes to these applied biosciences like pharmacology. They speak of a drug when they (top-up students) have already seen it, they already know the side effects, the site of administration and dose. We are left behind; the lecturer just moves on." (Second year student)*

Unlike Universities B, C, and D, University A only admitted diploma holders onto their degree, meaning that all their students were mature, and in active nursing employment. This means that their classes are more homogeneous in terms of age, prior knowledge, and clinical experience. Their learning needs could have been more similar than the diverse groups in the rest of the universities. The rest of the universities had more diverse classes explaining their lower mean bioscience scores.

Mixing groups did not appear to be the problem, but the failure to recognize the differences between the two groups of students and failing to utilize the advantage that mixing could bring to the younger students. This problem may be similar in the three universities with mixed groups. During the focus groups, the students emphasised that their limited clinical and prior bioscience experiences greatly hindered their learning right from the classroom. This is because one needs theory to be able to apply it to practice but you need some prior experience to relate the theory you learn to the practice you will do. It is a mutual

relationship. These students recalled the difficulties they had when learning biosciences together with the mature students who already had prior bioscience knowledge from the diploma level. They recollected incidences when a lecturer mentioned medicines which were new to them but familiar to their mature colleagues. They reported that their colleagues already knew the drugs, the indications, doses, side effects, and contraindications whereas everything was totally new to them. Most of the applied bioscience was new to them and they needed more time and support to make those connections in addition to learning the core science of the drugs:

> *"Actually, we can't compare ourselves to someone who has already been in the system. They studied these bioscience courses during their diploma. Those people are well off than we are more when it comes to applicable courses like pharmacology. The lecturers speak of a drug when they have already seen it and even used it for years. They already know the side effects, the site of administration and dose. We have nothing to even start with but the lecturer just moves on." (Second year student)*

> *"They should remember that we have more to learn because we are direct from high school. We have limited experience and we need more teaching and hands on bioscience learning. We need to be taught from the basic skills to the more advanced ones." (Third year student)*

> *"So, you find that those who already have the clinical experience are the ones going to benefit. I am a fresher; these things are not part of my work (I do not have prior experience). I need more support because it is my first time. At the end of it, you just go back to read and cram to pass." (Fourth year student)*

Combining the two groups without proper control of the classroom dynamics reduced the confidence of the younger and less experienced students to participate in the classroom and meet learning needs. From the participants' statements, the top-up students were more in number and tended to dominate the classroom dynamics and the teacher tended to teach at their pace and focus on their learning needs leaving the others behind:

> *"The lecturer can ask:' do you know this drug?' Now since most of the class are top-up students, the class says yes. Even when you do not know it you just keep quiet. You find that those who already have the clinical experience are the ones going to benefit and the rest of us who are from A-levels will just sit down to pass the time." (Fourth year student)*

"The extensors dominate. The school tends to act on our complaints but that only happens when extensors also complain about it. If it is just us, they do not take it seriously. When extensors complain, that is when they act. The Quality Assurance officer noticed it and spent time came to confirm from us if the incident actually happened." (Fourth year student)

From the focus groups, these students tried to ask questions (which were likely to be obvious to most of the mature students), but the teachers failed to recognise and interpret them as indicative of their disadvantage relative to their colleagues. Ignoring the needs of the direct students appears to have demotivating them from making more attempts for support:

"We feel oppressed when we are mixed with those extensors. We cannot ask any questions because our questions may look to be less important to the majority. So, you end up not asking them, but I would ask if we were not mixed." (Third year student)

"If direct students are learning together with the top-up students the lecturers do not mind about you. When you still ask a question, the lecturer replies like 'you people are not following'. Forgetting that we don't know." (Third year student)

"Instead of the lecturer interpreting our question that maybe some students fresh from high school have a problem understanding, or they are not getting it clearly, the lecturer says that we are not following." (Third year student)

Mixing cohorts should only be done with proper assessment and skills to manage learning needs. This study extends our understanding of the characteristics which predispose learners to difficulties in learning, which will help teachers to give more support to those students. Perhaps the teachers were not aware of this association and assumed that their classes had similar learning needs thus encouraging them to mix. In conclusion, although lectures were the dominant in bioscience teaching, students faced difficulties relating to their passive nature, the classroom dynamics due to mixing of groups, and the lack of motivation and preparation for higher education. Unlike other courses, biosciences are complex in nature and are usually difficult to understand and apply to nursing, especially when not applied at the point of teaching. The students were more likely to understand biosciences when they were directly related to a common problem in clinical practice. When biosciences are taught in isolation of practice, retention becomes more difficult. Relating bioscience concepts to practical examples in the clinical area may make all the difference between a good lecture and bad one. Despite some negative opinions of participants, lecturers could have had some

usefulness in conveying bioscience content, although they required addition of other active methods of learning to improve retention and application.

As already explained, teaching in the classroom was more structured, scheduled and controlled in terms of when it happened and who facilitated it. Within the CLE, teaching appeared more unstructured, and, on many occasions, students had to identify their learning needs and seek out teachers who would support their learning. According to the respondents, clinical teaching was through ward rounds and clinical case presentations.

Ward rounds

The participants reported that ward rounds were important in learning biosciences in the clinical context. Ward rounds were headed by a consultant physician and conducted weekly, although intern doctors conducted their own for the rest of the week. The perceived usefulness of medical ward rounds to bioscience learning was tied to their focus on biosciences. Ward rounds appeared to bring biosciences at the forefront of decision making and were seen to be actively used as a tool to identify, explain, investigate, and manage clinical problems. In other words, ward rounds were a great platform upon which to connect biosciences to clinical practice. In addition, medical ward rounds were headed by very knowledgeable medical specialists. These specialists were always at hand to recap core science aspects related to the patients' health condition and supported students to make links with clinical practice:

> *"During the ward round, the one who clerked the patient presented the case to the team. The student would discuss the medical diagnosis, the medical and nursing management, the pathophysiology, pharmacology…. they talk about each and everything. The specialist was there to guide and correct the students. I derived benefit from the teaching that he was doing." (Fourth year student)*

> *"But that man (consultant) had matter (knowledge). He had vast knowledge about the patients' conditions. He was just talking, and all the biosciences were connecting; he was asking questions and I was silent. Okay it was my first day and my first ward round. All I can say now is that I wish I had attended more of them." (Second year student)*

The nature of the medical ward rounds was that all patients were seen by the interdisciplinary team in an organised manner. This means that the students had opportunities to learn about many bioscience aspects linked with other aspects of care in a single day. In addition, opportunities were available for junior doctors, intern doctors, or medical students to present clinical cases as the rest of the team listened, after which they asked questions and made joint clinical decisions. This interdisciplinary learning mimicked the nature of their future workplaces and increased their uniqueness and value as members of an interdisciplinary team. They got opportunities to practice some clinical nursing skills related to the patients they saw:

> *"All the students are there with the patient and the lecturer. The lecturer listens to the presentation and gives feedback." (Third year student)*

> *"Now I know that a ward round is for bioscience knowledge." (Second year student)*

The findings from this study suggest that medical ward rounds were the most important platform through which the nursing students learned and connected bioscience to practice. They reasoned that ward rounds were a vital resource for bioscience learning because they were headed by very competent and knowledgeable medical specialists and were open to all students. The students stressed the importance of the clinical teachers' bioscience knowledge in supporting their learning of bioscience:

> *"We mostly learn biosciences from doctors during ward rounds. I try to be part of them to learn the biosciences." (Third year student)*

> *"I have noticed the difference when a medical doctor teaches and when another professional teaches biochemistry. The difference is in the depth of the content they teach, the explanation. They usually explain something, and you really understand, you connect things. But the others who also did not understand the bioscience concepts very well tend to go off-key (unsatisfactory). They just peruse through the material." (Fourth year student)*

> *"The lecturers who are teaching us biosciences should make sure that they understand what they are going to teach before they come to teach." (Fourth year student)*

The exhaustive nature of the bioscience teaching during the medical rounds made them the single most important source of contextualized bioscience teaching in practice. The

specialists were highly experienced and intimately familiar with the presenting health conditions under study. They could tell the students most of the science they needed to learn about the condition. They explicitly linked the science courses and other aspects of care to holistically manage patients to optimum health. This means that by the end of the round, a lot of learning had taken place given the large number of patients. The students therefore were able to learn about many aspects of care linked to biosciences in a single day:

> *"By the end of the day, you have learnt the bioscience and how to manage five different conditions. This information sticks with you and you cannot forget." (Fourth year student)*

> *"They use it as a learning opportunity to ask questions, discuss bioscience issues and make clinical decisions based on the underlying bioscience. You get the chance to listen to all cases on the ward." (Third year student)*

> *"You have to wait for the intern doctor to learn the biosciences. They know the patients in and out because they review them daily." (Fourth year student)*

> *"We really find attending ward rounds very, very useful. "(Second year student)*

It appears that although these students had limited support, they were willing to learn from anybody that was knowledgeable and willing to teach them. They forged learning relationships with those they viewed as important resources of bioscience learning. They also took initiative for their own learning, sought learning opportunities, and negotiated the politics of the clinical learning area:

> *"I can say how we learn in the clinical area. We search. Like you search for what you want to learn and learn that. If you are lucky to get someone willing to help you, approach that person and that is a bonus." (Fourth year student)*

> *"I sometimes follow-up the doctor who admitted the patient and ask the reasons for their decisions. If there is an operation that is going to happen, I contact the intern doctor who will perform the operation. They give me the tasks to prepare the patient for theatre. When you follow the patient to the theatre and ask them questions, they explain things to you. I sometimes use the intern's notes and use them to learn." (Third year student)*

"When it comes to the bioscience, I utilize the intern doctors, senior students, and consultants who are there. I have found the presentation sessions of other students very useful. When I listen to their case presentations, I get a chance to learn biosciences." (Third year student)

The students appeared to be proactive in searching for knowledge, specifically by identifying what they needed to learn and shadowing doctors or directly asking for support. It appears that when it came to learning biosciences, they mainly went to the doctors and to nurses when they needed to learn the clinical skills.

Medical doctors appeared to highly value biosciences and ultimately were seen to use it to inform clinical decisions. This could explain why the doctors tended to incorporate biosciences to their routine clinical care. The value that doctors placed on biosciences appears to be linked to the professional culture and the view that medicine has a more established bioscience body of knowledge and therefore their reliance on bioscience to make clinical decisions appears to be stronger, something that the students found supportive to their learning. The doctors were seen to discuss and actively apply bioscience knowledge to clinical decisions at the bedside of the patient. The value of biosciences in medicine appears to have trickled down to their clinical culture. Basing clinical decisions on the underlying science appears to have supported the students to understand and later apply that knowledge to other patients:

"The doctor who taught me that in the clinical area did it really well because I could see him relating the biochemistry of nutrition where the patient was." (Fourth year student)

"I sometimes follow-up the doctor who admitted the patient and ask the reasons for their clinical decisions. They explain the science to you, and it makes sense to you." (Third year student)

"It now made more sense to me to tell the patients to eat more fruits and vegetables. So that when the patient also eats carbohydrates and protein alone it does not actually work." (Fourth year student)

The specialists supervised the whole process and were at hand to guide the discussion and ask the relevant questions at the bedside. This means that teaching on ward rounds was in the context where the practice was taking place: the patient's bedside. As explained earlier,

nursing students in this study valued learning which took place at the patients' bedside. The bioscience aspects they learned were clinically contextualized by relating learning to real patients in question:

> *"I learn a lot when students are presenting cases to a consultant who is available and cares to teach and ask relevant questions. The students present the cases at the bedside, and he is there to observe, guide and ask the questions." (Third year student)*

> *"The specialist was there to guide and correct the students." (Fourth year student)*

> *"If the cycle is complete at the patients' bedside, the knowledge will stick better." (Fourth year student)*

> *"For me this is the best to learn bioscience is when the patient is really present and the lecturer cross checks what I am doing. For example, if I state in my presentation that the presenting complaint is fever, the lecturer should check with the patient to find out that the problem is actually fever and not diarrhea." (Fourth year student)*

Away from the consultants who were available once a week, Intern doctors were invaluable in the learning of nursing students. They held their own medical round every day together with junior doctors. Unlike the doctors and nurses who worked on shift basis, the interns worked longer shifts. They were more available to answer questions. They were more involved in the management of all patients implying that they were more familiar with the patients' conditions:

> *"We mostly learn from doctors during ward rounds. In some wards, rounds are not done daily with consultants. The interns hold rounds daily, so I try to be part of them to learn the bioscience." (Third year student)*

> *"The nurses are not always there because they work on a shift basis so you may not always meet them. The intern doctors, however, are always available. They see their patients through the day and know them well. Interns are willing to teach students." (Third year student)*

> *"When I follow the patient to the theatre and ask the interns questions, they explain things to you. I sometimes use their notes and use them to learn." (Third year student)*

The students described the medical interns as more approachable than the nursing staff. They were also more willing to teach the students perhaps because they were still under

training themselves and felt empathetic to the students' needs. It could also be that the intern doctors were more confident in their bioscience knowledge and how it relates to clinical practice owing to the central position the biosciences held in medicine:

> *"It is usually intern doctors who are interested in teaching us." (Fourth year student)*

> *"The intern doctors are also not harsh. So, when you ask them questions, they really explain things to you." (Third year student)*

> *"But in most cases, most of the nurses lack the knowledge themselves. So, some of them are even scared to explain such things to you. If you ask a bioscience related question, she will only tell you the basics, but she can't explain the deep bioscience behind what she is doing." (Fourth year student)*

> *"I have never seen a nurses' ward round. I have only seen them performing the procedures. Nurses do not assess patients as a team and make clinical decisions based on their assessments." (Third year student)*

The nurses on the other hand may have appeared to be less willing to teach biosciences because they were not confident in their bioscience knowledge and therefore were not able to teach the students. From the students' narratives, it appears that the nurses' level of bioscience confidence was related to the relevance they attached to biosciences to their clinical practice. In addition, the nurses appeared to have felt inadequate due to inferiority to their other colleagues, preferring to rely on the decisions of the physicians than on their own knowledge:

> *"Nurses feel inferior. For example, I am aware that the lab staff will test the samples the nurse has collected. The nurse will do the bedside nursing, but they do not even see the relevance of the nursing student wanting to see what happens in the lab. Yet when you do so, you would do your nursing even better because you know what microbes you are dealing with." (Third year student)*

> *"That is why you find that when you ask the nurse a bioscience question, she tells you to ask the doctor. You must know that at the degree level. Yes, there are boundaries in professions but what is wrong with wanting to know more? If I am discouraged from learning the doses of medications, how will I know that the prescriber has made an error?" (Third year student)*

"Many nurses lack confidence, so they don't bother with emphasizing some aspects to their students." (Third year student)

Secondly, the nature of the medical ward rounds was that they were conducted in an interdisciplinary manner. The clinical decisions were justified using available evidence made jointly by the team under the guidance of the consultant. When students learn biosciences in an interdisciplinary manner, they can learn from different professionals and students. For example, the doctors were more knowledge in the biosciences and in using them to make clinical decisions, while the nurses were more competent in the procedural skills. During the ward rounds, medical students, and interns presented clinical cases from which the nursing students gained bioscience knowledge, something that would not have happened if the nursing students and medical students and interns studied alone. Interdisciplinary learning also appears to support students to communicate, defend their clinical decisions, and understand the rationale behind each other's' clinical decisions:

"When it comes to the bioscience, I utilize the intern doctors, senior students and consultants who are there. I have found the presentation sessions of other students very useful. When I listen to their case presentations, I get a chance to learn biosciences." (Third year student)

"I have never seen a nurses' ward round. I have only seen them performing the procedures. Nurses do not assess patients as a team and make clinical decisions based on their assessments." (Third year student)

"On the ward during the clinical placements, the most important people we learn the skills from are the certificate nurses (enrolled nurses). They teach us how to give injections, cannulation, and things like giving IV fluids." (Second year student)

"I sometimes follow-up the doctor who admitted the patient and ask the reasons for their decisions." (Third year student)

"I feel prepared in pathophysiology because it was well taught. I can answer the questions the consultant asks. I can defend my nursing decisions." (Third year student)

Despite having vast bioscience knowledge, the health professionals outside of nursing were perhaps not familiar with the bioscience needs of the nursing students on the degree program and therefore were not in position to customize their teaching to the needs of the

nursing students. Perhaps they were unfamiliar with the scope and depth of the bioscience knowledge nursing students needed. For example, the students noted that the doctors often closely associated with medical students when it came to learning biosciences in the clinical area and not the nursing students. Some doctors were surprised when nursing students asked bioscience questions, possibly questioning the value of bioscience knowledge to the nurse:

> *"The intern doctors most of the time associate with medicine and not nursing. They mostly teach the medical students around them. So, when you ask bioscience questions when you are a nursing student, most of them are perplexed; they wonder, what is this person talking about?" (Second year student)*

> *"They are surprised as to why a nursing student would ask a bioscience question. There does not seem to be inter-professional understanding of what nurses at our level require." (Second year student)*

Although doctors were viewed as the 'experts' of bioscience knowledge in clinical practice, their own knowledge of nursing was limited and as such they could not prescribe the depth and scope of biosciences needed by the nursing students. Their understanding of the bioscience needs of the nurses was limited. For example, the participants pointed out that some doctors valued nurses who did not seem to use bioscience knowledge. The nurses who did not question the doctors' decisions regarding patient care were viewed as good nurses. They largely ignored the opinions of the nurses who appeared to use bioscience knowledge to contribute to the clinical management of their patients. This could be due to a knowledge gap in what level of knowledge the registered nurses need and their contribution of that knowledge to patient care. The doctors could also have felt that nurses who were able to apply biosciences to their practice and question the physicians' clinical decisions were crossing their professional boundary and encroaching on medicine. The students felt that bioscience knowledge supported registered nurses to collaborate with the physician in patient care and act as gate keepers who look out for the interests of the patients:

> *"At the degree level, we are at a reasonably senior level of nursing, and we are supposed to be leaders of other nursing cadres. We are the professionals in the nursing field, not the doctors. The doctors are the professionals in medicine not nursing. We are supposed to lead the other nurses and meet the doctor to collaborate in the patients' care. But the senior nurses just keep following the team without giving any professional opinion or asking questions." (Fourth year student)*

"Most of the nurses just read what the doctor has instructed, and they perform the procedures. They do not stop to think why. Whatever the doctor has said, they just run and do it without taking a step back to ask if it is the right thing to do. The doctors keep saying: these are the best nurses." (Fourth year student)

"Those nurses who give their professional opinions to the doctors regarding the patients' condition, especially when the nurse can relate the biosciences, the doctors largely ignore because they think that is only the work of the doctors." (Fourth year student)

The students still felt that nurses with good bioscience knowledge and skills would better serve as teachers. They emphasised that the doctors were uncertain of the scope of bioscience needed for competent nursing practice. They could not tell how much to teach and how to connect that to nursing. This could explain why the doctors often associated with the medical students more than the nursing students. There seems to be a gap in the interprofessional understanding of the level of biosciences RNs need:

"But for those bioscience courses, I would wish we go with our lecturers, we conduct our own nurses' ward round then we would learn better. They would know what we have learnt, and the standard required to learn at our level." (Second year students)

"I could not ask the consultant anything because he did not know me. So, when we go with our own lecturers, who know what we need. They our weaknesses and strengths and things can be easier." (Third year student)

"The university should hire experienced nurses who have some preceptorship or mentorship training. They should be available in the clinical are and be available for the students. They would help us to teach biosciences at our level. "(Fourth year student)

Although nursing students benefited from medical ward rounds, they were often passive participants, watching from the side-lines. The participants referred to their learning as 'attending ward rounds' and having to listen to others and not actively participating. The whole exercise appeared to be designed for those in the medical profession. It could be that the ward rounds were more associated with medicine given that they were led by physicians and presentations were from medical students and interns and not nursing students and interns. It appears that some physicians may not have understood the significance of the ward

round to the nursing students. That it was the best opportunity available to them to learn and link biosciences to clinical practice. This could explain why they asked some nursing students to leave the round to do some other duties:

> *"We really find attending ward rounds very, very useful." (Second year student)*
>
> *"He (the medical specialist) was just talking and for me I was just there. He was asking questions and I was silent." (Second year student)*
>
> *"But for sure if you could manage to join them (the medical students) while he (the consultant) is teaching them, you would benefit. Because they would be presenting, and during the ward round, the one who clerked the patient presents the case to the team." (Fourth year student)*
>
> *"I benefitted a lot from that consultant although he was not directly teaching me, I managed to listen in and derive benefit from the teaching that he was doing." (Fourth year student)*
>
> *"For example, I wanted to attend a ward round to learn more about a patient's condition. I wanted to know how the doctor came up with that diagnosis. I wanted to apply my pathophysiology, but the doctor only kept asking me to leave the round and take off blood samples. Instead of first letting me to learn about the patient's condition." (Third year student)*
>
> *"I wanted to learn more and connect the things I had learnt earlier to the condition the patient presented with. I was not given that chance. I was told to collect blood specimen and take them to the lab." (Third year student)*

This theme highlights the importance of ward rounds in the learning of biosciences in clinical practice. They provided the single most important platform where all bioscience courses and non-bioscience concepts were integrated in practice alongside clinically experienced personnel and students from different professions and HEIs. Although this was the case, most of those outside of the nursing profession were unaware of the degree to which biosciences were useful to the practice of nursing. Strengthening active participation of nursing students in the ward rounds could go a long way in further supporting nursing students to learn and integrate biosciences in practice. This study also adds to the longstanding debate of who is best placed to teach biosciences in nursing.

Clinical case presentations

The participants in this study argued that presenting clinical cases to lecturers and colleagues was effective in recalling and linking bioscience theory to clinical practice. It encouraged collaborative learning as classmates and the teacher could ask questions relating to the patient. Collaborative learning in the CLE appeared to support the teacher to interact with the learners, answer questions, identify learning gaps, and address them immediately while the patient was present. If each student presented a different case from that of the colleagues, students would learn different conditions under the guidance of the same teacher:

> *"By the end of the day, you have learnt the bioscience and how to manage five different conditions. This information sticks with you and you cannot forget. But when you present alone, to a distracted lecturer and you get no feedback and cannot even ask questions, you feel like you have not learnt from the clerkship and your colleagues have also not learned from what you have presented." (Third year student)*

Presenting clinical cases before colleagues and teachers encouraged them to invest more time and energy into understanding the bioscience cases and prepare to answer any questions that could arise from their presentation. Although the students valued case presentations as vital in their bioscience learning in the CLE, it was not often used by the teachers. According to the students, some of their teachers seemed less interested in their profession that is why they did not listen and give feedback to them on their case presentations. According to them, the students had to take the initiative to ask the lecturers to attend the presentations. Some alluded to having many clerkships that were not presented to their lecturers because the lecturers rarely came around. The reasons for the limited involvement of the lecturers in case presentations were not clear but their absence was detrimental to the students' learning:

> *"There is nothing that motivates a student more than when you know that you have to present a clinical case in front of the lecturer and fellow students. You are pushed to the limits of researching and understanding the underlying bioscience and you want to be able to defend your decisions." (Third year student)*

> *"The times I have been able to present any case to anyone when it is not an assessment, it is me who has to chase after someone to listen to my presentation. When he comes, he does not seem to be interested. They do not listen. When you are*

presenting the case and the lecturer is on WhatsApp, you cannot say 'excuse me, I am presenting, please listen to me'. You cannot say that." (Third year student)

"When you present the case in front of the lecturer and fellow students, everyone gets the chance to learn, ask questions and the lecturer gets the opportunity to identify the learning gaps and make them the focus of future learning for the students." (Fourth year student)

"Our lecturers don't love what they are doing. I presume that a lecturer who is interested in the profession would take a moment to see what you have done. At least touch the patient. He or she will be eager to tell you something you have missed because he/she loves the profession. But the lecturer looks at you and folds his arms, then asks you a few questions and goes away." (Fourth year student)

At the time of data collection, the students were divided between the various departments, with a pair working on each department. Each student presented their case to the lecturer. There was limited collaborative learning among these students. This means that case presentations only benefited the individual student and not the rest of the class. The students felt that they should not be split between the departments since their class sizes were small. They thought that they would learn better when they studied together as a group instead of one student presenting to a lecturer. They argued that splitting them would also make clinical supervision more laborious and their learning would not be uniform:

"Since we only are 7 students, it would be better if we are not split up to different departments. We should all be in the same place so that we learn the same thing and supervision is less laborious." (Third year student)

"Splitting us into groups spreads us to broadly and coordinating our learning will become more difficult. When the lecturer comes, we would present 7 cases from the same department and all of us will learn from each other's' presentations. We would get more time to learn from the lecturer and from each other such that the short time we have on the ward is spent learning and receiving feedback from each other and our teachers." (Third year student)

"When they spread the class too broadly, the few students learn less. We will not be able to learn from different conditions from the presentations from all the students in the group." (Fourth year student)

It appears that the nursing students took charge of their own learning when they advanced on their program. They reported taking initiative to look for interesting clinical cases to gain confidence in applying biosciences in practice. For example, some clerked patients and asked colleagues, clinical staff, or lecturers to listen to their case presentation and give them feedback. This process was not initiated by the teacher, but the students and no score were expected. It was done for learning purposes and did not affect students' academic progress. These learners seemed to have reached a level where they actively sought knowledge related to clinical bioscience problems:

> *"One day I happened to get interested in a tetanus patient. I worked hard and did all the examinations. I did the interventions and even learned how to use the fluid balance chart and the muscle relaxant. I was really interested to show the lecturer that I was interested in this case and show him how much I had done." (Fourth year student)*

> *"We mostly take our own initiative to learn. When I was placed in the clinical area, I knew that I was on my own. So, I set my own objectives depending on how I performed the previous day. If I want to go and perfect cannulation, that is what I will do. I make a conscious decision to ensure that I have at least cannulated three patients." (Fourth year student)*

> *"I know that my teachers will not follow me up. This is my future, my profession, and my life. At the end of the day, it is me and myself." (Fourth year student)*

> *"I can say how we learn in the clinical area. We use search. Like you search for what you want to learn and learn that. If you are lucky to get someone willing to help you, approach that person, that is a bonus." (Fourth year student)*

Case presentations as a method of learning biosciences in the clinical area appears to have motivated students as they progressed on the nursing program, to take initiative for their own leaning by identifying interesting clinical cases and asking colleagues and interested lecturers to listen and critique. This study suggests that as students progressed on their nursing degree, they created their own learning opportunities. They formed informal support groups where they could learn, reflect on feedback, and improve their own practice. This finding may indicate achievement of adult learning skills required in higher education as the students prepared to enter practice:

"We were studying cell physiology. I read a lot (did prior reading). I got my friends together and we discussed questions related to the topic. We did this with the hope that we would meet some of them in the forthcoming exam. I knew how the lecturer was teaching and could tell the areas of emphasis because I was attentive when he hinted on some points during the lecture." (Fourth year student)

"In some cases, we look for the patient ourselves, clerk and present to our colleagues. The nursing procedures and the management. They listen and give me feedback. "(Fourth year student)

Theme 3: Clinical supervision

At the time of data collection, the university had delegated the clinical supervision of the students to the hospital. This means that the personnel responsible for the clinical supervision were employees of the hospital. The university appeared to have limited involvement which also limited their control over what and how their students learn and who supervises them. The nursing students, who were the recipients of clinical supervision, felt that this supervision arrangement was not effective in supporting them to learn and apply their bioscience knowledge in clinical practice. They proposed another arrangement where the university trains, employs, and pays their own clinical supervisors. The supervisors would be university employees working in the clinical area to supervise their students:

"The university should hire staff and specialists and pay them as the university to teach the students. So, if you are a student at this university, you are under the supervision of that staff member and you are accountable to them." (Fourth year student)

"We think that the university should hire experienced and senior staff who have some preceptorship or mentorship training. They should be available in the clinical area and be available for the students." (Fourth year students)

It appears that although the university delegated the hospital to carry out clinical supervision for their students, the hospital was not fulfilling its duty to the satisfaction of the students. For example, clinical teaching should be done by health professionals who have a higher qualification than the degree if they are to supervise preregistration nursing students. In practice, most of the nurses only have certificate and diplomas in nursing and midwifery, qualifications which are lower the degree the students are training for. Although these staff

may be competent in the procedural skills, they are not likely to understand the core bioscience underlying their own practice and later support their students to apply that knowledge in practice. According to the participants, degree nurses are rarely employed by the hospital and when they are, they are in senior management positions and are not available to carry out clinical supervision:

> *"You find that on the whole ward, it is only the in-charge who like has a master's in nursing, or even just a bachelor's degree. The rest are certificate and diploma nurses who may not be able to explain to you the bioscience concepts behind the procedures they are undertaking." (Fourth year student)*

> *"So, you only find the only person with the degree is the only one who can explain something to you, and you also understand. So, they are there but rare." (Fourth year student)*

> *"On the pediatric ward, I learned from a bachelor nurse. But you rarely find them employed by the hospital. Those who are employed are in-charges who are always busy in their offices." (Third year student)*

> *"The school should they employ clinical instructors to teach us." (Third year student)*

The nurse with a degree in nursing would have studied biosciences at the degree level. It means that they are more likely to know the standard of biosciences that the students need unlike a diploma or certificate nurse who had limited instruction in biosciences. This however is not to imply that all registered nurses are competent enough to teach and support the preregistration nursing students to learn and apply bioscience knowledge in practice. The students reported that among the few registered nurses in clinical practice, a small number was able and willing to teach biosciences to their students. For example, on occasions, Registered nurses reviewed treatments prescribed by the physicians. They appeared to rely on bioscience knowledge to guide their clinical decisions and review medical notes:

> *"When we try to ask the nurses with a bachelor's degree to explain some of those things to us, they still kind of can't do it well. There just a few times when you get a nurse to teach you biosciences on the ward." (Fourth year student)*

> *"I will disagree to some extent because on a few occasions, nurses take charge and I have seen a few first reviewing the treatment to see if it is correct. I have seen it on the paediatric ward. I have seen it on the medical female ward and the surgical ward.*

It is not always 100%, but I have sometimes seen nurses starting to reason out some of the things the doctors have written or ordered and even doing better." (Fourth year student)

They added that registered nurses in their CLE generally did not meet the required standard of competence in the biosciences. They reasoned that the Registered nurses may had difficulties in learning and applying biosciences in practice during their preregistration nursing training. This suggests that RNs in practice may not adequately support students to link and apply biosciences in practice because they have limited knowledge themselves. This means that they may not be able to confidently engage with biosciences and autonomously make clinical decisions, choosing to rely on the physicians:

"Our senior nurses are not meeting the expected level of competence and confidence in nursing matters related to biosciences. They just wait for the doctors' orders. They keep asking about the doctors' orders. Whatever the doctor has said, they just run and do it without taking a step back to ask if it is the right thing to do. How will they detect the errors if they don't step back and think?" (Fourth year student)

"I think most of the degree nurses actually lack bioscience knowledge themselves, so they do not think and function at the expected level of competence when it comes to biosciences. They most likely did not grasp biosciences while they were students." (Fourth year student)

Perhaps the proposed clinical supervision arrangement could work for University D in the long term as it would lift the burden of supervision off the shoulders of the already busy staff. It would guarantee that the students will always find a trained and qualified clinical supervisor whenever they go for placements. The students would be accountable to a designated supervisor and motivation would increase. The university, supervisors, and students would be more proactive in identifying the learning gaps, addressing them, and improving the overall learning experiences of students on placements. The supervisors would also be more accountable to the university and ensure that the learning objectives of the students are met. It would mean that the university would be more involved in how their students learn while on clinical placements and not assume that the hospital will adequately supervise their students.

The university had a clinical coordinator whose role was to ensure the smooth running of the clinical placements. A clinical coordinator was the most visible member of the

university during clinical placements. She carried out the inductions to the hospital where students were familiarized with the various wards, departments, and laboratories and allocated the students to the different wards. Once they commenced their clinical placements, participants claimed that the coordinator concentrated on ensuring that they reported to the practicum sites and did not participate in any clinical supervision or teaching:

> *"We are taken by the coordinator for clinical placement. We are oriented, for example that 'this is a TB ward, this is a medical ward, this is a paediatric ward'. After being oriented, she will tell say 'number 4 you will go on the medical ward'. After assigning you the ward, you will not see the coordinator anymore." (Second year student)*

> *"Our clinical coordinator only comes to check your attendance. She never checks to find out what we are learning and whether we do it right. She checks the registration book and leaves" (third year student).*

Some students speculated about why the clinical coordinator might have been less involved in their learning. They thought that perhaps she had a big workload or did not care about their learning. I addition, it was unclear from this discussion whether the job description of the clinical coordinator involved teaching, supervision, and monitoring of learning. What is clear is that the involvement of the university in the clinical placements of their students was minimal at the least:

> *"They don't teach you; they don't supervise you or check on you. They even know we are direct students, but they just do not care. I do not even know what is wrong with them. They just don't care, or they also don't know what to do." (Fourth year student)*

> *"If our clinical coordinator is so busy, they should change her. I do not know if she has too much work or she does not care. They should come to teach us, or they should employ instructors to teach us. They should go further than that." (Third year student)*

Unlike the academic context, the pool of clinical supervisors appeared to be largely informal. It was not apparent to the students who was responsible for their supervision. In practice, the nursing students did not appear to have formal mentors and clinical preceptors dedicated to support and teach them biosciences in the clinical areas. The participants did not know why no one was there to supervise them. They reasoned that probably their lecturers'

absence was due to a lack of financial support from the university towards clinical supervision. Others speculated that their lecturers were too busy with other university-based roles to supervise them. The lecturers mainly did not also fulfil the role of supervisor but took on the role of clinical assessor, only coming to the clinical placement site during summative assessments. The students expressed the need to have their lecturers follow them up to the clinical area and supervise them. They recognized that without clinical supervision, the clinical placement became was a waste of time for them. The absence of a clear clinical supervisor in practice made participants to feel alone:

> *"Maybe the school program does not encourage the lecturers to come to the clinical area. I think they are not paid that extra allowance to travel to the hospital because we only see them during assessment." (Third year student)*

> *"When we go to the hospital, we are on our own. At least if our teachers followed us there. At the end of the day, the clinical placement ends up being a pass-time. You just stay quiet and wait for the time to pass." (Fourth year student)*

> *"Currently, we only see them (lecturers) during clinical assessments." (Third year student)*

On institutional level, the students reported limited visible involvement of their university in their clinical learning. Some alluded to disinterest on the part of the university on what was really going on with them in the placements. They reiterated that the university neither followed them up, constantly checked their learning, nor advocated for their learning needs. They used words such as 'thrown', 'abandoned', 'trapped', 'on our own' to imply this feeling. No one checked on them or asked them about their experiences:

> *"I was thrown just there without any guidance. You must hustle for yourself. When you ask yourself where to start from, it is by luck if the staff in the hospital are willing to work with you." (Third year student).*

> *"We need our lecturers' guidance. We expect to have student directed learning. We expect it but surely, surely, we are not doing business, we are not doing education, we are learning how to deal with matters of life and death, very sensitive work. So, I feel that the lecturers have abandoned us. They should follow us up to the clinical placement." (Third year student)*

"You find that when we go to the hospital, we are on our own. We are going to deal with lives so we should not be left on our own." (Fourth year student)

The visible absence of lecturers and formal clinical supervisors meant that the students were largely on their own and were less accountable for what they did. Although they reported feeling lost initially, they worked out ways to learn by looking for anyone who was willing to guide and support them. They were willing to learn anybody who was able and willing to teach and support them. It was a way of coping with the absence of formal supervision and guidance. They particularly found intern doctors, intern nurses, and colleagues approachable and willing to guide them:

"We have no supervision. We all know that students are sometimes stubborn. If we are not closely supervised, we lose track. We need to be held accountable." (Second year student)

"We are willing to learn from anybody that can teach, and I have learned from the lowest nursing cadres. The only problem is that the bioscience support is lacking. I must put myself down below to someone's level." (Third year student)

"While in the hospital, since there is no lecturer to guide us, the nurses there are too busy to help us, so we try to talk to the Medical interns." (Fourth year student)

"I was fortunate to meet an intern nurse the first time I had a clinical placement. She supported me and gave me learning opportunities. I freaked out a lot and made lots of errors, but she was there to support me. None of my supervisors came to check on me. I was lucky that the intern nurse was supportive." (Fourth year student)

"Sometimes students who are at least a year ahead are actually very helpful, they guide you through, you ask questions, and they explain to you. For example, they can explain to you how prostaglandins affect pain and how analgesics for example relate to temperature." (Third year student)

The participants described the CLE as crowded with students especially during term time. The hospital received students from several institutions offering medical, nursing, medical laboratory, pharmacy programs, at certificate, diploma, and degree levels. It also serves as a training hospital for medical, pharmacy, and nurse interns. This would be advantageous to the learners in some way because it presented opportunities for interdisciplinary clinical learning. Furthermore, it would create a platform for collaboration

between universities to improve teaching and learning and the overall clinical experience of students. It appears that there was also limited collaboration among the HEIs. On the downside, crowding with students could reduce the time available for teaching and learning because many students compete for the same patients and teachers:

> *"The ward is busy with a variety of students: certificate students, diploma students, degree nursing students, pharmacy students, and interns. So, in most cases they (staff) don't even get time for us to consult with them." (Second year student)*

> *"We are too many students on the ward. When you arrive, you are given work to do and are not taught. At the end of the day, if I say I should assess a patient and learn from that condition, the patient is too tired to comply" (Third year student)*

There was a divide between what the staff expected from the students and how the students could do. The staff appeared to view these preregistered nursing students as nurses who could work with minimal supervision. The students on the other hand viewed themselves as nursing students who were fresh from high school. They saw themselves as lacking clinical experience and looked to the staff for supervision to learn and help with the clinical roles under supervision. This difference could explain why the nurses tended to send students to undertake clinical tasks without supervision and the students refused citing a lack of experience. This resulted in tensions between the staff and students, often demoralizing the student:

> *"In the hospital setting, when we go there, they do not see us as students. They perceive us as health workers. The nurses see us as if we are experts when we have just come to learn. When they see you in the uniform, they suppose that you know, when you don't." (Fourth year student)*

> *"If somebody says to you, 'you can't do that at your level? You are a degree nurse, but you don't know anything!' I am just from high school and don't have any clinical experience. You don't just feel belittled, but you lose confidence." (Second year student)*

> *"For example, when I was on the ward round, the nurse in-charge sent me to do something, and I never knew how to do it because I had never seen or done it. When I told her that I did not know, she told me 'At your level?' 'At the bachelor's degree?' I*

got embarrassed and ever since then, I just go to sign in (register my attendance) and go away." (Third year student)

"Even when you make a mistake, someone will say, "you see this bachelor nurse" not putting it in mind that I am a direct student right from high school. I am just a student and maybe it is my first time to see such a clinical condition." (Third year student)

Viewing students as nurses instead of student nurses could have led the staff to side-line the students' need to learn and instead asked them to perform clinical tasks without supervision. The students viewed the staff as more interested in having them around to help them with their work as opposed to teaching them. They did not appear to recognize that they were preregistration nursing students from A-levels and had no prior clinical experience. It therefore seems that there was a divide between the priorities of the students and those of the hospital staff. The students appeared to focus learning and applying knowledge, while most hospital staff viewed students as a source of extra help with work and seemed to be less bothered by the students' needs and leaning goals:

"We are just a source of labor for the hospital, but our own learning needs are not met. They don't even stop to think that I have my own objectives to achieve." (Third year student)

"I passed over the hospital to visit a sick relative. When the nursing officer saw me, she said 'Musawo (nurse) you have come. Now I am free to go. The patients are there (participants all laugh), and she just left.' I took over her duties there and then, something that I had not planned to do." (Fourth year student)

It appears that clinical supervision was generally lacking in this context although the clinical environment was teeming with opportunities to reinforce and apply biosciences. These opportunities were thwarted from the time the students arrived due to the limited support from the university and clinical staff. The students felt that their learning needs were largely ignored. No none was out there in the clinical areas to look out for their interests. At the end of the four clinical days on the department, the students largely did not achieve their learning objectives:

"In most cases we just go to the ward to help them do their routine work and duties but come back home without learning anything." (Fourth year student)

"In our case, we are not helped to learn, but we just come to do their work for them. We only take off samples and give drugs. You just go and find your way." (Third year student)

Although bioscience theory and practice are important for competent nursing practice, and were required alongside clinical nursing skills, in this practice setting, procedural skills appeared to be prioritized over biosciences. There was an unmet expectation from the nursing students for more explicit bioscience learning and teaching within practice settings. Biosciences within nursing practice were not emphasized as part of the package required for safe and competent nursing practice:

"Biosciences are not emphasized. We actually just go there to do routine work, to only learn the clinical skills, but they cannot explain to you what lies beneath the skills they are teaching you." (Fourth year student)

"We were not led to think that we were seeking to understand what we'd learned in class. The main objective was clinical skills. What they teach you is not bioscience. They tell you: Do this, do this." (Second year student)

"Their main focus is telling you to perform the clinical skills, but we were not helped to learn the bioscience behind what we were doing." (Third year student)

In addition to side-lining biosciences, there appeared to be some implicit fragmentation of the bioscience theory from the nursing skills learned even though some of them, like drug administration, were bioscience in themselves. The student nurses noted that they were generally not supported to link the nursing skills they were learning to the biosciences behind them. They even had limited consciousness of the relevance of the bioscience theory to their clinical practice to the extent of performing clinical skills and making clinical decisions. This limited awareness of the importance of biosciences could be due to the fragmented way of teaching. The teaching segmented the sciences from each other, the non-bioscience courses, and clinical practice:

"I never realized. We have never appreciated the relevance of biosciences in clinical practice to that extent." (Second year student)

"We were not even really aware that biosciences were connected directly to the patients we were dealing with. The emphasis was on clinical skills." (Second year student)

"According to me, the problem is that when we are learning biosciences, we are not told how they are related to clinicals (clinical practice). They don't tell us how they are related at all. For them they just teach you and leave you there. It is up to you to find out the clinical part of it." (Third year student)

"But in the class, we don't get all that knowledge. We do not get much from the lecture. For example, it is only last semester that I realized why vitamins are important, because they help in the absorption of proteins and other nutrients. But prior to that, the lecturer never emphasized on that, that vitamins are vital in absorption of other nutrients." (Fourth year student)

The limited awareness of the relevance of biosciences to clinical practice limited the time available for applying them in practice. Some of the participants regrettably noted that in the first years when they received direct their bioscience teaching, there was limited emphasis on understating the biosciences to apply in clinical practice. They realized much later when the chances of applying the sciences to practice are limited. They recommended that the relevance of biosciences to clinical practice is emphasized early enough to allow students time to learn the practical application of biosciences:

"In year one, it is not in the mind that I have to understand them and ensure that you connect them to practice. I only realized this requirement when it was almost too late." (Third year student)

"We need to recognize the application of biosciences to clinical practice earlier. We have only realized some of these things recently after meeting patients." (Third year student)

"You only appreciate the practical things later, when the chance to integrate it is gone." (Third year student)

The perception that biosciences were sidelined in favor of the skills could be due to the shortage of competent bioscience lecturers and the methods used to teach these skills. They could have contributed to the devaluation of the sciences which underlie them. Most of these skills were taught using an apprenticeship method. Within practice, there was a limited pool of qualified and competent nurses in the employed in the public sector who were able to teach biosciences in clinical practice settings. Nursing students knew that some bioscience courses were difficult to teach, and that a few teachers were able and willing to teach them

effectively. They were also aware that this limited pool of bioscience teachers wielded power in the HEI and CLE. They were therefore cautious not to upset this balance:

> *"When they are teaching you the clinical skills, they tell you: Do this and do this. Most of the time they don't know the scientific rationale for the procedure." (Second year student)*

> *For example, if they give you diazepam to administer to the patient and you ask her (the nurse), what are the side effects of this drug, she will tell you to go and read from the book or from this paper that comes with the drug (the leaflets). She cannot tell you about the pathophysiology behind it (scientific rationale)." (Second year student)*

> *"The nurses who are able and willing to teach us biosciences on the ward are rare. I only know of one: the in-charge of the female medical ward; She is very willing to answer the bioscience questions related to nursing" (fourth year student).*

> *"We are trapped. The people who have got a masters in biosciences are few, so if you push so much on a lecturer (continuously complain), you may not get someone to teach you, because the school depends on the lecturer" (fourth year student).*

> *"Some courses like biochemistry are very difficult to teach. There is only one person in the whole school who can teach biochemistry and has been teaching that course since the nursing program started. So, he tells you to complain well knowing that nobody else is able to teach the course" (fourth year student).*

As already discussed, the students were registered on to the course directly from A-levels. They had no prior bioscience training and limited clinical experience prior to enrollment on the nursing degree. In addition, they had limited skills in learning at the higher education level. Learning in higher education is often very independent and student led, requiring intrinsic motivation and time management skills. Most of these students had never studied in university meaning that they were in unfamiliar terrain. Placing them in the clinical area with limited guidance would be unrealistic and detrimental to their learning.

They wanted the university to hire, train, and pay clinical mentors/supervisors to teach them. They claimed that the staff and of the hospital viewed teaching as an addition to their role rather than a part of their primary role. In fact, some participants narrated times when staff suggested that they were supposed to be paid separately to teach them. These experiences could validate the student's claims that they felt that staff viewed teaching

students as an addition to their clinical roles not a part of it. Indeed, teaching is a part of the role of staff in the teaching hospitals. The reasons for viewing teaching as a separate role for which they wanted separate renumeration are not clear. Directly employing clinical teachers would serve this group well, given that they had limited prior clinical experience and needed to learn nursing from the bottom up. They needed more support to learn and connect the science to clinical practice:

> *"They should remember that we have more to learn because we are direct from high school. We have limited experience and we need more teaching and hands on bioscience learning. We need to be taught from the basic skills to the more advanced ones. Start teaching us as if they are teaching certificate students because we are fresh from high school." (Third year student)*

> *"In fact, it is preferable to give up on consulting from senior nurses. You just have no alternative but to go to a doctor. But the doctor is always busy. But if at all you are lucky, and you find them in the doctors' room, they tell you they're tired and need to go home. I have been on ward all day. and for us we had little knowledge that we must learn from the ward more than from lectures, but no one is out there to teach us." (Second year student)*

> *"You reach the clinical area, and you don't see anyone to teach you. Sometime even the nurses we try to cling to for a chance to see how they perform their procedures tell the student 'but you know your school is not paying me to teach you. Are you going to pay me?" (Fourth year student)*

> *"Now when we reached the ward, it just a few nurses who would give us the time to teach us those procedures." (Third year student)*

> *"I have gone there (to the hospital) and I am a fresher, these things are not part of my work (I don't have prior experience), you can't expect a nurse who is also busy with her work to also give you time? It cannot happen." (Fourth year student)*

> *"It goes to the extent of some staff asking a student that 'how much will your university pay me to teach you?' Where should we go then?" (Fourth year student)*

> *"When the consultant saw me, he said 'you man you are supposed to pay me. You have not paid here'." (Fourth year student)*

This study suggests that nurse educators had limited involvement in the clinical teaching and learning of the nursing students. The nurse educators appeared to be more involved in classroom teaching and clinical assessments than clinical teaching and supervision. This could explain why the students reported feeling 'dumped', 'abandoned', 'on their own', denoting a lack of sponsorship and turned to interns and senior students for guidance on clinical learning. A supervisor would ideally sponsor the students by supporting their entrance and legitimate participation into the community of practice as well as identify learning opportunities:

> *"In our case, the lecturers don't come, when they do, they don't have time, and they ask you to present to them (alone) without other students or the patient present. You can't even ask any questions." (Third year student)*

> *"Sometimes students who are at least a year ahead. Some are actually very helpful, they guide you through, you ask questions, and they explain to you that this is how this comes about." (Fourth year student)*

> *"When it comes to the bioscience, I utilize the intern doctors, senior students, and consultants who are there. I have found the presentation sessions of medical students very useful. The students are not from my university but when I listen to their presentation, I get a chance to learn biosciences." (Third year student)*

Within this CLE, it appears that gaining entrance into the community was not obvious. The clinical staff first had to trust the student before letting them be part of the community. It is not clear whether the students' ability to contribute to the clinical work was used as a prerequisite or a test of trust before entry into the community or for another purpose. In addition, teaching students was mostly contingent upon the student providing labour. The clinical staff expected the student to contribute to the work before they could teach them. The students also appeared to understand this unwritten agreement and appeared to strive to fulfil the staffs' expectations. The students appeared to find it difficult to negotiate this unwritten agreement. Their limited clinical experience constrained their ability to substantially contribute to the clinical work to the expectations of the clinical staff. Some participants alluded to staff asking them to perform basic nursing tasks which they had not done before or for which they had limited confidence to perform unsupervised, yet the staff had limited time to teach them. It appears that the students wanted to participate in the community of practice as observers until they were confident enough, yet staff valued their

participation with skills like those of qualified nurses. So, when the students expressed feeling alone, they meant in part, that they lacked sponsorship. Their lecturers, who were more familiar to them seemed to fit the role of sponsor only that their presence and participation in the community was very limited. They needed a sponsor to grant them access to the group:

> *"It is difficult to get the staff in the hospital to work with you. Some in-charges are very harsh. They ask for too much explanation from the student to even trust you. They make it too hard for students to settle down to start work." (Third year student*)
>
> *"The nurses there expect you to work. Whatever they say is what you should do. So, when you arrive, you are given work to do and are not taught." (Third year student)*
>
> *"If you show them (the clinical staff) that you respect them and you demonstrate that you are willing to work (take initiative and contribute to the labor force), and are willing to learn from them, they can teach you." (Second year student)*
>
> *"In the process of shadowing the staff member, he or she will send you to do some work so that you get to be taught. So, it is a give and take." (Second year student)*

The difficulties in accessing learning and expectations from the clinical staff could explain why these students kept reiterating their need to have their lecturers follow them up to the clinical area. The participants expressed their fears at the prospect of failing to fulfil the expectations of the clinical staff. At times, tensions arose when students did not undertake the tasks required by the staff due to their lack of experience or supervision, the staff interpreted the students' actions as refusal to perform tasks, laziness, or defiance. Students reported being labelled as 'the lazy group' for failing to perform the tasks expected by the nurses, with some staff stating that they would not work with them. The students reported interpreting the staff members' actions as viewing them as a source of labour rather than as students in need of learning. The staff appeared to almost equate the students' lack of experience to being 'Registered nurses with no experience', in contrast to pre-registration nursing students who lacked previous clinical experience. These tensions automatically placed the students at a disadvantage because they needed the same staff members to support them to learn:

> *"For example, it is your first time, and someone is sending you to catheterize. You tell the staff that I have only done it on the model (mannequin). But now they say: 'you can't catheterize a patient? I am going to stop working with students from your*

university.' This someone cannot understand that it is your first time on the ward. So, you lose confidence, you feel isolated." (Second year student)

"For example, when I was on the ward round, the nurse in-charge sent me to do something, and I never knew how to do it because I had never seen or done it. When I told her that I did not know, she told me 'at your level?' 'at the bachelor's degree?' I got embarrassed and ever since then, I just go to sign in (register my attendance) and go away." (Third year student)

"At other times they assume that you know what to do and they just push you to go and do it. I usually just tell them that I don't know how to do it. And will not perform the procedure without supervision because I will likely make an error that can cost a life. Who then is to blame for this?" (Fourth year student)

They cited examples of when they reflected on the work done at the end of the week and found that they did not meet their learning objectives despite contributing to the clinical work. Perhaps they learned something in more implicit ways than they could measure. The more clinically experienced students were more likely to gain acceptance into the community and get learning opportunities than those with limited experience because they could contribute to the work and required less supervision. This could explain the quantitative results which suggested that clinically experienced students had better transfer of bioscience knowledge on antibiotic resistance then those with limited clinical experience:

"When they see us, going to ward, most especially during these placements, they can't put us into consideration. They do not consider us because they have very many students to help them with the work. For example, you find these students who are finalists and degree students who already have a diploma. They know what to do and can do the work without bothering the nurses." (Second year student)

"When I return home, sit down and ask: what have I learnt today? I find that I have learnt nothing. I keep doing the same thing all day, all week. The clinical rotation ends, and I move to another department, and the same thing happens all over again. What am I gaining from all this? I just keep walking." (Third year student)

"I would draw blood and take it to the lab. Then the lab person would say, drop it there and go, without letting me to at least see how the tests are carried out. At the

end of the day, I am on my feet, exhausted from the walking but I have learned nothing new, only done exercises." (Third year student)

The lack of clinical supervision meant that the role unavoidably fell on the shoulders of the clinical nursing staff who appeared to lack the teaching skills, time, and bioscience knowledge to meet the learning needs of the students. It should be noted that most nurses in practice do not have university degrees and may not be aware of the learning needs of preregistration nursing degree students. In fact, the participants agreed that by virtue of their academic and clinical preparation, certificate, and diploma nurses, who students mostly interacted with, were not competent enough to teach them or supervise their clinical bioscience learning. They maintained that most nurses could not explain the bioscience rationale behind the procedures and skills they performed. They were not confident in the bioscience matters within nursing practice Their training and subsequently their practice emphasised the procedural skills and largely side-lined biosciences. The participants thought that these clinical nursing staff were not to blame because they did not have such training. Despite the general lack of bioscience application in nursing practice, the participants, noted that the nurses were very competent in the nursing skills and when they got time for students, they taught them. The student nurses identified Enrolled nurses as the group from whom preregistration nursing students learnt the clinical nursing skills:

"*Some of them are even scared to explain such things to you. If you ask a bioscience related question, she can't explain the deep bioscience behind what she is doing." (Fourth year student)*

"It is very difficult to learn biosciences from senior nurses. For example, in the regional referral hospital, a senior nurse on a given ward is a diploma holder who has never studied biochemistry. If you try to consult from them, it is an insult to her." (Second year nursing student)

"On the ward during the clinical placements, the most important people we learn from are the certificate nurses (enrolled nurses). Thy teach us how to give injections, cannulation, and other procedures like giving IV fluids." (Second year student)

There were a few examples where nurses in practice demonstrated competence in bioscience matters. They were perceived to integrate biosciences knowledge in their day-to-day nursing activities. For example, some nurses on the medical, surgical, and paediatric wards reviewed and rectified the doctors' prescriptions. This could have arisen from

knowledge of microbiology and pharmacology, as the nurses reviewed the indications for the medications and doses:

> *"I will disagree to some extent because on a few occasions, nurses take charge and I have seen a few first reviewing the treatment to see if it is correct. I have seen it on the paediatric ward. I have seen it on the medical female ward and the surgical ward. It is not always 100%, but I have sometimes seen nurses starting to reason out some of the things the doctors have written or ordered and even doing better." (Second year student)*

The scope of practice defines the actions, procedures, and actions a healthcare practitioner is permitted to perform in keeping with the terms of their professional license. In the case of nursing, the scope of practice limits the roles of the nurse to what is in keeping with their level of education and experience as demonstrated by the competence. The expectation is that the student nurse would be equipped with the knowledge and competencies related to their scope of practice as registered nurses. The students claimed that the absence of effective clinical supervision from competent registered nurses meant that they lost track of what was within their scope of practice and what was not. Another participant specifically explained that the lack of clinical supervision in the bioscience aspects of nursing led them to side-line nursing management. For example, one participant noted that student nurses did not write or implement nursing care plans in routine clinical practice a factor that may affect their learning and competencies upon graduation:

> *"With the clinical placements, you find yourself doing things that are not related to your future role. If your lecturer were there, he would help you to focus on the learning objectives for your level and help to assess how far you have reached." (Third year student)*

> *"In most cases were not doing nursing management but medical management. We do not apply nursing care plans. We only write them for exams but not routinely. Otherwise, we will qualify as nurses, but not be competent. They should be more supportive." (Third year student)*

Of concern was an example given by a participant where a nursing student was asked to perform a nursing procedure without supervision. A patient was to be operated on and the student was asked to insert a urinary catheter. The student inserted the catheter in the wrong place, but no one noticed because she was not supervised. Such incidents where students

could work independently could put the student and patient in danger and contravene the principles of clinical supervision and the code of nursing practice:

> *"The patient was being prepared for theatre. The student nurse was not supervised, and she inserted the catheter in the vagina. She ballooned the catheter and wheeled the patient to theatre. No one asked why the patient had no urine in the urine bag. The students learn on their own." (Fourth year student)*

In addition to defining professional boundaries, clinical supervision by competent clinical teachers was important in protecting or shielding students from being sucked into strenuous and unfocused clinical activities. Clinical supervisors would form a buffer for students to be protected from the perceived exploitation by staff for providing labour and give them protected space to learn and apply biosciences with minimum distractions that would arise from the absence of supervisors and learning focus. This is because the supervisor who is competent in the biosciences would direct their clinical learning and practice by encouraging them to engage in activities that are relevant to their future role. In addition, supportive clinical supervision would also motivate students to get more serious about their learning. They would be more serious when they knew that a lecturer would hold them accountable for their actions:

> *"When you have no direction, anyone can pull from your learning. If the staff see you with your lecturer, they cannot bother to make you do their work as they sit around." (Third year student)*

> *"For me this is the best way for me to learn when the patient is really present and the lecturer cross checks what I am doing. The students will be accurate with what they claim because they know that the lecturer will crosscheck." (Third year student)*

For example, the students did not make and apply nursing care plans in their practice. Nursing care plans are tools used by professional nurses to provide care tailored to the patient's needs. Writing a nursing care plan requires learners to apply problem solving and critical thinking and integration of bioscience and nursing to identify actual and potential needs/risks, make nursing diagnoses, planning care, implementing care, and evaluating care. The nursing care plan contains a section on rationales for nursing interventions, implying that they would promote the student's ability to explain and defend their chosen course of care using underlying scientific and non-scientific reasons:

"We don't apply nursing care plans. We only write them for exams but not routinely. Otherwise, we will qualify as nurses, but not be competent. They should be more supportive." (Third year student)

Theme 4: Assessment and Feedback

Bioscience courses were assessed theoretically and practically. Theory assessments were mainly in the form of written exams and viva voce. The practical assessments were in the form of objective structured clinical examinations (OSCEs) and Objective structured practical examinations (OSPEs) and clinical case presentations. OSPEs are objective assessments used to assess practical aspects of the curriculum. OSCEs on the other hand are examinations to the assess clinical knowledge, skills, and attitudes of students (Radhika et al., 2015). For example, during an OSCE, a candidate demonstrates the process they went through to obtain a patient's history, performing heat to toe assessment and the nursing care performed. All bioscience courses were assessed theoretically through written examinations. In the first and second years of the nursing programme, students sat for discrete bioscience assessments. Written assessments were mainly summative in nature taking place in the middle and at the end of each semester. A standard written examination included multiple choice questions, short essay questions, and long essay questions lasting three hours.

From the onset, the participants stressed that although integration of bioscience concepts was not emphasized during the teaching of many of the bioscience courses, they were expected to integrate these concepts during assessments. Misalignment of assessments with teaching was predominantly in the form where bioscience application questions were set yet application was not explicitly emphasised during teaching. In addition, some assessments included content that was not taught, or which was covered and assessed earlier in the program. Many learners found this challenging and pointed out microbiology and biochemistry as the courses where they mainly found challenging. Learners asked to have more practical application into their bioscience teaching to provide the necessary support to apply theory to practice during assessments. This would support them to link theory and practice early in the program:

"It happened in microbiology. The teacher set application questions, but they never taught in that way to help us relate microbiology to clinical problems" (Third year student).

"We were expected to apply the theory we were taught to practical problems, something we had never learned to do." (Fourth year student)

"In biochemistry, I asked the lecturer how the enzymes related to what we were going to do in the clinical area, but the answer I got did not help the situation. During the exam, we were required to apply biochemistry to a clinical problem. We had never learned to do so anywhere along the course." (Fourth year student)

"The lecturer did not teach well but expected us to be able to integrate that microbiology to the clinical problems. I wish they would teach the small he has and then assess." (Third year student)

The learners seemed inclined to the thinking that assessments were on the aspects of biosciences that the teacher taught in class, those aspects that were in their notes. The participants' narratives regarding assessments indicated that they often looked to their teachers for their learning, suggesting that the system of bioscience learning was predominantly teacher centred. Indeed, lectures were the major method by which bioscience concepts were taught in this setting, which could explain the laidback attitude of the students regarding taking charge of their own bioscience learning. This could also be a result of the education system which is predominantly didactic, and the students may not have obtained the independent learning skills expected for higher education:

"What appeared in the exam was not in the notes. We had to find those on our own. The whole affair was a mess." (Third year student)

"When I checked the notes the lecturer gave, they were completely different from what appeared in the exam. There was no coordination between the person who taught and the one who set the exam." (Third year student)

In addition to written exams, the students had oral assessments in the form of Vivas at the end of each bioscience course. During a viva assessment, each candidate sat before an examiner and was asked questions on different aspects of the course. The participants called their oral assessments descriptive in nature. It appears that they generally assessed lower levels of knowledge such as knowledge recall and comprehension and largely lacked higher orders such as application, analysis, synthesis, and evaluation. This means that the quality of the Vivas may not be meeting the required standards of assessment for the nursing degree:

"You sit in front of the lecturer, and he/she asks you questions on anything, and you reply." (Second year student)

"Most of the viva questions are 'describe'. Describe the pathophysiology of malaria. Describe the life cycle of malaria." (Second year student).

According to some participants, viva assessments were too short in duration to comprehensively assess bioscience knowledge. Some participants claimed that some assessors asked irrelevant questions in some viva assessments. They felt that the five minutes allocated to assess each student were not well utilized by the assessors. They could not readily recall such complex bioscience information in five minutes as in this case. Perhaps viva assessments should occur more often and for longer than five minutes for a more comprehensive bioscience assessment. In addition, teaching went on during the week ends when their mature entry colleagues were having lectures and well into their revision weeks because some lecturers used this time to cover material that they did not teach when they were absent:

"The viva sessions were too short, about 5 minutes, and when you got there, they ask you things that were not relevant. They don't give you feedback." (Third year student)

"You find that the face-to-face viva, you come over and the person asks you what you ate last night. Then they ask you what a parasite is and before you conclude, he says, your time is done." (Third year student)

"We don't have revision week. We usually have lectures panicking to come up till the last day before the exams start. Yet they keep skipping classes." (Fourth year student)

"According to the school they are fulltime but when they come to work, they work part-time. Some tell us that they do not have time, so they tell us to come during the weekend and public holidays, like this one who just skips classes." (Fourth year student)

The students appeared to engage with different learning resources for different purposes. For example, they tended to use the notes in the PowerPoint slides and the areas lecturers emphasised during lectures to pass assessments. They used the notes and lecturers' points of emphasis during teaching to anticipate what would be assessed and concentrated on that. Given that these learners tend to revise at the level at which they anticipate being assessed, lower quality assessments may reduce the students' independent learning to surface

principles. The students may not adequately engage with the bioscience content given that they do not expect to be assessed that way. In addition, the earners reported using other sources such as textbooks and the Uganda Clinical Guidelines (UCG), a pocketbook for guidance on common clinical conditions, to learn biosciences:

> *"I knew how the lecturer was teaching and could tell the areas of emphasis because I was attentive when he hinted on some points during the lecturer. So, when we sat for the exam, the questions we discussed were among the ones that were set in the exam." (Fourth year student)*

> *"During lectures, some lecturers emphasize some aspects of bioscience and that prompts me to pay more attention to that because that is likely to appear as a question in the exam." (Fourth year student)*

> *"I read textbooks more than slides. I read the slides at the end of the semester only to pass the exam. But if I want to really learn, I read textbooks. When I go for my holidays, I look for opportunities to practice. I sometimes go to private clinics. With clinics, they give you more opportunities to learn. I also use the UCG. I use it a lot. It helps me because there is no condition I have encountered in practice, and it is not there." (Third year student)*

In addition to the written and oral assessments, students were assessed using Practical assessments. These were in two forms: Objective Structured Clinical Examinations (OSCE)/objective structured practical examination (OSPE) and clinical case presentations. The practical bioscience assessments were summative in nature. During the OSPE/OSPE, each student rotated through ten stations, each lasting five minutes after which the student moved to the next station. Each station was independent of the other, meaning that the candidate could start from any station and completes the cycle. Each station was designed to test a clinical or practical competence such as performing a task on patients, mannequins, or simulators. Examiners at each station observed the candidate and assessed and scored them using an agreed checklist. They assessed students' communication skills, decision making, and knowledge. Therefore, individual students were assessed comprehensively on many aspects.

The participants reiterated that although OSCE/OSPEs were useful assessments, they were not always well coordinated between the personnel that set the assessments and those that teach the courses. Sometimes the students were assessed on content they had not yet

learnt or content that was covered and assessed the previous semester. The students were caught off-guard when they found questions requiring recalling content taught the previous semesters or content that had not been taught. Perhaps the lecturers who taught them had limited or no input in what appeared in their OSCEs. The students were not prepared to have such assessments and found recalling content from the previous semesters in only five minutes per station and in front of an examiner very difficult:

> *"It happened in the OSCE, the lecturer who set the exam was different from the one who taught. What made it worse was that the one who set the questions asked about things we had not even learnt in class. She set things we had already learned the previous semester, and we had not revised for that because it was already assessed." (Fourth year student)*

> *"Even if you have the idea, you cannot perfect the answer, because it is not part of what is expected to be asked at the time, yet you are before an examiner, right in front of you." (Fourth year student)*

The other form of assessment was clinical case presentations. In clinical case assessments, the students clerked patients and presented their findings and nursing interventions to their assessors. Clerking patients involved taking a complete patient history, performing physical examinations, recording the findings, and writing, implementing, and evaluating a nursing care plan. The clinical case assessments should ideally take place in the clinical area with a standardized patient, and one or two assessors. The nursing students were expected to have performed all the required nursing care prior to the assessment. During the assessment, the student can be asked to present the case and perform various tasks such as clinical assessment of different systems or perform a set of clinical skills. In addition, they would answer questions relating to the patient's medical and nursing diagnoses and justify their clinical decisions. As noted earlier, clinical assessments were integrated in nature and not explicitly bioscience focused.

Some participants reported that some assessors did not meet, interact, or allow students to demonstrate their bioscience knowledge and clinical skills at the patients' bedside. Most preferred to conduct the clinical assessment from a side room yet the patient was on the ward and could be accessed. The importance of an assessor coming to the clinical area for a clinical assessment would be to observe how the learner interacts with the patient and relates biosciences concepts relating to the patient with other aspects of care. These assessments can

also be used by the assessor to crosscheck to confirm the student's claims. When assessment happens away from the patient, it is very difficult to carry out the necessary checks to validate the student's findings. Clinical assessments should ideally take place in the clinical context.

Some assessors spent very little time assessing the learners and opted to score the write-up rather than the practical elements. The learners were confused as to the relevance of a lecturer coming to the ward and not letting the student to present and demonstrate their bioscience knowledge and clinical skills on the patients' bedside but opt to use a side room or office:

> *"Yes, the assessment is still a problem. We are assessed more theoretically. We do not see the relevance of presenting a clinical case from the side room or office, without the patient being there. We could still do that in the class. We feel we should be assessed more practically." (Second year student)*

> *"The lecturer comes for your assessment but sits in a room and asks you to present a clinical case! The patient is on the ward; the lecturer is on the ward, but he will not even want to see the patient. I wonder why they come to the ward at all, if they won't see the patient I am learning from." (Third year student)*

> *"I know of one lecturer that won't see the patient you are presenting or try to find out if the patient even exists. She asked what I did and asked a few questions. They do not ascertain whether you really did what you say you did. The student can just forge the case, come and present and get marks." (Fourth year student)*

Although 'side room assessments' happened in many case assessments, some participants reported that at times an assessor was present at the patient's bedside and cross-checked to validate the student's findings. When it happened, the students reported satisfaction with the assessment experience and reported to have learned from it. The students were also satisfied when assessors gave candidates adequate time to even ask questions after assessments:

> *"There were a few times when the lecturer made an effort to crosscheck what the student claimed to have done with the patient." (Fourth year student)*

The participants mentioned that the time dedicated to clinical case assessments was insufficient to present clinical cases and get valuable feedback. Although each candidate was

allocated adequate time for clinical case assessment, this was not followed in practice largely due to assessor absenteeism. The reasons for assessor absenteeism were not apparent at the time of data collection, but it reduced the time allocated to each candidate because few assessors had to assess all the students on the same day:

> *"There was a specific time allocated to assess each student, but the schedule was never followed. At one time there was only one lecturer present for all the students. The lecturer only gave me 2 minutes to present my case." (Fourth year student)*

> *"Sometimes there were supposed to be 5 lecturers assessing but only 2 appeared. So, the two lecturers who were present could not assess all the students adequately, because the time was limited." (Fourth year student)*

The limited time and 'side room assessments' demoralized the students and did not appear to meet the students' expectations. Candidates were usually allocated patients the day before the assessment. The students spent hours preparing for each clinical assessment but were disappointed when assessors opted to conduct assessments away from the patient and spent a few minutes listening to them. They wanted to spend more time with their assessors, given the little contact they had with them during clinical placements. They felt that the presence of their lecturers would be utilized more when the assessment took place at the patient's bedside and ample time was given to them to interact with the assessor and obtain valuable feedback:

> *"Yes, you have spent over 24 hours preparing for the assessment, but the lecturer does not even see your intervention. When you plead for some time to listen to you, they say 'it is okay. We are going to mark your write-up'. But I have spent a long time to prepare. I have even read beyond what is expected in preparation for my assessment." (Fourth year student)*

> *"But I want you to listen to this case properly. I want you to give me your time and give me feedback that is constructive to help me improve or sustain the good things I have done. Correct me where necessary and even see the interventions I have done." (Fourth year student)*

The attitude of many of their assessors, the reduced contact time, and assessing them away from the patients made them wonder whether their assessors were interested in supporting them at all or just 'pass through' the nursing program. When learners are not

afforded adequate time for assessment and feedback, it defeats the purpose of clinical case assessments. They speculated as to what could have caused the attitude of their assessors. Some thought that some lecturers were not interested in their profession, claiming that those who were interested in the profession would take time to assess the students adequately and give valuable feedback. Others speculated that some assessors could be more interested in earning money from the assessments rather than supporting the learners to gain from the assessments. Others attributed it to a focus on assessment for purposes of giving scores rather than concentrating on long term goals such as mastering a bioscience skill or concepts for life and applying such knowledge to solve clinical problems:

> *"I was really happy about how I managed to care and advocate for the patient, and I wanted my lecturer to also appreciate that. But the lecturer came and showed me that he was not interested in whatever I had done. He just wanted to come and see the paper (write-up), give marks, and go to get his money." (Fourth year student)*

> *"I presume that a lecturer who is interested in the profession would take a moment to see what you have done. At least touch (examining) the patient. He or she will be eager to tell you something you have missed because he/she loves the profession. They do not love what they are doing. They do not love their profession. They only care about the money. They love money." (Fourth year student)*

> *"He is not worried about your learning. Maybe they just aim at giving the score, but I need to learn because this is my future. All I want is to learn as a student, not just the marks." (Third year student)*

The most common methods of assessment in practice were clinical case presentations although OSCE/OSPE assessments were also conducted in the university. Clinical case presentation is a method of learning and assessment where a learner's knowledge and skills are appraised. During case presentation, the student is assigned to a patient in the clinical area. Each candidate is usually given 24 hours to familiarize and interact with the patient and prepare to present the case for assessment.

The students' preferred formative assessment appeared to be clinical case presentation, the same method that was used for summative clinical assessments. Their preference for formative clinical assessments in the presence of the patient, classmates, and the nurse lecturer further reinforces their perception that assessment was indeed a learning opportunity and that it should take place in authentic clinical contexts. This assessment in a

collaborative learning environment appeared to be important for them to critique each other's presentations. This study also suggests that collaborative formative clinical assessments motivated learners to adequately prepare given that the lecturer and classmates would be present to ask question and learn from each other:

> *"It would be better to have case presentations regularly where the lecturer follows us up and when they assess each student in the presence of a patient and fellow students. All the students are called, and the student presents when the lecturer is also around." (Third year student)*

> *"It would be good that I leave what I am doing to join my colleagues when I see them presenting a case. I would join them and listen and compare with my own thoughts. I should be allowed to ask questions." (Third year student)*

> *"When the lecturer comes, we would present 7 cases from the same department and all of us will learn from each other's' presentations. We would get more time to learn from the lecturer and from each other such that the short time we have on the ward is spent learning and receiving feedback from each other and our teachers." (Third year student)*

> *"They give students patients with different conditions. When it comes to the presentation, all the students are there with the patient and the lecturer. The lecturer listens to the presentation and gives feedback. They use it as a learning opportunity to ask questions, discuss bioscience issues and make clinical decisions based on the underlying bioscience." (Third year student)*

It therefore appears that assessing students away from the bedside may fragment learning and the assessor would not be able to identify learning gaps and institute appropriate measures to support students. The student would not get valuable feedback from the assessor and know what to reinforce and what to improve. This could account for the students' dissatisfaction with their clinical assessments. The participants wanted to have their clinical assessments at the patients' bedside, where they could clearly demonstrate their knowledge and skills in a practical way to obtain maximum benefit. They maintained that assessments beside their patients would bridge the theory-practice gap. The reasons for this were not apparent to the students but could be linked to time, motivation, and workload.

What is clear from this study is that the students did not understand why a clinical assessment would take place away from the patients, given that their class size was small, the patients were available and willing to participate. Most of the time, the assessors did not meet the patients, interact with them, or even allow the candidates to demonstrate their bioscience knowledge and clinical skills at the patients' bedside. Most of them wondered how the assessor would effectively assess them without observing and verifying the accuracy of their claims. They wondered how relevant the questions assessors ask would be to the clinical problem if they did not physically observe the student directly applying biosciences. The participants demanded to have their clinical assessments at the patients' bedside, where they could clearly demonstrate their knowledge and skills in a practical way to obtain maximum benefit:

> *"I want my lecturer to come to the patient's bedside and ask me to palpate the patient while he is observing and give me feedback on where I went wrong." (Third year student)*

> *"When the lecturer came, he just glanced at the patient and then we went to the side room to present the case. I was really interested to show the lecturer that I was interested in this case and show how much I have done. I wanted to show him that I have put in some effort." (Fourth year student)*

They maintained that assessments beside their patients was preferable although this was not the case because assessors appeared to prefer presentations in the side rooms. The reasons for this were not apparent to the students. They did not understand why a clinical assessment would take place away from the patients, given that their class size was small, the patients were available and willing to participate.

> *"We don't see the relevance of presenting a patient case in the clinical area from the side room or office, without the patient being there. We could still do that in the class." (Fourth year student)*

> *"We don't present the patients case on the bedside. We use the side room. Sometimes we use the office." (Fourth year student)*

> *"It is a small class that can be assessed in one day. But you find that they come for a few minutes and go away." (Third year student)*

The assessors did not meet the patients, interact with them, or even allow the candidates to demonstrate their bioscience knowledge and clinical skills at the patients' bedside. Most of them wondered how the assessor would effectively assess them without observing and verifying the accuracy of their claims later give them feedback:

> *"I know of one lecturer that won't even listen to your case. She will not want to see the patient you are presenting, even try to find out if the patient even exists. She will only ask what you did and ask a few questions. They do not really go deep to ascertain whether you really did what you say you did. The student can just forge the case come and present and get marks." (Fourth year student)*

> *"But I can just get the information from the file and present it. The lecturer does not even check to find that I am doing the right thing. My learning needs were not met… I was disappointed." (Third year student)*

> *"The other times, they will ask you questions quickly. Even if you do not know, you will say you know, and they will not take time to crosscheck if you are really saying the truth. They say, 'you go I am done; I only have two minutes. How will he really score me?" (Second year student)*

The limited contact of assessors with the patients was not only detrimental to their learning but also very demoralizing given that they spent long hours preparing for these assessments. The limited interaction of learners with their lecturers in clinical practice could account for why some learners waited for clinical assessments to ask questions about concepts they did not understand:

> *"I usually get frustrated when it is time for exams and the lecturer gives you a patient. You then spend the day working on this patient. You clerk, diagnose, bathe the patient, make the bed, and do all the necessary nursing care. The next morning, you are there very early before your teacher comes. But guess what? This teacher will come and say, 'I only have 5 minutes to tell me about your patient' (all laugh). 'Give me the summary.' That is all the teacher does." (Fourth year student)*

> *"You have wasted all your energy trying to prepare for the assessment, but the lecturer does not even see your intervention. (Third year student)*

> *"That hurts a lot. The lecturer comes and says 'give me the diagnosis. Aha, what have you done? That is all. Five minutes for sure! You have really done a lot and you want*

to show your teacher that you have done something but what can you present in 5 minutes?" (Third year student)

"In our case, the lecturers don't come, when they do, they don't have time, and they ask you to present to them (alone) without other students or the patient present. You cannot even ask any questions." (Third year student)

As already reported, the students in this context maintained that biosciences should be taught and assessed more practically to support them to more explicit links in practice. The limited links of biosciences to practice, even within the clinical area raise questions as to the relevance of clinical assessment and whether the scores assigned to students reflect the knowledge and competence of the candidates.

Feedback

The participants recognized that feedback was an important aspect of assessment of bioscience learning and application. Feedback gave them something to go back to and work on to improve on their knowledge and practice of biosciences. They however maintained that it was uncommon for an assessor to give constructive feedback to them after assessments. In fact, when asked about the feedback on their practical assessments, they all laughed, implying that feedback was either never given or that it was not done to their satisfaction. They specifically picked up the term commonly used by their assessors, "you are not serious", to mean that the presentation or write-up had multiple mistakes, but the mistakes were not pointed out to them. Sometimes, when feedback was given, it was not specific to individual students which left them confused because it did not explicitly point out any area to reinforce or improve:

"Which feedback? Is there any feedback anyway? When he comes, he does not seem to be interested. They do not listen. When you are presenting the case and the lecturer is on WhatsApp, you cannot say' 'excuse me, I am presenting, please listen to me'. You cannot say that." (Third year student)

"They don't give individual feedback to students after assessment. You will not even know which area of the course you need to improve or reinforce. You are left in suspense. Sometimes the lecturer will come to the class and say, 'you guys did not perform well on the clinical exam'. That feedback is general." (Third year student)

The nursing students were dissatisfied with the way feedback was given to them during routine clinical presentations and scheduled university clinical assessments. Some of the assessors used a language that demotivated and sometimes embarrassed learners in front of colleagues. One participant described an example of when she was given feedback in a way that was embarrassing yet she devoted her efforts to prepare for the assessment. The good things about her assessment were not recognised or mentioned during the feedback:

> *"The lecturer demoralized me when she said that I had presented rubbish and wasted her time. She did not recognize the effort I put in to prepare for that case presentation. Even then, I was not told where I went wrong or how to improve. This was said in front of my classmates. She never said anything good about what I had done." (Fourth year student)*

> *"You feel like you wasted 24 hours which were not appreciated. The lecturer does not even recognize the effort I put in." (Fourth year student)*

> *"When you as the student go out of your way to do something like that, you expect the lecturer to come and say "oh, you have done well". (Fourth year student)*

The students expected to learn from the feedback. They expressed the need to have the positive and negative aspects of their assessments pointed out immediately after their assessments in a way that would support them to improve in the future. Although they wanted to receive timely feedback on each assessment to help them identify areas of improvement, this was not the case. They could not even make judgements on which assessment needed improvement within an individual bioscience course because the marks were combined into a whole:

> *"You won't even know which area of the course you need to improve or reinforce." (Fourth year student)*

> *"After the assessment, I am not given constructive feedback, I only wait for the score. I am not told where I am weak or strong." (Third year student)*

It appears that feedback in this context was limited. It was unfortunate that observation of the students' skills during clinical placements was rare and therefore assessors are limited in their feedback. Overall, feedback was either not given or was not satisfactory because it was generalized or vague, thus rendering it unusable for improvement of learning.

There were a few times when valuable feedback was given by assessors. The students reported satisfaction with their assessment when personalized and timely feedback was given:

> *"There was this rare incident when a lecturer came to assess me. The patient's white blood cell count was too low. I asked her questions because she opened the floor to me even if it was an exam. That was the first and last time a lecturer ever gave me time to listen to my case and allow me ask questions." (Third year student)*

There was a disconnect between the students' expectations about feedback and what happened in practice. From the accounts of the participants, the main aim of the assessments in this setting was largely summative. Limited effort was put into supporting learners to improve or reinforce good practice, skills, and behaviour. Assessment and feedback appeared to be reduced to marks and grades rather than identifying learning gaps and improving retention and application of bioscience knowledge. The students' expectations on the other hand were largely formative. They wanted to learn from the feedback given, more so given the little support they received from their lecturers and clinical staff during clinical placements. Giving valuable and timely feedback in a way that is constructive was important to these students. This includes identifying areas of strengths and weaknesses and working with the learner to devise ways in which to improve.

The findings from this study suggest that feedback on bioscience learning was generally limited. There is limited supporting studies to this finding in biosciences. In addition, the feedback given was not specific, individualized and given in a timely manner. Students also noted that feedback was not professionally delivered, meaning that it was not constructive. As evidence of this, participants noted the language that some nurse educators embarrassed them before colleagues on their clinical assessments. This observation could be due to a general lack of training in academic and clinical nursing pedagogy and assessment.

Conclusion

This chapter has presented the findings of this project. The quantitative findings indicate that generally, nursing students struggle to retain and apply bioscience knowledge to clinical practice. This study has also identified the factors associated with bioscience knowledge. I have presented the four themes that emerged from the qualitative data analysis: bioscience curriculum; teaching methods; clinical supervision; and assessment and feedback.

Chapter 6: Discussion

Contribution of Biggs' 3P Model to this study

Biggs' 3P model formed the structure to support the arguments in this study, connecting this research to existing theory (Lynham, 2002). It was important in representing the key variables associated with the teaching and learning to biosciences in nurse education. It described the underlying assumptions of how these variables interact and set the limits to the scope of this study. For example, the 3-P Model illustrated how clinical experience, age-group, and employment status were associated with bioscience success. Relatedly, it demonstrated how contextual factors such as bioscience curricula, teaching methods, clinical supervision, assessment and feedback, and institutional procedures were related to other variables. It supported me to make sense of how context affects overall learning and bioscience success in nurse education.

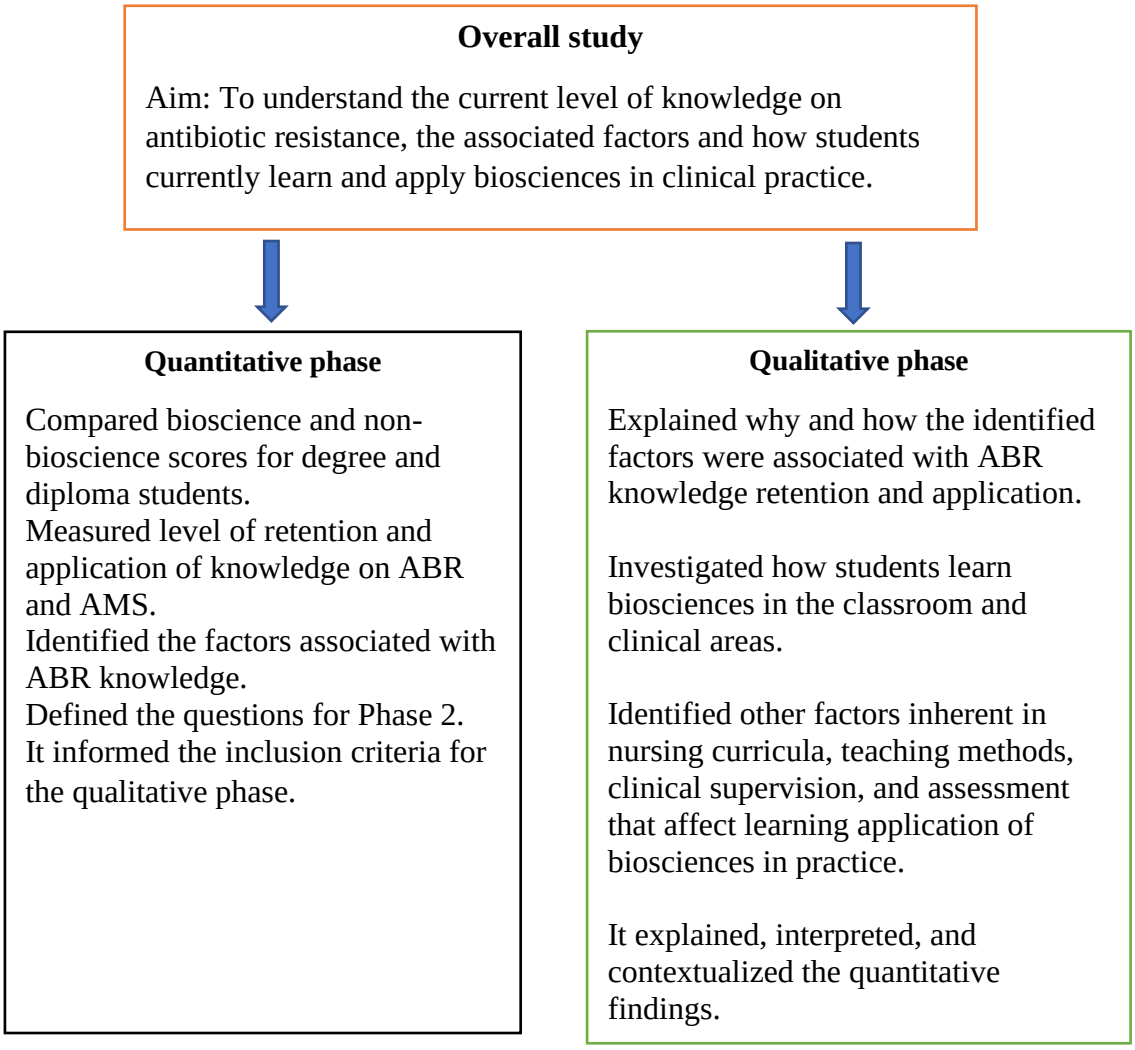
One of the criticisms of the 3-P Model its limited applicability in real-life situations (Howie & Bagnall, 2013). Reciprocally this research contributed to our understanding of the 3P model by supporting Biggs' argument that personal and environmental factors contribute to how effectively nursing students engage with bioscience content. For example, Phase 1 indicated that student factors contributed to bioscience success (learning outcomes). Phase 2 further contributed to the 3P model by identifying and explaining the contextual factors related to bioscience learning. In addition, the findings importantly show that students who effectively engage with biosciences through deep learning achieve bioscience success as well as form better links with new bioscience content.

Indeed, exploring the bioscience problem in nurse education has contributed to our understanding of this model within the context of higher education. This study provides a novel contribution to understanding of the 3P model in nurse education, identifying this as one of the situations under which the 3P model can be widely applied. From this model, teachers must align their approaches to teaching to nursing curricula, assessment and feedback process as well as creating conducive academic and clinical learning environments to achieve the desired learning objectives.

Comparison of Quantitative and Qualitative Results

This study was conducted in two phases with each phase contributing to the overall study as summarized in Figure 7 below. The overall research took the form of a sequential explanatory design utilizing pragmatism to answer the research questions. Mixed methods were used because the questions could not be comprehensively answered using one method, thereby necessitating mixing. Quantitative and qualitative data were connected at the data collection stage, where the results from Phase 1 were used to refine the research questions, design, and data collection in Phase 2. The interface of the two phases started from quantitative data analysis to the focus group interviews.

Figure 7: The contribution of Phase 1 and Phase 2 to the overall project



As explained in the methods chapter, using mixed methods was important because the strengths of one method offset the weaknesses of the other, thereby strengthening the overall study through giving a broader and deeper understanding of this less understood problem. For example, whereas the quantitative arm was strong in providing the broader parameters of the problem, it was weak in supporting our understanding of the environment in which the bioscience teaching, learning, and application took place. It was also limited in supporting us to understand how the people within this context behave, something that the qualitative arm was able to do. Despite the advantages that the qualitative arm brought to this study, it had a potential to make subjective interpretations of the researcher and generalization was more difficult, something that the quantitative research would do. There were no conflicting results between the quantitative and qualitative phases. Using mixed methods provided a more comprehensive and complete picture of the bioscience problem in Uganda.

This chapter will discuss the findings, reflecting on ABR and task-shifting and current nursing practice. It will answer the research questions of this project, explaining the students' knowledge of ABR, the associated factors, how students learn and the level of support they receive to learn and apply biosciences. This will in turn add to the body of knowledge which is the goal of a PhD project. I will draw upon the findings of this research and relevant literature to discuss this phenomenon. The discussion will be guided by the research questions and themes generated from the qualitative phase.

This research sought to answer the following research questions:

1. What level of explicit knowledge of Antibiotic Resistance do nursing students currently have as they complete their degree program and enter practice?
2. What factors are associated with acquisition of bioscience knowledge among nursing students completing their preregistration nursing degree in Uganda?
3. How do nursing students learn biosciences in the classroom and on clinical placements?
4. What are the students' perceptions of the support they receive to learn and apply biosciences?
5. What factors affect the application of bioscience knowledge in clinical practice among nursing students in Uganda?

Level of explicit knowledge on Antibiotic Resistance

Nursing students in this context generally found biosciences more difficult to retain and apply in practice than non-bioscience courses. Only 38.4% passed all bioscience courses while 90% passed all non-bioscience courses. This was regardless of the level (diploma or degree) and year of study. They had a good level of general theoretical knowledge on ABR, but this knowledge was limited to certain roles. They had limited understanding of the role of the nurse in antibiotic stewardship. For example, although most of the students agreed that nurses have a central role in antimicrobial stewardship, most (95%) failed to identify most of the core roles of the nurse. Their knowledge was limited to patient education on adherence to antibiotics and the nurse's role in administering antibiotics. None of them identified infection prevention and control (IPC) practices such as hand washing, disinfection and sterilization, surgical prophylaxis, aseptic techniques, antibiotic monitoring and surveillance, or the collection of culture and sensitivity samples as core nursing roles related to ABS.

As discussed in the literature review, the ABS functions of the nurse are routine and integral to their work. They are the usual, the routine activities nurses do, and literature recognizes that successful stewardship programs should bring nurses to the forefront. The failure to recognize the core roles of the nurse in ABS by students who were exiting higher education to enter practice shows that they may enter practice without the minimum required level of understanding of what their core roles in stewardship are.

Nurses being the backbone of the healthcare system in Uganda means that we may lose the battle against AMR if nurses and students are not adequately supported to understand and recognise their routine roles as central in the fight against resistant organisms. This finding may be explained by the lack of an explicit course or module on AMR within the nursing curriculum. This vital aspect of bioscience which students routinely encounter in clinical practice has been side-lined or implied and now needs to be brought to the forefront within nursing programs.

Nursing students generally had low levels of bioscience knowledge as portrayed by the scores from the primary and secondary data. They scored poorly on questions on the core science questions which assessed recall and understanding of the relationships between bacteria, antibiotics, and bacterial infections. Most of the students could not link resistant bacteria to specific antibiotics to which they are commonly resistant. The knowledge of

commonly resistant bacteria would be important for a nurse to be able manage patients with or at risk of infection with resistant strains. This signals a gap in their knowledge, understanding, and ability to use sound bioscience knowledge to guide clinical nursing decisions relating to ABR and general nursing. It may limit them from being resourceful participants in ABS programs upon graduation.

Bioscience knowledge transfer questions showed greatest weaknesses. This shows that nursing students found it difficult to apply bioscience knowledge to new clinical problems and is attributed to the fact that a significant proportion of them scored poorly on the core science questions, although no significant correlation was detected. These findings are similar to previous studies which showed that preregistration nursing students experienced various forms of difficulty with bioscience courses (Craft et al., 2013; Malik et al., 2018; Montayre et al., 2021). The low level of bioscience knowledge is related to several factors discussed next.

Factors Associated with the Levels of Bioscience Knowledge.

Four factors were associated with the levels of knowledge on antibiotic resistance. They included: age-group, route of entry on to the nursing program, employment status, and university. Mature students were strongly associated with better retention and application of bioscience knowledge to clinical practice situations. Generally, nursing students who enrolled after their diploma in nursing were associated with bioscience success, unlike their counterparts enrolled directly from A-levels. In addition, students who were employed were associated with higher scores. Lastly, students from university A performed significantly better than the other universities.

The bioscience problem is complex and some of the factors which contribute to it are embedded within the students' background. The four factors above add to our understanding of why some students may find it more difficult to retain and apply knowledge on antibiotics resistance. A mature preregistration student who has a diploma in nursing and clinical nursing experience was more likely to retain and apply ABR knowledge in practice. In contrast, a student is more likely to struggle to retain and apply bioscience knowledge to clinical practice if he/she is younger and enrolled directly from A-levels and has no clinical experience. As noted in the literature review the diploma entrants come to the nursing degree with a stronger applied bioscience background and years of clinical experience before enrolment. In contrast,

the students who came directly from A-levels only had A-level science knowledge which was not linked to clinical practice. This placed them at a disadvantage in comparison to the mature students. The qualitative findings identified experience of learning at higher education level as a factor that affected the students' learning. For example, having a diploma obtained in a HEI meant that that student came to the degree program with prior experience of adult learning.

Younger preregistration nursing students in Uganda found biosciences more difficult because they had limited adult learning skills to effectively engage with bioscience content courses on a deeper level. They were not well prepared to learn in higher education institutions and their laid-back attitude meant that they were not prepared for the academic demands of this level. The findings demonstrate that preparation for higher education is an important determinant of bioscience learning and application in clinical practice and confirms existing literature. Preparedness for higher education in terms of possessing the relevant skills for higher education and working hard and engaging with bioscience content in appropriate ways is key in learning (Jensen et al., 2018). Limited skills to learn at the higher education level contributed to the bioscience problem in this context.

Similar to the present study, younger students find the academic intensity of learning sciences at university overwhelming because they come with mistaken preconceived ideas of how teaching happens and the demands of learning at higher education (Karaoz, 2004; Porter et al., 2009). They quickly learn that their expectations were unrealistic (O'Donnell, 2011), that they were unprepared. As a result, they may be demotivated to learn (Vinson et al., 2010). This study concurs with these observations because the students expressed their shock at the demands on their time and commitment to the nursing program. They came with the attitude that learning in higher education was easier. They were not prepared for the massive transition from high school where learning was largely didactic to higher education where adult learning skills are required. They admitted to finding it difficult to cope and ultimately learn and apply biosciences in clinical practice.

There were no preparatory courses that would support these students with the independent learning, yet the independent work started as soon as they got to university. These learners contended with learning complex science content at the start of their program when they were still adjusting to the demands of higher education. They reiterated that it took them some time to adjust to the new way of learning and had to be internally motivated to

cope. A lack of preparation for higher education contributes to difficulties in learning and may increase attrition rates from nursing programs (O'Donnell, 2011). What is clear is that students with independent learning skills are bound to cope better with the pressures of higher education (Crabtree et al., 2006; Pryce-Miller, 2010) and meet their learning objectives. The less prepared ones spend considerable time engaging with the complex and numerous bioscience content before moving on to practice (Gordon et al., 2017). They are more likely to lose confidence, self-efficacy, and the determination to learn during the transitional period (Vinson et al., 2010). Adult learning skills call for independent learning, an active search for knowledge, and responsibility for learning. These skills develop over time implying that unprepared students are likely to struggle to apply biosciences for a considerable period. This explains why the quantitative results indicated that the younger students had more difficulties in applying bioscience knowledge in clinical practice.

In addition to having higher education learning skills, the mature students had applied bioscience subjects as part of their diploma curriculum unlike their younger colleagues who only had A-levels biology and chemistry. Clearly higher education experience achieved at diploma level and clinical experience was more advantageous than having A-levels science alone. Owens and Moroney (2017) agreed noting that although greater bioscience achievement was associated with A-level science and mature entry, A-level science in isolation was not a guarantee of bioscience success because the students had to have the skills to use the science to retain and apply to practice. This means that although the students in the present study had strong science backgrounds, they failed to effectively engage with biosciences because they had limited adult learning skills.

The second factor that contributed to bioscience success was clinical experience gained through employment. In this study, employment was associated with better bioscience outcomes (mean score 68.82) than those who were unemployed (64.53, $p = 0.001$). The students working in the nursing profession had higher mean bioscience scores (69.36) than those who were employed elsewhere (61.67) or those who were unemployed (64.53). The results indicated that 88% of the mature students were also employed in the nursing profession. Most of them continued working throughout their studies meaning that they continued practising and honing their knowledge and skills, relating them, and becoming more competent unlike the students who were studying full-time. For example, University A operated a work-study model where students continued working alongside their studies. This explains why the students from this university had the highest mean bioscience score (69.38).

In the work-study program, students spent two days studying within the university and worked the rest of the week.

In addition, the policy in Uganda requires diploma holders to have at least two years of clinical experience prior to registration on the degree program. This means that the top-up students come to the nursing degree with at least two years of clinical experience, while their A-level colleagues did not. The unemployed students had limited points of reference especially when it came to understanding the clinical relevance of bioscience concepts. During the focus groups, these students emphasised that their limited clinical experiences greatly hindered their learning right from the classroom. This is because one needs theory to be able to apply it to practice but you need some prior experience to relate the theory you learn to the practice you will do.

These findings contrast with Salamonson et al. (2009) who found that students involved in any part-time work were at a disadvantage when it came to passing pathophysiology. In addition, part-time work in the nursing profession was even more disadvantageous than working part-time elsewhere, although the difference was not statistically significant. This position was also supported by a study by Salamonson et al. (2012) which found that working in term-time negatively affected the students' GPA. For this study, it was suggested that a new curriculum model accommodating the dual roles of nursing students be explored. The difference between the finding in the above studies and the present study stems from the model of the nursing curriculum and the differences in clinical context. For example, the nursing roles and tasks in Uganda could be more expanded than those contexts due to task-shifting and therefore require more science content. The nursing roles of the employed students were more tied to their studies and therefore more relevant to understanding and applying biosciences in clinical practice.

The factors explored in this study are important for curriculum planning. They will help nurse educators and higher education planners to identify nursing students who are at risk of failing or struggling to pass bioscience courses. This study also shows that clinical nursing experience is associated with bioscience success and application in clinical practice. This may help nurse educators to increase the support given to students enrolled directly from A- levels. The results point to the need to create more stimulating academic environments where nursing students can intimately link biosciences to clinical nursing problems, even in the academic context at the earliest possible opportunity.

How Nursing Students Learn Biosciences in the Classroom and on Clinical Placements.

Learning is influenced by the curriculum and how it is implemented. The nature of the curriculum contributed to how and when bioscience content was delivered. There was a strong presence of bioscience theory on nursing curricula in this study. There were seven bioscience courses as already discussed in the literature review. The students in this study felt that there was too much content to cover in a short time. A study of the overt curriculum of one university in Uganda suggested that science subjects consisted of about 50% of the courses taught in the first two years and 30% in the third year. This contrasts with other studies in the UK (Taylor et al., 2015) and Australia (Ralph et al., 2017), where students called for more biosciences in their programs. For example, Logan and Angel (2014) reported a decline in the credit hours allocated to science teaching, although science content integration in nursing courses increased between 2012 and 2014 in nine Australian universities between 2006 and 2012. Taylor et al. (2015) reported a diminishing teaching time spent on biosciences in the UK., varying from 0.4% to 0.2% of the total teaching time.

The nurse educators and students currently contend with having to teach/learn complex bioscience material in a limited time. Crowding of curricula is corroborated in other studies in the UK (McVicar et al., 2015; McVicar et al., 2010), Australia (Whyte et al., 2011) and New Zealand (Montayre et al., 2021). According to McVicar et al. (2015), biosciences are notably crammed in the first years of the program, and learners are expected to later apply this same knowledge in practice, which students find difficult (Doggrell & Schaffer, 2016).

The curriculum was crowded because it leans towards medical rather than the nursing practice. This is linked to the longstanding notion that nursing has to establish its own body of bioscience knowledge and still relies on the medical discipline to dictate its scope and depth of biosciences (Casey, 1996) and or that the nursing profession in Uganda is still dominated by the medical profession when it comes to biosciences. There is too much content in the curriculum that nursing students do not necessarily need or can apply in clinical practice. As mentioned in the literature review, nursing has relied on medicine for its bioscience, leading to limited opportunities to determine its own depth and scope of bioscience body of knowledge required for competent practice at the registration level (Casey, 1996).

Although the curriculum in this context was crowded and had a strong theoretical bioscience presence, there was limited application of the theory taught. The students asked for more applied bioscience. The curriculum had too much content, but a lot of this teaching time was dedicated to theory with limited contextualisation to clinical practice. Therefore, in this respect, there was diminished applied bioscience teaching in this context and therefore this study corroborates previous studies showing that there is diminished bioscience presence on the taught curriculum, largely due to decontextualized teaching (Davis, 2010; Fell et al., 2016; Molesworth & Lewitt, 2016).

Bioscience curricula are delivered differently across the globe. For example, in Australia (Logan, 2008) and Uganda, bioscience courses are taught separately, while they are more integrated in Nepal (Shrestha et al., 2018). In the UK, some HEIs teach them as separate courses/modules, whereas others first teach them separately then, integrate them in the later years. The mode of bioscience teaching affects integration and linkages that the students can make in practice. For example, in this context, bioscience teaching was largely decontextualized from clinical practice which limited their ability to link biosciences to clinical practice given that they had limited prior clinical experience.

The students stressed the importance of connecting bioscience theory to practice as the means to establish and maintain their engagement with biosciences and subsequently improve retention and application in practice. They identified three ways biosciences can be linked to clinical practice during teaching: (1) using relevant clinical examples during theory teaching, (2) recapping bioscience theory before performing nursing procedures in the CLE, and (3) learning biosciences at the patients' bedside. This finding broadly supports the work of other studies where nurses and students called for more linkage of bioscience to clinical practice (Al-Modhefer & Roe, 2009; Molesworth & Lewitt, 2016; Rafferty & Kyriacos, 2016) to support learning in the academic and clinical contexts.

Linking and applying biosciences to actual nursing practice is key in supporting retention and application of biosciences in nursing practice (Montayre et al., 2019). Moreover, integrating biosciences within nursing care and curricula is more critical given the emerging epidemics and task-shifting which are expanding the nurses' scope of practice (Fawcett et al., 2016; Perkins, 2019). However, linking bioscience teaching to nursing practice has remained challenging for nursing, with Johnston (2010) attributing this to the unstructured and haphazard way bioscience knowledge is applied to clinical situations.

Previous studies have demonstrated the value of teaching and learning environments that connected bioscience theory to practice (Christensen et al., 2015; Craft et al., 2013; Eraut, 1995; Rafferty & Kyriacos, 2016; Shrestha et al., 2018) as those that supported bioscience learning.

Implementing the bioscience curriculum in ways that support linkages between bioscience courses would support students to retain and apply biosciences. Bioscience courses all pertain to the human body and therefore are complementary, yet they are taught discretely. The students found it more difficult to recall and understand content they studied in the first half of the programme to apply it during the second half. The students did not dismiss discrete teaching of courses, rather, the teaching which completely isolated bioscience courses from each other, and limited apparent connections among the courses. What was clear from this study is that bioscience courses should be connected at some point, in some way early in the program to support students to link them. They suggested to have these courses taught close to each other and to when they had clinical placements such that the linkage to each other and to clinical practice becomes more apparent. This finding is like an earlier study undertaken in Australia among registered nurses and bioscience academics. Their participants preferred an initial discrete course delivery and integration of bioscience in the remaining portion of the curriculum (Ralph et al., 2017).

Confining biosciences to the earlier portion of the curriculum may limit the students' ability to understand and apply the concepts in practice. Other studies have recommended teaching bioscience courses well into the final year (Craft et al., 2013; Craft et al., 2017c; McVicar et al., 2010). Indeed, participants in the current study preferred to spread the teaching along the program given that currently the teaching is in the first years when they have limited adult learning skills to effectively engage with the complex content and they lacked clinical experience to connect the theory to practice. This would encourage integration of bioscience throughout the nursing program (Birks et al., 2011; McVicar et al., 2015; Molesworth & Lewitt, 2016), consistently linking theory to practice throughout the program (Ralph et al., 2017). In addition, it would ensure a strong bioscience presence throughout the curriculum and open other avenues for contextualizing science in theory, clinical teaching, and assessments.

Lectures were the main method of teaching used to deliver bioscience content in this study. The students however agreed that those lectures were largely passive and ineffective in

meeting their learning needs. The teacher centred focus of lectures did not effectively support them to retain knowledge and as such encouraged surface learning approaches which predominantly concentrated on passing assessments rather than learning (Biggs, 2012; Trigwell et al., 1999). The students resorted to rote learning through cramming to pass assessments but openly admitted to not remembering most of what they crammed. Current literature suggests that lectures dominate bioscience teaching (DeChellis, 2020) because science courses are information intensive (Entwistle, 2007; Krontiris-Litowitz, 2009) which need students to memorize unlike the more active methods which prompt learners to interact with the course material and peers to a deeper level. Lectures normally focus on lower order thinking was observed in DeChellis (2020) which may encourage surface learning as observed in the present study.

The teachers in this study may have used lectures based on their own level of formal instruction and preferences. According to Oleson and Hora (2014), the instructors' own experiences of learning bioscience material influenced how they taught these courses. These learning and teaching methods develop over time and are linked to what the teachers perceived as 'working' as they build more experience (Oleson & Hora, 2014). Bioscience teachers tend to use lectures because they received their instruction the same way and tend to construct their thinking and teaching along the same lines. For example, DeChellis (2020) observed that the lecturers predominantly used lecture methods even though class sizes were small, and they could use more active methods. This type of teaching linked to the teacher's own reflections is what Kolb (2014) described as experiential learning. Experiential learning is built on past learning of transformative experiences. The experiential learner experiences, reflects, then acts and learns again. The entire learning and teaching cycle then becomes a culmination of the individual's learning experiences and actions (Kolb, 2014). Indeed, lectures have dominated bioscience teaching in higher education and these teachers may have formed these experiences along the way and used them in their own teaching.

The participants felt that the teacher-centred nature of lectures made learning even more difficult because there was a lot of complex content. They perceived their lecturers as over relying on lectures and overrating them as effective in supporting their learning. Evidently, there was a disconnect between what the students perceived lectures to be and what their teachers were doing. For these students, lectures were demotivating, shallow and dry. They felt less encouraged and prompted to learn and participate in their learning. This was not to mean that they did not recognize that they were active participants in their own

learning or that that bioscience knowledge was irrelevant. Rather, the content was complex, and their limited clinical experience and adult learning skills made learning more difficult. Some admitted to predominantly looking up to the teacher to provide most of the required content.

As expected, as the students progressed into more practically intensive courses and gained more clinical placement experience, their perception of lectures gradually moved from understanding content to linking theory to clinical practice in meaningful ways. The third-year students thought that lectures did not form a good foundation for retaining and later applying theory to practice. They felt less able to link the science to practice. Students in the final semester of year 4 perceived lectures as less important in overall bioscience success. They were displeased with the suggestion that lecturers were important in bioscience success, stating that lectures were a waste of their time because they could read and understand the content on their own. This was linked to the persistent lack of integration and application of theory to clinical practice, confirming prior studies that noted that nurse education has indeed grappled with implementation of bioscience teaching for a long time (Clancy et al., 2000; Jordan & Reid, 1997). Evidence on who, what, how much, and how to teach biosciences is still debatable despite having researched this issue for decades.

Health professional students are motivated to adopt deep learning strategies when content can be applied to clinical practice (Shah et al., 2016). Those who have difficulty in understanding what they learn but fear failing courses often resort to reproducing what is taught. They also tend to focus on information they believe is important for assessment (Evans et al., 2003) not for long term retention and application (Gordon & Debus, 2002). What is evident from this study is that the bioscience portion of the nursing curriculum should be revised to include bioscience aspects that are most clinically relevant and applicable to nursing practice.

Lectures may be good for teaching large classes but in this context, the classes were often mixed and therefore more diverse. Indeed, nursing classes are becoming more diverse (Whyte et al., 2011) and teachers may be tempted to use lectures to deliver bioscience content. However, mixing cohorts with limited recognition and support for the unique learning needs of each group as in this context, was detrimental to bioscience learning. There are benefits when cohorts learn together, such as learning from and supporting each other but only when they are given the support they need to learn. Clearly mixing A-level leavers and diploma holders without providing extra support for the less clinically experienced students was identified to limit their understanding and application of biosciences. The teachers could

have mixed the two groups to save teaching time and reduce workload, but the unique learning needs of the less experienced students were not put into consideration prior to mixing the groups.

Combining the two groups reduced the confidence of the younger and less clinically experienced students to participate in the classroom and meet learning needs. These students were less than 10 per class compared to their colleagues who were usually double that number. The mature students tended to dominate the classroom dynamics and the teachers tended to teach at their pace and focus on their learning needs leaving the others behind. The teachers failed to recognise and interpret their questions as indicative of their disadvantage relative to their colleagues, further demotivating them. Identifying the limitations which predispose learners to difficulties in learning will help teachers to give more support to students. Perhaps the teachers in this context were not aware of this association and assumed that their classes had similar learning needs thus encouraging them to mix. Whyte et al. (2011) urged teachers to use cohort demographic characteristics to identify more 'at risk' students early on and support them. Bakon (2017) added that that recognizing the learning needs of different students will go a long way in reducing challenges with biosciences in the more diverse classes. As nursing classes become more diverse, bioscience teachers should understand the limitations of each group prior to attempting to mix them.

In conclusion, although lectures were the dominant method used in bioscience classroom teaching, they were generally ineffective in supporting retention and application of bioscience knowledge. This is because (1) they were largely passive; (2) the classes were more diverse; (3) the students had limited preparation for higher education; and (4) there was limited connection of theory to clinical practice.

The Clinical Learning Environment

The main clinical context in which learning was situated was a large Regional Referral and Teaching Hospital. The clinical staff are expected to teach in addition to their clinical roles. Ideally, bioscience teaching in CLE was embedded in practice, as part of the whole clinical experience not separate courses as in the classroom. For example, when teaching urinary catheterization, the mentor/teacher would recap the anatomy of the urinary system, the steps involved in the procedure, the equipment required, indications and common nursing concerns such as infection prevention and control as an aspect of antimicrobial stewardship. Students would integrate the science and nursing aspects of the procedure as

applied to a real patient. The teacher would draw the students' attention to the indications (rationale), explain the underlying science aspects, any comorbidities of the patient prior to performing the procedure and assess pain levels and any other risk factors. Emphasising aseptic technique as a way of preventing the introduction of pathogenic microorganisms into the urinary system as well as protecting the nurse from cross infection would bring out the aspects of antimicrobial stewardship.

After the procedure, the learners would discuss the characteristics of the urine. For example, dark yellow urine could suggest dehydration or reduced fluid intake, which could necessitate starting a fluid balance chart. The fluid balance chart could trigger a discussion on homeostasis. In case a urine sample is required, the teacher should emphasize which portion the urine should be collected (fore urine, midstream, or hind stream) depending on the indication and explain to the students the scientific rationale for such a decision. The teacher could initiate a discussion on the possible urinary tract infections and possible causative organisms. Lastly, the group discusses the actual and potential risks and how a nurse can recognize and manage them effectively. The teacher would emphasize record keeping and patient monitoring.

This example illustrates how a practice teacher could teach a nursing skill and the bioscience concepts behind it, thus combining the skill and the science. The depth of the content and participation of students would depend on the level of the learners. It would help the student to bring all the aspects of care into a whole at the patient's bedside. The norm in this context, however, is that the teaching in clinical placements emphasised the skills thus limiting the learning and application of bioscience reasoning.

The clinical workplace in Uganda usually has very many patients and a few nurses with many students from different disciplines, levels, and HEIs. The staff are usually very busy and have less time for teaching. In such cases, teaching may be viewed as an extra role rather than integral to the clinical staffs' routine work. The Royal College of Physicians (RCP, 2015) toolkit on teaching the acute medical unit recognises that the teaching and clinical roles may appear to conflict and as a result, the teachers may feel too busy to teach. They however stress that clinical staff can overcome this apparent conflict by defining the teaching and learning sessions clearly and establishing a shared understanding with the students as to how and when teaching will take place right from the start of their clinical placements (RCP, 2015).

Unlike the university context, where teaching was scheduled and controlled, the teaching in the clinical setting was less defined, even to the students. One of the reasons the students cited for this was that the staff were very busy and could not set adequate time aside to teach. This explains why there was an unwritten relationship between the clinical staff and students, where the students were expected to help the staff with their work and the staff would teach them in return. The limited time to teach and clinical experience put the direct students at a disadvantage because they were likely to be taught less since they could not contribute much to the labour.

The students in this study identified ward wounds as the most common method of teaching biosciences in the CLE. Indeed, ward rounds are a useful platform for training and development of junior healthcare professionals and students, "presenting a major opportunity for education and training" in the CLE (RCP & RCN, 2021, p. 28). During the ward round, students and junior professionals can take on the role of ward round lead, a process known as reverse ward rounds. This is done under direct supervision of senior clinical staff, after which students are given feedback during the round and at the end. According to the RCP and RCN (2021), the experience of reverse ward rounds provides an ideal opportunity for trainees to acquire and practice practical skills and competences using relevant clinical evidence. Ward rounds were the most important bioscience learning platform for students in this CLE. They supported them to connect bioscience theory in clinical practice, thereby contextualizing bioscience learning.

One of the major reasons for this was that they were led and supervised by consultants who had vast knowledge and clinical experience. They were able and confident in explaining the science and non-science basis of the care and management plans, supporting the students to understand the relevance of using that knowledge in making clinical decisions in the most practical way. RCP and RCN (2021) explain that during the ward rounds, the consultants often generate questions for the team and demonstrate their use of evidence-based clinical care through clinical storytelling. They commonly hold clinical conversations such as explaining rationale for clinical decisions and management plans using prevailing evidence from the patients' condition. In addition to the clinical skills and hard science, ward rounds offered more holistic learning because students studied the soft skills such as ethical practice, communication, teamwork, and professionalism (Rajasoorya, 2016). All this was situated in the most contextualized clinical environment, the patients' bedside.

Previous studies suggest that nursing students linked the quality of their bioscience learning on clinical placements to a mentor's bioscience knowledge. Mentors who were knowledgeable in the bioscience were perceived as more confident in teaching and supporting students to apply biosciences to nursing practice (Logan & Angel, 2011; McVicar et al., 2010). They were able to motivate them to think through their clinical decisions and were viewed as supportive of their learning (Fell et al., 2016). Newly qualified nurses also agreed that their ability to transfer biosciences was supported by teachers who were knowledgeable in biosciences (Montayre et al., 2021). As mentioned throughout this report, CLEs are the cradle for pooling bioscience theory and practice together with other aspects of care and teachers who relied on a vast bioscience knowledge were critical in making this happen.

As explained in the literature review, the medical profession has a more developed body of bioscience knowledge and nursing traditionally depended on this for its own practice. The medical consultants have developed a culture where it is expected to use bioscience knowledge. The medical consultants highly valued teaching and used bioscience knowledge in their clinical decisions. Workplaces which prioritize biosciences offer more opportunities and support to learn and integrate biosciences (Fell et al., 2016). On the other hand, a work culture which devalues biosciences is detrimental to learning (Logan & Angel, 2011). Unlike nursing students, the medical students and junior doctors were given the opportunity to clerk and present clinical cases to the team, detailing their care and management plan and gain valuable feedback. They were expected to be able to defend their clinical decisions using the prevailing science and non-science evidence. According to RCP and RCN (2021), ward rounds give students the opportunity to review patients first, think through their decisions and present their management plan to the team with the consent of the patients. The discussions would emanate from what has been presented and the clinical teacher would use various techniques to enhance learning.

Ward rounds in this context were effective in supporting bioscience learning in part because they offered learning opportunities at multiple points, which explains why medical consultants appeared to value and engage in clinical teaching. For example, they can teach through thinking aloud, demonstrating, generating questions, stimulating discussions, and encouraging trainees to research on doubtful concepts (RCP, 2012). The RCP and RCN (2021) added that ward round team leads can support learning by encouraging students to think aloud, demonstrate clinical skills and decision-making processes to the team. The

reverse ward rounds where students swapped roles with senior practitioners supported learners to have hand-on practice and safely demonstrate their knowledge and competence under supervision.

The students in this context also found intern doctors to be a great resource for learning biosciences. They stressed that unlike the nurses and consultants who worked shifts, intern doctors worked longer hours and were more available to support them. They were also more approachable to the nursing students than any other staff. The interns were also highly knowledgeable because they were expected to have adequate knowledge to undertake their roles and defend their clinical decisions (Rajasoorya, 2016). The consultants gave intern doctors learning tasks based on assessments and investigations, which kept them abreast with their practice. This gave them the confidence to support the nursing students by explaining bioscience concepts and answering questions. This is demonstrated in this context by the fact that intern doctors held their own daily rounds and were very familiar with the patients' conditions and confidently answered bioscience questions. They were also more willing to teach the students perhaps because they were still under training themselves and felt empathetic to the students' needs.

Previous studies on general clinical mentorship attest to the value of clinical teachers who are available, enthusiastic, and able to teach as supportive of learning in the CLE (Jokelainen et al., 2011; Myall et al., 2008). Nursing students placed mentors' enthusiasm and ability to teach as supportive of bioscience learning. Therefore, the students perceived intern doctors to be more supportive in applying biosciences because they were available and willing to teach them. These factors motivated them to seek help from them. Although it was not their role to teach and support nursing students, intern doctors were willing to take on this role. They were internally motivated to support students amidst the competing demands in clinical practice in addition to being knowledgeable in the sciences (Fell et al., 2016).

The multidisciplinary nature of the teaching and learning during the medical ward round was important in learning. Ward rounds are a "focal point for the hospital's multidisciplinary team to undertake assessments and care planning" (RCP & RCN, 2021, p. 5). During the ward rounds, a lot of learning took place because the patients' problems were reviewed and clarified, clinical goals were set using prevailing evidence and the team coordinated on the management of the patients. Each professional group had an input in the discharge management, communication with patients and family, patient assessment, and

documentation (Rajasoorya, 2016; RCP & RCN, 2021). At the end of the day, students learned a lot because learning was more holistic and conducted in a multidisciplinary manner.

According to Laskowski-Jones (2016), interdisciplinary healthcare supports professionals and learners to understand their roles and expectations within the healthcare workplace (Peek & Campbell, 2020). This was clearly demonstrated in this study because interdisciplinary working familiarized the students into the culture of the workplace, it mimicked the nature of their future workplaces, and increased their awareness of their uniqueness and value as members of an interdisciplinary team. Despite these advantages, most educational models in healthcare are still profession specific, which may cause learning to be fragmented for those receiving (Laskowski-Jones, 2016). Learning in silo has its advantages such as professional socialization but adoption of multidisciplinary education builds team collaboration and problem solving. In addition, members appreciate the various contributions of the professional groups and "anticipate each other's actions", to make it easy to recognize when a course of action is expected and communicate more effectively (Laskowski-Jones, 2016).

Modern ward rounds have expanded the role of non-medical staff to take on roles beyond what they have traditionally done (RCP & RCN, 2021). For instance, nurse specialists may "lead and coordinate clinical decision-making" and the doctors' traditional roles may be shifted to advanced nurse practitioners (RCP & RCN, 2021, p. 14). Such advanced roles require a requisite bioscience foundation to competently lead clinical decision-making and to effectively communicate to the patients and carers (Davis, 2010; Friedel & Treagust, 2005) and members of the interdisciplinary team (Fell et al., 2016; Jordan, 1999; Logan & Angel, 2011). These benefits motivated the nursing students to learn biosciences from the ward rounds.

The students kept attending ward rounds because they were the single most important clinical teaching activity from which they gained the most contextualized bioscience learning. They also offered protected time for bioscience learning. Caldwell and Atwal (2003) suggested that ward rounds were ideal for interprofessional learning in clinical practice because unlike other clinical activities, ward rounds by nature had 'protected time' for discussion of the clinical problems with the whole team, although this was dependent on the team lead. For this reason, the students in this context valued them more given that there were limited opportunities to get protected time to learn biosciences elsewhere within the CLE.

Although ward rounds were valuable in supporting nursing students to understand and apply bioscience in clinical practice, the consultants and intern doctors whom they heavily relied on had limited understanding of the nurses' scope of practice. This means that they had limited knowledge of how much the nursing students needed, when, and for what. In addition, being doctors, they could not adequately link their teaching to clinical nursing practice. This explains why the consultants and intern doctors interacted more with the medical students than the nursing students. This finding is in keeping with a recent report by RCP and RCN (2021) which revealed that while consultants viewed teaching as a part of their role in clinical practice, they primarily referred to teaching medical staff and students and the other professional groups would learn if they were present.

Bioscience knowledge is important in supporting nurses to confidently communicate with other healthcare professionals (Fell et al., 2016; Logan & Angel, 2011). They need to be knowledgeable communicators able to advocate for patients within the multidisciplinary team (Jordan, 1999). The nursing students in the present study remained largely passive because they had limited confidence in their bioscience knowledge or that they felt at the bottom of the professional hierarchy. As explained earlier, interdisciplinary teamwork and learning helps professionals to understand each other's scope of practice (Laskowski-Jones, 2016; Peek & Campbell, 2020), which could help doctors to anticipate the nursing students' learning needs and tailor their teaching to them in a more effective manner. Nursing students have been seen to learn biosciences by tapping into the wealth of professional knowledge and experience from non-nurse professionals (Fell et al., 2016). Indeed, the CLE in Uganda is ideal for preregistration nursing students because of the many staff involved in the teaching of degree students (Drasiku et al., 2021). Bjørke and Haavie (2006) however cautioned clinical teachers outside of the nursing profession on the need to be conscious of the professional expectations and educational standards required of preregistration nursing students prior to teaching them. Awareness of the expected learning outcomes for student nurses would support the clinical teachers to appropriately facilitate learning sessions (Drasiku et al., 2021).

The respondents preferred to learn biosciences from nurses, in particular their own lecturers through nurse-led ward rounds. They preferred to present clinical cases under the supervision of competent and supportive nurse supervisors. For example, during wound dressing, they would conduct reverse rounds where nursing students would lead by presenting the clinical case and doing the wound dressing, defending clinical decisions, and

communicating the patients' needs to the team. Learning through case presentations has been reported to be effective in preparing nurses for advanced clinical roles such as nurse practitioners which have a greater need to learn case presentation although it is not routine within their training. The skills of case presentation are important because they support the learner to provide holistic care in a more autonomous way (Coralli, 2006). The RCP (2011) supports the learning in clinical practice using case presentations, encouraging students to identify interesting cases and presenting them to the clinical team or peers. It was one of the ways they recommended clinical teachers to explicitly support work-based learning.

In the era of task-shifting, learning, and applying biosciences using case presentations may support students in Uganda to retain and apply more advanced knowledge to meet the expectations of the expanded roles. This is because the student will be motivated to be well versed with the patients and work towards acquiring and demonstrating competence through defending clinical decisions when they present the cases before clinical experts and colleagues. This is the case in this study because as students progressed into more clinically intense years, they actively sought knowledge and informally formed discussion groups with colleagues to present clinical cases to each other and learn as a group. For example, final year students attested to working hard to ensure that they were ready to answer questions related to the patients' cases they were presenting.

This finding confirms earlier studies which claimed that nursing students can indeed construct their own learning in practice, despite unfavourable CLEs (Brammer, 2006). This study confirms that clinical teachers do not "hold the only key" to bioscience learning in practice (Allan et al., 2011; Brammer, 2006). Fell et al. (2016) supported this viewpoint, noting that final year nursing students in the UK became proactive in seeking bioscience learning opportunities in clinical practice, especially when their mentors appeared less eager or competent to teach. They looked for knowledge from other non-nurse professionals who were more willing and knowledgeable to teach biosciences. The innovative clinical learning strategy in this study may improve our understanding of the techniques nursing students use to learn and apply biosciences in clinical practice when they receive less support. It may be important in preparing future students for bioscience learning in practice (Allan et al., 2011).

The students' perceptions about the support they receive to learn and apply biosciences

Support in this context refers to any form of assistance given to the preregistration student through academic and/or clinical instruction, services, or resources to accelerate learning progress, achieve clinical competence standards and generally succeed in biosciences. Support in this discussion will be divided into two: support from the university and support from the hospital staff. Although there were a few times when students received adequate support to learn and apply bioscience to practice, the support they got was generally inadequate. First, the teachers appeared to be incognisant of the unique limitations that predisposed direct students to difficulties in leaning and applying bioscience knowledge. Indeed, as discussed in this report, these students were younger, with A-level science background and limited clinical experience. Mixing them was a deterrent to their learning because their learning needs were not met. Perhaps their teachers lacked adequate training on teaching skills and management of diverse groups of students. Indeed, the students confirmed that their bioscience teachers, the majority of whom were nurses, lacked formal teaching qualifications. They could have faced similar challenges in learning biosciences and were therefore not supportive because they were not well prepared to teach these courses in the first place. The nurse educators were viewed as good teachers of nursing courses but not biosciences.

The nurse educators were not competent in the biosciences, not well prepared to teach them, and therefore not confident. Studies report that students' attitudes to biosciences might be influenced by the nurse lecturers' confidence in teaching of biosciences (Bradley et al., 2006). This negatively impacts on learning (Davis, 2010) as in this study. This contributed to the perception that their nurse bioscience teachers were less supportive. This finding confirms earlier studies which reported a general lack of science qualification among nurse educators. It could also be a generational issue, with the older generation of RNs placing less value on biosciences. This is cited in literature as the reason why most bioscience teachers are not nursing professionals. This observation makes contextualization of bioscience to nursing practice difficult, contributing to low retention and application in practice.

In contrast, medical doctors were perceived as more supportive in learning in the classroom. Most had a postgraduate qualification in a medical discipline and were clinically active and experienced. They were more able to explain concepts to the required depth and most importantly, relate them to clinical practice problems. This was viewed as the most important quality for a good bioscience teacher (classroom). The students maintained that

they connected bioscience concepts when doctors taught biosciences. The doctors were perceived as more supportive owing to their own confidence in science and their skills in practice which they continuously integrated when applicable. Again, nursing students value teachers who integrate biosciences to clinical problems.

The students felt that the time dedicated to clinical placements was not enough to learn and apply biosciences and clinical skills. They compensated for this by looking for placement sites elsewhere over the holidays. The university was not supportive enough in this regard. In recognition of their limited clinical experience, they asked for more support from their university by creating protected time for additional clinical placements during recess term as a special arrangement for them. If protected time is made mandatory for this group of learners and charged on tuition, it will support them to improve their knowledge and skills on science.

Away from the classroom, there was limited visible collaboration between the university and clinical placement sites. The university was not visibly involved in their clinical learning, with some students alluding to disinterest on the part of the university on what was really going on with them on the placements. This was demonstrated through limited follow-up by university staff, assessment of their learning and advocating for their needs. They constantly asked for their lecturers to follow them up. They generally viewed the university as unsupportive of their clinical learning. The university should be visible on the wards to ensure that students achieve their learning objectives. The supervision model adopted by the university largely accounts for this perceived uninvolved attitude. The model disempowered the university in terms of determining the quality of teaching and learning what their students learn. Although CLEs are the most ideal contexts for connecting science theory to clinical practice (Fell et al., 2016), this process is not automatic. It requires quality and supportive contexts (Higgs et al., 2008). The model which limited the involvement of the university in the students' learning was perceived as unsupportive for their learning.

Access to learning opportunities is vital in the application of bioscience in clinical practice, given that learning is situated in the tasks students undertake. When nursing students enter the clinical practice environment, they try to gain access to the learning opportunities available. The CLE is often unfamiliar to inexperienced learners, and they quickly form relationships with individuals who can support them and familiarize them with this new context. The attempt by newcomers to enter and become part of the community of practice is what Lave and Wenger (1991) called peripheral participation, an integral part of the

engagement in the community of practice. This theory helps us to understand how student nurses gain access to the learning activities in clinical placements without being full members of the community of practice. The learning in practice is integral to the opportunities that learners can get to engage with the community. Learning is improvised practice, embedded within what the learners do, it is situated within the social constructs of the community of practice. This means that student nurses need legitimate peripheral participation to have opportunities to learn, which opportunities are afforded by the community members (Molesworth & Lewitt, 2016).

Being situated at the periphery means that students rely on nurses to grant them access to participate in the community activities. This means that nurses can block or provide learning opportunities. This power dynamic may present opportunities or difficulties. The more clinically experienced students had easier access than those direct from high school, a factor which affected their bioscience learning. Nursing staff had the power to block or provide bioscience learning opportunities to students (Molesworth & Lewitt, 2016). They acted as gatekeepers to learning (Brammer, 2006). In fact, the students in this study knew the power that nurses had on their ability to access learning opportunities as well as signing off their clinical practice record books which determined their academic progress. They responded by developing strategies to create an environment of respect for the staff to gain access to the practice opportunities.

Contributing to the work, working alongside the staff was important in granting them access to learning opportunities. The staff members wanted to teach students who were motivated to work and willing to assist them in their duties. This is similar to other studies where nurses were more inclined to teach students who were actively involved in clinical nursing duties (Atakro et al., 2019; Drasiku et al., 2021; Mulabiza, 2018). The students in this study were aware of this unwritten expectation in practice, a finding is similar to a study by Molesworth and Lewitt (2016) where students had to ‘appear motivated and enthusiastic’ to be seen as contributing enough to the wok. This demand is understandable in this context, given the large nurse to patient ratio. In addition, the students are expected to participate in the clinical work under supervision (Arkell & Bayliss-Pratt, 2007) because their clinical learning is tied to doing (Kolb, 2014). According to Spouse (1998), sponsorship is an essential element in learning in professional practice settings. In this case, the sponsor takes the student under their wing and grants them access to learning opportunities by partaking in the nursing roles.

The lack of designated supervisors in this setting meant that the students had to form informal relationships with potential sponsors, who were knowledgeable and approachable to support them to access the community of practice. They understood that their chances of learning from the nursing staff lay in their ability to contribute to the work. The success of this relationship appeared skewed towards the staff because the students largely felt that they contributed to the labour, yet they got little support to meet their bioscience learning needs. They instead forged relationships with consultants and intern doctors to access the bioscience learning that was largely lacking from their nursing sponsors. In addition, some sought the support of older more experienced peers to meet the expectations of their potential sponsors.

The limited clinical experience of the students meant that there were times when they failed to meet the expectation of the staff to provide labour. This conflict emanated from the differences in the expectations each held of the other. For example, students reported times when staff asked them to perform certain tasks unsupervised, which they sometimes declined to fulfil citing inexperience. The reasons for staff asking students to perform tasks unsupervised in this setting are not clear but they may be linked the increased workload created by the high patient to staff ratio and number of students they were expected to teach. It was also linked to a common perception by some staff who view nursing students as nurses instead of student nurses which may lead to unrealistic expectations of the roles of the students and clinical staff. It may also lead to involving students in strenuous work without teaching them (Chuan & Barnett, 2012). Similarly, mentors in a study by Allan et al. (2011) did not value students' participation as observers. They felt that the students' supernumerary[7] status did not prepare them to become competent until they actually worked as qualified nurses. The demands placed on students by staff impact on their learning (Molesworth & Lewitt, 2016), this pressure was usually linked to the amount of work expected from the students. Learning in practice can be distorted in some respects when students are expected to be heavily involved in exhaustive work (Lave & Wenger, 1991). Students in the current study found it difficult to manage the requirement to work and meeting their own learning objectives. Similar tensions have been reported in other contexts (Allan et al., 2011; Smith, 2012).

[7] The notion that nursing students should not be counted as part of the workforce, at least from a practical perspective, while on placement, and should not be asked to work as such. This means that students will not, as part of their program of preparation, be contracted by any person or body to provide nursing care.

One would wonder how students were able to learn despite such challenges. Studies suggest that undesirable learning experiences do not always decrease learning (Brammer, 2006), rather, some learning comes out of the negative learning experience. The students in this study were proactive, constructing their own learning opportunities and as Brammer (2006) and Allan et al. (2011) noted, mentors are not the only source of learning in practice. They used other strategies to search for opportunities and achieve learning in clinical practice, even in incidences when nursing staff may gatekeep and not facilitate their access to the learning opportunities. Understanding these strategies is key in preparing students for clinical placements (Allan et al., 2011).

This study shows that clinical supervision was limited in part by the heavy workload on the nurses in addition to the teaching, a similar finding to earlier studies in Uganda (Drasiku et al., 2021; Museene, 2018). Another study established that indeed clinical supervisors in Uganda were overloaded with many roles and many students to teach (Birungi, 2011). The increased workload limited their ability to follow up students, which may explain why the students felt largely unsupported to learn in the CLE. Regrettably, qualified nurses may have few opportunities to formally learn biosciences after graduation. There is limited formal support to develop bioscience knowledge after graduation meaning that the preregistration period is the biggest opportunity to develop the founding blocks for future practice. Continuous Professional Developments (CPDs), for example usually target specific concepts and have limited clinical practical components. If changes are not made within nursing curricula, the lack of biosciences among nurses will be perpetuated and senior nurses will lack sufficient bioscience knowledge to apply in practice and pass on to the coming generation.

This study shows that HEIs and nurse faculty members have limited involvement in the clinical teaching of their students. This finding is confirmed in other studies in other contexts. There has been diminishing involvement of nurse faculty in the clinical preparation of their students over the years (Immonen et al., 2019). The role of the nurse educator in the clinical preparation of nursing students has continuously diminished despite evidence that they are more familiar with their students' stage of learning and therefore can better tailor clinical teaching and assessments to the students' needs (Calpin-Davies, 2001; Ekstedt et al., 2019). This observation is in keeping with the findings of the present study where students described their nurse educators as "knowing their strengths and weaknesses better" and will better support their learning in clinical settings.

Indeed, nursing students and clinical mentors have increasingly called for more involvement of nurse faculty members in clinical teaching in Uganda (Drasiku et al., 2021; Mulabiza, 2018) and elsewhere (Atakro et al., 2019; Immonen et al., 2019). Given their pedagogical preparation and competencies, nurse educators are in a better position to contribute to solving challenging situations faced by students (Arkan et al., 2018; Mikkonen et al., 2017; Pitkänen et al., 2018). They can better explain unclear issues to the learners and mentors (Juntunen et al., 2016). The limited involvement of nurse educators in this study is related to time constraints, a lack of confidence due to lacking updated and adequate bioscience knowledge and skills (Atakro et al., 2019; Drasiku et al., 2021), and a lack of clinical teaching skills (McVicar et al., 2015; Taylor et al., 2015), and the model of clinical supervision.

Factors Affecting the Application of Bioscience Knowledge in Clinical Practice

The CLE is the ideal context available in nursing education to optimize nursification of biosciences during learning (Fell et al., 2016). The factors that affected the application of biosciences in the current study were an aggregation of what happens in the classroom and clinical context. Application of biosciences in clinical practice was linked to what happened in academic contexts given that it is where learners first interacted with bioscience content. Theory was important in practice and vice versa (Molesworth & Lewitt, 2016). For example, introducing clinical examples in their classroom learning was important in understanding bioscience theory and students valued teachers who used clinical examples in theory learning (Al-Modhefer & Roe, 2009). Equally, learning in practice was more effective when theory was reviewed (Davhana-Maselesele et al., 2001; Kyriacos et al., 2005). This study has identified the factors that affected the application of biosciences in clinical practice among nursing students. These were tied to clinical supervision, the quality of teaching and teachers' attributes, the culture of the workplace, student factors, assessment, and feedback.

Clinical supervision supports students to become competent and confident professionals (Kilminster et al., 2007). Clinical supervisors would support students to make appropriate clinical decisions (Fell et al., 2016), provide a space for reflection and emotional support, professional development, compliance with professional expectations and practice. They provide opportunities, support, guidance, and feedback (Kilminster et al., 2007). It is an important element of learning in the clinical setting that supports students to integrate theory to practice. The model of clinical supervision and the quality of the supervisors were the most

important factors in the application of bioscience in clinical practice because they affected what and how students learned in practice.

In this context, each HEI had a bilateral agreement with the hospital, usually in the form of a Memorandum of Understanding, which stipulates the terms of their relationship. The university may choose to pay fees to the hospital which then identifies competent staff to supervise their students. The fees paid to the hospital may cover supervision in addition to sundries and equipment. Although literature on clinical supervision models currently in use in Uganda is limited, the facilitation/preceptor model is the most common model of clinical supervision in Uganda. The faculty member assigns a group of learners to nurses (supervisors) (Habimana et al., 2016). The nurses are responsible for the teaching of the students. This model has been documented to be effective because students felt supported by the preceptors (Kristofferzon et al., 2013). Choosing this arrangement means that the university delegates the clinical teaching and supervision of their students to the hospital, relying on it for 50% of the learning required for their students. Such a model is cheaper, and no additional clinical staff are employed by either party to do the same work. It however means that a supervisor who already has a full-time job has an added role of clinical supervision of students which may create a conflict between these roles (RCP, 2012). Indeed, this conflict has been documented to result in devaluation of clinical teaching in favour of routine clinical roles.

Alternatively, the HEI could use a facilitation/supervision model, where the clinical supervisors are university employed faculty. The faculty member directly supervises a group of students and ensures that the students achieve the learning objectives, including formative and summative assessments (Kristofferzon et al., 2013). In this case, the clinical supervisor is accountable to the university. Although we have a limited evidence of the effectiveness of this model in the Ugandan setting, it has been suggested to be the most effective model in Rwanda, a similar context to Uganda (Habimana et al., 2016).

The respondents in this study favoured this model because first, the teaching and other supervision roles would be lifted off the shoulders of the already busy clinical staff to faculty who are employed exclusively for clinical supervision. The faculty members who are trained in clinical teaching and have advanced nursing degrees would teach the students in clinical practice. This means that the clinical supervisor would understand the learning needs of the students since they would be RN prepared faculty. RN prepared clinical supervisors would understand the scope of practice expected of RNs and aim their teaching to meet the task-

shifted learning outcomes, unlike a lower-level nurse who has limited awareness and experience of this. This model guarantees that the students always have a faculty member present in the clinical area. The university would have more control over how their students learn and the quality of the teaching that they get, in contrast to the facilitator/preceptor model, where control is delegated to the hospital staff, who may have limited bioscience knowledge to teach the students at this level.

The clinical supervision model currently in use in this context and the limited involvement of the nurse faculty members raises questions as to whether the clinical staff tasked with clinical teaching by the hospital had the adequate skills to undertake teaching roles in the first place. A previous study in Uganda showed that that the nurses' perceived readiness for clinical teaching of preregistration students was tied to their clinical experience and prior teaching of certificate and diploma level students. They were not RNs themselves and had limited competencies to facilitate degree level learning beyond the procedural skills (Drasiku et al., 2021). Importantly, they had no formal training in clinical teaching. According Mkony et al. (2012), a lack of formal training in clinical teaching reduces the value that clinical experience brings to learning in practice and adversely affects the quality of learning for preregistration nursing students. This study shows that most of the nursing staff in this context had limited knowledge and skills to effectively supervise nursing degree students. This means that currently, most HEIs in Uganda have delegated 50% of the teaching of their students to clinical staff who have not been trained and are not competent to teach students at the nursing degree level.

Availability of dedicated clinical supervisors would support students to negotiate the hurdles within the clinical workplace and sponsor their entry into the community of practice. In addition, the supervisor would identify the students' learning needs and direct them to the required learning opportunities. Clinical supervision would also eliminate the risks related to students performing nursing procedures without supervision. In this context, learners were generally left unsupervised. The CLE in this context was highly deficient of bioscience teaching and learning because of the low levels of biosciences among staff nurses. This lack of connection of bioscience theory and clinical practice was tied to the lack of clinical supervisors who were competent in biosciences and clinical teaching. The supervision gap invariably sidelined bioscience teaching and management in nursing practice in favor of medical management. For example, the students reported not using nursing care plans in their routine clinical practice. This may limit the ability of the students to obtain the required

nursing competences. This finding confirms earlier research on the use of nursing care plans by nursing students while on clinical placements Atakro et al. (2019)

The lack of clinical supervision is critical, given that clinical learning is largely experiential. It was not uncommon to find students on their own with patients. Similar reports have been reported in other low resource settings such as Malawi (Msiska et al., 2014). Studies have explained that the limited supervision of undergraduate nursing students in low resource settings is associated with several reasons:

First, there is a limited pool of RN prepared nurses working in teaching hospitals where these students learn. Uganda and other low resource contexts have a severe shortage of RN prepared nurse educators (Atakro et al., 2019; Bvumbwe & Mtshali, 2018; Phillips et al., 2019), and the those available were either working in HEIs and research organizations leaving the few overworked RNs in practice to rely on non-degree prepared nurses to teach and supervise degree nursing students (Nyoni & Barnard, 2016; Omer et al., 2016). Most of the nurses tasked with supervising degree students only held certificates and diplomas in general nursing (Atakro et al., 2019; Msiska et al., 2014; WHO, 2020). The participants in this study concurred, noting that degree prepared nurses in their clinical placement hospital were few and were often too busy undertaking management roles to teach and supervise them. The nurses prepared below degree level are not well prepared to teach and supervise preregistration nursing students, who are working towards a higher qualification (Drasiku et al., 2021). The nurses in this context were not confident to teach bioscience concepts and support students. They instead side-lined them in favour of procedural skills, further devaluing biosciences. It is recommended that facilitators of university-based degree programs are prepared at higher qualifications than the qualification of the students they are preparing (Thompson et al., 2011; WHO, 2020).

In addition to procedural skills expected of all nurses, RNs are expected to demonstrate a transfer of learning to the clinical environment through application of all relevant bioscience aspects related to patient care (Y Botma, 2014). Non-degree nurses are often competent in procedural skills but may not be able to integrate the bioscience and non-bioscience knowledge to clinical reasoning expected at the degree level. This is because their own bioscience preparation is lower than the RN level (WHO, 2020). This invariably means that non-degree prepared nurses are in fact not educationally prepared and skilled to support learning expected at the RN level (Drasiku et al., 2021).

Unlike the nurses who largely devalued biosciences and were not confident to teach them, the doctors were largely knowledgeable and willing to take on the teaching role in practice. The students acknowledged that and looked to the doctors for their bioscience learning and nurses for procedural skills learning. Availability of knowledgeable, willing, and approachable teachers was important in the application of biosciences in practice. They however got a bit of their learning from the nurses and the other bits from doctors. This fragmented their learning and capacity to apply bioscience theory in clinical practice because their bioscience learning was contextually removed from the nursing roles.

As already noted, teaching of biosciences in practice is less organised and formal. There was no protected time for learning due to the limited time staff had to work and teach. These reasons may explain why they pleaded for protected time to carry out nurse-led bioscience learning in the CLE. This was similar to what Molesworth and Lewitt (2016) found where nursing students felt that bioscience specific clinical teaching would enhance their transfer of biosciences. Setting aside protected time to teach specific bioscience related content on placements would give them the opportunity to integrate their theory and apply it to patients.

A CLE which values biosciences and is seen to actively use it to make clinical decisions is important in application of bioscience. Medical doctors in this study valued and actively used of biosciences, which explains why the students looked up to them for most of their science instruction in academic and clinical contexts. Active application of science in procedural skills and other nursing roles was important in their learning. This supports why participants reported that applying biosciences in practice would be easier when the skills teaching was integrated with biosciences. Bioscience knowledge forms the foundation of procedural skills as pointed out by the participants in this study (Montayre et al., 2021). This means that RNs need the biosciences first to understand the procedural skills in terms of how to and why they are performed.

Secondly, biosciences most importantly support the nurse to interpret and act on the findings from the procedural skills and clinical assessments. According to Taylor et al. (2016), a solid bioscience foundation underpins critical thinking which in turn affects clinical decision making in nursing practice (McVicar et al., 2014). This means that CLEs that focus teaching on learning and perfecting procedural skills without explicitly underpinning that teaching on biosciences would be detrimental to critical thinking and decision-making.

Teaching clinical skills together with biosciences would make the linkage more apparent and possibly have this practice replicated through their future decision making during routine nursing care.

Situating learning in authentic clinical contexts was vital in supporting application of biosciences in practice. This is one of the factors which made ward rounds a more effective teaching method than the lecture method. Learning this way is more effective and more motivating because students are more involved in their learning (RCP & RCN, 2021) and learning happens in an authentic context where students can readily see how knowledge is actively used to make clinical decisions. In this case, leaners learn by observing, doing, and getting valuable feedback in a timely manner in authentic contexts.

This ties in with assessment because practical assessments were predominantly integrated and mainly took place in actual or simulated CLEs. For example, a student presenting a patient's case was expected, among other things, to explain the bioscience underlying complaint and explain the signs and symptoms, the pharmacological interventions and possible drug interactions. The learners were expected to demonstrate an understanding, integration of bioscience concepts, and clinical reasoning in clinical practice. In this context, assessment was mainly in four forms: written, oral, practical (OSPE/OSCE), and clinical assessments.

Understanding assessment in the context in which it happens is important in interpreting the behaviour and patterns within the given context. The education system in Uganda has been described as highly didactic (Sunal & Mutua, 2013) and exam dominated (Penny et al., 2008). Odama (2018) described it as "linear, highly centralized and reinforced by examinations set by a foreign body". Education success in Uganda is mostly measured by examination results, and formative assessments do not generally contribute to the final scores. The teaching largely aims towards passing exams and school administrations motivate teachers to help students to pass examinations, largely ignoring other areas of development (Odama, 2018). Allen et al. (2016) made similar observations adding that little importance is given to matters not closely linked to examinations. As a result, most of the assessments are not aligned with the strategic needs in practice. This attitude permeates into higher education, given that the students who enrolled on nursing degrees got their initial education and are admitted on merit of the examination results from the same system. It is therefore not surprising that the students in the present study voiced their concern that the teaching and

assessment in their program appeared to be more oriented toward scores rather than acquiring the required competences.

During assessment, assessors evaluate learners' communication skills, professional development, application of the nursing process, principles of health education and promotion, psychomotor skills and their scientific rationale (Khan et al., 2015). Alignment of teaching, learning, and assessment is vital in achieving the learning outcomes consistent with professional nursing practice (Brown et al., 2008). The common methods to assess bioscience learning include MCQs (Taylor et al., 2015), OSCE, clinical simulations (Logan & Angel, 2014; McVicar, 2009; Smales, 2010), case studies (Logan & Angel, 2011, 2014), and work-based assessments (Liu, 2012; Norcini & Burch, 2007; Robbins et al., 2018). Each method is varied in the level of bioscience learning objectives, with some assessing higher cognitive functions such as synthesis, application, and interpretation.

In this context, the lecturers' participation in the students' clinical learning was limited yet the students viewed their presence as an opportunity for them to meet and interact with them in practice settings. They referred to assessment as the only real mentoring opportunity. The reasons for this were not clear from this study but they may be linked to the limited contact students had with their lecturers while on clinical placements. Indeed, assessments are learning opportunities in practice. For example, medical education recognizes that learning and assessment are intimately connected, with increased recognition that learning is indeed the key objective of assessments (Norcini & Burch, 2007). Bioscience learning literature indicates that the type of assessment strategy used supports learning (Meehan-Andrews, 2009; Taylor et al., 2015). For this reason, nurse education and medical education are generally moving towards more active assessment methods since learning is an active learning process (Clouder et al., 2013) and students find bioscience are more understandable when active learning principles are used and the learning is contextualized to clinical practice (Fell & James, 2012).

A debate however is ongoing as to how nurse education can focus assessment and ultimately use it to bridge the theory practice gap (Bakon et al., 2016; McVicar et al., 2015). Some argue that aligning newer and more active methods may promote learning in assessment. For example, it can be used to achieve long-term learning (Boud & Falchikov, 2007). Importantly, assessment should take place in a context where the student practices actual work and therefore clinical practice should be an integral part of the assessment

context in nursing (Boud & Falchikov, 2007). Assessment is therefore more effective as a learning tool and a reflection of actual practice when what is assessed is in a work-based context rather than under test conditions (Liu, 2012). This clarifies why the students emphasised that their assessments should be at the patients' bedside rather than in a side office, away from the clinical context as it was commonly the case.

This study shows that assessment is indeed an extension of learning, with students viewing it as a valuable opportunity to check their own learning as well as to use the feedback to develop and achieve long-term learning goals. They valued assessment and feedback as important exercises, central to their learning and improvement, especially in practice. Bioscience assessment can indeed support learning (Meehan-Andrews, 2009), and should be viewed as such (McVicar et al., 2015). It is therefore important that nurse education considers bioscience assessment and feedback as vital in the learning and attainment of bioscience competence. It should be an integral rather than an isolated part of learning and be situated in authentic clinical contexts.

The student's ability to prepare for assessments in this context was affected by lecturer absenteeism. The participants stressed that their revision weeks were often taken up by unofficial last-minute teaching. Some lecturers did not turn-up for scheduled lectures and instead opted to send notes. Towards examinations, they tried to make up for the lost time by continuing to teach during the revision weeks. Within this context, absenteeism was not limited to bioscience lecturers. Teachers' absenteeism in Uganda is common. According to UNICEF (2018), more than 60% of teachers were absent in half of the public schools. The World Bank estimate was that 47.7% of the teachers in public schools at any point in time were not teaching (Wane & Martin, 2013).

Research evidence on lecturer absenteeism in Uganda is limited but some newspapers have suggested that it is rampant. For example, the Daily Monitor (2018) reported that although lecturers were scheduled to teach at least three times each week, many of them opted to teach once instead. This was most common among lecturers who were on permanent tenures in public universities. They often travelled upcountry for private business or complementary consultancy work or part time teaching in private universities. It is possible that the absenteeism in this context was due to similar reasons although this was beyond the scope of this study. When the revision weeks are taken up by lectures, students are not able to adequately prepare for assessments.

According to Molesworth and Lewitt (2016), just like other courses, bioscience assessments ought to be continuous from teaching to final assessments. This highlights the importance of formative assessment, which was largely limited in this setting, especially one with explicit bioscience elements. Ongoing bioscience assessments were necessary to for more explicit and integrated bioscience learning in practice. Compared to the classroom context, research that specifically focuses on bioscience learning and assessment in clinical contexts is still limited (Logan & Angel, 2011; McVicar et al., 2010) despite the fact that students spend at least 50% of their learning time in the clinical area (Fell et al., 2016). In addition, conventional bioscience teaching places greater responsibility on supporting bioscience application to the practice settings (Friedel & Treagust, 2005), which as this study shows is not adequately prepared to teach and support application of biosciences in practice. Continuous bioscience assessments throughout the program reduces the chance of learning content solely for exams. It increases the development of bioscience competences throughout the program because previously learned content is continuously reflected upon, cumulatively applied, and assessed along the way (Taylor et al., 2015).

Clinical assessments in this context were significantly lacking in bioscience aspects due to the limited involvement of bioscience teachers and decontextualizing clinical assessments, as well as limited time available to assess each candidate. Most of the bioscience teachers were doctors but only nurses carried out clinical assessments. Clinical assessors were nurse lecturers who were ill prepared to assess bioscience aspects owing to their own limited bioscience knowledge (Taylor et al., 2015). Involving the lecturers that are knowledgeable in biosciences in developing the assessment criteria alongside nursing lecturers is important in ensuring that bioscience specific criteria are included in clinical assessments (Taylor et al., 2015). They would also ask relevant questions and give students valuable feedback.

Within this study, although clinical assessments were in the hospital, they were decontextualized from the patient. The practice of assessing clinical competence away from the authentic context defeats the reasons for undertaking clinical assessment. The reasons for this practice were unclear in this context. What was evident in this context is that it reduced clinical assessments to written text in the students' report and ignored the most important aspect which is demonstrating clinical competencies. The students found hands-on assessments more valuable in demonstrating competence and explaining their scientific rationale for their interventions, and application of science in practice. They expressed their

fear of graduating with limited competences and experience, with some questioning their choice of having a clinical nursing career upon graduation.

If experiential learning in clinical practice is by doing, then assessment should be aligned in the same respect: doing. This is because assessment of clinical application, decision-making, linking of bioscience knowledge, and integration of clinical skills to clinical practice can only be assessed effectively through observing clinical practice (Wu et al., 2015). The goal of clinical assessment is to evaluate clinical competence, which is best done in clinical practice (Immonen et al., 2019), at the bedside. The student can also be assessed on communication, critical thinking, decision making, and assessors would have the chance to validate the students' findings and institute corrective measures in real time. These cannot effectively be assessed using a writeup. Mattison et al. (2020) added that assessment of competence should be based on what the candidate can do practically, with Liu (2012) adding that assessment of actual practice, what the trainee is doing, is a better reflection of what the student can do in practice. It is therefore surprising that this context rich with bioscience opportunities and patients who were generally willing to participate would still have clinical assessments away from the bedside.

According to Norcini and Burch (2007), direct observation of the interaction between the trainee and patient provides the best context for assessment of clinical skills, critical thinking, and application of theory to practice and more importantly giving of feedback. Without observation of that clinical encounter, the assessor cannot be sure that the student is competent (Liu, 2012). It would also affect the quality of feedback given because feedback depends on how close the students' actual practice is to the desired learning outcomes. In this study, the ability of the assessor to directly observe and assess learning on the bedside was important to the students but was generally lacking. Directly observing practice during assessment supports assessors to be more accurate in their feedback and motivates the students to identify learning gaps and improve future practice. In addition, it would encourage them to embed bioscience concepts in their clinical practice because it would be expected by the assessor. Validating a learner's ability to directly apply bioscience knowledge through validation of findings is motivating to nursing students (Fell et al., 2016; Montayre et al., 2021) and supports them to make more explicit links to practice. Limited contact of assessors with the patients was not only detrimental to their learning but also very demoralizing given that they spent long hours preparing for these assessments.

Feedback after assessment was generally limited in this context. When the feedback was given, it was neither comprehensive nor specific to the individual learners. At times, it was not delivered professionally or constructively, which embarrassed the candidates before colleagues. The reasons for these observations were not clear but they appear to be associated with time constraints, lack of professionalism, the deconstruction of assessments from authentic practical contexts, meaning that the feedback given would not be a true reflection of what the student did but rather what they said they did. In addition, the assessors lacked training on pedagogy and clinical assessment methods for nursing students. The other reason students attributed to the lack of feedback was that their assessors appeared to lack knowledge and confidence in the biosciences. Clearly, the students used assessment and feedback to improve future practice, have something to go work on. They clearly stated that the scores they obtained were not a true reflection of their competence. They were concerned that they would graduate with high scores but suboptimal knowledge and competences and may not be able to meet their patients' needs in the future. Assessment and feedback are powerful ways that educators can support learners to learn and apply bioscience in clinical practice (Norcini & Burch, 2007) and providing quality, timely, and consistent feedback is integral to the learning process and should be apportioned appropriate time, resources, and faculty training.

This chapter discussed the findings and their implications on the learning and application of bioscience concepts such as antibiotics resistance. It shows that the level of knowledge on antibiotics resistance among nursing students is low and consequently they are not able to apply it in clinical practice. This is worrying, given that task-shifting has placed greater demand for science on the RN to achieve the new expectations. The factors which affect retention and application of science knowledge in clinical practice are embedded in the curriculum and teaching approaches, culture of the CLE, clinical supervision, assessment, and feedback methods. Intrinsic factors such as age-group, clinical experience and preparation for higher education were associated with success in retaining and applying ABR knowledge in practice. Although lectures are predominantly used to teach in academic settings, they do not adequately support learning and application of biosciences. Ward rounds on the other hand were the most effective teaching approach in delivering bioscience knowledge in practice. Ward rounds contextualized learning and supported students to link theory to practice. Although there was limited support and clinical supervision, the learners forged informal relationships with staff and colleagues to achieve learning goals.

CHAPTER 7: Conclusions

Chapter seven will reflect on the Nursing Now campaign to forecast what the future of the RN should be considering the findings discussed in the previous chapter. I will make several recommendations generally and specifically from the findings of this project. The previous chapter has demonstrated that students currently have limited knowledge on ABR, and their stewardship practices are below the expected standard, yet they are exiting higher education and entering practice. Implementation of the bioscience curriculum is loosely linked to practice and students currently receive limited support to learn. RNs in Uganda may not effectively play their part in AMS programs yet the healthcare workplace is becoming more complex, with increased financial challenges, inequalities, more technological advances among others (McKinnon & Fitzpatrick, 2017). Nurse education should adjust to the changing demographics and health needs of the population served and this should be reflected in their educational preparation. Nurses are working more autonomously, and their roles are expanding from the traditional roles to newer roles that demand for more bioscience application (Perkins, 2019), yet this is not reflected in curricula and teaching as the present study shows.

The Nursing Now campaign, inaugurated in 2018, recognizes and seeks to uplift the status of nursing globally. It aims to empower nurses to make a greater contribution to the improvement of health globally in the 21st century (Crisp & Iro, 2018). They urge governments to strengthen the educational preparation of nurses to enable them to take on wider roles as leaders and specialists. The Nursing Now Campaign recommends key actions for nurse education. They urge nursing education bodies to promote nursing as a scientific profession which relies on science to solve complex health challenges for their clients, families, and communities (Holloway et al., 2021). This clearly points to the increased need for bioscience application in clinical practice.

Uganda is among the countries that subscribed to the ideals of the campaign to raise the status of nursing, even before the Nursing Now campaign was inaugurated. The intention was that as the status and educational preparation of the nursing workforce in Uganda improves, healthcare outcomes will follow (Aiken et al., 2014). Indeed, literature has linked RN level training to better quality nursing and patient outcomes (Grobler et al., 2016). Currently, Uganda's nursing workforce hierarchy starts from the enrolled nursing (certificate nursing), Diploma nursing, Bachelor of Nursing (RN) and Master of Nursing (Katungi et al.,

2016). Certificate nurses are the majority cadre of nurses in Uganda, comprising between 68% (Katungi et al., 2016) to 70% of the nursing workforce (Nanyonga et al., 2020). This implies that the healthcare system in Uganda heavily relies on enrolled nurses to deliver healthcare, yet these nurses have limited capacity to deliver quality evidence-based care and meaningfully contribute to health reforms (Nanyonga et al., 2020).

Uganda's goal, however, is to improve the educational preparation of nurses in line with the regional and international standards, a decision supported by several stakeholders (Brownie et al., 2016). For example, the East African Community tasked member countries to phase out the certificate nursing training and harmonize training across the region (EAC, 2014). Other countries such as South Africa now focus on training 20% of its nursing workforce at the degree level. Malawi, Mozambique, and Kenya have made similar shifts although none of them plan to phase out the lower cadres (Grobler et al., 2016).

A working paper on the feasibility of phasing out the certificate nurse cadre undertaken by Dr. Suzanne Kiwanuka investigated the implications of this decision on the overall goals of Uganda's health system. Uganda's strategic agenda is to achieve universal coverage and mostly relies on nurses to serve its population. There is a clear need and benefits to phasing out the certificate education, but the decision has its ramifications. Phasing out the certificate program means that Uganda will harmonize its nurse training, policies, and clinical practice with the rest of the region. It will also professionalize nursing and improve the quality of nursing practice (Abedi et al., 2019). Businesswise, training institutions are likely to increase revenue since a considerable proportion of the workforce (certificate nurses) will scramble to upgrade to meet the new minimum requirement. Ultimately, this will raise the status of nursing in line with the Nursing Now Campaign.

On the downside, the government of Uganda does not have the funds to support this big workforce to upgrade in time for the planned phasing out exercise. On the policy implementation level, Uganda's public service is not ready to attract, utilize, and retain RNs in sufficient numbers and as such, RNs are getting less attracted to the public sector. In practice, there is disharmony between RN prepared and non-RN prepared nurses and that RNs felt undervalued (Abedi et al., 2019). There is a lack of differentiation in job description and salary between the RNs and non-RNs. Many nurses who upgraded to the RN qualifications continue to be paid way below their new level (Abedi et al., 2019; Amandu et al., 2013) due to limited funding. These factors have contributed to resistance by non-RNs to

upgrade to the RN qualifications in addition to job insecurity that would come with taking time off to attain the degree. Preregistration nursing students and nurse faculty members feel that the clinical context in Uganda does not currently support their roles because compared to the level of robust educational preparation of RN nurses, the realities in clinical practice make incorporation of the RNs difficult. For example, many RNs in the public sector lacked logistics which limited their ability to undertake their roles effectively (Abedi et al., 2019). Phasing out the cadre that is the backbone of the health system without adequately funding them to upgrade and attracting, utilizing, and retaining the better alternative would do more harm than good.

Phasing out certificate education may disrupt the strides already attained in universal coverage since the health system heavily relies on this cadre to provide healthcare. Currently, RNs make up to only 2% of the entire nursing workforce in Uganda, the majority of whom work outside clinical settings (Nanyonga et al., 2020). In addition, there are underlying staff shortages, particularly in rural areas where enrolled nurses mainly work. Phasing them out would therefore cause more shortages for most of the population at least in the short term because most Ugandans live in rural areas.

Relatedly, phasing out certificate programs and training nurses at higher levels would incur costs in terms of money and time. For example, upgrading would cost the student or sponsor tuition, amenities, and transport. The majority of the HEIs with programs where nurses can upgrade are in urban areas, yet most of their potential students work in rural areas. They would incur transport and accommodation costs, time, and risks related to the weekly transit if they enrolled on a work-study program. If they opt for full-time study, then they must leave their jobs, losing a steady income they need to sustain them. In addition, there would be disruptions in the healthcare service delivery when nurses leave their workplaces to upgrade. The government is still struggling to pay its existing nurses who have upgraded, and this may be exacerbated when the majority upgrade. This means that the public sector may fail to attract and retain them which will either attract them to the private sector or they may seek to work abroad.

Despite this, UNMC is currently encouraging certificate nurses to upgrade following a decision to phase out the certificate cadre. It was envisaged that by 2025, the minimum education entry level for nurses would be a diploma in Nursing. This is likely to shift the nursing profession in Uganda (Abedi et al., 2019). Uganda will produce nurses educated at a

higher scientific and non-science aptitude, able to transfer learning in practice by demonstrating critical thinking, clinical judgment, and application of scientific rationale to their patients (Botha et al., 2014; Drasiku et al., 2021). The goal to phase out certificate nurse training may not be achieved by 2025 given the ongoing debate and effects of the COVID-19 pandemic on the economic and health systems.

Based on the above discussion, this study recommends holding off the phasing out of the certificate programs and first strengthen the RN degree. Given that there are few studies examining the educational preparation of RNs in Uganda, our knowledge of the effectiveness of the RN degree is still limited. Phasing out the certificate without concurrent efforts to research, understand and strengthen RN training to meet the current needs of the population will negatively impact on the healthcare system. As already pointed out, biosciences are important in supporting nurses to work more competently, yet this study clearly shows that the educational preparation of RNs in Uganda and to some extent diploma nurses is still insufficient. This study therefore recommends that the certificate programs be protected for the foreseeable future to sustain the healthcare provision. They should however encourage them to upgrade as the government sorts out the prevailing challenges.

The diploma and certificate nurses should be encouraged to upgrade because nursing students who already have a diploma significantly retain and apply knowledge on ABR and stewardship in practice better than their A-level enrolled counterparts. They are also better prepared to learn in higher education. Universities should embrace a work-study program for the students upgrading to the degree and diploma programs such that they are not taken away from their clinical roles. This would inadvertently improve their learning because as this study indicates, nursing students who were also actively employed in the profession were better at retaining and applying bioscience knowledge. Holding off the phasing out of the certificate programs or phasing them out more slowly would give nursing researchers and educators time to study and improve the training of preregistration students while also giving the public service time to adjust to this new cadre of nurses.

Considering the findings of this study, I make the following recommendations:

(i) Decongest nursing curricula and strengthen learning of the most essential bioscience content.

Rather than adding more bioscience content to nursing curricula as it was recommended in the studies undertaken in the UK, Australia, and New Zealand, this study recommends cutting back on the content. Stakeholders should determine which content is essential and good to know for RNs. Cutting back on the content will not only decongest curricula, but also allow more time to be dedicated to reinforcing the essential bioscience content. It will reduce some of the difficulties associated with a crowded curriculum.

(ii) Nursification of the bioscience portion of the nursing curriculum.

Currently, the bioscience portion of the curriculum relies on the medical model. The content is not explicitly linked to clinical nursing practice which explains why the students found linking the bioscience theory to practice difficult. Teaching was distanced from nursing and more skewed to medicine. Probably there were few RNs at the time of the curriculum design, and the medical discipline had a substantial input. It is time for nursing education, in conjunction with other stakeholders, to review the RN curriculum and align it with the competences required in clinical nursing practice of the 21st century. This would include prevailing local and global health aspects such as AMR, AMS and more recently COVID-19.

The delivery of the curriculum should reflect the reforms in higher education which advocate for competence-based methods (Frenk et al., 2010). In this case, teaching should aim to improve clinical competence through explicitly linking and applying bioscience theory in nursing practice. The lecture method decontextualized teaching yet educators expected students, who had limited clinical experience, to link them to practice on their own. Using relevant clinical examples in the classroom and recapping theory in practice teaching increase contextualization of biosciences to practice. Teaching at the patient's bedside ensures that learning happens in an authentic clinical context. For example, medical rounds were beneficial in linking theory to practice in part because they were embedded in the clinical context. Nursification could also be achieved by spreading the bioscience teaching along the nursing program, teaching these courses well into the later semesters. They should also be taught close to when students start clinical placements to ease recall and encourage the teachers to embed more science in their other courses. The science courses should be better

integrated, embedded in other non-science courses where possible and explicitly connected to clinical practice.

Bioscience content should explicitly be embedded in all clinical assessments. For example, this could be through ensuring that the assessment criteria explicitly require the candidate to understand and apply bioscience knowledge to practice. Involving bioscience teachers in assessments would have a considerable contribution improve the quality of assessments and feedback given to students. Bioscience teaching and assessments of biosciences should be aligned first to the overall learning objectives and to each other. Aligning teaching to assessments would mean that assessments are performed in a more authentic clinical context, at the bedside. Since learning in clinical practice predominantly occurs at the bedside, assessments should be in the same context. As shown in this study, assessing students in authentic clinical contexts would increase their motivation to actively seek knowledge to support the demonstration of their clinical competencies. In addition, just as theoretical bioscience assessments are prioritized, bioscience clinical assessments should be planned and implemented in a timely manner. The HEIs should put measures in place to reduce teacher and assessor absenteeism which contributed to the limited time for preparation for assessments and the time spent on assessment and feedback.

(iii) HEIs should adopt a supervisor model of clinical supervision.

This study recommends changing the model of clinical supervision from the preceptor to the supervisor model. Clearly the nurses in the CLE are overloaded, not well prepared, and confident to teach biosciences. The doctors on the other hand are teaching well, but the teaching has limited nursification. The supervision model will ensure that universities take charge of the learning of their students in clinical practice because they will employ, train, and develop competent RNs to undertake clinical supervision. It would not take away the contribution of the hospitals but increase the involvement of the universities in the training of their learners. As shown in this study and elsewhere, the clinical context is the most important place in which students integrate biosciences to clinical practice. Managing what happens in this context would give universities greater control of their students' learning. Employing and developing RN prepared clinical faculty would ensure that the supervisors are accountable to the HEIs. The students would also be more accountable to their supervisors thereby ensuring that they learn under supervision.

In addition, this model would protect the students and patients from the adverse consequences related to medical errors and would have a university link within the CLE. This model will also importantly increase explicit bioscience learning such that bioscience knowledge is used to inform practice instead of being sidelined. The students would no longer feel alone, abandoned, and unsupported to learn. The supervisor would identify learning opportunities in the CLE and support students to achieve competences acting as the sponsor into the community of practice. Competent RN prepared clinical supervisors will ensure that the students' learning is paced and assessed in a timely manner. They will ensure that students have protected learning sessions where they can apply bioscience knowledge instead of pulling them away from their learning to engage in laborious work as is commonly the case.

(iv) Ward rounds should form a significant proportion of the teaching in clinical practice

As noted earlier, nursing staff can take a leading role in conducting ward rounds in the modern workplace. Senior nursing professionals can undertake "independent ward rounds" acting as "senior decision-makers across a range of pathways"(RCP & RCN, 2021, p. 14). In addition, ward rounds are key learning platforms in clinical practice. As demonstrated in this study, ward rounds are currently the single most important learning opportunity for learning and applying biosciences in clinical practice. Students should be encouraged to actively participate and be more involved in ward rounds, as part of the nursing team among the multidisciplinary team. Active participation will encourage them to engage more with bioscience content in authentic contexts, apply bioscience knowledge in their clinical decisions under supervision. Ward rounds will encourage them to explicitly bring science to the forefront by gathering relevant information in their clinical practice. Case presentations during ward rounds will support students to defend their clinical decisions, build soft skills, work better and more confidently as part of a multidisciplinary team in the future. It would build their clinical competences and support them to take on the expanding roles of the RN since evidence suggests that the RNs need more biosciences in part due to their expanding clinical roles.

There should be more tangible involvement of RN prepared clinical supervisors to support the students to link the bioscience to nursing practice during case presentations and ward rounds. This is because the ward rounds and case presentations were mainly facilitated

by medical doctors, who had limited understanding of the science requirements of nursing degree students. The RN prepared supervisor would support the students to link the science teaching to their patients by applying the nursing model of care in contrast to the cure model of medicine. This reduces the tendency of nursing students to apply bioscience to clinical practice through the medical model.

(v) Give more support to students enrolled directly from A-levels.

HEIs should support their A-levels enrolled students to prepare them for higher education. For example, they could design mandatory courses to equip them with the skills required to learn in higher education. Relatedly, the direct entrants should be given more time for clinical practice, preferably during recess term.[8] These students were already cognizant of their deficiency in clinical skills and bioscience application in practice and already sought clinical practice opportunities informally over the recess term. The HEIs, in consultation with the student leadership, should formally adapt this and use the already available relationships with the CLEs to support this cohort of students to get more hands-on training.

Contributions to knowledge

This study adds to the knowledge base pertaining to the bioscience problem and AMS. To the best of my knowledge, this is the first study to explore the bioscience problem in nursing education in Uganda. Nurse education has grappled with finding the best ways to teach biosciences for over three decades. As Ratero et al. (2020) recommended, nursing should audit the current teaching methods and strengthen those methods which have the greatest success to retention and application of biosciences in practice. This study has contributed to this area by identifying and explaining why a ward round is an effective teaching method to support understanding and application of science knowledge to clinical practice. It has also identified some of the ways bioscience curricula and teaching can be nursified to support learning.

It further makes a unique addition to literature on the quality of RN preparation and the factors which uniquely affect this cohort in this context. An understanding of these will help planners and educators to design support structures for students to enable them to learn better. Amidst the escalating threat posed by AMR, the expanded scope of practice for the RN, and pressures on the health systems, the findings of this study are timely in drawing attention to

[8] A break between semesters, usually up to ten weeks for science programs in Uganda.

the urgent need to reform and strengthen the training and education of the future RN to tackle such emerging threats now and in the future.

Strengths and limitations

One of the important strengths of this study is its design. The sequential explanatory nature of this project means that the data collection in Phase 2 built on the results of Phase 1. Collecting qualitative data after analysing quantitative data enabled me finetune the qualitative research questions depending on Phase 1 findings, but also remain open to new information. It was also important in helping me to contextualize and understand the meanings of the quantitative results to further understand the bioscience problem (Warfa, 2016). It allowed the study to develop and evolve depending on the findings. Data collection and analysis was conducted separately for the two phases, which made it easier to describe, implement, and report the results (Warfa, 2016).

The data were collected from four universities using three methods, exploring the bioscience problem from different angles. In addition, the response rates were high thus increasing representativeness (Baruch & Holtom, 2008) and minimize the risks of bias (Smith et al., 2019). Collecting data from four universities was important because these universities were representative of the general characteristics of the universities in Uganda. For example, there was rural and urban representation, public and private universities operating different study models.

Most studies on the bioscience problem focussed on classroom learning and evidence on bioscience learning in clinical practice is just emerging (Fell et al., 2016; Molesworth & Lewitt, 2016). This study makes a unique contribution to our understanding of how students learn biosciences in practice and the factors which affect that learning. Notably, this study used ABR, a global health problem as an indicator of bioscience knowledge, further contributing to our understanding of the knowledge and application of antimicrobial stewardship in Uganda. My own understanding and experiences of bioscience learning as a student, bioscience teaching as a nurse educator and application in clinical practice in Uganda have immensely contributed to this study. I am familiar and understand this context, have worked there for years.

Like other studies, this study has limitations. It focused on the preregistration students who will be RNs, a small workforce now in this context. The restrictions brought about by

the COVID-19 pandemic meant that data collection in Phase 2 was abruptly interrupted. I had to stop immediately given safety concerns and closure of all Universities. I managed to use the data I collected up to that point to answer the research questions. In addition, the qualitative arm of this study focussed on the direct students but did not include students enrolled on the degree via the diploma route. The level of bioscience knowledge was restricted to ABR. The results of this study may not be generalized for other bioscience concepts in clinical practice. This study only investigated the bioscience problem during the preregistration period.

I spent a lot of time to plan and implement the two phases because I relied on Phase 1 to plan and implement Phase 2. Although these phases were in the same project, it felt like I was working on two projects given that I had to apply for ethics clearance at different times and from different organizations. Data collection was also months apart. Completing these research activities took considerable time (Warfa, 2016).

Direction for future research

This study relied on direct students who had more challenges with biosciences and relied on their reports to understand the advantages that top-up students had over them. Research should conduct comparative studies between direct and top-up students would bring the voices of both groups first-hand. Future studies should further explore the bioscience problem in Uganda and similar contexts. They should extend the research sample to include faculty members who teach bioscience courses to understand their perceptions of the importance of biosciences to nursing. They should further explore some of the challenges faculty face in teaching and supporting students to learn and apply biosciences.

Future research should also explore the clinical supervisors' confidence in teaching biosciences. Ethnographic research exploring the clinical placement culture of would be useful in understanding the key drivers and barriers to learning and applying biosciences. In addition, further study on the practical application of ward rounds as a teaching method for nursing students in clinical nursing practice should be undertaken. Relatedly, more studies should be undertaken on the practical implications of adopting the supervisor model of clinical supervision within this context. This study focussed on preregistration nursing students nearing completion of the degree and did not include newly qualified RNs. A longitudinal study into the bioscience problem post registration would expand our understanding of the bioscience problem among RNs.

Dissemination plan

The major stakeholders and end-users of this research include bioscience teachers, clinical supervisors, hospital managers and preregistration nursing students, HEIs in Uganda offering the nursing degree programme and other countries. In addition, the NCHE and policy makers at the UNMC would be interested in this study. A report of the findings will be given to the participating universities. This work will be presented in relevant conferences and published in peer reviewed journals where possible. A copy of this thesis will be submitted and uploaded on the university University of Salford Institutional Repository (USIR).

A reflection on my journey

Coming to the UK to pursue a PhD was the boldest move I have ever made to pursue something I was passionate about. Although I had been to the UK before for my master's degree, this was different for me because I was embarking on a journey in which I would spend years investigating one aspect of nursing. I had a rough idea of what I wanted to do, but it was obviously not polished in any way. I recently read my first draft and appreciated how much I have grown as a person and researcher. I initially looked to investigate how dynamic media can be used to support bioscience learning. I explored this for months until I decided to look at the bioscience problem in a broader and more holistic way. Investigating how dynamic media can be used to learn bioscience was a good starting point but it was too narrow to really understand this problem. With support from the supervision team, I took the leap to investigate the bioscience problem more broadly and, in more depth, thus justifying mixed methods. As already explained in the methods chapter, I come from a context which values quantitative research more than qualitative research. I needed some adjustment in my own mindset and use pragmatism to achieve the research objectives.

Indeed, the PhD project changed over time as more data emerged, and I acquired more skills. However, one of the most important ways in which this journey has changed me is that it has increased my confidence to make the decision to pursue a research career. I am an RN by background. I have taught nursing and science courses for years, but I now feel confident to pursue a research career in the long term. I have a long way to go regarding learning research, but I am not where I was four years back. I see things differently. I love teaching but feel that I can make a big contribution to research given the limited research capacity in my home country. The skills from this journey have increased my confidence to

work on other research projects. I have learnt how to plan projects, liaise with funders, work within timelines, multitask between projects. A PhD project is isolating in some ways, given that the student works largely on their own. Working on other research projects with experts who work in groups, has given me a unique opportunity to learn how to work as part of a team. In conclusion, I have learnt to work independently (under supervision) and as part of a group.

This project has shown that the science preparation of RNs in Uganda is inadequate to meet the expectations in practice. It has recommended reforms in the curriculum, teaching, clinical supervision, assessment, and support. Notably, bioscience deficiency has been demonstrated by low knowledge on basics of antimicrobial stewardship, yet nurses are central players in the fight against resistant strains. Sustained commitment at all levels to improve the educational preparation of the RNs is the way forward to upgrading the status of nurses and improve health systems in low resource settings like Uganda, who mostly rely on nurses for delivery of health care.

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Appendices

Appendix One: Ethical approval letters

University of Salford MANCHESTER

Research, Enterprise and Engagement
Ethical Approval Panel

Doctoral & Research Support
Research and Knowledge Exchange,
Room 827, Maxwell Building,
University of Salford,
Manchester
M5 4WT

T +44(0)161 295 2280

www.salford.ac.uk

28 August 2018

Dear Miriam,

RE: ETHICS APPLICATION–HSR1718-097 – 'Biosciences in nursing education: the level of explicit knowledge on antibiotic resistance among preregistration nursing students in Uganda' (Phase 1).

Based on the information that you have provided, I am pleased to inform you that ethics application HSR1718-097 has been approved for phase 1 of the study.

If there are any changes to the project and/or its methodology, then please inform the Panel as soon as possible by contacting Health-ResearchEthics@salford.ac.uk

Yours sincerely,

Professor Sue McAndrew
Chair of the Research Ethics Panel

University of Salford MANCHESTER

Amendment Notification Form

Title of Project:		
Biosciences in nursing education: the level of explicit knowledge on antibiotic resistance among preregistration nursing students in Uganda		
Name of Lead Applicant:	**School:**	
Miriam Nantamu	Health & Society	
Are you the original Principal Investigator (PI) for this study?		Yes
If you have selected 'NO', please explain why you are applying for the amendment:		
Date original approval obtained:	**Reference No:**	**Externally funded project?**
28/08/2018	**HSR1718-097**	Yes

Please outline the proposed changes to the project. *NB. If the changes require any amendments to the PIS, Consent Form(s) or recruitment material, then please submit these with this form highlighting where the changes have been made:*

The changes to this project will include a second phase to assess the effectiveness of a teaching intervention in supporting students to retain and solve clinical problems relating to antibiotics resistance among patients with post caesarean bacterial wound infections within a simulated situation.

Context

This phase follows the first phase where data was collected from four universities in Uganda using Survey (version 2, 20/11/2018). The first phase assessed the current level of knowledge on antibiotic resistance and identified the factors associated with the current level of bioscience knowledge among 3rd and 4th year nursing pre-registration nursing students in Uganda.

This phase seeks to build on the results of the first phase to assess the effectiveness of a teaching intervention in supporting students to retain and solve clinical problems relating to antibiotics resistance among patients with post caesarean bacterial wound infections within a simulated situation. Data will be collected at one of the universities where data were collected in the first phase.

Results from the first phase suggest that overall failure rates were 21.3% (n=207). Sixty percent and 69.6% (n = 207) of the students failed core biosciences knowledge and clinical application questions respectively. Only 30% reported good antibiotic use and 48% passed questions on antibiotic resistance. Overall bioscience success was statistically associated with

University of Salford MANCHESTER

Please say whether the proposed changes present any new ethical issues or changes to ethical issues that were identified in the original ethics review, and provide details of how these will be addressed:
The ethical issues in this phase the same as those in the first phase. These include voluntary participation, confidentiality, the freedom to withdrawal and informed consent.

Amendment Approved:	✓	*Date of Approval:*	08/01/2020

Chair's Signature:

Once completed you should submit this form and any additional documentation to the relevant Ethics Panel that reviewed the original proposal:

School of Health & Society	Health-ResearchEthics@Salford.ac.uk
School of Health Sciences	
School of Built Environment	S&T-ResearchEthics@salford.ac.uk
School of Environment & Life Sciences	
School of Computing Science and Engineering	
Salford Business School	SBS-ResearchEthics@salford.ac.uk
School of Arts & Media	A&M-ResearchEthics@salford.ac.uk

CLARKE INTERNATIONAL UNIVERSITY
LEAD · INNOVATE · TRANSFORM
RESEARCH ETHICS COMMITTEE

(+256) 0312 307406
rec@ciu.ac.ug
www.rec.ciu.ac.ug

22nd November, 2018

UG-REC-015

IHSU-REC/0118

Ms. Miriam Nantamu
Principal Investigator
University of Salford, Manchester
Salford, M5 4WT.
Manchester, UK

Category of review
[x] Initial review
[ ] Continuing review
[ ] Amendment
[ ] Reactivation
[ ] SAEs

RE: "BIOSCIENCES IN NURSING EDUCATION: THE LEVEL OF EXPLICIT KNOWLEDGE ON ANTIBIOTIC RESISTANCE AMONG PREREGISTRATION NURSING STUDENTS IN UGANDA".

Reference is made to the above mentioned protocol which was submitted to Clarke International University Research Ethics Committee (CIUREC) for initial review and approval.

You have addressed all the issues earlier raised and the committee is satisfied with the responses submitted in version 2.0 dated 20th November, 2018.

I am glad to inform you that your study has been approved for a period of one year from 22nd November, 2018 to 22nd November, 2019.

The documents approved include the following;

Document	Language	Version	Submission Date
Protocol	English	Version 2.0	20th November, 2018
Consent forms			
Informed Consent	English	Version 2.0	20th November, 2018
Data collection tools			
Semi-Structured questionnaire	English	Version 2.0	20th November, 2018

Please note that any problem of a serious nature as a result of this study to the participants should be reported to CIUREC and Uganda National Council of Science and Technology (UNCST) immediately.

Also note that annual report and request for renewal where applicable should be submitted at least one month before the expiry date of approval. In addition, you are also required to submit copies of the stamped approved documents to the Uganda National Council for Science and Technology (UNCST) before the study can commence.

We would like to congratulate you and wish you a successful conduct of the study.

Yours Sincerely,

CLARKE INTERNATIONAL UNIVERSITY
APPROVED / VALID UNTIL
RESEARCH ETHICS COMMITTEE

22 NOV 2018

Dr. Samuel Kabwigu
CIUREC Chairperson

Date

CLARKE INTERNATIONAL UNIVERSITY
LEAD · INNOVATE · TRANSFORM
RESEARCH ETHICS COMMITTEE

(+256) 0312 307400
rec@ciu.ac.ug
www.rec.ciu.ac.ug

09th December, 2019

UG-REC-015

CIUREC/0118

Ms. Miriam Nantamu
Principal Investigator
University of Salford, Manchester
Salford, M5 4WT.
Manchester, UK

Category of review
[ ] Initial review
[x] Continuing review
[x] Amendment
[ ] Reactivation
[ ] SAEs

RE: "CONTINUING REVIEW AMENDMENT AND OF BIOSCIENCES IN NURSING EDUCATION: THE LEVEL OF EXPLICIT KNOWLEDGE ON ANTIBIOTIC RESISTANCE AMONG PREREGISTRATION NURSING STUDENTS IN UGANDA".

Reference is made to the above mentioned protocol which was submitted to Clarke International University Research Ethics Committee (CIUREC) for continuing review and study amendment.

l am glad to inform you that your request was reviewed and found to be satisfactory and approval granted for a period of one year from 09th December, 2019 to 09th December, 2020.

The documents approved include the following;

Document	Language	Version	Submission Date
Protocol	English	Version 3.0	16th November, 2019
Consent forms			
Informed Consent	English	Version 3.0	16th November, 2019
Data collection tools			
Semi-Structured questionnaire	English	Version 3.0	16th November, 2019

Please note that any problem of a serious nature as a result of this study to the participants should be reported to CIUREC and Uganda National Council of Science and Technology (UNCST) immediately.

Also note that annual report and request for renewal where applicable should be submitted at least one month before the expiry date of approval. In addition, you are also required to submit copies of the stamped approved documents to the Uganda National Council for Science and Technology

(UNCST) before the study can commence.

We would like to congratulate you and wish you a successful conduct of the study.

Yours Sincerely,

for

Dr. Samuel Kabwigu
CIUREC Chairperson

CLARKE INTERNATIONAL UNIVERSITY
12/12/2019
APPROVED / VALID UNTIL
RESEARCH ETHICS COMMITTEE
P. O. Box 7782, Kampala - Uganda

Date

For: Executive Secretary
UGANDA NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Uganda National Council for Science and Te

(Established by Act of Parliament of the Republic of Uganda)

Dear miriam nantamu,

I am pleased to inform you that on **16/04/2019**, the Uganda National Council for Science and Technology (UNCST) approved your study titled, **Biosciences in nursing education: assessment of the level of explicit knowledge on antibiotic resistance (ABR) among preregistration nursing students in Uganda.**. The Approval is valid for the period of **16/04/2019** to **16/04/2020**.

Your study reference number is **HS313ES**. Please, cite this number in all your future correspondences with UNCST in respect of the above study.

Please, note that as Principal Investigator, you are responsible for:

1. Keeping all co-investigators informed about the status of the study.
2. Submitting any changes, amendments, and addenda to the study protocol or the consent form, where applicable, to the designated local Research Ethics Committee (REC) or Lead Agency, where applicable, for re-review and approval prior to the activation of the changes.
3. Notifying UNCST about the REC or lead agency approved changes, where applicable, within five working days.
4. For clinical trials, reporting all serious adverse events promptly to the designated local REC for review with copies to the National Drug Authority.
5. Promptly reporting any unanticipated problems involving risks to study subjects/participants to the UNCST.
6. Providing any new information which could change the risk/benefit ratio of the study to the UNCST for review.
7. Submitting annual progress reports electronically to UNCST. Failure to do so may result in termination of the research project.

Please, note that this approval includes all study related tools submitted as part of the application.

Yours sincerely,

Hellen Opolot
For: Executive Secretary
UGANDA NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Appendix Two: Permission letters

MBARARA UNIVERSITY OF SCIENCE & TECHNOLOGY
FACULTY OF MEDICINE
OFFICE OF THE DEAN
P.O. Box 1410, Mbarara, Uganda.
Tel: +256-485 660 584 +256-772 350 425 Fax: +256-4854-20782

Ref: MUST/FOM/51/1

January 28, 2019

Ms. Miriam Nantamu
University of Salford, Manchester
43 The Crescent
M5 4WT, Salford

Dear Ms. Nantamu

Re: PERMISSION TO COLLECT DATA FROM BACHELOR OF NURSING STUDENTS IN MBARARA UNIVERSITY OF SCIENCE AND TECHNOLOGY

Thank you for your letter concerning the above mentioned subject.

I confirm, I received all the documents I requested for, i.e a full proposal and copies of the Consent document signed by Clarke International University Research Ethics Committee.

Permission has been granted for you to undertake the proposed study which will involve 3rd and 4th year, Bachelor of Nursing students at MUST. My understanding is that, you will only collect data for the tool submitted with your proposal.

By copy of this letter, you will report to the Head, Nursing Department who will tell you the best time to engage our students. Please note that the semester has just started but as time goes on, the students will become busy and it will be difficult to disrupt their academic programs. I expect you to share a report of your findings with the Faculty at the appropriate time.

I wish you all the best in your research work.

Sincerely

Assoc. Prof. Gertrude Kiwanuka
DEAN

c.c. Head, Nursing Department - MUST

E-mail: *dean.medicine@must.ac.ug* **Website:** *www.must.ac.ug*

University of Salford, Manchester,
43 The Crescent
M5 4WT, Salford.
M.Nantamu@edu.salford.ac.uk

10/12/2018

MOUNTAINS OF THE MOON UNIVERSITY
11 DEC 2018
P. O. Box 837, Fort Portal (U)
DEPT. OF NURSING & MIDWIFERY
PRINCIPAL

The Dean, School of Health
Mountains of the Moon Uni
P.O.Box 837, Fort Portal, U

Through:

The Head of Department, N and Midwifery.
Mountains of the Moon U
P.O.Box 837, Fort Portal, U

Permission granted
MWANUKO CLEMENT
For Dean SHS

Dear Sir/Madam,

My name is Miriam Nanta PhD candidate in the University of Salford. I am working on a research project to improve the le biosciences among nursing students (Bachelor of Science in Nursing). At this stage, I am interes ow how much bioscience knowledge nursing students have as they complete their degree pr

I have obtained approval fro the ethics committee in my university and from the Research ethics committee of Clarke Interna University (Please find them attached) to undertake this study in Uganda.

I am now requesting for a nting me permission to collect data from students on Bachelor of Nursing program in Mo the moon University. I intend to collect data from in the 3rd and 4th year students, in February 20

I look forward to hearing f

Yours sincerely,

Miriam Nantamu

BUGEMA UNIVERSITY

Main Campus
32km, Gayaza - Zirobwe Road
P.O. Box 6529
KAMPALA - UGANDA
Tel: 256-312-351400
Fax: 256-312-351460
Website: www.bugemauniv.ac.ug

Kampala Campus
2 miles Bombo Road
Between Total Petrol Station
& Makerere Yellow Primary Sch.
Muganzi-Awongerera Rd
P.O. Box 6529 KAMPALA - (U)
Tel: +256 312 266 630 / 631

RESEARCH DIRECTORATE

REF: BU-REC-2019/0001

To : Uganda National Council for Science and Technology
PI :
Miriam Nantamu
Principal Investigator (PI)
Univeristy of Salford, Manchester,
Salford, M5 4WT.
Mancehester, UK

RE: CLEARANCE TO UNDERTAKE RESEARCH AT BUGEMA UNIVERSITY

This is to declare that; whereas Miriam Nantamu seeks to undertake data collection at Bugema University on the topic "Biosciences in Nursing Education: The level of explicit knowledge on Antibiotic Resistance among preregistration nursing students in Uganda"; whereas the Principal Investigator has obtained Ethical Clearance from a registered REC in Uganda (UG-REC-015; IHSU-REC/0118) fulfilling the necessary requirements as per NCST; whereas she has further requested BU-REC to be allowed to undertake her research at BU; the same is granted to her to collect data from Bugema University Nursing Students (phase 1 study), provided she adheres to the required research ethics conduct and obtains final clearance from UNCST before study commences.

Paul M. Mukasa, PhD
Chairperson
BU-RESEARCH ETHICS COMMITTEE

cc. Vice Chancellor,
Deputy Vice Chancellor,
Dean, School of Health Science

A CHARTERED SEVENTH-DAY ADVENTIST INSTITUTION

MOUNTAINS OF THE MOON UNIVERSITY

OFFICE OF THE VICE CHANCELLOR

Our Ref: VC/MMU/25120
Your Ref:

Date 25th January 2020.

To
Ms. Miriam Nantamu
University of Salford, Manchester
United Kingdom

Dear Madam,

RE: PERMISSION TO COLLECT DATA FROM NURSING STUDENTS AT MOUNTAINS OF THE MOON UNIVERSITY

Your follow up research on antibiotics resistance is non- intrusive, quite important and of applied nature.

You, therefore, have permission to collect data from the students on Bachelor of Nursing program at the School of Health Science. You are also advised to get in touch with the chairperson of MMU research and ethics committee if you need any other advice on ethical issues.

Good Luck in your research.
Yours Sincerely

Prof. John M Kasenene
Vice Chancellor, MMU.

Cc: Assoc. Prof. John Rubaihayo
Chairman Ethics Committee, MMU.

P. O. Box 837, Fort Portal, Uganda. Tel +256 483 660 388 Email: vc@mmu.ac.ugWebsite: www.mmu.ac.ug.

THE AGA KHAN UNIVERSITY

May 07th, 2018

Dear Student,

RE: PERMISSION TO CARRY OUT A RESEARCH STUDY FROM AKUSONAM, UGANDA.

I am writing in response to your request to undertake a research entitled **Biosciences in nursing education: the level of explicit knowledge on antibiotic resistance among preregistration nursing students in Uganda.**

I am happy to inform you that I agree to your being involved in conducting this study among undergraduate students in Aga Khan University-Kampala. Please note that this is subject to meeting all ethics requirements and obtaining ethical approval from the university research ethics committee of Aga Khan University.

Yours faithfully

Joseph Mwizerwa
ACADEMIC HEAD/PRINCIPAL

Colonel Muammar Gaddafi Road P.O. Box 8842, Kampala, Uganda.
Telephone: 256 41 349494, 349307 Fax: 256 41 349303 E-mail: info@aku.ac.ug
Website: www.aku.edu

Appendix Three: Participant Information Sheets

PARTICIPANT INFORMATION SHEET FOR PHASE 1

Title of study: Biosciences in nursing education: the level of explicit knowledge on antibiotic resistance among preregistration nursing students in Uganda.

Name of Researcher: Miriam Nantamu

1. Invitation paragraph

I am inviting you to participate in this research study. Before you decide on taking part, you need to understand why this research is being done and what activities you will be involved in. Kindly take time to read the following information, then take some time to decide on whether you would like to participate. Please forward any questions you have, and I will be happy to provide additional information.

This study will assess the quality of bioscience teaching you have received on the nursing degree programme, not your own ability to get a good grade on a test. You will be asked to answer forty-six survey questions on antibiotic resistance to help us measure this knowledge more precisely.

2. What is the purpose of the study?

The primary purpose of this study is educational: a research study to investigate the level of biosciences knowledge you have as you prepare to exit the nursing program. In particular, you will be assessed on the kind of knowledge you have on antibiotic resistance towards the end of your nursing degree. This is part of a wider project which will be used to design an intervention to improve the learning of biosciences, and to support the transfer of biosciences theory to nursing practice.

3. Why have I been invited to take part?

You have been invited to participate because you can provide valuable information for this research study. The study aims at investigating the level of bioscience knowledge that nursing students have upon graduation. Being in your 3rd/4th year places you in the best position to help us know the level of knowledge you will go into nursing practice with when you graduate. You will be among a group of other 3rd and 4th year nursing students that will participate in this study across the country.

4. Do I have to take part?

Participation in this study is purely voluntary. I will describe the study to you, again, and go through the information sheet which will be given to you. You will be asked to sign a consent form to show that you have agreed to participate in the study. If you decide to take part and later no longer wish to continue, you have the right to withdraw from the study at any time, up to 14 days after data collection. You will not need to give the reason for your withdrawal, and this will not in any way affect your examinations outcome.
You will be asked to make a note of the code on your survey such that your responses can be withdrawn should you wish to withdraw within the 14 days. You will not be able to withdraw from this study after this date.

5. What will happen to me if I take part?

This participant information sheet contains all the information about the research and your rights as a participant. You will be allowed some time to think about your decision and to ask questions related to the research. After getting answers to your questions, you will be asked to read and sign the consent form. After agreeing and signing the consent form, you will be asked to complete the survey.
You will be involved in the following activities: (1) Spend up to 20 minutes completing a paper-based survey on Antibiotic resistance; (2) receive a face-to-face presentation (of about an hour) to highlight and reinforce the concept of antibiotic resistance. All these will take place on the same day (to avoid preparation), in the same place. You will be in a classroom environment, but you have the option of completing the survey outside of the classroom. One of the survey sections will ask for personal information about you, such as your gender, your age, marital status, and year of study, but not your name. You will only complete one survey.

6. Expenses and payments?

For your participation in the study, no monetary expenses will be borne on your part, only your time. The study will occur during the normal university calendar.

7. What are the possible disadvantages and risks of taking part?

You will be exposed to very little risk of suffering inconvenience, as you will only be required to recall bioscience knowledge regarding antibiotic resistance.

8. What are the possible benefits of taking part?

By participating in this study, you will contribute to our understanding of the quality of teaching of bioscience courses on the preregistration nursing curriculum. This information will be used to improve the quality of teaching of biosciences. After completing the test, you will receive a lecture on antibiotic resistance and stewardship. The lecture will increase your awareness of the importance of antibiotics, antibiotic resistance, and antibiotic stewardship. You will be equipped with knowledge to contribute to slowing the trend of antibiotic resistance. It will help you to understand the rationales behind nursing actions with regard to infection prevention, antibiotic handling, prescription, and patient education.

9. What if there is a problem?

If you have a problem or concern about this study, please speak to the researcher (XXXX) who will endeavour to deal with your concern. If you are unhappy with the assistance offered by the researcher, you can formally complain to the research supervisors (XXXXX). If you remain unhappy and wish to complain formally you can do this by contacting the Research Supervisor on XXXXXX or XXXXXX. If the matter is still not resolved, please forward your concerns to Professor Susan McAndrew, Chair of the Health Research Ethical Approval Panel, Room MS1.91, Mary Seacole Building, Frederick Road Campus, University of Salford, Salford, M6 6PU. Tel: 0161 295 2778. Email: s.mcandrew@salford.ac.uk

10. Will my taking part in the study be kept confidential?

Individual participant data from the test will be anonymized. Your name will not appear anywhere on the survey. Each survey will be given a code. You will be asked to sign a consent form prior to agreeing to participate in the study. You will be asked to put the signed consent form and the completed survey in a sealed envelope (envelope will be provided). I will make a list of the names and corresponding codes (not your answers) to ensure that I know who has consented to participate in the research study. I will make a soft copy of the list and securely store it on an encrypted computer, only accessible by myself.
All electronic forms of the data (including the completed surveys) will be held on a password protected computer, only known and accessed by the researcher.

The data collected in the survey will be solely used to measure the level of bioscience knowledge you possess upon completion of the pre-registration nursing program. It will not be used for any other

purpose. The data collected will be used to inform the wider research project, helping to benchmark the level of bioscience knowledge, and will be used to design an intervention to support the learning of biosciences among pre-registration nursing students. All surveys will be securely stored and disposed of after 3 years as recommended by the Joint School Research Ethics panel.

11. What will happen if I don't carry on with the study?

If you choose to withdraw from the study before you finish the survey, then the information collected from you will be destroyed and you will be removed from the study immediately. If you wish to withdraw from the study after your completed survey is collected, you need to do so by contacting the researcher up to 14 days after data collection. In doing so, your data will be removed from the study and will be destroyed. Any data that is part of the study after 14 days will remain part of the study.

12. What will happen to the results of the research study?

The results obtained from this study will be published in a reputable journal, in nursing and higher education conferences. The author will make a summary of the results available at your university upon completion of the study. You will not be identified in any report or publication made from this research.

13. Who is organising or sponsoring the research?

The researcher is funded by the Commonwealth Scholarship Commission in the UK, and the University of Salford, Manchester.

14. Further information and contact details:

For any specific information about this research, please speak to the researcher on the following contacts:

EMAIL: XXXXXXXXXX

CONSENT FORM

Title of study: Biosciences in nursing education: the level of explicit knowledge on antibiotic resistance (ABR) among preregistration nursing students in Uganda.

Name of Researcher: XXXXXXXXX

Please complete and sign this form **after** you have read and understood the study information sheet. Read the following statements and select 'Yes' or 'No' in the box on the right hand side.

1. I confirm that I have read and understand the study information sheet Version 2-21st -Augist-2018, for the above study. Yes/No
2. I have had the opportunity to consider the information and to ask questions Which have been answered satisfactorily. Yes/No
3. I understand that my participation is voluntary and that I am free to withdraw within 14 days, without giving any reason, and without my rights being affected. Yes/No
4. If I decide to withdraw after 14 days, I understand that the information I have given to the point of withdrawal, will be used in the research. Yes/No
5. I agree to participate by answering questions on antibiotic resistance Yes/No
6. I understand that my personal details will be kept confidential and will not be revealed to people outside the research team. Yes/No
7. I understand that my anonymised data will be used in the researcher's thesis, academic publications, conferences, and presentations. Yes/No
8. I understand that the data obtained from this study will be archived for 3 years after graduation of the researcher. Yes/No
9. I agree to take part in the study: Biosciences in nursing education: the level of explicit knowledge on antibiotic resistance (ABR) among preregistration nursing students in Uganda.

_____	_____	_____
Name of participant	**Date**	**Signature**

_____	_____	_____
Name of person taking consent	**Date**	**Signature**

Participant Information Sheet for Phase 2

Title of study: Biosciences in nursing education: Experiences of learning and applying biosciences in clinical practice among Preregistration Nursing Students in Uganda
Name of Researcher: Miriam Nantamu

1. Invitation paragraph

I am inviting you to participate in this research study. Before you decide on taking part, you need to understand why this research is being done and what activities you will be involved in. Kindly take time to read the following information, then take some time to decide on whether you would like to participate. Please forward any questions you have and I will be happy to provide additional information.

This study will assess your experiences of learning bioscience courses on your program.

2. What is the purpose of the study?

The primary purpose of this study is educational: to assess your learning experiences and identify any factors that affect your learning. This is a continuation of a larger study to improve the learning of biosciences, and to support the transfer of biosciences theory to nursing practice.

3. Why have I been invited to take part?

You have been invited to participate because you can provide valuable information for this research study. Being a preregistration nursing student, you are in the best position to help us know how much bioscience knowledge you can retain and apply to clinical practice situations. This participant information sheet contains all the information about the research and your rights as a participant.
You will be among a group of other nursing students that will participate in this study across the university.

4. Do I have to take part?

Participation in this study is purely voluntary. I will describe the study to you, again, and go through the information sheet which will be given to you. You will be asked to sign a consent form to show that you have agreed to participate in the study. If you decide to take part and later no longer wish to continue, you have the right to withdraw from the study at any time, up to 14 days after data collection. You will not need to give the reason for your withdrawal, and this will not in any way affect your examinations outcome.

5. What will happen to me if I take part?

This participant information sheet contains all the information about the research and your rights as a participant. You will be allowed some time to think about your decision and to ask questions related to the research. After getting answers to your questions, you will be asked to:

1. Take some time to think about your decision and to ask questions related to the research.
2. Read and sign the consent form.
3. Spend between 60 to 90 minutes in a focus group discussion with other students in your cohort.

6. Expenses and payments?

For your participation in the study, no monetary expenses will be borne on your part, only your time. The study will occur during the normal university calendar.

7. What are the possible disadvantages and risks of taking part?

You will be exposed to very little risk of suffering inconvenience, as you will only be required to recall your experiences of learning bioscience courses.

8. What are the possible benefits of taking part?

By participating in this study, you will contribute to efforts to improve the retention and application of bioscience knowledge in solving clinical nursing problems. This information

will be used to improve the quality of teaching of biosciences in academic and clinical settings.

9. What if there is a problem?

If you have a problem or concern about this study, please speak to the researcher (XXXX) who will endeavour to deal with your concern. If you are unhappy with the assistance offered by the researcher, you can formally complain to the research supervisors (XXXXX). If you remain unhappy and wish to complain formally you can do this by contacting the Research Supervisor on XXXXXX or XXXXXX. If the matter is still not resolved, please forward your concerns to Professor Susan McAndrew, Chair of the Health Research Ethical Approval Panel, Room MS1.91, Mary Seacole Building, Frederick Road Campus, University of Salford, Salford, M6 6PU. Tel: 0161 295 2778. Email: s.mcandrew@salford.ac.uk

10. Will my taking part in the study be kept confidential?

Individual participant data from the test will be anonymized. Your name will not appear anywhere in the transcripts or report. Each survey will be given a code.
All electronic forms of the data will be held on a password protected computer, only known and accessed by the researcher.

11. What will happen if I don't carry on with the study?

If you choose to withdraw from the study before you finish the study, then the information collected from you will be destroyed and you will be removed from the study immediately. If you wish to withdraw from the study after your completed survey is collected, you need to do so by contacting the researcher up to 14 days after data collection. In doing so, your data will be removed from the study and will be destroyed. Any data that is part of the study after 14 days will remain part of the study.

12. What will happen to the results of the research study?

The results obtained from this study will be published in a reputable journal, in nursing and higher education conferences. The author will make a summary of the results available at

your university upon completion of the study. You will not be identified in any report or publication made from this research.

14. Further information and contact details:

For any specific information about this research, please speak to the researcher on the following contacts:

EMAIL: XXXXXXXXXX

Appendix Four: Consent forms

Informed Consent to Participate in Research

I am asking you to take part in a research study called:

Biosciences in nursing education: assessment of the level of explicit knowledge on antibiotic resistance among preregistration nursing students in Uganda.

The person who is in charge of this research study is Miriam Nantamu. The research will be conducted in four universities in Uganda.

Purpose of the study

The purpose of this study is to:

To investigate the level of biosciences knowledge you have as you prepare to exit the nursing program. In particular, you will be assessed on the kind of knowledge you have on antibiotic resistance towards the end of your nursing degree.

Study Procedures

You have been invited to participate because you can provide valuable information for this research study. The study aims at investigating the level of bioscience knowledge that nursing students have upon graduation. Being in your 3rd / 4th year places you in the best position to help us know the level of knowledge you will go into nursing practice with when you graduate. You will be among a group of other 3rd and 4th year nursing students that will participate in this study across the country. This participant information sheet contains all the information about the research and your rights as a participant.

If you take part in this study, you will be asked to:

1. Take some time to think about your decision and to ask questions related to the research.
2. Read and sign the consent form.
3. Spend up to 20 minutes completing a paper-based survey on Antibiotic resistance.
4. All these will take place on the same day (to avoid preparation), in the same place.
5. You will be in a classroom environment, but you have the option of completing the survey outside of the classroom.

Benefits

By participating in this study, you will contribute to our understanding of the quality of teaching of bioscience courses on the preregistration nursing curriculum. This information will be used to improve the quality of teaching of biosciences.

Risks or Discomfort

This research is considered to be minimal risk. That means that the risks associated with this study are the same as what you face every day. There are no known additional risks to those who take part in this study. You will only be required to recall bioscience knowledge regarding antibiotic resistance.

Compensation

You will be provided with lunch as compensation for your time during your participation in the study.

Privacy and Confidentiality

I will keep your study records private and confidential. Certain people may need to see your study records. By law, anyone who looks at your records must keep them completely confidential. The only people who will be allowed to see these records are:

The research team, including the Principal Investigator and those involved with the study.

I may publish what I have learned from this study. If l do, l will not include your name. l will not publish anything that would let people know who you are.

Voluntary Participation / Withdrawal

Participation in this study is purely voluntary. I will describe the study to you, again, and go through the information sheet which will be given to you. You will be asked to sign a consent form to show that you have agreed to participate in the study. If you decide to take part and later no longer wish to continue, you have the right to withdraw from the study at any time, up to 14 days after data collection. You will not need to give the reason for your withdrawal and this will not in any way affect your examinations outcome. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study.

You will be asked to make a note of the code on your survey such that your responses can be withdrawn should you wish to withdraw within the 14 days. You will not be able to withdraw from this study after this date.

You can get the answers to your questions, concerns, or complaints

If you have any questions, concerns or complaints about this study, or experience an adverse event or unanticipated problem, contact the researcher on 0704 900953. If you have questions about your rights as a participant in this study, general questions, or have complaints, concerns or issues you want to discuss with someone outside the research, call the CIU-REC Chairperson, Dr. Samuel Kabwigu on (0779610100) & the executive secretary of UNCST on (0414-705500) respectively.

Assessment of understanding

Please check which box best describes your assessment of understanding of the above informed consent document:

☐ I have read the above informed consent document and understand the information provided to me regarding participation in the study and benefits and risks. I give consent to take part in the study and will sign the following page.

☐ I have read the above informed consent document, but still have questions about the study; therefore I do not give yet give my full consent to take part in the study.

_____ _____

Signature of Person Taking Part in Study Date

_____

Printed Name of Person Taking Part in Study

_____ _____

Signature of Person Obtaining Informed Consent / Research Authorization Date

_____

Printed Name of Person Obtaining Informed Consent / Research Authorization

PARTICIPANT INVITATION LETTER

Dear student,

We are conducting an assessment as part of the research study to aimed at improving the teaching of biosciences and improve retention and application of biosciences to clinical nursing practice. This phase is following up on a previous survey we conducted countrywide among preregistration nursing students which increased our understanding of how much bioscience knowledge nursing students possess as they complete their Bachelor of Nursing degree.

As a preregistration nursing student, you are in the best position to give us valuable firsthand information on how much bioscience knowledge you will retain after a teaching intervention in a classroom setting and in the simulation laboratory.

You will need about 30 minutes to complete the test before and after the intervention. Your responses to the questions will be kept confidential. Each test paper will be coded to help ensure that your identity is not revealed throughout the research and dissemination processes.

After the teaching in the skills laboratory, you will undergo an objective structured clinical examination in the simulation laboratory to assess your retained skills in biosciences. Instruction in the practical skills of biosciences will take place in bite-size sessions each week, but your assessment will take place on one day (lasting 40 minutes).

You will receive no financial compensation for your time, but in return, you will acquire theoretical knowledge and practical skills which will support your future nursing practice. In addition, you will be given lunch for the times you will be taught and assessed. Your participation in this study is very valuable in adding to the body of knowledge in nursing education and clinical nursing practice.

If you are willing to participate in this study, please come to the venue that we shall agree on. Thank you.

XXXXXX (researcher)

Appendix Five: Survey

Please answer the following questions.

Instruction: Please tick against the most correct answer or write out the answer where necessary.

A. Demographic characteristics

Your gender is: (**tick one)**	Male □ Female □	
Your age is		
Nationality		
Marital status **(tick one)**	Never married □ Married □ Living together □ Divorced /separated □ Widowed □ Other ……	
Religion **(tick one)**	Catholic □ Anglican □ Islam □ Pentecostal □ Seventh Day Adventist □ None □ Other □	
Tribe **(tick one)**	Acholi □ Alur □ Baganda □ Bagisu □ Bakiga □ Bakonzo □ Banyankore □	Basoga □ Batoro □ Iteso □ Lango □ Lugbara □ Karamojong □ Other □ ……
Program of study		
Route of entry on programme **(tick one)**	Direct entry (A-levels) □ Top-up/extensor/completion (from Diploma in nursing) □	
Year of study		
University of study		

B. Knowledge questions on antibiotics

Please tell us if you agree or disagree with each of the following statements by ticking the relevant box.

	Agree	Disagree
1. Amoxicillin is an antibiotic	☐	☐
2. Aspirin is an antibiotic	☐	☐
3. Antibiotics are useful for bacterial infections	☐	☐
4. Antibiotics are useful for viral infections	☐	☐
5. Antibiotics are indicated to reduce any kind of pain and inflammation	☐	☐
6. Antibiotics can cause secondary infections after killing good bacteria present in our organism	☐	☐
7. Antibiotics can cause allergic reactions	☐	☐
8. Colds and coughs should always be treated with antibiotics as patients will recover more quickly	☐	☐
9. Antibiotics should always be prescribed as preventive measures to fight against future infections	☐	☐
10. Antibiotics can treat influenza	☐	☐

C. Please select the correct answer to the following questions on antibiotics and bacteria

11. One of the following is a macrolide antibiotic

    A. Lamivudine

    B. Clindamycin

    C. Erythromycin

    D. Amoxicillin

12. One of the following is a fluoroquinolone antibiotic

    A. Clarithromycin

    B. Cephalexin

    C. Erythromycin

    D. Ciprofloxacin

13. Which of the following pairs are gram positive bacteria?

    A. H. Pylori and Pseudomonas aeruginosa

    B. E. coli and Clostridium tetani

    C. Staphylococcus aureus and Streptococcus pneumoniae

    D. Pseudomonas aeruginosa and Staphylococcus aureus

14. Which gram negative bacteria commonly causes bloodstream infections and nosocomial infections?

    A. Pseudomonas aeruginosa

    B. Staphylococcus aureus

    C. H. Pylori

    D. Coli

D. Prescription practice questions

Please select the correct answer to the following questions

15. A 4-year-old girl has had diarrhoea for 4 days (3 stools/day). She has no history of fever and the temperature is 36.8 degrees Celsius. Which treatment do you propose?

A. Amoxicillin p.o.

B. Ceftriaxone IV plus Oral Rehydration

C. Amoxicillin-clavulanic acid p.o.

D. No antibiotic treatment, only oral rehydration

16. A 6-year-old child has a fever of 38 degrees Celsius, purulent rhinitis, and angina for two days. On inspection, the throat is reddish but there are no purulent formations. Which treatment do you recommend?

A. Amoxicillin p.o.

B. Ceftriaxone IV

C. Amoxicillin-clavulanic acid p.o.

D. No antibiotic treatment, only oral rehydration

17. Which one of the following antibiotics is safe during pregnancy?

A. Amoxicillin

B. Ciprofloxacin

C. Gentamicin

D. All the above

18. Which one of the following antibiotics has the best activity against anaerobes?

A. Ciprofloxacin

B. Metronidazole

C. Cotrimoxazole

D. Amoxicillin

19. Methicillin resistant - Staphylococcus aureus is susceptible to

A. Vancomycin

B. Doxycycline

C. Clindamycin

D. All of the above antibiotics

When are you more likely to recommend or prescribe antibiotics?

20. When the patient has a cold or sore throat
    - ☐ Yes
    - ☐ No
    - ☐ Don't know
21. When the patient is a child below five years with fever
    - ☐ Yes
    - ☐ No
    - ☐ Don't know
22. When there is no laboratory facilities to test for the causative organism
    - ☐ Yes
    - ☐ No
    - ☐ Don't know
23. When the patient asks for an antibiotic
    - ☐ Yes
    - ☐ No
    - ☐ Don't know
24. When the patient can afford to pay for the medications
    - ☐ Yes
    - ☐ No
    - ☐ Don't know

Please reliably tell us about your practice regarding antibiotic use

25. Do you usually stop taking antibiotic when you start feeling better?
    - □ Yes
    - □ No
26. Do you take antibiotics only when prescribed by the doctor?
    - □ Yes
    - □ No
27. Do you keep leftover antibiotics at home because they might be useful in the future?
    - □ Yes
    - □ No
28. Do you share antibiotics with a sick family member or friend?

    - □ Yes
    - □ No

29. What do you do with unused antibiotics?

……
……....

E. Knowledge and awareness about antibiotic resistance and antibiotic stewardship

Please answer the following questions by ticking against your chosen response.

30. Have you ever heard about antibiotic resistance? Yes □ No □

31. In particular, has the problem of antibiotic resistance been introduced to you during your Bachelor of Nursing program? Yes □ No □

32. Have you ever heard about antibiotic stewardship? Yes □ No □

33. In particular, have you discussed the role of the nurse in antibiotic stewardship during your Bachelor of Nursing program?

Yes □

No □

34. Do you feel that nurses have a professional role in reducing antibiotic resistance?

Yes □

No □

35. If yes, what do you think the nurses' professional role is in reducing antibiotic resistance?

……..…

…….

F: Mechanism of action and contributing factors to antibiotic resistance

Please tell us if you agree, disagree, or don't know to each of the following statements:

	Yes	No	Don't know
36. Antibiotic resistance happens when a bacterium loses sensitivity to an antibiotic.			
37. Some bacteria are naturally resistant to certain types of antibiotics.			
38. Bacteria can acquire antibiotic resistance through genetic mutation.			
39. Bacteria can acquire resistance from other bacteria through conjugation.			
40. Bacteria can acquire resistant traits from another bacteria by way of viruses.			
41. Bacteria can acquire resistance from bacteria DNA existing freely in the environment.			
42. Bacteria may acquire efflux pumps that expel antibiotics from the cell.			
43. A single bacterium can acquire resistance to multiple antibiotics using different mechanisms.			
44. People can pass on resistant bacteria to others through coughing and unwashed hands.			
45. Prescribing broad-spectrum antibiotics increases antibiotics resistance.			
46. Antibiotic Polypharmacy (the practice of concurrently administering many different antibiotics for the treatment of a single disease) can increase antibiotic resistance.			
47. Poor infection control practices by nurses contribute to the spread of antibiotic resistance.			
48. Use of antibiotics in livestock production and agriculture contributes to antibiotic resistance.			
49. Exposure to antibiotics appears to be the principle risk factor of antibiotic-resistant bacteria.			
50. Antibiotic resistance can be minimized by using narrow-spectrum therapy after identification and susceptibility testing of infectious bacteria.			

Appendix Six: Interview schedule

Semi-structured discussion guide

1. How are bioscience courses taught in your university?

   Which teaching methods are used in your university?

   At which points of the nursing program are bioscience courses taught?

   Who teaches biosciences in your university?

   Do you think the teaching methods currently used were effective in supporting you to understand?

2. How are your clinical placements conducted?

   Who supervises your clinical learning?

   Do you think your supervisors support your learning? Please elaborate on your answer.

3. How are biosciences assessed in your university? Do you find your theory assessments useful? How are your clinical assessments done? Who assesses you? Do you find the process useful? Were you given feedback on your assessment? How was it done?

4. Which problems did you encounter while learning bioscience courses?

   Tell me more about what you think causes these problems.

5. How best can you be supported to retain course content?

   Do you feel that the clinical environment supports you to apply biosciences to practice?

   Which activities most support your learning?

   Who has played the most important role in supporting your learning?

   Please explain why?

   Can you give an example?