Health Informatics: An Inter-Disciplinary Perspective of Nursing and Information Technology Practitioners' Education

by

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DECLARATION

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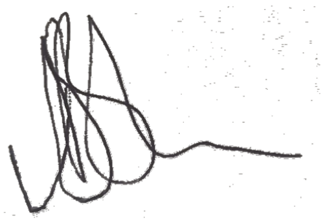
Signed  **Date 26 February 2025**

ABSTRACT

INTRODUCTION: The current educational programs for health informatics do not sufficiently develop the relevant competencies of health and informatics practitioners to provide a quality healthcare service enabled by digital health. In addition, the complexities of the diverse health and digital health domains due to environmental changes and technological advances place a burden on ever-changing relevant competency needs of the workforce within different contexts. In South Africa there seems to be limited research on the integration of relevant nursing informatics in nursing education aligned to relevant nursing practice as well as health domain knowledge for informatics practitioners.

METHODOLOGY: A simple mixed methods design was employed to explore the competency needs of nurse and informatics practitioners. The study was divided into three sections: semi-structured questionnaire was employed to explore the attitudes, competency needs and training of Post Basic nurses students; Unstructured interviews for the perspectives of the Nurse Educators and the Informatics Educators on the competency needs and training of the nurse and informatics students respectively; results from the INDEHELA project; and Unstructured questionnaire for the perspectives of Health Informatics Experts on the competency and training needs of Informatics Students. Thematic Analysis was conducted on the results

RESULTS: The assessment of attitudes of the nurses indicated that there is a positive attitude towards informatics technology. Students assessed themselves and indicated seven themes of topics that they would like to gain skills. Educators concurred with the topics and indicated that the best form of training would be integrated learning within the core Nursing course. Health Informatics Experts indicated eleven themes of topics of competencies and stated that for the African Context it is best to use African examples or train within an African setting.

CONCLUSION: Although nurse have a positive attitude towards informatics technology, there is a need for training of nurse in basic informatics technology. There is a need for training of the nurse educators for them to be able to lecture in Nursing Informatics. A collaborative approach from experts in both disciplines is necessary for the development of the competencies. It is important for informatics practitioners to have domain knowledge of health to effectively collaborate with health practitioners. The skilling of either practitioner results in three Health Informatician roles: A Nurse Informatician with health domain knowledge and some informatics knowledge; A Digital Health Informatician with informatics domain

knowledge and some health knowledge and a Health Informatician an expert in both domains of knowledge.

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DEDICATION

To my son Mbongeni Bhebe, may you reach greater achievements and blessings in your life.

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CHAPTER 1 RESEARCH ORIENTATION

1.1 Introduction

Good health care is an important factor for all individuals world-wide. Statistics from the World Health Organisation (WHO 2014: 138; South African National Department of Health, 2019), show that for every 10,000 people in South Africa there are 7.8 physicians, in contrast to 49 nurses and midwives per 10,000 people. The lack of adequate personnel exposes health workers to highly stressful yet sensitive working environments, while still having to maintain optimal patient care. This may be alleviated by the introduction of Health Information Technology to aid Health workers in their praxis (Aljaber *et al*., 2021). This development of technology to support various fields is noted in International Strategies. One of these include the objectives of the Sustainable Development Goals, which point to the support of domestic technology, development, research, and innovation in lower and middle-income countries (Pandey *et al.*, 2022). This is supported by the objectives 3.12 and 4 which point to capacity building through the provision of inclusive and quality education, which would include ICT training, technical engineering and scientific programs (United Nations (UN), 2016). Having knowledge in emerging technologies has provided a vast opportunity for the implementation of ICT solutions in Health Care Systems (HCS) care that could facilitate in improving the work environment for health-workers to provide their primary goal of patient care (Machleid *et al.*, 2020).

1.2 Research Positioning

In this inquiry an interdisciplinary approach was adopted. This is due to the characteristic that (1) in interdisciplinary studies more than one discipline is being regarded; (2) , Interdisciplinary studies analyse, synthesize and harmonize links between disciplines into a coordinated and coherent whole; (3) interdisciplinary creates its own theoretical, conceptual and methodological identity; and (4) interdisciplinary has the capacity of generating new disciplines (Schroeder, 2022; Vladova *et al.*, 2024). To understand the interdisciplinary nature of this study a definition of Health Informatics and Nursing Informatics was needed. For purposes of this research, two definitions are used, one with a Health Informatics perspective and the other from a Nursing Informatics lens. The definition for Health Informatics by Hersch (2009:2) which is used, states, health informatics, that combines computing and information science (Davies *et al.* 2020), is *"the optimal use of information, often aided by the use of technology, to improve individual health, health care, public health, and biomedical research*". The definition reflects the diversity of training and perspectives needed for health informatics as a practice (Gadd *et* *al.*, 2020). The Nursing Informatics definition used is "*Nursing Informatics is the integration of Nursing, multiple information, and information management with information processing and communication technology, to support the health of people world-wide, including the management and communication of that information as well as the aspect of people, families and communities being involved in the management of their health information*" International Medical Informatics Association (IMIA) (2016). This enables the nurse with the identification and uses in nursing practice (Bickford, 2017). From the definitions it can be deduced that there are two core fields that influence both health informatics and nursing informatics domains. The health and clinical sciences as well as the informatics again combine other different disciplines and perspectives.

Several studies mentioned the different disciplines, for example, Jones *et al.* (2023) propose the following foundational domains for biomedical health informatics as adopted by American Medical Informatics Association (AMIA).

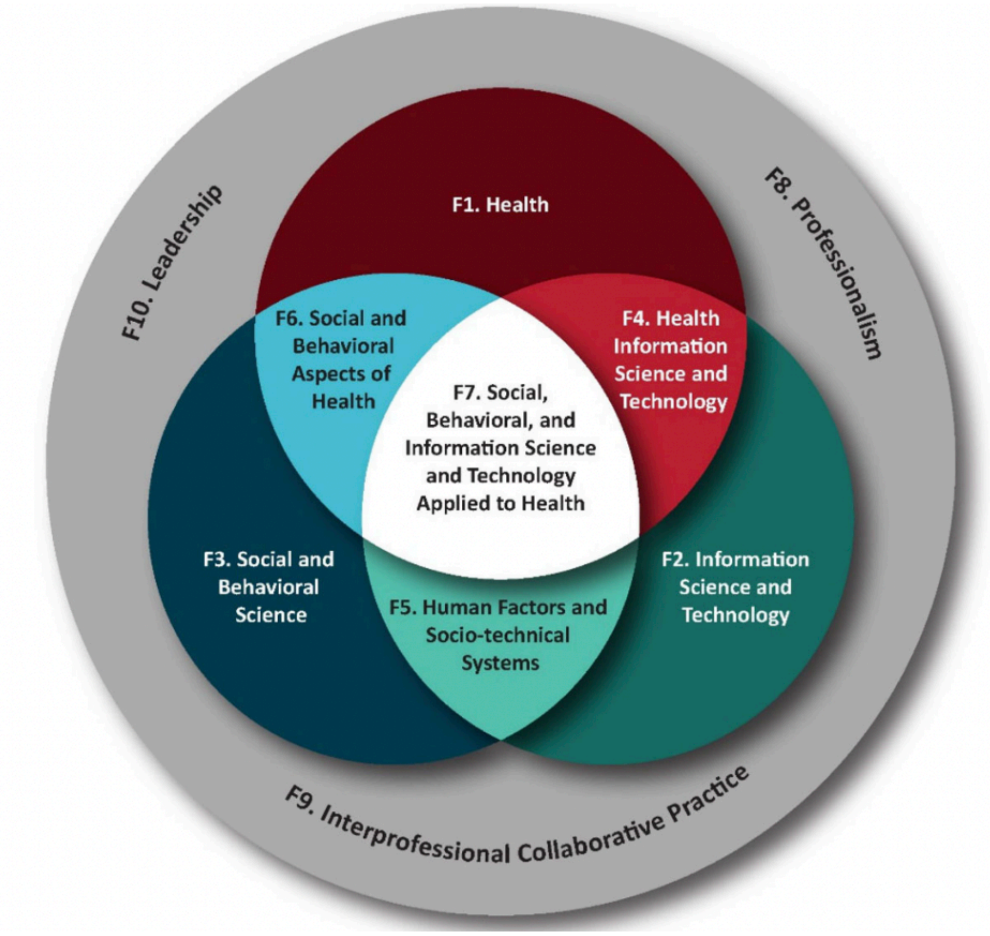

Figure 1-1 AMIA foundational domains (Jones et al., 2023:1595)

This study uses these AMIA proposed foundational domains (Figure 1-1) for its focus on nursing informatics but delineated and simplified to show the research positioning of the study as depicted in Figure 1-2.

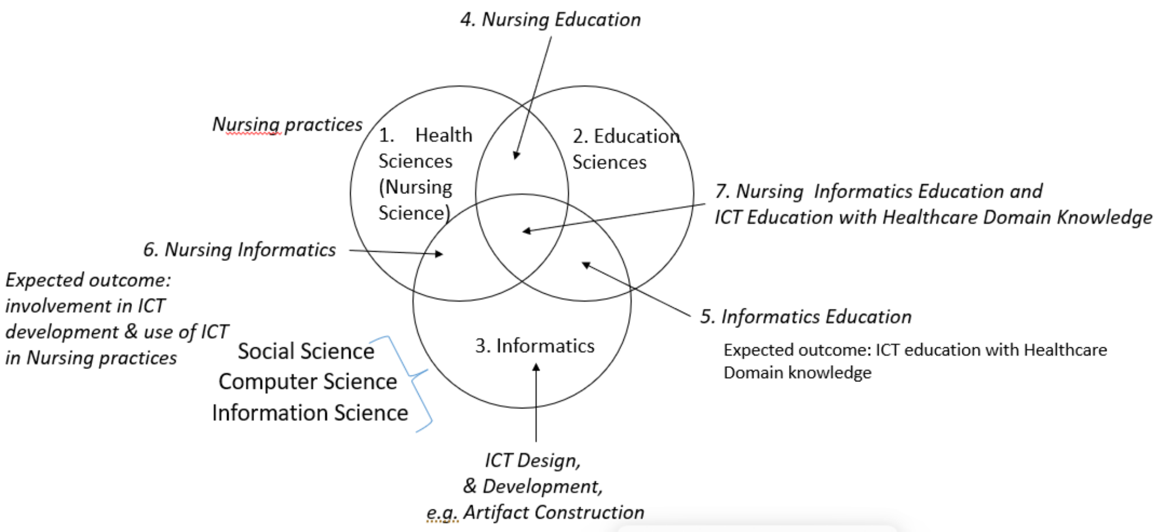

Figure 1-2: Research positioning of the study

Since this inquiry investigates the competencies that would be suitable for the context of health informatics and nursing informatics, an education sciences lens is necessary to complement the health and clinical sciences and the informatics sciences. To delineate the research, it was important to explore the areas of overlap between the fields, to understand, the different features that would need to be included in the study and those that would be excluded. Seven areas of study were identified. The domains for this study's inquiry are 1 to 7 with the intersection of the three main disciplines (7) representing the focus of the study with the following lens objectives of exploring nursing informatics education and ICT education with healthcare domain knowledge.

This research was conducted using the following discipline lenses, as illustrated in Figure 1-3 below:

- Health Sciences, this brings in the health epistemology into the inquiry and the Healthcare empirical focus on Nursing Sciences.
- Informatics Discipline incorporates Information Sciences epistemology from which Information is derived as the field of Health is an Information reliant area, Computer Science epistemology from which the technology lens is obtained for the inquiry, and

Social Sciences epistemology as Informatics and Healthcare is a people-oriented domain therefore there was need for the interactions with people to be included.

- Education Sciences epistemology which brings in the Educational Epistemology which has a focus on Health Education and ICT Education.

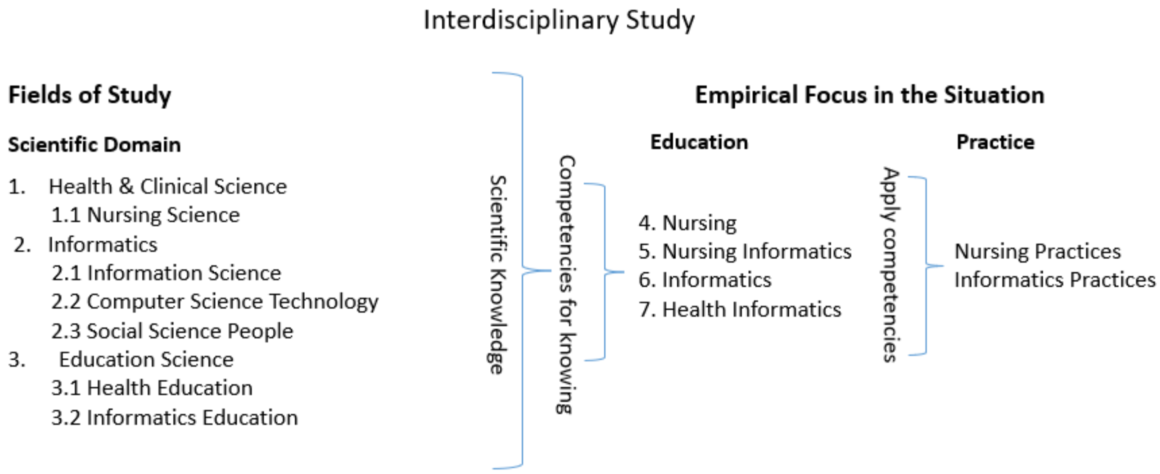

Figure 1-3: Fields of Inquiry

Five fields were identified from Figures 1-3 as relevant to the research; these were further broken down, identifying the topics of interest that would inform the research. A break down to further determine the fields, focus, and context of the study is indicated in Table 1-1 below. This provides a guid to the topics of exploration for both the Literature and the data collection, as well as the variables of consideration for the research.

Table 1-1 Delineation of the fields and focus of the study and the context within the study

Fields of Study	Sub-fields	Focus of study	Context within the study
1. Health sciences	Health systems	1.1 Health systems	SA Health system
	Nursing sciences	1.2 Nursing in practice	Nursing work practices
2. Education sciences	Health education	2.1 Nursing education	Nursing course
	Informatics education	2.2 Informatics education	Informatics course
3. Informatics with Health domain knowledge	Information Sciences	3.1 Health information (EHR, PHR, etc.)	Heath information in practice
	Computer Sciences	3.2 Information technologies	Digital technologies development and implementation in practice
	Social Sciences	3.3 Information systems and technology use	Health Information Systems (HIS) and Health Information Technologies (HIT) use in practice
4. Nursing Informatics	Health and clinical sciences overlap with informatics	4.1 Nursing informatics	Nursing informatics within a specific context
5. Nursing Informatics Education	Health and clinical sciences overlap with Education and Informatics	5.1 NI Competencies frameworks	A demonstration of NI Competencies
6. ICT Education with Healthcare Domain Knowledge	Informatics with Health domain knowledge overlap with Education	6.1 Informatics Competencies Frameworks	A demonstration of HI Competencies

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1.2.1 Researcher Positioning

The Researcher began the study from a background of Information Technology, having a master’s in computer science. In addition to this the Researcher had more than 10 years’ experience in education. This enabled the Researcher to assess and explore the participants perspectives on informatics competencies relevant in the health domain. The Researchers

Main Supervisor is a heath informatics expert providing more depth to data analysis and integration. The Researcher however had a lack of health competencies, the provision of a second Supervisor with a nursing background and a PhD in Informatics whose topic was on health informatics, enabled a better understanding of the health competencies suitable for nurses and informatics practitioners. Although the researcher had background in education, in order to uncover a broader perspective on competencies, the study included nurse and informatic educators. In addition, the Researcher was involved in Health Informatics research initiatives, like the INDEHELA where a health informatics course was designed. This provided greater context on the research gap, philosophy and approach.

1.2.2 Location Positioning

The location of the Researcher influenced the methodology of the study. The Researcher as a CPUT student was able to interact with the students, educators and experts as they were involved in one way with CPUT. In addition being in the context of South Africa and Africa, the Researcher could relate to the complexities of the contexts and assess the competency needs of the contexts.

1.3 Background

Digital health technologies have the potential to enable and transform healthcare much more than what is currently the case, and it seems that the adoption of new technologies is often hampered by the human ability to comprehend and implement the benefits of such technologies. The gap between the availability of digital health technologies and the digital capabilities of health practitioners is widening (Morris *et al.* 2023). Instead, several barriers, such as infrastructural and technical issues combined with work-related concerns and increase in costs limit the adoption of digital health technologies in practice (Borges *et al.*, 2023; Schueller, 2021). The increased usage of digital health technologies by nurses, demanded that they be equipped with knowledge on the usage and manipulation of the digital health technologies. This would help nurses in the understanding of the relationship and impact between health data to support their decision-making and healthcare practices (Bickford, 2017; Chipps *et al.*, 2022). As the environment of digital health technologies evolved with technology, literature noted that some of the technologies either failed to be used or were discarded as they were not sustainable (Mihalas, 2014). This brought to the fore the need for IT practitioners to have some Health domain knowledge, enabling them to understand the context better and be able to implement resilient digital health technologies (Mantas and Hasman, 2017).

Both health sciences and informatics are complex fields characterized by complexity, highly specialized areas, and covering a vast spectrum of domains with different roles and practices. In health sciences, health professionals are expected to be highly competent to deal with the many risks of healthcare services. It can be regarded as a human-oriented discipline that deals with life and death. On the other hand, informatics is also complex but with a technology focus with the potential to improve practices, etc. Some examples are developer, business analyst, etc., within the fields of software engineering, information technology, information systems, informatics, etc. Health professionals use digital technologies, such as services, systems, devices, applications, etc.as part of their practice to plan, deliver, document, and rehabilitate the care service they provide (Jarva *et al.*, 2024). Health informatics is the overlap of health sciences and informatics and not the combination of their respective fields.

The Health and Nursing Informatics field core tenants, provide a background knowledge on the components that make up the field. These are included in the fields of our research and involve for the Health and Clinical field an understanding of what is Healthcare, Healthcare Systems and Nursing as the research Health domain. For the Education Filed, a knowledge of the characteristics of Informatics Education and Nursing Education. For the Informatics field, knowledge on Health Information Systems, Health Information Technology and Health Information Technology use.

1.4 Healthcare Informatics Education in Nursing

Healthcare is defined by the Oxford Dictionary (2020) as “The organised provision of medical care to individuals or a community”. This definition is extended by the Merriam-Webster Inc (2022) adding that healthcare is “efforts made to maintain or restore physical, mental or emotional well-being by trained and licenced professionals.” Within the South African context, Healthcare provision can be either Private or Public. This is offered at either one of four levels of care. These levels are Primary Care, Secondary Care, Tertiary Care, or Quaternary Care. In these various Care provisions, patients are referred from Primary Care to Quaternary Care, dependent on the nature of disease or infirmity that the patient would have. These levels of care are structured within a Healthcare System that is implemented.

Healthcare Systems are defined as a set of services provided by “institutions, people and resources involved in delivering health care to individuals” (World Health Organisation, 2003). Healthcare Systems are established at different levels of society. These maybe at international level, macro being national or country level, micro at institutional levels or nano at individual levels. Healthcare System can be centralized or decentralized. In a Centralized System authority and power for decision making lies with the macro levels of government.

Decentralization, which is practised by many countries, involves transferring authority and power from the macro levels of government to the lower levels (Sreeramareddy and Sathyanarayana, 2019). In South Africa, the International Healthcare System that is used is the Bismarck Model. This system advocates for a Healthcare System that utilises both private and public providers (Wallace, 2013; Busse *et al.*, 2017). In addition to the Bismarck Framework, South Africa utilises a decentralised System of Health Systems governance. Within the South African Healthcare System is the Digital Healthcare Plan. This Plan according to the Department of Health strategy, involves the utilisation of ICT in addressing infrastructural backlogs in the health sector. The benefits of this would be that it would enhance the South African healthcare system's delivery capability, governance capability, workforce capability, and learning capability (DOH South Africa and CSIR, 2014). In their revised 2019/2024 strategy the Department has five aims for their eHealth Strategy, these are: (1) Digitisation of Infrastructure, with an integrated platform; (2) Digitisation of all clinical business processes; (3) Ensuring electronic health records are completed; (4) Advancing mHealth in Community based Environments; and (5) Advancing Knowledge based workers within the Health Domain (South African National Department of Health, 2019).

1.4.1 Education

"*Education is the process of living through a continuous reconstruction of experiences. It is the development of all those capacities in the individual which will enable him to control his environment and fulfil his possibilities*" (Dewey, 1916:50). The theory of education comprises of Development of capacities occurs through a process that affects how individuals think, feel and act. Curriculum design for a program involves a lot of components. These maybe at Supra, Macro, Meso, Micro and Nano level of structures (Van den Akker *et al.*, 2006). Core to these structures is the design of a program that addresses learning paths of student, ensuring that they meet the different stakeholder needs. The Supra curricula is the curriculum that is set at an international level, an example of this would be curricula needs set by the World Health Organisation (WHO) or in the case of Nursing and Health Informatics curricula set by the International Medical Informatics Association (IMIA), American Medical Informatics Association (AMIA) or Health Informatics in Africa (HELINA) or any Continental Informatics association. The curriculum at the Macro level is the national syllabi as the designated country curricula. For the Nursing Education in South Africa this is determined by SANC. The Informatics Curriculum is determined by the Council for Higher Education (CHE). The meso-curriculum is determined by the Institutions as they identify the program outcomes that are in alignment with their Institutions values and objects from the Macro Curriculum. The micro curriculum is the enacted curriculum that the educators impart to their students. This includes instructional materials, tools and technologies that will be used and assessment of students' competency outcomes. The Nano level of curricula is at the Individual level, where experiential learning process occurs, and competency outcomes are attained. At all levels of curriculum design, there are factors that influence the derivation of the curriculum. This is at the instructional, materials, the stakeholder needs and the resources that are required to enact the program. This study focuses on the competency outcome needs from the perspectives of the students who are working in practice and educators who enact the curricula and experts who have both the foundational competencies in their fields and the practice knowledge. The outcomes of this study would inform the practice, the shaping of the program design, the content of instructional material design and development of competencies for Nursing and informatics students in Nursing and health informatics education respectively.

1.4.2 Nursing

Nursing is defined by the Nursing Act of 2005 as "*a caring profession which supports, cares for and treats a health care user to achieve or maintain health and where this is not possible, cares for a health care user so that he or she lives in comfort and with dignity until death*". (National Department of Health, 2005). Central to the nurse in their practice is the Nursing scope and Nursing process. The Scope of Nursing can be described as the roles, functions, responsibilities, and activities that registered nurses are taught and authorised to conduct (Association of Registered Nurses of Newfoundland and Labrador, 2006). These vary, dependant on the different levels of education and experience that a nurse practitioner would have. They involve having skills in supporting, promoting, caring for and treatment of a health care user to achieve, maintain health or live in comfort and dignity until death. In the provision of care, nurses apply the Nursing care plan by means of the Nursing process. The Nursing process comprises of assessment, diagnosis, outcome identification, planning, implementation, as well as evaluation (Pope *et al.*, 1996:41-43; Mahmoud and Bayoumy, 2014). Nursing Practice involves a wide range of specialisations, these maybe in orthopaedic Nursing, cardiac Nursing, palliative care, perioperative nursing, emergency nursing, oncology nursing, radiology, obstetrical nursing tele-nursing and nursing informatics. For a nurse to practise, they need to be registered. Within South Africa a nurse can be registered in five categories of education, these are: (1) professional nurse; (2) midwife; (3) staff nurse; (4) auxiliary nurse; or (5) auxiliary midwife. Registration allows the nurse practitioner to be able to work within their scope of practice (National Department of Health, 2005).

1.4.3 Nursing Education

The earliest historical nurse education was noting of apprenticeship that nurse practitioners would take under the auspices of a senior more experienced practitioner. This was noted in the earliest formal training recorded in Guangdong, China as well as the training introduced by Florence Nightingale at St Thomas Hospital (Morin, 2014). The training of nurses was then combined with Higher Education training, resulting in 2 and 4-year training programs for registered nurses (Harker, 2017; Scheckel, 2016). This enabled the integration of nursing theoretical foundations to support the clinical practice. Scheckel (2016) notes that in practice it was noted that nurses with theoretical background perform their duties better than those who had been trained through apprenticeship. With technology increasingly being used in the health domain, theoretical foundations in nursing and informatics have become a necessity (Haux, 2010). With the evolution of technology within healthcare it became more evident that it was necessary for nurse practitioners to be trained in informatics (Mantas and Hasman, 2017). It was not only necessary for nurse practitioners to be able to use the technology, but to have informatics competencies that would enable them to analyse the technology and make valued judgement on the design, development or purchase of a health information system. (Thimbleby, 2013; Ückert *et al.*, 2014).

1.4.4 Informatics Education

Informatics is the "*knowledge and competencies about computational structures, processes, artefacts, and systems."* (Hersh, 2009:2). Informatics education considers the knowledge and competencies required of an individual to use, create, design, develop, implement as well as analyse domain properties and relations in its core disciplines (Caspersen *et al*., 2018). The core disciplines to be considered for the Informatics discipline are Computer Science, Information Science and Social Sciences. The core tenants of each discipline form the tenants of the informatics discipline. The computer science discipline brings to informatics foundations about the design, development, implementation, and use of technologies. Information Science brings to informatics the foundations that information permeates all levels and contexts of society; information evolves according to decisions that are made concerning it; and information flows through processes and environments animated and inanimate (Kolin, 2011). The Social Sciences discipline brings its foundations of theoretical foundations of the environment in which technologies are implemented and used. This environment includes the people who technologies are intended for and the behaviours within the context of practice with the aim of bringing about sustainability (Layton, 1997).

1.4.5 Informatics

In addition to the definition of informatics being *a discipline focused on the acquisition, storage, and use of information in a specific setting or domain*" (Hersh (2009:2), Friedman (2009) adds to this definition noting that people are an essential component of informatics. This means that the discipline considers the interaction between information and people in addition to the construction of technologies, interfaces, systems, and organisations. It involves the study of systems that represent, processing, communicating, and storing of information. Thus, informatics provides a link between its foundational disciplines with its own theories and methodologies.

1.4.6 Health Information Systems

Health information systems (HIS) are indicated by Almunawar and Anshari (2012) as forming the intersection between information systems and healthcare business processes. This intersection involves the interactions of social actors, technologies, information, and data practices of information systems development (Boell and Cecez-Kecmanovic, 2015). The purpose of these interactions is for decision-making that provides better care. There are two ways of categorising Health Information Systems. The first method used by Beaumont (2011) is by identifying the technologies that are used within the Health Information Systems. The second noted by the Department of Health and CSIR is by the activities around data flows within the Healthcare System (Katurura and Cilliers, 2018). Central to both is the use of Electronic Health Records (EHR), Electronic Medical Records (EMR) and Personal Health Records (PHR). An EMR is a database that is a "digital" version of the patient chart and contains all the traditional information about a patient that would be found in a paper chart, including medical history, allergies, treatments, and medications" (Nara, 2020:10). EMRs are created and managed by medical institutions that provide patient care. PHR contain the health and medical history of an individual and is created, maintained, administered, and owned by the individual or the caregiver where a patient is not able to do so (Park and Yoon, 2020). The compilation of an individual's health data from the EMR and the PHR is known as the Electronic Health Records (EHR) of a person.

1.4.7 Health Information Technology and Health Information Technology Use

Health information technologies make use of "*hardware and software to process, store, retrieve and share Health Information, data and knowledge for communication and decision making in the healthcare sector*" (Mostert-Phipps *et al.*, 2013:147). Blumenthal and Glaser (2007) refers to health information technology as the circulatory system whose blood is

Information. Bailey and Pang (2004) notes that Health information technology has the potential to transform health care delivery, bringing information where it is needed and refocusing health care around the consumer. This includes improving the health of individuals, the performance of providers, improved quality, cost savings, and greater engagement by patients in their own health care. (Blumenthal and Glasser, 2007). With the increase in emerging technology, the nature and type of health information technology that can be used within a Health Information System is diverse. Technologies such as Big Data, Internet of Things, Artificial Intelligence, Blockchain, and Mobile technologies (Fernández, 2017; Grandia, 2017). Central to the use of health information technologies is the capturing of data at its source. This, according to Ahmad *et al.* (2018), increases the number of correct diagnoses made and reduces errors. With the capturing of data at source and emerging technologies, it means that simple solutions are no longer sufficient for the challenges in healthcare (Vehko et al., 2019). This also means that within the scope of practice of health practitioners, informatics education is a necessity.

1.4.8 Informatics Practitioners Praxis in the Health Field

Digital Canada in their survey of the roles in the health informatics field may take, identified 28 roles that IT Practitioners may practice, which are distributed in 7 categories, Senior IT Management; Architecture; Application Implementation and Support; Security; Quality Assurance and Testing; Service Desk; Network, Storage and Other Infrastructure Support of which the largest role group comprised of 34% Application Implementation and Support (CIHI, 2009). Institutions are evolving to adopt an enterprise health information systems, thus requiring informatics practitioners who have knowledge in both Informatics and Health, (Longenecker *et al.*, 2011). The architecture of health information systems covers all the key functional departments in a hospital institution, these are formed by components of health systems and are utilised for "*collecting, processing, storing, retrieving and transferring*" EHR and required information amongst practitioners (Locatelli *et al.*, 2012). Health information systems architecture delineates its component context to include: the terminology used, the database record structure, work-flow and decision-making, as well as systems architecture. This is important knowledge that forms the foundations for systems design, development, use, implementation, and maintenance. These health roles and features require Informatics practitioners who have competencies that are in alignment with these components.

1.4.9 Nursing Informatics

Conceptualised in the 1970s, Nursing informatics is still a young discipline whose epistemology is evolving (Gadd *et al.*, 2020; Mantas, 2016). Although nurses work in collaboration with all health field practitioners, their use of information technology as a tool in their practice is ubiquitous (Shortliffe and Blois, 2014). This pervasiveness of technology influenced the emergence of Nursing Informatics as a discipline to provide a platform from which nurses will be able to utilise technology to improve the delivery of care (Elsayed, 2016). The establishment of a discipline requires formulation of definitions, methodologies, and frameworks to guide the education, research, and implementation of systems within its domain. Historically, the earliest mention of Nursing Informatics definition by Hannah *et al.* (1985:181), who stated "*The use of information technology in relation to any of the functions which are within the purview of nursing and which are carried out by nurses. Hence, any use of information technology by nurses in relation to the care of patients or the educational preparation of individuals to practice in the discipline is considered Nursing informatics*". This definition emphasises the nature of knowledge and contribution to knowledge that the discipline could possibly have (Schwirian, 1986). This was expounded upon by Graves and Corcoran (1989) who, in their exploration of the field, pointed out its multidisciplinary nature by defining nursing informatics as "*A combination of computer science, information science, and Nursing science designed to assist in the management and processing of Nursing data, information, and knowledge to support the practice of Nursing and the delivery of Nursing care*". This definition provided a platform on which further explorations on definitions and frameworks was conducted (Turley, 1996; Staggers and Thompson, 2002; Effken, 2003). Exploration on the competencies that would be required, that would inform the foundations for education and training in Nursing Informatics this sentence is incomplete.

1.5 Nursing Informatics Education Competencies Frameworks

With the evolution of technology, there are diverse technologies that can be used for the same procedures (Wright *et al.*, 2012). This has brought to the forefront the need for Health Practitioners especially Nurse Practitioners to have informatics knowledge (Mantas and Hassman, 2017). Several International competency frameworks have been developed to address the need for competencies for Nurse Practitioners (CHIA, 2012; Valenta, et al, 2018; Bichel-Findlay *et al.,* 2023). The earliest of these competency frameworks was developed by Staggers *et al*. (1999) and the results were competencies that fell within three knowledge and skills categories. These were Computing Skills, Informatics Knowledge, and Informatics Skills. Computing skills they described as computing literacy, where a student learns proficiency in the use of computer hardware and software; Informatics knowledge is the theoretical and conceptual basis for the specialty; and Informatics skills are the use of methods, tools, and techniques particular to informatics. After the Staggers competencies the next framework that took into consideration competencies internationally and was used as a reference in the International Medical Informatics Association (IMIA) Framework (Mantas *et al*., 2010). Unlike the Staggers Competencies which considered competencies for nurse practitioners only, the IMIA framework considered competencies for Health Practitioners of a wider diversity, in Health Informatics and in addition Non-Health Practitioner competencies. Using the Staggers and IMIA as references the next international framework was the HIT Comp framework developed in 2017, followed by the TIGER framework in 2018 (Hübner *et al.*, 2018) which considered informatics competencies from a nursing perspective. The HIT Comp framework considers competencies for both health and non-health practitioners, while the TIGER framework considers health informatics competencies for nurse practitioners. In 2019 the TIGER framework was updated with its competencies framing them to include the roles and competencies proposed by the HIT Comp framework. An IMIA taskforce, established in 2017, recommended in 2023 that a second revision of competencies, which referenced competency frameworks from Australia, Canada, Saudi Arabia, European Union Horizon, United Kingdom FCI, and AMIA be considered (Bichel-Findlay *et al.*, 2023). These frameworks form a referential basis for the development of competencies for nurse practitioners as well as informatics practitioners.

1.6 Statement of Research Problem

The current educational programs for health informatics do not sufficiently develop the relevant competencies of health and informatics practitioners to provide a quality healthcare service enabled by digital health (McLane *et al.,* 2021). There seems to be a gap between the preparedness of and the nurse's informatics and digital health competencies needed in practice (Kleib *et al.* 2021). Health informatics education needs to keep pace with the evolving digital health landscape currently and in future in both disciplines of healthcare and informatics (Thate and Brookshire 2022). Competency frameworks include duplications and may lack relevance (Davies *et al.*, 2022). It is not clear to what extent the identification of digital competencies for different Health practitioner groups has been consolidated and analysed. It is therefore important to focus on the competencies relevant to the needs of a particular group's care practices (Nazeha *et al.* 2020).

In addition, the complexities of the diverse health and digital health domains, due to environmental changes and technological advances, place a burden on ever-changing relevant competency needs of the workforce within different contexts (Weber *et al.* 2022). Educational programmes need to consider competency requirements of nurses who are challenged by rapidly expanding digital health (Kinnunen *et al.* 2023). Practitioners need to be encouraged to become competent in using digital health in their practices and healthcare organisations need to ensure that the workforce is capacitated in the use of digital technologies (Morris *et al.* 2023). Additionally, Mantas and Hasman (2017) indicate the lack of understanding by informatics and health practitioners of each other's fields due to communication problems and therefore there is a need for an intermediary to facilitate between the two professions. Holden *et al.* (2018) state that there is a need however to increase interest in defining and implementing the role of a health informatician in inter-professional healthcare teams to assist with real-life problem solving.

The intersection between health sciences and informatics may not be aligned to the required competencies in the two respective disciplines due to lack of context-sensitive competency frameworks that cater for all levels and specialization roles (Munene *et al.*, 2020). Globally It is challenging to integrate health informatics in health informatics education for continuing professional development of digital literacy and capability in practice (Lokmic-Tomkins *et al.*, 2024). Harerimana *et al.* (2021) note that context may not sufficiently considered especially in lower and middle-income countries such as African countries.

The gap that this study focuses on is that in South Africa there seems to be limited research on the integration of relevant nursing informatics in nursing education aligned to relevant nursing practice (Chipps *et al.*, 2022; Le Roux *et al.*, 2024), as well as in informatics courses where health domain knowledge may not sufficiently support digital health technology developments Mantas and Hasman (2017).

1.6.1 Research Aim/Purpose of Research

To understand what are relevant nursing Informatics and health informatics competencies that would be appropriate for educating nursing and informatics practitioners to practice within the nursing and health informatics domain in South Africa.

1.6.2 Research Questions, Objectives and Methods

The research questions (RQ), sub research questions (SRQ), objectives and methods are outlined in Table 1-2.

Table 1-2: Research, and sub-research questions

Research Question 1: How suitable is the global Health Informatics and its competencies for the training of nurse and ICT practitioners in a health domain in an African context?	
SRQ 1.1: What are the competencies needed by nurses to use ICT as part of their work in practice in an African context?	SRQ1.2: What is the current situation of Heath Informatics Education for Nurses and ICT Practitioners in an African context?
Objective: establish the attitude and competencies for digital technology use in practice	Objective: To determine the current status of the respective programmes globally and in a specific context
Methods: literature review, questionnaires (nurses), interviews (educators and experts)	Methods: literature review; course outlines; interviews
Research Question 2: Why is the intersection between health sciences and informatics complicating the design of relevant education for the required competencies in the two respective disciplines?	
SRQ2.1: How do nursing informatics courses develop competencies to equip nurses' involvement in digital health technologies development and support?	SRQ2.2: How do informatics courses develop/prepare ICT practitioners to involve nurses in the development and support of digital technologies to enable nursing practices?
Objective: To determine how nursing informatics courses develop domain competencies to involve nurses in digital health technologies development and support	Objective: determine how informatics courses develop domain competencies in ICT practitioners in digital health technologies development and support
Methods: literature review; questionnaires (nurses); interviews (Nursing educators)	Methods: literature review; course outlines; interviews (Informatics educators and HI experts)

1.6.3 Research Philosophy

In this study, pragmatism is used as the framework that guides the philosophy of study and the methodology used in the study. Pragmatism's tenets lie in the ontology that research is not committed to one system of philosophy and reality (Creswell, 2009). It comprises a complex, rich external 'reality' with practical outcomes of ideas, and a flux of processes, experiences, and practices. Pragmatists' epistemology believes in obtaining the practical outcomes of knowledge in particular contexts. It advocates that 'true' theories and knowledge are those that enable successful action, with a focus on problem-solving and informed future practice as contributions (Mackenzie and Knipe, 2006). Pragmatism methodologies provide a platform for working with multiple methods, different worldviews, and different assumptions. as well as different forms of data collection and analysis (Frey, 2018). In order, to overcome research strategies biases, researchers conceptualised methods that may include triangulation (Jick, 1979); mixed methods and other transformative methods (Creswell, 2009; Tashakkori and Teddlie, 2003). Pragmatism brought to the fore axioms that allowed researchers to conduct research that would maximise the use of the advantages of both quantitative and qualitative research designs; while the weaknesses that each can be overcome by the other.

The pragmatist characteristics of the connectivity of knowledge and action is in alignment with the philosophy of this study as the disciplines Nursing Informatics Education (NIE) and Health Informatics Education (HIE) including their sub disciplines of nursing, health, informatics and education to solve practical problems within their contexts (Kaushik and Walsh, 2019; Voorheis *et al.*, 2023). In solving these problems this study is not aligned to one form of paradigm but seeks to make use of the strengths found in both the quantitative and qualitative paradigms.

1.6.4 Research Methodology

For this inquiry pragmatic mixed methodology approach was implemented. Data collection was done from three participant groups, these included the deployment of a questionnaire whose participants were Nursing Students. Interviews were conducted with Nursing and Informatics Educators and a Survey was administered to Health Informatics Experts. The enquiry was cross sectional taking place in South Africa, focusing on the work practice of Nurse and ICT Practitioners. The units of analysis are the attitudes of Nursing Students towards Nursing Informatics and the competencies of Nursing and Informatics Practitioners in Nursing Informatics and Health Informatics respectively. For the data analysis an interpretivist approach using a qualitative lens was utilised. Thematic analysis of the data collected from questionnaires and Interviews will be conducted.

1.6.5 Context of Study

The study was conducted with participants from Cape Peninsula University of Technology which is the largest University in the Western Cape. CPUT offers more than 80 undergraduate and postgraduate courses in six faculties. These are offered in the fields of Applied Sciences, Business and Management Sciences, Education and Social Sciences, Engineering and the Built Environment, Informatics and Design, as well as Health and Wellness Sciences. The Research context included participants from the Information and Technology Department as well as the Nursing Department. CPUT Health Informatics Stakeholders that were in collaboration with both departments were also included. This provided a lens through which Nursing Informatics Education and ICT Education with Health knowledge domain could be explored.

1.7 Research Design

In this study the convergence design strategy was used to obtain answers to the research questions. This was in alignment with the research purpose for triangulation; seeking convergence of findings; complementarity or examining different overlapping aspects of nursing informatics education and health informatics education; expansion, adding breath and scope to a study. The elements of the research design are outlined as illustrated in Figure 1-4.

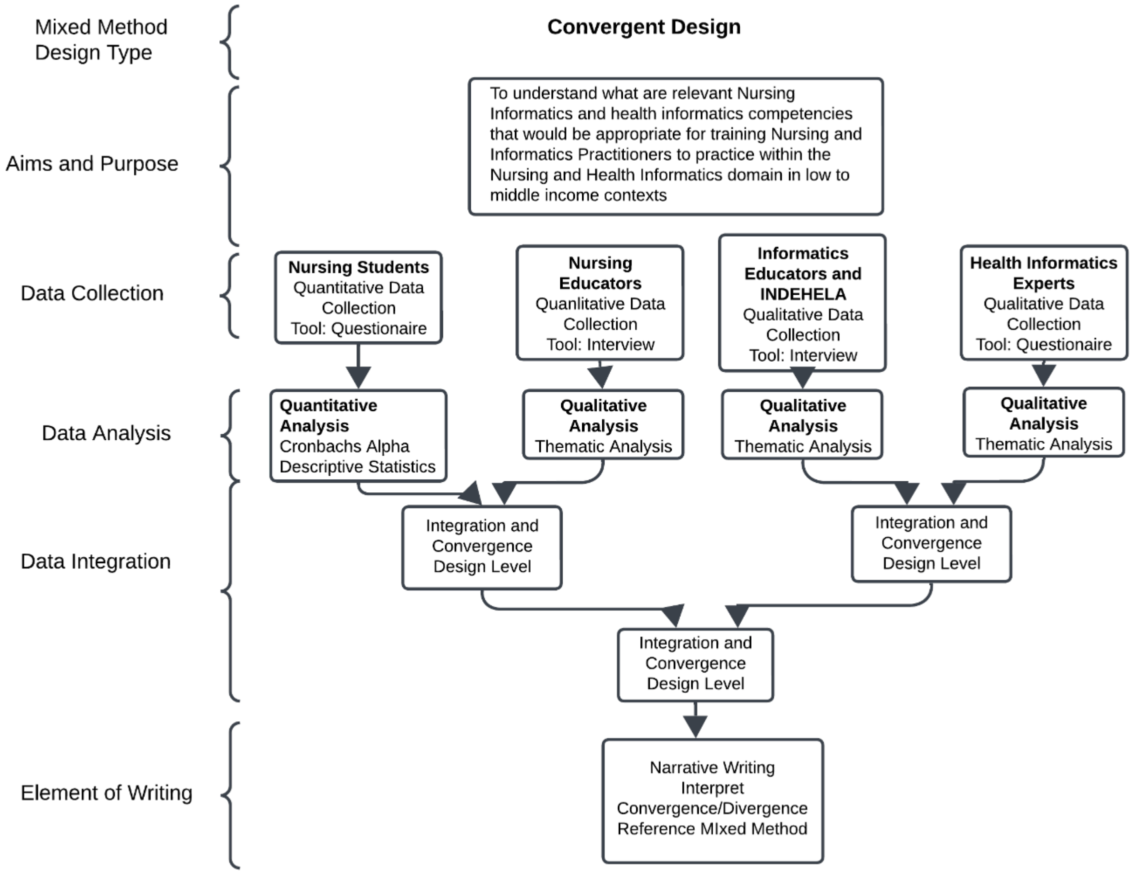

Figure 1-4: Research design

1.7.1 Data Collection

To gain a holistic understanding of the problem, data was collected from multiple participants. The perspectives of three stakeholder participant groups were explored in the study. The participant description, criteria and methodology is outlined in the following sections.

1.7.1.1 Nurses Perspectives

In this study due to the paucity of literature it was important to have an analysis of the current context, a preliminary determination of needs, and a perspective of desired competencies. To determine these characteristics, a questionnaire was administered to Post Grad Nursing Students. The questionnaire was administered with an objective of exploring the research context, for answers to Sub Research Questions (1) What are the competencies needed by nurses to use ICT as part of their work in practice in an African context? and (2) How do nursing informatics courses develop competencies to equip nurses' involvement in digital health technologies development and support? Convenience sampling technique was used as the sampling method for the selection of participants. The questionnaire was administered to Nursing Students as they have the following three criteria's: ((1) They had foundational knowledge of their area of Nursing and Midwifery; (2) They had some experiential praxis within their speciality, the minimum being 2 years fulltime in-service training, and (3) they are conducting some academic research. They must already have extended linkages between their theory and practice so they should be able to make judgement on Nursing Informatics competencies within their domain.

1.7.1.2 Nursing and Informatics Educators

In this Phase, Semi-Structured Interviews were conducted with Educators from both the Nursing and Informatics Departments. This was done to probe further into the competencies that Nursing Students would require as well as the competencies Informatics Students would need. Purposive Convenience Sampling was used as the sampling method for selecting the Research Participants. The selection of participants for Interviews was dependant on the following criteria. (1) Being and Educator in one of the Specialities, Nursing or Informatics. Additionally, the selection of the Informatics Educators was depended on (1) Lecturing within the Information Technology Department and (2) Involvement in Health Informatics Studies. The Lecturers were interviewed to probe and explore their perspectives on the Competencies for the Nursing Student and Informatics Student. The HIT Comp and the TIGER frameworks were used as tools to provide foundational knowledge on the composition of competencies for these students.

1.7.1.3 The INDEHELA Case

This study draws from the Informatics Development for Health in Africa (INDEHELA) collaborative projects of a period from 2001 to 2015 with the participation of the student and supervisors. The projects were based on previous experiences and findings, such as for example, Saranto *et al.* (2001). The details about the INDEHELA case will be presented as a narrative using materials that Prof Mikko Korpela, the project leader, have presented at different platforms. The outcome of the capacity development project is a health informatics fundamentals course that was co-designed with the participation of the INDEHELA project members from Finland, South Africa, Nigeria, and Mozambique. The course outline was analysed using the domain areas aligned to the latest IMIA guidelines for biomedical and health informatics as well as the IT2017 framework for information technology. This serves as one of the data sources used for the empirical part of the study to illustrate the collaboration of both health and informatics researchers, educators, and post-graduate students.

1.7.1.4 Health Informatics Experts

A Questionnaire was administered on Google Forms and sent to participants. Convenience purposive sampling was used as the sampling method for selecting the participants. The selection criteria for participation, was that the participants should have at least a Master's Qualification and at least 5 years' experience within the Health Informatics field within Africa. The participants who were selected also had some affiliation with the development or training of Health Informatics Courses at CPUT. An Unstructured Questionnaire was administered, with the objective of determining competencies that were suitable for Informatics Students to gain domain knowledge within the Health Informatics field.

1.7.2 Data Analysis

Data Analysis was done at each level of data collection. For the nurses questionnaire descriptive analysis was conducted to understand the underlying elements of the nurses attitudes and competencies in informatics. For the Educators and Health Informatics Experts data, thematic analysis was conducted to unpack and analyse the data to develop meaningful information in categories and themes (Hsieh and Shannon, 2005).

1.7.3 Data Integration

In this study data integration was conducted at the level of the study design. A convergence design was used in the study. According to the method proposed by Creswell and Clark (2018) the following procedures were conducted:

1. Integration data analysis procedures are to be conducted as follows:
    a. Obtain results by analysing quantitative or qualitative data.
    b. Look for common concepts across the results.

c. Compare the quantitative and qualitative results for each concept.
d. Determine in what way the results confirm, disconfirm or expand each other.
e. Interpret and resolve differences.
f. Use different procedures for data transformation.

2. Develop side by side comparisons of quantitative and qualitative results through a narrative or comparison joint display,

1.8 Ethical Considerations

This study acknowledges that the ethics of work practice and research established and observed. The following ethical principles will be upheld in this study (Mouton, 2011):

- **Professional Ethics**: Endeavour to be objective, avoiding bias and ensuring integrity in research design, data analysis and data interpretation. Endeavour for honesty in all communications. Keep promises and agreements; act with sincerity; strive for consistency of thought and action. Be open to sharing data, results, ideas, tools, and resources and appreciative of criticism and new ideas. Respect intellectual property
- **Societal Ethics**: Safeguard confidential communications. Strive to promote social good and prevent or mitigate social harms through research, public education, and advocacy. Avoid discrimination against colleagues or students on the basis of sex, race, ethnicity, or other factors that are not related to their scientific competence and integrity. Appreciate and respect relevant laws and institutional and governmental policies.
- **Participants Ethics**: When conducting research on human subjects; respect participant's rights to anonymity and confidentiality; respect the participants' rights to privacy, dignity, and autonomy.

1.9 Delineation of Study

This inquiry was conducted within the domain of CPUT and Africa. Participants from CPUT were Nursing Students, Nurse Educators, and Informatics Educators. Participants from the African context comprised ~~of~~ Health Informatics Experts who had experience within context. The units of analysis which are the attitudes and competencies were based on the input obtained from the participants. The Health and Clinical Science component that this study explored was the Nursing field. The informatics domain that this study focused on was the Information Technology field. The education component that this study focused on was ~~on~~ competencies that would be appropriate for training Nursing and Informatics Students to practise within the Nursing and Health Informatics domain.

The findings will not be generalisable because only one institution was included in the study. The study also only considered nursing as an example of the health domain and information technology (IT) to represent an informatics example. The focus is also only on the identification of health informatics competencies and does not consider the design and implementation of health informatics courses. However, even though the findings cannot be generalised, they may still contribute towards a better understanding of the digital competencies needed by both nurses and IT practitioners, especially in a context where formal education programs in health informatics are limited.

The units of analysis were the attitudes and competencies based on the input obtained from the participants. The health and clinical science component that this study explored was the nursing field. The informatics domain that this study focused on was the Information Technology field. The education component was on competencies that would be appropriate for training nursing and informatics students to practise within the nursing and health informatics domain.

The proposed conceptual framework is also not yet tested and could serve as an example that could be further developed.

1.10 Contribution of Research

Outcomes from this research are considered as methodological, theoretical, and practical contributions. Each is discussed next.

1.10.1 Methodological Contributions

Since Nursing Informatics is a multidisciplinary course, methodological contributions are on the approach towards implementation of research in the discipline are necessary as a one size fits all policy does not produce relevant training. Guidelines for approaching the development of nursing informatics and health informatics training programs within situated work practice contexts in Africa. This last sentence in this paragraph needs more clarification.

1.10.2 Theoretical Contributions

The Theoretical contributions of this inquiry lie in the following sciences: the education sciences; informatics sciences, and the health sciences. Within the informatics sciences there are three sciences of consideration: social sciences; computer sciences; information sciences and natural sciences. Outcomes from the study will be classified in the relevant sciences, providing a holistic theoretical overview of the study.

1.10.3 Practical Contributions

Five practical outcomes were produced from the inquiry: (1) Nursing informatics competencies aligned to their nursing practice needs; (2) Nurses' attitudes towards digital technologies; (3) Health informatics competencies needed to develop digital technologies for health practices; (4) The different health informatician roles; (5) Proposed Nursing informatics conceptual competencies framework for the African Context.

1.11 Thesis Outline

This thesis is structured into eight chapters illustrated in Figure 1-5.

Chapter One introduces ~~to~~ the topic of study. The research positioning and a brief discussion on the different discipline topics that influence the shaping of the research study/ The Context of Study, the research problem, the motivation and rationale of the study, research strategy as well as the structure of the thesis, are presented in the first chapter.

Chapter 2, the Literature Review chapter presents a deep review of the study. It provides a deep overview of the literature on the topic. The chapter describes, summarizes, evaluates and clarifies the literature on the different discipline topics that influence the study. Topics considered are on the Healthcare context with a look at the Nursing Context; Education with a look at Informatics and Nursing Education; Informatics within the Health field and Nursing Informatics. Contexts considered are in the African and South African Contexts. These topics provide the foundations for understanding the contentions and contradictions that are present in addressing Health and Nursing Informatics Education. In this respect a discussion is raised on various theoretical perspectives of Health and Nursing Informatics Education.

Chapter 3, the Research Strategy presents the philosophical paradigms and the research methods for the study. Educational Design Research is the Research Strategy employed in the study. This chapter presents the background to the EDR, the philosophical underpinnings of the approach, and suitability of the using the approach in the study.

Chapter 4, Phase One presents the results from the data collection of a questionnaire administered to CPUT Post grad students. Analysis of the questionnaires to explore the attitudes and competencies of the students. A brief discussion of the results is provided, and outcomes of proposed competencies and a competency framework are presented.

Chapter 5, Phase Two – Nursing Educators presents the second phase of exploration on the competencies for Nurse Educators. It presents the results from interviews conducted with Educators from the Nursing Department. An analysis of the interviews is conducted, and a discussion on the outcomes presented. The proposed competencies for Nurses are further explored and competencies for Informatics Students are proposed.

Chapter 5, Phase Two – Informatics educators presents the second phase of exploration on the competencies for Information Technology Students. It presents the results from interviews conducted with Educators from Information Technology Departments. An analysis of the interviews is conducted, and a discussion on the outcomes presented.

Chapter 6, Phase Three – Health Informatics Experts presents the data collection of the perspectives of health informatics experts. In this phase the results of a questionnaire administered to Health Informatics Experts are presented. The analysis of the results is indicated and the outcomes of proposed competencies and perspectives on the African Context are presented.

Chapter 7, the Discussion, Conclusion and Recommendations presents summary of the process of the research as indicated in the thesis structure and data collection. A discussion on the research questions and the outcomes from the data collection. The chapter looks at the contribution to research, the assumptions and limitations and recommendations derived from the research.

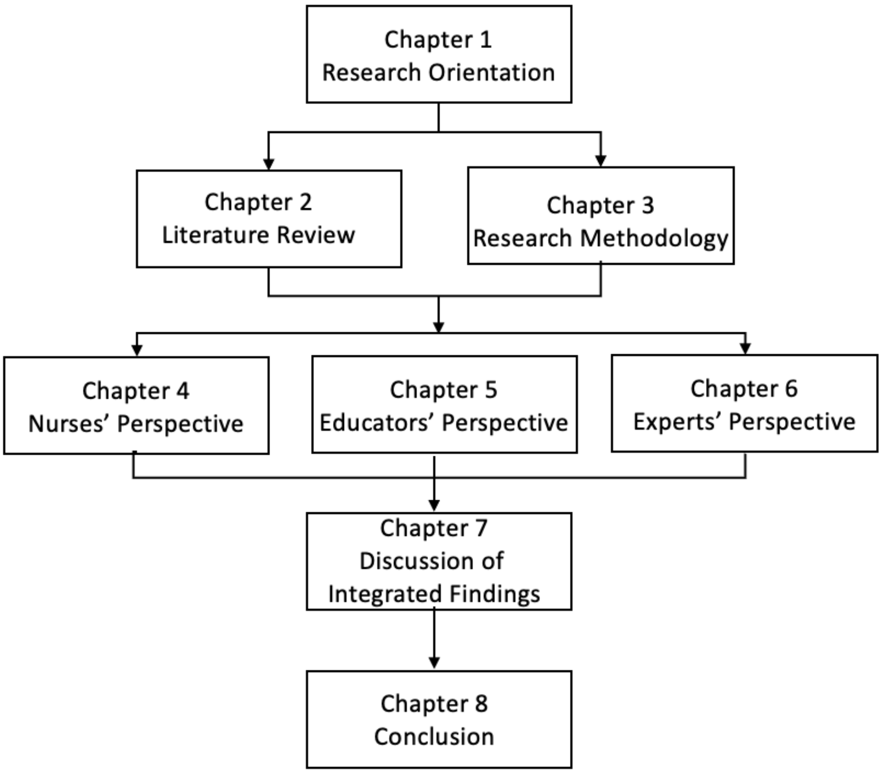

Figure 1-5: Thesis Outline

1.12 Chapter Conclusion

This chapter served to introduce the study. The inquiry was positioned within the constructs of Health Sciences, Informatics Sciences and Educations Sciences~~.~~, indicating the scope of the study. An exploration of the contexts of Nursing Informatics and Health Informatics was conducted. The research philosophy and methodology was indicted, and contributions of the research to the body of knowledge and practise were noted. The next Chapter will explore in more detail the literature around the context of the study to providing a more comprehensive description of competencies within Nursing and Health Informatics.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

The benefits of using Information Communication Technology (ICT) in the health sector has been documented since the 1960's when first used for statistical purposes (Masic, 2014). This chapter discusses the literature on competencies in health informatics with a specific focus on nursing informatics in a lower to middle-income country (United Nations, 2019). A narrative review was conducted as it enables the provision of a broad overview of the topic of health and nursing informatics. According to (Grant and Booth (2009), narrative reviews are useful to establish the current status of the body of knowledge of published studies by using keyword searches. The keywords are linked to the different concepts of this study to guide the investigation to address the identified research gap. In addition, forward keyword (references and authors) searches were used to find the most recent related studies and backword searches (references and authors) were used to stablish the views and findings of seminal authors (Levy and Ellis, 2006). The databases used are the scientific ones, e.g. ScienceDirect, Emerald, Google Scholar, PubMed, EBSCO as well as MEDINFO.

There are many studies considering similar aspects, in different combinations, of the concepts relevant to this study. This could therefore lead to the unintentional omission of relevant findings because this approach lacks details about the strategies for searching, scoping, inclusion/exclusion, and quality considerations associated with critical, scoping, and systematic literature reviews. In addition, the fast advances of technology may lead to a limited lifespan of a specific keyword, e.g., health information technology that is now referred to as digital health to provide for all the new developments. A PhD study typically takes a few years and more recent references may be omitted from the formulation of the problem statement to address the research gap, identified at the start, that the study attempted to address. Although the literature was considered throughout the study to incorporate more recent trends and issues, the starting point of the study was based on the literature reviewed at that stage. This influenced the development of the data collection instruments while more recent literature was considered during the finalising of the literature review chapter, as well as the analysis and interpretation stages of the study.

Key search terms used in the review were informed by the research positioning as discussed in Section 1.2 and are health and nursing informatics education or health informatics or nursing informatics. To further understand the African context, a review of the eHealth strategies of countries in Africa was conducted. From the literature review, the following key topics which are discussed in the chapter were identified as important to this research study. As part of the health sciences field, the specific topics are healthcare, healthcare systems, South African healthcare and nursing. As part of the informatics field within the health domain, the topics are; health information systems; health information technology; health information technology use and informatics in Africa. To cover the field of education sciences, a discussion of informatics education within the domain of health topics: health education; nursing education; nursing education competencies and nursing informatics education will be outlined. This would be followed by an overview of health informatics in Africa and South Africa will also be covered to gain a contextual understanding.

2.2 Health

Firstly, the definition of health to be used in this study is given. This is followed by a discussion on healthcare, health systems, South African health systems and to be concluded with a discussion of the status of digital healthcare in South Africa.

2.2.1 Health Defined

To conceptualise how technology can be utilised in the health field, it is important to understand the basic concepts that govern the field of health. Understanding healthcare and its implications on the health field's functioning provides an overview of the structure of the health discipline, which forms a key construct of the health informatics and nursing Informatics disciplines. The WHO (1946:100) defines health as being "*a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*". This forms the foundation of all things pertaining to health, as it is the overall objective of the health discipline. McCartney *et al.* (2019:28) propose the definition of health as "*A structural, functional and emotional state that is compatible with effective life as an individual and as a member of society"*. Schramme (2023) refers to the "*complete*" aspect of the WHO definition and argues that complete may be seen as perfect health, but it may not be attainable and suggests that holistic is a more suitable state to aspire towards.

Globally, the health discipline is defined by the following key features. "*The global health system includes the transnational actors that have a primary intent to improve health and the poly-lateral arrangements for governance, finance, and delivery within which these actors operate*" (Hoffman and Cole, 2018:4). Salm *et al.* (2021) conducted a systematic literature review and based on the qualitative synthesis of the related literature find that a definition of global health depends on the different aspects associated with it of which one refers to the vagueness of global health which has multiple meanings, and historical influences. One such definition could be that global health in its broadest sense is defined as "*an area of research and practice committed to the application of overtly multidisciplinary, multisectoral and culturally sensitive approaches for reducing health disparities that transcend national borders*" (Salm *et al.* 2021:11).

The health discipline is one of the key disciplines in health and nursing informatics, this Chapter considers the key concepts in health that form the backbone of healthcare. In this section the following will be considered healthcare and health care systems will be considered, and how they form the core structure of health. Thereafter the South African healthcare system and the digital plans in the country's eHealth strategy are considered and nursing as it is key to this study.

2.2.2 Health Care

Healthcare is defined by the Oxford Dictionary (2022) as organised provision of medical care to individuals or a community. This definition is extended by the Merriam-Webster Inc (2022) by adding that healthcare at the level of care, are the efforts made to maintain or restore physical, mental, or emotional well-being by trained and licensed professionals. These definitions denote the need for trained professionals providing care to individuals or communities. Thus, at the core of healthcare is the training of professionals in the diagnosis and treatment of individuals. One of the key concerns in the training of professionals is the health metrics or performance indicators. Healthcare of a context is managed by health metrics that provide a measure for the level of care or the intensity of effort required to diagnose, treat, preserve, or maintain an entities physical or emotional status. These entities may comprise ~~of~~ either a healthcare service provider, a consumer, or a patient. The metrics are compiled by the relevant country's government for statistical records, and they are of importance to regulators, policymakers, researchers, and clinicians, as they use them as a measure of the health performance of a country (Braithwaite *et al.*, 2018). They are aligned with the international goals of the WHO, as well as the current Sustainable Development Goals (SDG). According to the United Nations (UN) the goal for SDG3, dealing with health, is to ensure every person can live a healthy life and promoting wellbeing for all at all ages (SDGS/UN.org/goals). The African Union (AU) prioritised health and nutrition as part of their Agenda 2063 for healthy and well-nourished citizens (au.int/en/agebda2063/sdgs). Although SDG3 specifically deals with health the other SDGs, the others such SDG1 (no poverty), SDG2 (zero hunger), SDG4 (quality education), SDG5 (gender equality) etc. all have an impact on the health and wellbeing state of people.

Health metrics according to the WHO (2008) assist in guiding resource allocation, monitoring progress, enhancing accountability, and meeting with the same approaches the needs of all users in healthcare provision. Healthcare provision can be either through private or public or public-private partnerships and can be at either one of four levels of care. These levels are primary care, secondary care, tertiary care, and quaternary care (Van Straten *et al.*, 2017). Primary care occurs at the first point of care when a patient sees either a licensed practitioner or a non-physician primary care provider such as for example, a nurse practitioner (Young, 2016). Primary care plays a role in providing health services in local communities either as day-care centres or local clinics (Muldoon *et al.*, 2006; Montesanti *et al.*, 2018). Home and community care services, a part of the healthcare level of care, are a prelude to primary care and include services provided by health professionals at home or in community settings. Secondary care or hospital care is the second level of healthcare service provision. Secondary care or hospital care is the second level of healthcare service provision. Secondary care provides specialised care as well as some primary care (Erdmann *et al.*, 2013). Tertiary care is the third tier of care, where the institutions at this level receive referrals from either primary or secondary care institutions. Tertiary care institutions specialise in providing advanced treatment services and complex medical and surgical interventions. Quaternary Care is considered an extension of tertiary care, where the services offered are in limited health centres, as it is highly specialised. These levels of care are important in identifying the workflows of health practitioners in their provision of care for referrals, and continuous care.

A computerised system implementation within these levels of care would require input from both ICT and health practitioners, who are aware of the intricacies in referrals and treatments at each level of care and between the levels of care. This would need practitioners who are trained in both health and informatics as indicated in this research inquiry.

2.2.3 Healthcare Systems

Healthcare systems are defined as a system of activities with the primary purpose to promote, restore or maintain health." These activities include all organizations, institutions, people, and resources whose primary intent is to promote, restore, or maintain health (WHO, 2007). Healthcare systems are established at different levels of society, these may be at the international level, macro being national or country level, micro at institutional levels, or nano at individual levels.

Health systems consist of organisations, institutions, resources, and people to improve and maintain health according to sustainable development goal 3 for all people (WHO, 2010:18). The components of a health system are service delivery; healthcare workforce; information;

medical products, vaccines, and technologies; financing; and leadership/governance. All of these require digital technologies to enable their services, systems, or processes and the two most important components are the healthcare workforce and financing.

Internationally there are four main models of Healthcare Systems namely the Beveridge Model, the Private Insurance Model, the Bismarck Model, and the National Health Insurance Model. (Lameire *et al.*, 1999). The Beveridge Model advocates for a national health service which predominantly is for public providers and is supported by taxation. It is modelled in the United Kingdom, Italy Spain Sweden, Denmark, Norway, Finland, and Canada. The private Insurance model or also regarded as an out-of-pocket funded model (Wallace, 2013) advocates for predominantly private funding and is managed mostly by private providers or individuals. The Bismarck model advocates for a pluralistic system of both private and public providers. This model is the one that is used in France, Germany, Austria, Switzerland, Belgium, Holland, Japan, and South Africa. The National Health Insurance (NHI), Model incorporates characteristics from both the Beveridge Model and the Bismarck Model. In the NHI model at the National level, the government acts as the central single payer for procedures and the providers.

The healthcare system at the country level is classified as either centralized or decentralized. A centralized healthcare system is described as one where all authority for the healthcare system is controlled from a central macro level of the government. All structures report to the central government structure, and policies are conceptualized in a top-down structure. Decentralization is conducted by many countries to improve the responsiveness and performance of their healthcare system. It involves transferring authority and power from the macro levels of government to the lower levels. This means a transfer of power from the national to the subnational levels of government, the transfer of authority from the Government to the private sector as well as legally independent autonomous state organizations. There are four models for which decentralization can be implemented within a country, these are political, administrative, fiscal, and market decentralization (Lameire *et al.*, 1999). In Africa, most of the countries have implemented the Bismark Model of healthcare systems, with the Government being the central payer of the medical needs of its country's population.

Central to Healthcare Systems is the influence of international strategies. The latest of these is the Sustainable Developmental Goals (SDGs) also known as Agenda 2030, developed by the United Nations (UN) (United Nations (UN), 2016). The SDGs comprise of 17 priority goals developed by the UN. Nested in the SDGs is goal number 3 which advocates for Universal Health Coverage (UHC) by ensuring healthy lives and promoting wellbeing for all at all ages.

For there to be universal health coverage, there is a need for health data to be accessible to all stakeholders involved in delivering quality healthcare. This has been one of the challenges in the achievement of SDG 3 (United Nations (UN), 2019). In lower and middle-income countries this is especially important for the measurement of social determinants of health and healthcare systems strengthening (Olaniyi *et al.*, 2022; Vera *et al.*, 2017). To enable this goal in healthcare systems, digital technologies can provide a means for the capturing, administering, decision support, and disseminating of Information (Nabyonga-Orem, 2017).

An understanding of healthcare systems is of importance to this study as this informs the context in which training for nurse and informatics practitioners will occur. Understanding for example in South Africa that the Bismark System is in use provides the knowledge that nurses who work in either one of two contexts, the public healthcare system and the private healthcare system need. Each healthcare system has its own contextual environments of practice and differing information technology tools are used in each depending on the operating environment. This influences the nature of health or nursing informatics competencies required for training. An understanding of the healthcare systems also provides knowledge of the stakeholders who will influence the implementation of training as well as who will benefit from the training.

2.2.4 The South African Healthcare System

The context for this inquiry is South Africa, which was selected as the country that seems to have the oldest and the best healthcare system in Africa (Esterhuizen and van Rensburg, 2021 ; Global Health Security Index, 2019). The healthcare system provides care within the constraints that are prevalent in all lower and middle-income countries, which are disease prevalence, resource restrictions, inadequate health provision capacity, limitations of remote healthcare provision, and financial constraints (Maphumulo and Bhengu, 2020; Ndebele and Enaifoghe., 2024).

Historically from 1652-1795, the South African healthcare system was largely influenced by the Netherlands nationals who had settled at the Cape. From 1795 – 1803 the Cape Colony was handed over to British control who in 1803 handed it over to the Bravarian Republic under DeMist a French Revolution humanist. DeMist established the first State Health Department called the Health Bureau (Coovadia *et al.*, 2009).

In 1891 the Cape Colony began the registration of nurses and midwives, and formed a council to administer the registration authority, namely the Colonial Medical Council. The Colonial Medical Council administered from 1891 till 1910, when the council was renamed to the

Provisional Medical Council, which operated from 1910 until 1928, when the first Public Health Act was introduced during its term. In 1928 the council was renamed again to the South African Medical and Dental Council and administered until 1944 when the South African Nursing Council (SANC) was established. This became the governing body that develop and implement policies and macro strategies for all nursing healthcare professionals, practicing in South Africa. It is through SANC that the educational macro policies are determined and the outline for meso and micro implementations of the macro strategies. These influence the delineation of the curriculum content for nurse practitioners and provide a context for the macro vision. These are both important to this inquiry as it considers the competency needs of nurse practitioners in nursing informatics.

At the International level, the South African healthcare system adopted the Bismarck pluralistic system where there are both private and public healthcare providers (Ndebele *et al.*, 2022). The effectiveness of the Bismark system is largely dependent on its governing system. In South Africa, during the apartheid era, this system had some challenges in its implementation. The private service offered care which the public healthcare was unable to offer (Government of the Republic of South Africa, 2014). According to Kautzky and Tollman, (2008) this era was the darkest in the health history of the country as it consisted of social fragmentation of health services; and the deregulation of the health sector. They note further that during this time churches played a major role in the provision of healthcare as the bulk of the population was severely under sourced in terms of healthcare and did not have the means to pay for services that were provided. The latter was afforded by those who had the means to pay or are able to afford medical aid. From this era came forth a lot of socioeconomic-related inequalities in health outcomes in South Africa (Bredenkamp *et al.*, 2021). The system outcomes followed through to post-apartheid era where public healthcare, although subsidised by government, still required a lot of resources. Although the system has been in place for more than a decade , Gordon *et al.*, (2020) noted that challenges of the pluralistic system observed in South Africa are inequalities of provision of care due to inequality in the affordability of cost of care and medicine as well as the ability to pay for either private or public care. In addition to affordability, although the health indicators improved, there is still a big gap in achieving total Universal Health Care (UHC) (Health Systems Trust, 2021). This led to the proposal of implementation of the National Health Insurance System as a replacement for the Bismarck System (Ataguba, 2021).

At the macro level South Africa has nine provinces and utilises a decentralised administrative model in its public healthcare system. Each province is in charge of its own healthcare systems which are translated into five levels of hospital care: district hospital; regional hospital; tertiary hospital; central hospital; and specialised hospitals (South African National Department of Health, 2012). The gazette by the Department of Health (DoH) states that a district hospital provides primary healthcare as the first level of care. It is supported by the regional hospitals which provide the next level of care to referrals from district hospitals. Regional hospitals receive support from and refer patients to tertiary hospitals. Tertiary hospitals provide more specialised care than regional hospitals and refer patients to central hospitals. Central hospitals are associated with a Medical School and also provide training to healthcare practitioners. Central hospitals receive national referrals from other hospitals. The last level of hospital care is the specialised Hospital which provides care to patients with specialised diseases, such as TB, psychiatric services, infectious diseases, and rehabilitation services (Whittaker *et al.*, 2011)

An exploration of the South African Healthcare System provides an understanding of the nature of the research context. It provides a better understanding of the diverse influences on health and nursing informatics education and provides a foundation on which the study can best approach the exploration of competencies that nursing and informatics practitioners need. It is within this system that health ICT systems, more recently referred to as digital health, are utilised. The digital healthcare plan for South Africa is outlined based on the Southern African healthcare system, which includes the strategic goals, that support the goals set in the National Health Plan and is discussed in the following section.

2.2.5 Digital Healthcare for South African

In 2009 the National Department of Health and the National Health Information Systems Committee of South Africa spearheaded a project for an eHealth Strategy in South Africa. In 2010 a draft proposal was circulated for comment and finally produced in 2011 as the eHealth strategy which was in alignment with the Health Sector priorities of 2009-2012. In 2012 (DOH South Africa, 2012) the document was endorsed as the eHealth roadmap for South Africa with a vision of providing a long and healthy life for all South Africans. The 2012 eHealth Strategy was revised in 2013 in order to draft a “first version of a National Health Normative Standards Framework for eHealth in South Africa" (HNSF). The primary objective of the National HNSF for South Africa is to set the foundational basis for interoperability as articulated in the eHealth Strategy South Africa 2012-2016 (DOH South Africa and CSIR, 2014). The HSNF collapses the 10 priorities set by the 2012-2014 eHealth Strategy into 7 priorities partitioned into 2 categories: (1) Enabling environment and (2) Information Communication Technology (ICT) environment. In their revised 2019/2024 (South African National Department of Health, 2019) strategy the Department had five aims for their eHealth Strategy, these were: (1) Digitisation of Infrastructure, with an integrated platform; (2) Digitisation of all clinical business processes; (3) ensuring electronic health records are completed; (4) Advancing mHealth in Community-based environments; and (5) Advancing knowledge-based workers within the Healthcare domain. This draft led to the conceptualisation of the National Digital Health Strategy 2019-2024 (South African National Department of Health, 2019).

The National Digital Health Strategy has nine goals in its vision, of which goal number nine is to develop the necessary digital skills of the workforce to the capacity to enable their meaningful participation in digital technology support and implementation. These skills are needed which would be integral for the implementation and use of the tools in Health ICT in additionally addressing infrastructural backlogs in the health sector (South African National Department of Health, 2019). The use of ICT tools is to "*digitise all business processes across the health service platform, prioritising service enhancing benefits*." (South African National Department of Health, 2019:30). An integral part of this vision was the inclusion of an eHealth strategy as a tool for facilitating this synergy. The 2030 plan envisions a long-term strategic plan which the Department of Health has set to achieve "*health for all*", which is in alignment with SDG number 3 for Universal Health Coverage (United Nations (UN), 2016).

In their sub-strategy for 2020 to 2024 the Department of Health envisioned achieving the following actions: The enhancement of the system's service delivery capability, its governance capability, its workforce capability, and its learning capability (South African Department of Health, 2019:35). Providing a workforce that will be "*providing the information needed for evidence-based reporting, planning and action at facility level and above*" (South African National Department of Health, 2019:25). This, the Department acknowledges is essential for progress to occur. In addition, the Department envisions the conversion of all paper records from core and support functions to be computerised (South African Department of Health, 2019). In their strategy, the South African Department of Health (2019) , outlines three health ICT systems that are currently being implemented in the Western Cape, in the areas of (1) Continuity of care between hospitals with the Electronic Continuity of Care Record (eCCR); (2) the provincial health data centre system that stores data from all the provinces; and (3) a single patient viewer system that ensures continuity of care for a patient where several health practitioners need to access the patient's record at the different points of care. With these systems in place, the department acknowledges the need for capacity building, which would include training health practitioners in Information Communication Technology (ICT) Systems, so that health practitioners, especially nurses who mostly operate at the point of care, are able to utilise the systems. It however, notes that this can only be accomplished by working together with the entire government and all the stakeholders involved in healthcare services. This should also include the eHealth Strategy of the Department of Health. The South African Department of Health aims to provide health to all by utilizing technology as far as they can (The Department of Health, 2019). The Western Cape Government Department of Health (Western Cape Government Health,2014) in alignment with this strategy as a province also planned to ensure that all Western Cape citizens are “techno-savvy” by 2030. This motion has provided a fertile landscape of support for innovative technologies in the health sector, especially for use in remote rural areas, and as a result the need for training of health workers as well as citizens to benefit from digital health technologies.

With a backlog of paper records that require digitisation and the implementation of new ICT systems within the Department of Health, there is a need for the realisation of goal number 9 of the National Digital Health Strategy as the development of “*enhanced digital health technical capacity and skilled workforce for digital technology support and implementat*ion” requires an understanding of the competencies required to fulfil the duties of support and implementation of the systems (South African National Department of Health, 2019:25). For nurses, the largest group of health practitioners, this would require some competencies in nursing informatics, while for informatics practitioners this would require some health informatics domain knowledge.

2.2.6 Nursing

An understanding of the context of the Nursing field is imperative in this study as this forms one of the core disciplines of Health Informatics. This is important as competencies are determined by context which influences the nature of nursing practice (Hübner *et al.*, 2016). Nursing is defined by the Nursing Act of 2005 (National Department of Health, 2005) as “*a caring profession which supports, cares for and treats a health care user to achieve or maintain health and where this is not possible, cares for a health care user so that he or she lives in comfort and with dignity until death*”. This is done through the services of nurse practitioners, who according to the Act are deemed capable of assuming responsibility and accountability to practice as a nurse (National Department of Health, 2005). In the provision of care, nurses apply the nursing care plan by means of the nursing process. It comprises the nurse having competencies in assessment, diagnosis, outcome identification, planning, implementation, as well as evaluation as they care for their patients (Pope *et al.*, 1995), Ali, 2022).

To be able to practice as a nurse, all nurses should hold one or more credentials as prescribed by the relevant professional body that regulates the education, training, and practice standards of the nursing profession. This would depend on the scope of nursing practice and education.

The Scope of nursing practice can be described as the roles, functions, responsibilities, and activities that registered nurses are taught and authorised to conduct. (Association of Registered Nurses of Newfoundland and Labrador, 2006). According to the South African Nursing Council (2013), the scope of practice considers the role and boundaries of practice. These roles include performing competent, safe, and ethical care; utilising Nursing knowledge for critical thinking, using their judgment and skills; performing skills in the provision of safe care. These include restorative, supportive, and promotive practices; collaboration with other healthcare practitioners; and the advocating or creating of healthcare systems (South African Nursing Council, 2013).

In order to be able to practice nurses need to be registered with the national governing body. In South Africa, to practice nursing, they are required to be registered with the South African Nursing Council (National Department of Health, 2005). SANC is the governing body of all Nursing affairs that govern the implementation of the relevant policies and the macro educational processes of the nursing field in South Africa. According to the core SANC Act defining nursing in South Africa (National Department of Health, 2005) a nurse can be registered in at least one of the following categories: (1) professional nurse; (2) midwife; (3) staff nurse; (4) auxiliary nurse; or (5) auxiliary midwife. After completing their diploma or degree course, nurses can then specialise in three categories, namely, public health, oncology, and occupational health. On completion of their specialisation course, they can practice in a wide range of specialised areas in clinical, teaching, administration, research, and consultancy (Duma *et al.*, 2014).

In the South African health context, the ages of practicing nurses range from mostly the 20s to the ’60s, as the retirement age is 65 years. The current cohort of nurses includes both digital natives and digital migrants depending on whether nurses have been exposed to the use of digital technology in their practices. Even when digital technologies are available, access to such technologies and uptake by individuals to use them do not depend on their age (Roos and Hoffman, 2022). A Health Informatics Education program would need to cater to both classifications of students and specifically focus on digital literacy (Reid *et al*., 2023) to develop their digital capabilities as an essential requirement to cope in a digital world. South Africa offers comprehensive Science, Technology, Engineering and Mathematics (STEM) training for its high school students, to provide a competency foundation that enables the younger generation of registered nurses to be digital natives of innovation and technology (Roos and Hoffman, 2022). The older generation, who are registering for their nursing degree or for a postgraduate degree may be digital immigrants depending on their exposure to digital technologies in other aspects of their lives. They may be interested in advancing their digital technological skills in their work practices (Wright *et al.*, 2012). SANC, in their education report (Education and Standards, 2005) acknowledges the need for Informatics competencies, indicating that there should be knowledge in Information technology and information management that support health care and that these should be integrated in a nursing education curriculum.

2.3 Education

Firstly, education in general is discussed and is then discussed as education in healthcare in Sub-section 2.5, and specifically for nursing informatics education in Sub-section 2.8.

2.3.1 Introduction to Education

According to Abulencia (2021), education is the process where an individual acquires or imparts knowledge and skills from a more experienced person. The person develops skills essential to daily living, learns social norms, develops judgment and reasoning, and learns how to discern right from wrong. The ultimate goal of education is to help an individual navigate life and contribute to society once they become older. According to the World Vision (2023) as individuals become educated, they develop problem solving skills, become more self-reliant and empowered, have a more stable life, possibly with more financial security and are potentially able to contribute economically to various facets of life and ultimately society. Frenk *et al.* (2010) describe education as needing to be relevant within the contexts where the people live and try to sustain a living. Although education develops individuals, it is not a guarantee to secure a job.

The evolution of education happens from the times of Dewey as having three phases: (1) The first generation, which starts at the beginning of the 20th century, had a science-based curriculum, whose curriculum was institutional and provided by Universities; Around mid-century, the second generation brought the problem-based instructional innovations, this had a problem-based curricula and was provided by Academic Institutions; the third generation which they recommend should be systems base, has a curricula which is competency based and is driven by competency institutions. The latter is the guiding format for this study as it looks into the competencies of nurses and IT practitioners in nursing informatics. A competency-based approach is a disciplined approach which requires the graduates of the curriculum to attain competencies and achievements to become proficient to meet a specific job requirements Frenk et al (2010). In the absence of a job offer, it also equips individuals to sustain a living through entrepreneurial opportunities. In this study the competency approach is considered for nurses to demonstrate the necessary knowledge and skills to practice their profession according to the guidelines of the relevant professional authorities.

The concept of competency encompasses a broad range of abilities, integrating complex cognitive capabilities with specific skills (Frenk *et al.*, 2022). Input into a competency-based approach curricula focuses on the outcomes that are required from the educational programme. It is a bottom-up approach, where the competencies are synthesised from the practitioners who already have extensive experience in practice to be integrated into curricula (Frenk *et al.*, 2022; Bader and Hamada, 2015). To deliver a competency-based curriculum, it is imperative that learners know, can apply, and execute knowledge, skills, and abilities professionally desired by the profession (Frenk *et al.*, 2022). During the time a learner studies at an educational institution, existing jobs functions and roles are continuously changing and with the vast advances of digital technologies, current practices are no longer meeting the demand of benefitting from new and streamlined practices. Practices continuously change and new jobs are created that require different, and in some cases, more advanced competencies. This makes it impossible for new graduates to have all the competencies required in the workplace (Pang et al ,2019). Therefore, the education offered by educational providers is not enough to ensure future required competencies, either in professional proficiency or personal wellbeing. As a result, the previously separate life stages of learning and work become connected (Frenk *et al.*, 2022). To design a competency-based approach curricula one needs to take a bottom-up approach to decide on what competencies are to be taught and the instructional medium of those competencies (Kim, 2019). When deciding on a competency, Gruppen *et al.* (2012, 2016, 2019), suggest five characteristics that should be considered: A competency should: (1) focus on performance considerations; (2) reflect the expectations of professional industry ; (3) emphasize behavioural measures that depend on integrating knowledge, skills and attitudinal aspects; (4) use a performance criteria standard that is created by practitioners or professionals in the field; and (5) be transparent and accountable to all stakeholders. To decide on the instructional process, Kim (2019) proposes that teaching the competencies needs to take a staggard approach where competencies are learnt in stages and built upon each other towards the exit level outcomes of the qualification. This should also consider the new digital technologies that are now available for instruction using the Internet and emerging technologies for online, distance and face-to-face instruction (Frenk *et al.* 2022). According to Frenk *et al.* (2010:1931) "*curricula reform is linked to institutional transformation*", they propose that institutions need to adopt the competency-based approach for them to have relevant graduates.

In most professions continuous professional development (CPD) education opportunities are provided to reskills and upskill the workforce (Merry *et al.*, 2023), They considered the barriers and facilitators for CPD development, implementation focusing on sustainability from a system, individual and environment perspectives. They did a scoping review of the literature for lower and middle-income countries. They emphasise the importance of the buy-in of all the relevant stakeholder considering contextual factors and using a regulatory perspective based on the identified needs.

Experiential learning is providing the learner with a hands-on opportunity to apply their knowledge and skills as needed in practice through action and reflection. Work-integrated learning (WIL) is experiential learning but in partnership with employers within the industry. Work-integrated learning arrangements are included in a curriculum to expose learners to the practice as part of the world-of-work orientation. Zegwaard *et al.* (2023) remind us that competency-based education is complex and there is a need to also develop competencies during WIL. They suggest requirement types such as in the context of 1) competency frameworks; 2) learner reflection and feedback; 3) This study only focuses on the formal education where educational institutions offer qualifications to prepare learners for a specific profession.

2.3.2 An Overview of Education Curricula

Curricula design can be considered to function at four levels (Van den Akker, (2013), Priestly *et al.*, 2021), namely the supra level for the international curricula; the macro level for the national syllabi; the meso, curricula which comprise the educational institution's values and objectives; and the micro curricula which are the enacted curricula that occurs in the classroom when educators impart knowledge to their students and the nano curricula for individuals' experiential learning and attainment of competency outcomes (Taguma *et al.*, 2018). In this study, the focus is at the micro and the nano levels of education, and not the macro or supra levels of curricula. These are the focus because the considerations of program design and competency needs from the perspectives of the educator and the individual student or practitioner. Curriculum design is also considered in terms of how the outcome of an intended curricula, is implemented in practice (Fry *et al.*, 2024). The latter consideration is most used in the meso and micro levels of curriculum development and implementation, where the outcome details of final enacted curriculum outcomes are decided to allow for application possibilities related to the environment of the service. Van den Akker (2013) proposes a venerable spider framework that illustrates the various components of learning that have to be considered in an enacted curriculum. This is illustrated in Figure 2-1 below.

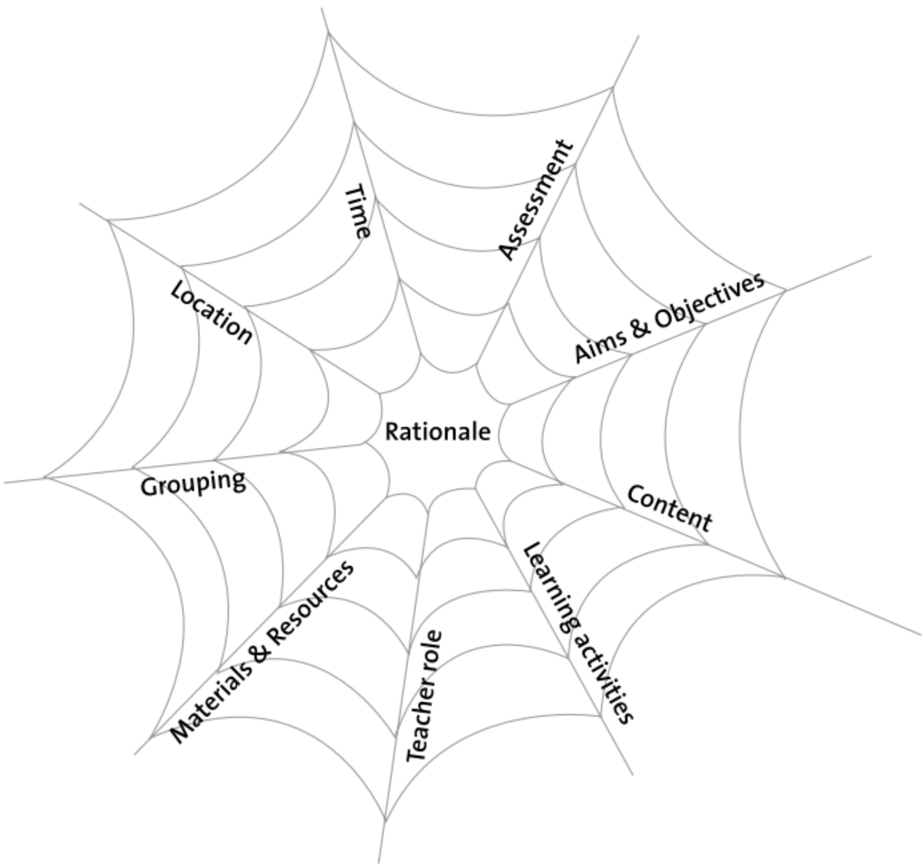

Figure 2-1: Curricular Spider Web (van den Akker, 2010:130)

The Spider Web illustrates the efforts for keeping curricula balanced, consistent and sustainable, where the links in a spider web illustrate that they are as strong as their weakest link. Table 2-1 illustrates the components of each link in the spider web.

Table 2-1: Curricular Spider Web (van den Akker, 2010:130

Rational or Vision	**Why are they learning?**
Aims and Objectives	Toward which goals are they learning?
Content	What are they learning?
Learning Activities	How are they learning?
Teacher role	How is the teacher facilitating learning?
Materials and Resources	With what are they learning?
Grouping	With whom are they learning?
Location	Where are they learning?
Time	When are they learning?
Assessment	How to measure how far learning has progressed?

As this study explores the nursing informatics competencies that nurses and it practitioners need to be able to practice, it will only focus on all the rationales of the spider web except assessment. It will cover the competency needs that influence the content, learning activities; and the program design that in turn will influence the teacher role, the grouping, location, and time of the curricula. The study is in alignment with what Fry *et al.* (2021) identify as credit descriptors which include competencies that form the core of the educational program. These also influence the determination of learning outcomes.

2.3.3 Competencies

In general, we understand that ”Competence” refers to the state of being able to perform specific actions (Attallah and Hasan, 2022). Competency refers to the ability that a person needs to demonstrate to be effective in a job, role, function, task, or duty. Competency (Figure 2-2) includes job-related behaviour; motivation in approaching tasks; and the skills and knowledge applied to a task (ACM & IEEE, 2021). Competency is, therefore, an indication of human behaviour combined with skills and knowledge application in performing specified tasks (The Harvard University Competency Dictionary [Har2). In addition to knowledge (“knowing what” and skills (“knowing how”) a third dimension is added, namely disposition (“knowing why”) connected to the task and within a specific context. Task frames skills and knowledge within dispositions where the person moderate their choices, actions, and efforts to achieve an expected outcome in an effective manner.

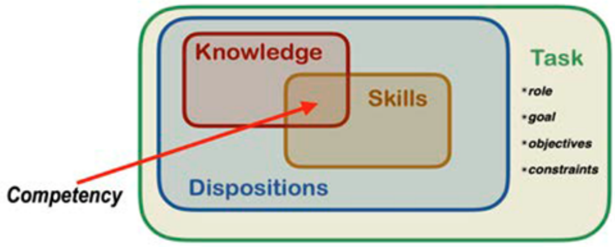

Figure 2-2: Competency as knowledge + skills + disposition applied to a task (Source: CC2020 Report:47).

Possible dimensions of competency are centrality, specificity, definability, developability, knowledge inclusion, measurability, mastery, performativity, and transferability (Mulder, 2017). A model for informatics education in Germany provides for the following areas, namely content, process, and quality. Based on their work they propose the following definition for competency: "*Competency integrates knowledge, skills, and dispositions and is context-situated*" (Frezza *et al.* 2018:155) and has the following dimensions: skills, knowledge, disposition, and context. Their addition of context is to explicitly link the competency to an authentic situation related to a specific problem or issue where the competency is needed.

For the health informatician or nursing informatician, Moore and Shaw-Kokot, (2012) suggest a competency profile that collectively comprises a unique blend of knowledge, skills, attitudes, and judgments obtained from a variety of disciplines such as informatics, health, and management, etc. in a broad range of environments and practice settings. They define knowledge as primarily cognitive or intellectual qualities that allude to content knowledge and conceptual mastery. They further describe skills as being more practical qualities that people develop and learn over time with practice and through interactions with others. They define dispositions as the attitudes people have to apply information and abilities to solve issues or deal with matters of interest. While context-situated denotes the circumstances surrounding issues, problems, and aspects of the workplace where competencies are demonstrated. This study addresses knowledge by exploring topics of interest within health and nursing informatics education, it looks at the attitudes of the nurses towards nursing informatics, all of this is considered in the context of health, nursing and informatics education.

In more recent years the need to consider sustainability in response to global sustainable development goals require competencies specifically to deal with such societal challenges

(González-Salamanca *et al.* 2020; González-Pérez and Ramírez-Montoya, 2022). With the fast technological advances in an increasingly digitised world, specific skills to learn, communicate, collaborate, and solve problems as identified by the United Nations Educational, Scientific and Cultural Organization (UNESCO) are needed. These skills are referred to as Twenty-first-century skills to operate and live in a knowledge society and to provide for a sustainable future. González-Salamanca *et al.* (2020) in their systematic literature review, considered the following categories of teaching and learning for the 21st century; curriculum; ICT; assessment tools; personalised learning paths; and curriculum co-design. They conclude that the skills, including ICT, needed to function at work must be incorporated into educational and training programs in a comprehensive and transverse manner. González-Pérez and Ramírez-Montoya (2022) consider the latter in view of the impact of the fourth industrial revolution which is characterised by disruptive technologies that need new processes and practices. In their literature review, they consider, what they refer to as Education 4.0, the need for transversal competencies such as critical thinking; cooperation; collaboration; communication; and creativity, in addition to discipline-specific competencies.

The competencies specific to informatics and nursing informatics within the health domain are discussed in subsections 2.6.3 and 2.8.5, respectively.

2.4 Informatics

The term Informatik or Informatique was first coined by Dreyfus, in March 1962, describing it as the use of computers to process and store information (Dreyfus, 1962). It was later defined by Fourman as "*the science of information to study the representation, processing, and communication of information in natural and artificial systems*" (Fourman and Fourman, 2002: 1). According to them, informatics comprised of two components, information and technology. Informatics was further defined by introducing the concept of context in which the Information is found and processed and Hersh (2009:2) later describes informatics as a discipline focused on the acquisition, storage, and use of information by people with the use of technology in a specific setting or domain. Informatics has four key properties that can be derived from these definitions, namely information, people, technology and context. These characteristics position informatics as an interdisciplinary field (Brandao, 2018; Hersh, 2009 Manyazewal *et al.*, 2021;; Masic, 2013). A domain focus for the application of informatics adds the domain specific aspects to its focus, for example. business informatics, health informatics, nursing informatics.

An understanding of the concepts and paradigm of the Informatics discipline is key to understanding the characteristics that will form part of the ontology of nursing and health informatics disciplines which are applications of informatics focused on a specific healthcare discipline. This additionally enables better determination of the competencies that would be required within the disciplines.

2.4.1 The Computing Field Enabling Digital Health

The computing field encompasses different computing subfields such as Computer Engineering (CE), Computer Sciences (CS), Information Systems (IS), Software Engineering (SE), and Information Technology (IT), and more recently Cybersecurity (CCS) to also cater in future for Data Sciences (DS) and new enabling technologies (ACM and IEE. 2021). Most of the discussion around competencies in the computing field in this section is derived from the CC2020 project report (ACM and IEE. 2021) that represents the views, knowledge, and experiences of all the prominent bodies in the computing field based on a collaborative process to reach a consensus (Clear *et al.*, 2020; Impagliazzo and Pears, 2018; Frezza *et al.*, 2018). The main contributors to the design of the curricula for qualifications in the computing field are the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE) (2021). The purpose of the CC2020 project is to provide guidance in evolving computing environment as it affects computer-related qualifications globally in response to the fast advances in the computing field. They followed the following principles, namely, that any education programs need to be flexible to deal with not only the current landscape of computing but also to cater to future developments in multiple contexts; that society in its entirety needs to be considered in future trends and visions; that it must be able to adapt to new computing endeavours while supporting existing technologies, systems, and services. Due to the continuous fast advances of technology, any computing program will always be in a state of flux and therefore requires an agile approach to continuously respond to changes.

The computing qualifications are positioned against two axes: vertically as computer and hardware on the lowest level and organisational system issues on the highest level. In the horizontal axis, it positions qualifications from theoretical on the lowest to application on the highest. It is important to note that the computing field focuses on the design, development, and implementation of technology artifacts, systems, services, etc. Although the application of such digital solutions is applied in a specific domain of use, it still is with a technology focus. Figure 2-3 illustrates the positioning of the IS, IT, and SE and all computing qualifications. The CE and CS qualifications were not included in the figure extract presented here since they are positioned towards the lower ends of both axes and therefore with no overlap with domain-specific qualifications.

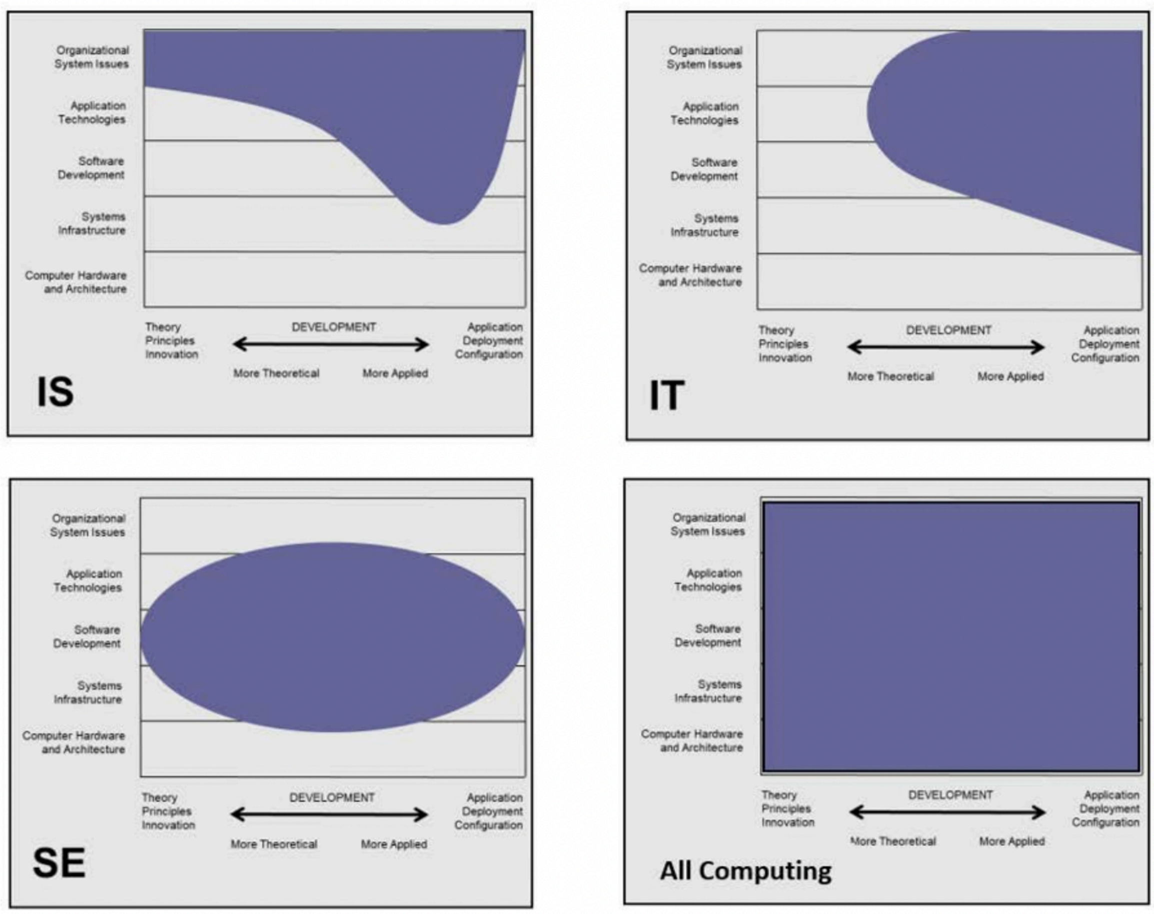

Figure 2-3: Positioning of computing subfields (ACM and IEE, 2021:39)

The global commitment to prioritise sustainable development goals to benefit society that extends beyond the organisational domain also impacts the role of computing in achieving these goals. In addition, the importance of appropriate enabling technologies in the workplace to facilitate digital transformation and infused use extends application towards transformation. In Figure 2-4 a proposed position of digital health relevant to the indicated computing subfields is on the vertical axis from application technologies to society and covers the entire horizontal axis from a more theoretical to transformed organisational infused use. Vertical provision is made for the organisational domain, e.g., business, education, healthcare, etc. followed by a societal focus to provide for the impact of global challenges on society. The horizontal axis was extended to deployment, rather than implementation, followed by the transformed organisation where the use of the digital component is considered in the real-world situation in practice. The reason for using deployment rather than implementation is that once digital solutions are implemented there is still a lot more that will influence them being embedded in the organisation. Future computing qualifications or other qualifications with a computing component, such as for example health informatics are therefore positioned post the design and development process from its application to its use to determine the level of transformation. It overlaps with the software methods and application technologies of the computing qualifications but then from a domain perspective. Issues related to the organisation domain and societal matters, as they impact the organisation, are relevant to new computing qualifications or qualification components.

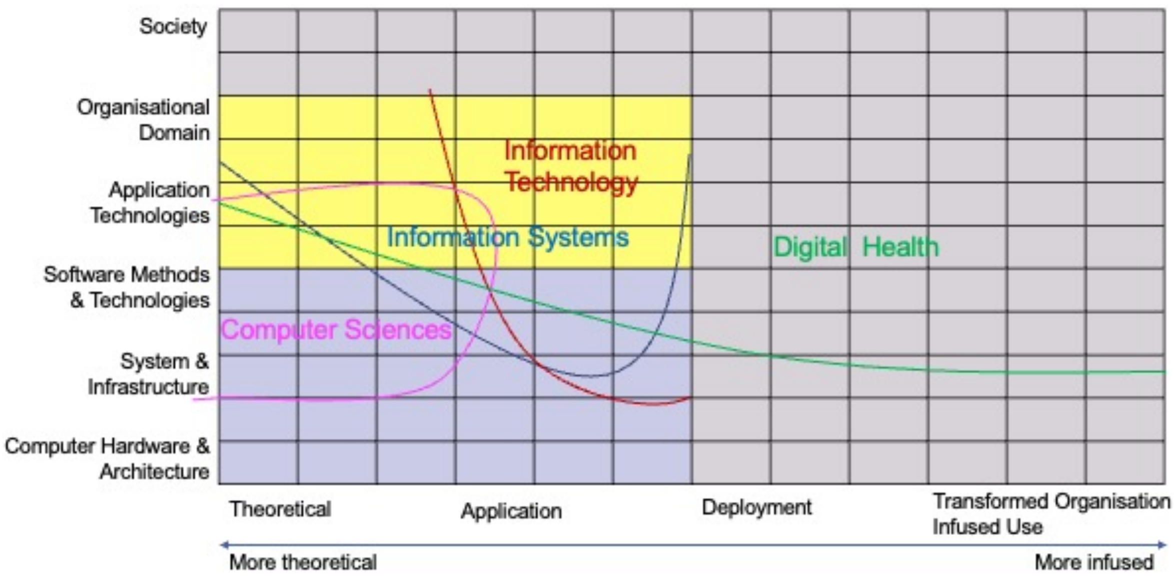

Figure 2-4: Positioning of digital health (adapted from ACM and IEE, 2021)

Although Figure 2-4 also provides for a more encompassing positioning for all computing, it does not consider the extensions of the two axes to be more specific about what these extensions could be.

In the CCS2020 report (ACM and IEE. 2021)., the word computing refers to a goal-oriented activity requiring, benefiting from, or associated with the creation and use of computers, and more recently the focus became more on the increased need for security and data as an important resource to support and enable work and decision-making. In the past few years, there was a shift in moving from a knowledge-transfer, skills-based education to competency-based education.

2.4.2 Informatics Practitioners Praxis in the Health Field

Informatics practitioners are involved in the entire life cycle of digital technologies, i.e. application implementation and support occur throughout the different units of a HIS and require information technology practitioners who are skilled in the design, development, implementation, maintenance, and support of these applications. (Longenecker *et al.*, 2011) Note there is a need for these practitioners to have a good understanding of the health domain with related competencies as health institutions are implementing enterprise systems. To understand the IT nature of these enterprise systems, a listing of the diverse systems by Beaumont (2011), identifies eight different types of HIS that IT Practitioners may implement, namely clinical and administrative health IS; The Electronic Health/Patient Record (EHR / EPR); financial and clinical health IS; Decision Support Systems (DSS); robotics and simulators; telemedicine, telematics, eHealth Systems; and computer simulations. HIS may also be set up on an enterprise level and implemented throughout the healthcare facility.

Applications development is one of the core competencies that IT students are taught to gain the relevant domain knowledge from other fields in informatics, for example, business competencies (Hovenga and Grain, 2013; The Joint ACM/AIS IS 2020 Task Force, 2020). To obtain a reference of recommended health competencies for informatics practitioners, Digital Health Canada, and HITComp propose frameworks and competencies where roles for IT practitioners are indicated (Clear *et al.*, 2020; Impagliazzo and Pears, 2018; Frezza *et al.*, 2018). As IT practitioners implement applications it is an advantage to them to understand the nature of the data in that context as well as potential application challenges that can be avoided.

In his study on the success and failures of application implementation of Health Systems, Heeks (2006), identifies what he calls a gap between an application's design and the actual artifact in use, which causes application implementation failures. He recommends that for the gap to be resolved there is a need for hybrid informatics and health practitioners with domain knowledge of both fields. These can then enhance the success rates of health applications development and their implementation as was reiterated further by Mantas and Hasman, (2017) who recommend the collaboration of hybrid competent practitioners who have competencies in both fields. This advocates the need for informatics practitioners to have some knowledge related to the health field. LeBlanc, (1996) The training of which would have to be structured so as to accommodate their work activities (Baayd *et al.,* 2023*;* Adeniyi *et al., 2024;* Blanchard and Thacker, 2023). in his study on HIS opportunities and challenges, analyses the knowledge gaps that IT practitioners have in health and proposes three archetypes that are crucial for IT practitioners to understanding healthcare, namely: technical rationality; managerial rationality; and medical rationality. Technical rationality assumes that everything is objectively rational and free from subjective, political, and cultural influences. Thus, the IT practitioner can design and develop systems emphasising on specifications and technical designs. This however has a challenge of standardisation of HIS to enable interoperability of the systems. Managerial rationality considers the socio-political and economic environment in which the technology is to be incorporated. Medical rationality looks at the wide and massive resistance to HIS since its inception. Of these knowledge gaps technical rationality addresses the competencies that information technology practitioners, need to lessen the challenges in usability, standardization and interoperability in the design and development of HIS.

Exploring further technical rationality, it is important to understand the challenges that practitioners face when implementing applications within the health field. (Marna *et al.*, 2014) identify the following challenges in health systems implementation: Standardisation of health systems, data privacy, interoperability, sustainability, data quality, and usability are critical challenges and potential competency areas. Kim *et al.*, (2017) in their systematic review of the safety and problems arising from the implementation of applications in the health field, reiterate these and identify eighteen problem areas, grouped as software, hardware, and system design and development, that occur due to IT problems. Software and hardware challenges are indicated as it is important for the platforms on which the applications reside, to form part of the development configurations.

To understand the need for understanding the nature of health data, it is important to ask, if there is indeed a need for information technology practitioners to have health domain knowledge. According to Hadar *et al.* (2014), domain knowledge is assumed to foster communication and a mutual understanding of the users' needs within that domain. However, IT domain knowledge provides for the development of collaboration, these competencies should enable students or practitioners to resolve design, development, and implementation challenges in conjunction with collaboration with domain knowledge experts. To understand the need, an overview of a clinical information ecosystem and its elements is necessary. This is illustrated in Figure 2-5 (Goossen-Baremans *et al.*, 2017). An application developed in the health context needs to include modules that are relevant to each component of the system. The key to note is that applications, devices, and systems have their foundations based on Clinical Practice Guidelines (CPGs) and Detailed Clinical Models (DCMs). Additionally, to link knowledge to guidelines and protocols, decision support is needed. This adds to the complexities of the development and implementation of health systems including complex structures and processes where the informatics practitioner would need to have some health domain knowledge.

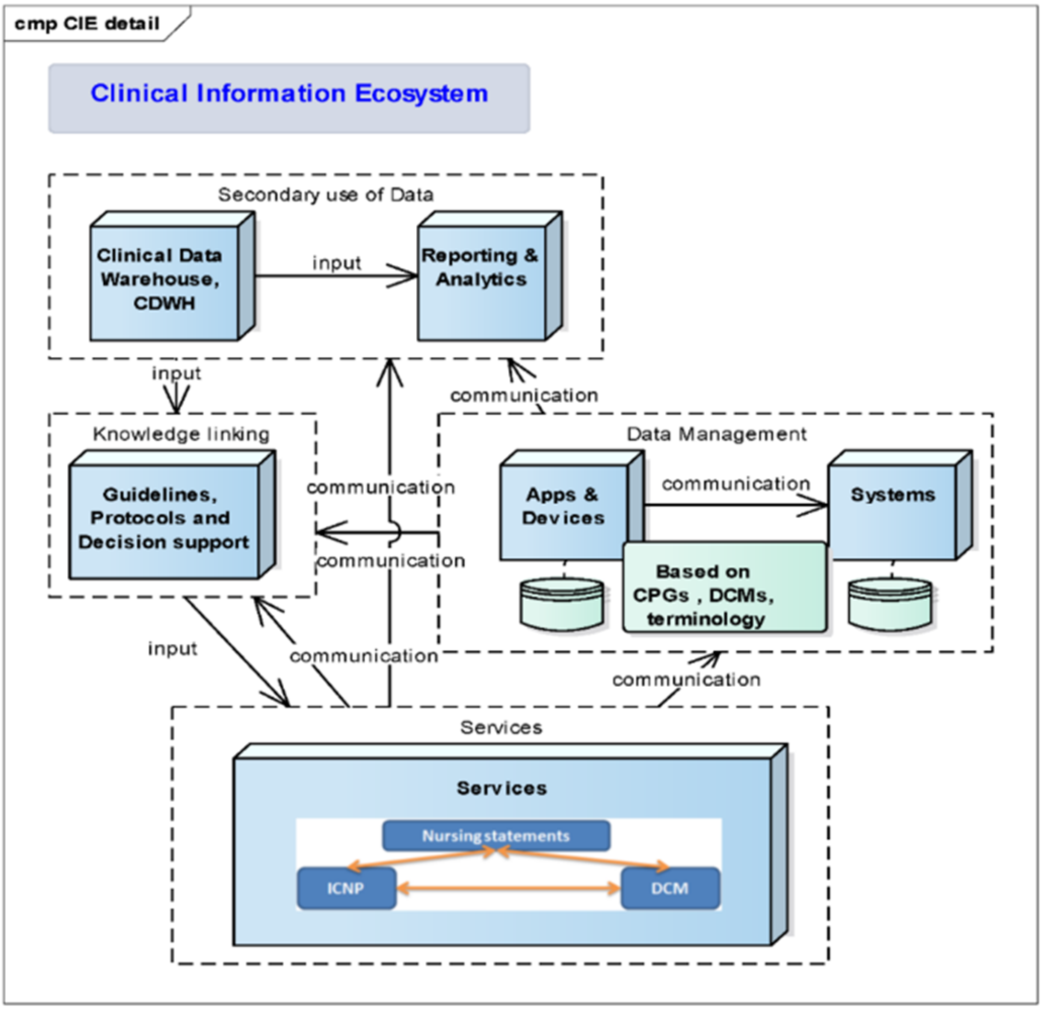

Figure 2-5: Clinical Information Ecosystem and Elements of use to the ENR (Goossen-Baremans et al., 2017)

In their practice analysis exploring the nurses' experience in health systems development Martikainen *et al.*, (2020), note that the health practitioners, although willing to participate, could not influence Health Information Systems (HIS) development in their preferred ways. Additionally, HIS development requires a time commitment from healthcare practitioners and they feel that time could rather be spent in providing care. They, therefore, prefer to collaborate with developers who already have some domain knowledge as well as being familiar with the context of use. The advantages for IT students/practitioners of having domain knowledge has been proven to be an advantage of application development, from the requirements elucidation to the implementation of the new or improved HIS, services, or technologies (Gadd *et al.*, 2020; Niknafs and Berry, 2017;Shaft and Vessey, 1998). These are summarised in Table 2-2. which was compiled from a narrative literature review of design, development, and implementation articles on Health Information Systems or applications. Criteria were that the articles were using case studies as their research strategy, written in English, and were from

2010 to 2020. This time-period was selected as it was when the International Medical Informatics Association (IMIA) first published its competencies which included competencies for Informatics Practitioners. Domain Knowledge needs were analysed and classified into either knowledge that should be known or applied by the informatics student or practitioner.

Table 2-2 Summary of the health domain knowledge needs for Information Technology Students/Practitioners

Knowing within the health domain, is:

- the relationship between clinical variables, common vocabulary, basic knowledge across all health informatics domains, and the environment. (Gadd *et al.*, 2020).
- where the data is coming from and how the model output is being used. Enhancing health decision-making, processes, and outcomes support (Gadd *et al.*, 2020).
- the various standards in the healthcare domain (Mandel *et al.*, 2016; Michie *et al.*, 2017).
- the Integration standards: This can be called the glue of healthcare technology ecosystem such as Health Level-7, HL7-FHIR, (Mandel *et al.*, 2016).
- the policies around healthcare information systems (Sheikh *et al.*, 2011).

Applying:

- Ensuring that the product needs to conform to various Safety and Regulatory Standards such as IHE, HL7 and others. (Mandel *et al.*, 2016).
- Improving the quality and reliability of data management and information systems. Data Governance, Management, and Analytics (Sheikh *et al.*, 2011).
- Developing? Health Information Systems (Creswell *et al.*, 2013; Gadd *et al.*, 2020).
- Integrating frameworks: Healthcare Information Technology Standards Panel (HITSP) and Healthcare Enterprise (IHE) (Michie *et al.*, 2017).
- Testing the functionality, clinical usage, the environment the software will be use (Creswell *et al.*, 2013).

2.4.3 Health Information Systems (HIS)

Boell and Cecez-Kecmanovic (2015:4959) propose that Information Systems (IS) be defined as being a web of relations in which social actors, technologies, information, data, practices of IS development, or use and other things are interacting and mutually co-constituting. This web of relations, as health information systems (HIS) within the health context is described by Almunawar and Anshari (2012) as an intersection between information systems and the healthcare business processes. This intersection provides the tenants for decision-making within the health field and according to the WHO is comprised of four functions, which are: (i) data generation, (ii) compilation, (iii) analysis and synthesis, and (iv) communication and use (WHO, 2009).

The main purpose of health information systems decision-making is to provide quality and efficient patient care (Haux, 2010). Having been in existence since the 1970s, health information systems have evolved from stand-alone systems that were implemented in various capacities such as: capturing patient demographic data at the reception; hospital accounting and finance management to the nurse manager's desk for reporting; and critical care systems monitoring the patient’s condition. The advancement of technology has now enabled these stand-alone systems to be integrated into health information systems to integrate the collecting, processing, reporting, and use of related information required for providing effective healthcare services managed on all levels of health services (Lippeveld *et al.*, 2014).

Health information systems are mainly found at secondary care facilities or hospitals, and few are found at the primary care level (Oluwakemi, 2020). Closely associated with a HIS are the terms Electronic Medical Records (EMR), Electronic Health Record (EHR), and Personal Health Record (PHR). An EMR is a database that is an electronic version of the patient chart with clinical information that is created and managed by medical institutions that provide patient care. It contains all the traditional information about a patient's treatment that would be found in a paper chart, this includes the patient's medical history; the orders and results of any physical examination or tests; information relating to allergies; and other factors that may need special consideration (Lippeveld *et al.*, 2014; Tsai *et al.*, 2020; Tsegaye and Flowerday, 2021).

Personal Health Records (PHR) also form part of the body of electronic medical records and contain the health and medical history of an individual, PHRs are created, maintained, administered, and owned by the individual or the caregiver in the case where a patient is not able to do so (Park and Yoon, 2020). The compilation of an individual’s health data from the EMR and the PHR is known as the Electronic Health Records (EHR) of that person. Both the EMR and the PHR contain the health data of individuals and a compilation of the sum of the history of a person’s health data is known as an Electronic Health Record (EHR) (Roehrs *et al.*, 2017). The EHR is the outcome of the digital conversation of paper-based patient information and is defined as: “*a longitudinal electronic record of patient health information generated by one or more encounters in a care setting*” (Menecherni and Collum, 2011:48). However, EHRs are not really implemented/adopted in sub-Saharan Africa. The barriers typical to the context of LMICs are lack or limited electricity, connectivity, digital skills, and the prioritisation of EHRs (Odekunle, Odekunle and Shankar, 2017) and research of EHRs remain an important consideration (Jabali *et al.*, 2022).

EMRs are organised as records within the software database of an Institution' Health Information System. The architecture of Health Information Systems covers all the key functional departments in a hospital institution and is formed by components of health systems utilised for processing the EHR among health practitioners illustrated in Figure 2-6 (Locatelli *et al.*, 2012). Health information systems form a web of relations that can be described as a clinical health information ecosystem. This Information Ecosystem encompasses the core departments of a hospital, namely the administration and management; front office; clinical functions; shared services; and other external regional or national EHRs. This ecosystem involves the exchange of information through health records and patient registries, with the main aim of providing tools for diagnosis, prevention, and treatment at all levels of healthcare, enabling efficiency and accountability.

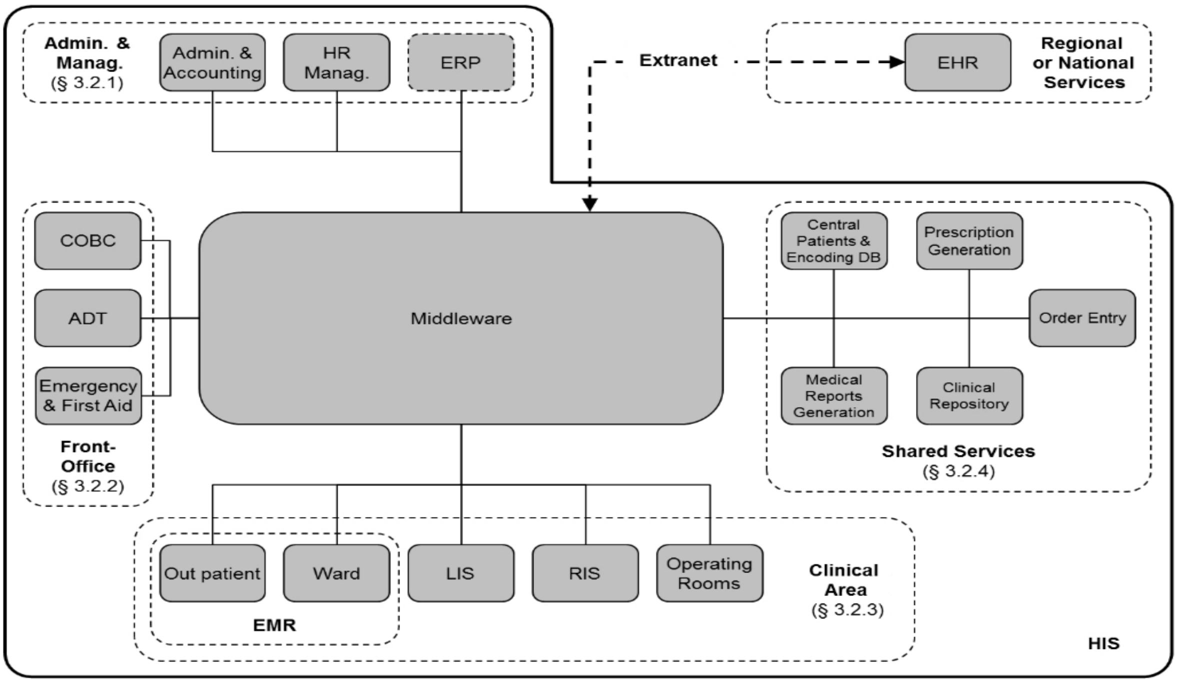

Figure 2-6: Conceptual Architecture of a Health Information System (Locatelli et al., 2012)

With emerging technologies permeating the domain of Health, there are diverse types of Health Information Systems. These are integrated within enterprise health information systems forming areas where information technology students have roles to play in the design, development, maintenance, management, and use of these systems. Four levels of The structure of an enterprise health information system may have four levels, namely: A complete paper-based system; a localised computer system for patient administration; a fully networked, centralised IT-based system for clinical and patient administration; and a fully networked, centralised IT-based systems, where clinical data is captured at the point of care (PoC) by healthcare professionals (DOH South Africa and CSIR, 2014). In the first enterprise health information system, focusing on administration and clinical care all the patient health records and registries are paper- and file-based in filing cabinets. In the second, the localised computer systems are used predominantly for patient administration for registration and appointment scheduling where clinical data is still mostly paper-based with standardised forms. Data from such systems is not shared with other healthcare providers at different facilities. The third health information systems are the fully networked system with a centralised database for clinical and patient administration where clinical data is captured, with some electronic and paper-based records. Electronic Health Records (EHR) are stored in a centralised database and Electronic Medical Records (EMR) are accessed by local systems for clinics, community health clinics (CHCs), general practitioners, laboratories, radiology units, pharmacies, and other healthcare-related facilities. The final system is a fully networked centralised system where clinical data is captured at the source, at the point of care by the healthcare practitioners. Patient details are kept in an electronic form to form the local EMR. A shared EHR system is centralised for a local hospital facility as well as on a district, province, or national level. A consideration in the creation of a centralised healthcare information system is the standards that form the Electronic Health Records of the different systems that are used by healthcare practitioners.

Data standards influence the Nursing terminology that a Health Information System would use. Within a health information ecosystem, there are different EMRs, and different systems using different data standards. These system standards are available as the Integrated Health Enterprise (IHE), Health Level 7 (HL7) v3, ISO 13606 and OpenEHR, International Standards Organization (ISO), and EN ISO S 13972 Detailed Clinical Models (DCM) (Tsegaye and Flowerday, 2021). The challenge that occurs within the Ecosystem is the integration of data standards so that systems are able to communicate with each other. There are four types of interoperability characteristics, which are technical, syntactical, semantic, and organisational. Technical interoperability involves the connections between hardware and software components. Syntactical interoperability handles the words that are used between systems, to co-join similar words and words that have not been included in other systems. Semantic interoperability deals with the meanings that are assigned to the information to ensure that they are in alignment. Organisational interoperability handles the business side of

Interoperability so that an organisation's objectives are met and are in alignment DOH South Africa and CSIR, 2014); Roehrs *et al.*, 2017).

Knowledge of the HIS provides contextual background on the IS used in Healthcare. This provides a background on the environment in which both the nurse and informatics practitioners will work. This background is especially important to informatics practitioners as it provides some key points which they can consider when designing, developing, and implementing HIS. This is important for this study as it provides an overall background on how the practitioners would use health information systems and the type of competencies that would be important for them.

2.4.4 Health Information Technology (HIT) towards Digital Health

Information Technology is defined as "*the study of systemic approaches to select, develop, apply, integrate, and administer secure computing technologies to enable users to accomplish their personal, organizational, and societal goa*ls."(Association for Computing Machinery (ACM) IEEE Computer Society (IEEE-CS), 2017:18). They further state that these systematic approaches are applied within a context, for the advancement of that context. This has greatly influenced the development and implementation of information technologies within the health field. Health Information Technologies (HIT) make use of "*hardware and software to process, store, retrieve and share Health Information, data and knowledge for communication and decision making in the healthcare secto*r" (Mostert-Phipps *et al.*, 2013:545). These characteristics make up the traits of emerging technologies within the domain of healthcare.

Health Information Technology (HIT) is becoming increasingly important in healthcare in order to track the quality of healthcare and facilitate patient outcomes. Using HIT helps improve the patient experience of care, and population health and reduces cost. (Perez, 2017; Piscotty *et al.*, 2015). With the increase in emerging technology, the nature and type of health information technology that can be used within a health system is diverse. This includes technologies such as Big Data, the Internet of Things (IoT), Artificial Intelligence (AI), Blockchain, and Mobile technologies (Fernández, 2017; Grandia, 2017). Digital health has become the overarching term to refer to technologies that could progress health in all its facets (Abernethy *et al.*, 2022). Digital health includes health technology applications that use artificial intelligence, machine learning, sensors, analytics, and several more which means that the workforce in healthcare services and sciences needs to continuously be upskilled. It has also become a requirement to achieve sustainable development goals and the social determinants that shape health need to be considered. This means that digital health infrastructures need to be implemented, enhanced, and maintained to progress in digital health. The importance of considering the human element for HIT implementation and use as indicated by Buntin *et al.* (2011) remains a priority. Each of these technologies is developed to be better able to collect information on patient safety that will assist in analysing data patterns of failures and identifying measures that would eliminate patient safety risks and hazards (Heeks, 2006).

The benefits of innovative technologies within healthcare have been articulated. However, the implementation of innovation comes with a disruption of the workflows of healthcare practitioners (Bergey *et al.*, 2019). Carroll (2017) in her critical analysis of healthcare technologies states that these innovations are disruptive and transformative, she provides thirteen innovations that have disruptively transformed healthcare work practice. To name a few of them: (1) wearable technologies replacing voice pagers and telecommunications within the clinical experience of Nursing; (2) surgical robotics transform the care delivery and care quality in surgical care; (3) remote monitoring is disruptive in the intensive care hospital process; and (4) mobile handheld tablets transform the paper-based capturing at the point of care. The disruptiveness of Health Technology is on the workflow of nurses as they use the technology, this can be eased by the training of the nurses in Nurse Informatics (Fernández, 2017).

2.4.5 Digital Health Use

Health Information Technology has provided many benefits, which range from: promoting the ease of documentation; quick retrieval of required information; prevention of medication errors; monitoring alerts, and; increasing the use of evidence-based practice; (Ahmad *et al.*, 2018; Mahoney, 2011) This is due to the plethora of emerging technology that is used within many spheres of healthcare requiring relevant competencies to design, develop and support them.

One of the core uses of Health Information Technology is the capturing of clinical documentation or EHR at the point of care (Vehko *et al.*, 2019; Brown *et al.*, 2020). This entails an electronic patient charting of the medical history, diagnosis, treatment plans, medications, radiology images, and lab results for each patient (Portilho, 2018). Competencies for achieving this are: mapping patient searches; resource assessment for the patient's needs; identification of specific characteristics that pertain to a patient (Ahmad *et al.* 2018). The advantages of capturing data at the point of care have been noted as an increase in the number of correct diagnoses and a reduction in the number of medication errors, thus increasing the scope and quality of clinical decision-making (Ahmad et al 2018).

Although there are advantages to using computing technology in healthcare, healthcare practitioners working in primary healthcare indicated that this involved high time pressure.

Bergey et al (2019) notes that healthcare practitioners indicate that they were spending more time at the computer, taking away time spent at the bedside, and requiring systems that do not take much time to retrieve and search for data. Brown *et al.*, (2020) echo this stating that EMR systems should be more reliable and user-friendly as this was a frustration that practitioners have working in high-pressure environments. Martikainen *et al.*, (2020) however, note that having Informatics practitioners who understand the needs of clinical practitioners based on the workflows in a healthy environment will result in improving HIS and their uses. This provides an opportunity for informatics practitioners to design and develop relevant technologies (Vehko *et al.*, 2019). They state that simple solutions are no longer sufficient for the challenges in healthcare since systems that integrate patient treatment points and care pathways are needed. These would enable a better flow of information between professionals, organisations and the patient.

Due to the complex nature of computing and its wide application across several levels and different domains, it is important that computing-related competencies and terminologies are acceptable and understandable by a diverse range of people to meet the different levels of required knowledge and skills. Another important consideration is for courses to be culturally sensitive and to allow for diversity to adapt to different local contexts. Future developments are in the areas of digital experiences; interactive technologies; ambient computing; cognitive technologies; robotics; and more. This means that persons working in computing fields will need to continuously upskill their competencies to cope with their job responsibilities. This will not only apply in the areas of analysis, development, implementation, and support but also applies to the managers and users of digital health (Assyne *et al.* 2022).

For example, Assyne *et al.* (2022) propose a unified competency framework for software professionals where they differentiate between hard, soft (personal and social), and essential competencies. They stress the importance of involving the stakeholders, whom they have identified as software professionals, educators, and the software industry. Their model places the different competency categories on the levels of basic, performance, and delighter based on the three stakeholder group's perspectives.

2.4.6 Informatics In Lower and-Middle-Income Countries (LMIC) / Digital Health in Africa

In 2005 the WHO recommended that member countries consider "*drawing up long-term strategic plans for developing and implementing eHealth services within the health sector and health administration"* (WHO, 2020). This was in response to the potential benefits that had been observed from telehealth since the 1989 agreement. In the Health field, the advancement of eHealth has provided diverse possibilities for the use of technology. This is Africa, a continent that consists of 12% of the world's population, and promises greater opportunities for reaching remote areas where resources are greatly restricted (Asah and Kaasbøll, 2023). In a continent, where countries are still developing, the WHO, 2019 statistics, record a paucity of practitioners indicating that there are "*40 Nursing and midwifery professionals per 10000 population*". A late bloomer of technology, Africa has made great technological strides with countries like South Africa, Nigeria, Ghana, Kenya, and Tanzania noted as forerunners within the health field (Republic of Uganda Ministry of Health, 2016).

Restricted by a lack of resources and having much of the population in remote areas, for technology to be relevant and sustained, it must be tailored to be resilient within the context. (Tiihonen *et al.*, 2008; Mahoney, 2011).- An overview of the eHealth strategies provides a lens to understand the complexities, that nursing and informatics practitioners manage within African contexts.

An overview of the eHealth strategies indicates that areas of concern in the implementation of eHealth are: limited digital health leadership capacity at national level; limited multisectoral arrangements for digital health; inconsistent adoption of standards and interoperability frameworks; limited data protection and system security regulations; limited financial resources; low level of health worker involvement in digital health; lack of sharing of evidence limits the development of best practices; linking fragmented regions; governance; (WHO Africa Region, 2021; Stroetmann, 2018). In most countries there is a four-tier provision of care, primary, secondary, tertiary, and specialised care. In public health, Primary healthcare is the first level of care for the majority of patients' health journey. Patients are attended to by community care workers, general practitioners, nurses, or midwives within their varied communities or clinics. Should the patient require more specialised care, the patient is referred to the next level facility, usually the nearest hospital, which provides secondary care (Young, 2016; Montesanti *et al.*, 2018). Depending on the severity of the condition of the patient, the patient may be transferred to tertiary-level health care for more specialised care. It is within this continuum of the referral process of health care that digital technologies can be integrated via eHealth.

An overview of the ICT applications used shows that most health institutions have some computing equipment, imaging and printing systems, internet, and a Local Area Network (LAN) to provide for sharing and exchange of patient data. Health Management Information Systems (HMIS) implemented by member states are the District Health Information System (DHIS) which has an option of implementing a web interface application the WebDHIS (Department of Health, 2019) In addition to the HMIS member countries on a national level other applications such as Human Resources for Health Information System (HRHIS), Administration Registry, Stock Monitoring Systems, Statistics Databases, Disease Surveillance and Response Systems, Management Information systems, National Insurance Fund Systems as well as Decision Support Systems may be available (Koumamba *et al.*, 2021). All the countries in their eHealth strategy, advocate for the strengthening of telemedicine applications, which include mHealth, Personal Digital Assistance (PDA), and cell phone applications. Of note, however, is that there are few systems that capture data at the point of care during the nursing process. Nurse practitioners interact with computers either (1) after each stage of the process; (2) once the nursing process is completed; or (3) in Managerial Decision Making and Reporting (Gaumer et al., 2007). Despite this, WHO member countries acknowledge a need for a health information highway where institutions are connected through a network, and data is shared instantly once it is captured at the source (Department of Health, 2019) This would enable clinical data to be shared between practitioners, allowing more informed patient care, in addition to, providing a holistic understanding of the different systems within the practice.

The integrated African Health Observatory (iAHO) is a platform to improve the availability and quality of health data (Serge *et al.*, 2024). The African Information Highway (AIH) forms part of the statistical capacity-building programme to electronically link African countries with health being one of the portals (ibid). Better quality health data should strengthen health systems and to improve health outcomes.

Considering the above points, it is clear that any education or training program for health professionals need to provide them with the necessary knowledge and skills to become competent in dealing with digital technologies in practice. This knowledge would be in alignment with the epistemology of the 2018, TIGER competencies, which consider health informatics as a practical lens for approaching informatics for nurses (Hübner *et al.*, 2018).

A key theme that was mentioned by the member countries is the inadequacy of skills to implement, use and maintain health information systems (World Health Organization-Africa Region,2013). The ratio of patients to health practitioners is very high and compounding this, in most countries informatics skills are inadequate even though being considered critical skills (World Health Organization-Africa Region,2013; World Health Organization-Africa Region,2010). Most countries acknowledge a need for a paradigm shift in the skill set outcomes for nursing and IT practitioners with the rise of technology within the Health domain (World Health Organization-Africa Region,2006; World Health Organization-Africa Region,2010). Each professional requires some interdisciplinary domain knowledge from both the health and informatics domains. Focal areas of education and training themes considered by states were leadership and governance; information sharing and data management; infrastructure; interoperability and standards; policy and legal regulations; programming; coding and compiling data at health facilities; telehealth and mHealth; change and adoption including research, innovation, and development (World Health Organization-Africa Region,2010; Kokol *et al.* (2018)).

Despite many challenges which, to mention a few, include lack of funding, weak infrastructure, fragmented stakeholder system structures, high-cost legacy systems, and duplication of patient information in diverse systems (Ruhode et al, 2013;World Health Organization-Africa Region,2021), member countries approach eHealth with a holistic plan of implementation (World Health Organization-Africa Region,2010). System Architectures provide a conceptual overview of the interactions of subcomponent structures within the National HMIS's. This is indicated in the Health ICT systems and applications that are in use in countries both at national and vendor levels. However, as Ghana (Ministry of Health Ghana, 2009) acknowledges, capacity building needs to be directed toward the long-term sustainability of Health ICT technology. In addition, as recommended by South Africa (Department of Health, 2019) an understanding of stakeholder journeys in health, ensures ascertaining competencies is more relevant.

2.4.7 Informatics and Digital Health in South Africa

There are various initiatives that have been implemented for digital health applications, in South Africa. Wright et al. (2017) outlined the Electronic Health Systems in use by 2017, this is summarised in Table 2.3 below.

Table 2-3: Electronic health information systems (EHIS) for public health care in South Africa (summary of EHIS from Wright et al 2017).

Level	System	Functionality of System	Areas where System is used
Patient Level HIS: Clinical care and supporting services systems	eHealth@Joburg	Primary care EPR is being implemented by Med-e-Mass. Clinical notes are entered into the system with templates for mother and child health and non-communicable diseases.	83 facilities in the City of Johannesburg

	Additional EPR Systems	EHR systems in the public health care sector.	In KwaZulu-Natal province, some hospitals use the Medicom or Meditech EPR system. The Western Cape use the Unicare EHR systems. Hospitals in the Limpopo province also use the Unicare or Medicom EPR systems
	TrakCare Lab	Responsible for all diagnostic pathology in the public sector	Used by most laboratories in the National Health Laboratory Service
	Picture archiving and communication systems (PACS):	Current digital radiology imaging machines use the Digital Communications in Medicine Standard (DICOM). PACS vendors use different formats for non-image data (patient identifiers and clinical details), file registry and repository	Many South African public sector hospitals have implemented PACS systems
	JAC Pharmacy System	Pharmacy dispensing and stock control system	installed in most hospitals in the Western Cape, 70 facilities in 2015
Patient and Operational level HIS: Administration systems	*CLINICOM Hospital Information System*	Provides patient demographic and hospital administration data	Used by nearly all hospitals in the Western Cape
	Delta 9™ Hospital Information System:	Little detail is provided	Used in 108 institutions (hospitals and clinics)
	Patient Administration and Billing System (PAAB)	Used for administration	
	RxSolution:	Stock control programme	Implemented in clinics and hospitals in five provinces
	Primary Health Care Information System (PHCIS):	Provides demographic data and ICD 10 codes for patient visits.	Implemented in public-sector community health sectors and clinics in the Western Cape
	Patient Record and Health Management Information	Patient Record and Health Management	Operated by the City of Cape Town (capital of the Western Cape) in primary care clinics

	System (PREHMIS)		
Operational and Strategic Level HIS: Monitoring and Evaluation systems	*National Health Patient Registration System*	Allows identity verification and records the reason for a visit	Installed in 650 public PHC facilities countrywide
	DHIS	District Health Management Information System (DHMIS) responsible for the collection and analysis of routine healthcare data from all primary care facilities and district hospitals in the public sector	All primary care facilities and district hospitals in the public sector

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In 2018, the National Digital Health Strategy for South Africa 2019–2024 (Department of Health Republic of South Africa,2019) outlined five priorities they desired to achieve by the end of the period 2019 to 2024. These were:" (1) Development of a complete health electronic record; (2) Digitisation of health systems business processes; (3) Establishment of an integrated platform and architecture for health sector information system; (4) Development of High impact mHealth for community-based interventions; (5) Development of digital health knowledge workers" (Department of Health Republic of South Africa,2019). The department identified further the following Digital Health Information Systems: The Health Patient Registration System (HPRS) which is an EHR in the context of National Health Insurance (NHI); MomConnect a mHealth initiative which educates women on antenatal and post-natal services; Stock Visibility System (SVS) used by clinics and hospitals as a stock management system;

In 2024 the Department of Health outlined the Health Management System (HMS) which is to be implemented for the National Health Insurance (NHI). The system is divided into three main parts: the Electronic Medical Record (EMR) including the Electronic Health Record (EHR), the Primary Modules, the Theatre Slates Module and additional modules (Department of Health Republic of South Africa., 2024). In 2025 Latif (2025) further explored digital health technologies in South Africa, and discovered the following applications indicated in Table 2.4.

Outcomes from these studies indicate the presence of a gap in capacity for the use and the development of these digital health technology systems. Wright et al (2017) report that health workers had a paucity of computer literacy skills in addition they could not comprehend the importance of the systems to their work practise as they could not see the competencies they would need. In their development of the national strategy the Department of Health also noted the need for building a workforce with competencies that can identify critical technical skills required to implement the strategy as well as institute career paths, from basic courses through to higher education. (Department of Health Republic of South Africa,2019).

The study aims to address the skills gap identified from the implementation of Health Information Systems and Digital health technologies. As practitioners could not comprehend relevant skills, the study aims to uncover nursing informatics and health informatics competencies for nurses and informatics practitioners that are suitable for practise and context.

Table 2.4: Health App categories based on their functionalities and the health services as listed by Latif (2025)

Health App categories and Examples
• Telemedicine Apps: Enable virtual physician consultations and remote healthcare services. Examples include Hello Doctor, Kena Health,Quro Medical • Health Information Apps: Share knowledge resources on symptoms, diseases, and self-care practices. Examples include MomConnect, HealthDart. • Patient Health Records Apps: Digitise, exchange, and monitor longitudinal patient treatment data. Examples include Vula Mobile,Vantage App, and HealthID. • Health & Wellness Apps: Focus on tracking fitness, biometrics, and providing lifestyle change nudges. Examples include Fitbit, Twilight, Strave, Sleep, My Fitness Pal • Personal Health Monitoring Apps: Capture individual health data for self-surveillance, such as period trackers, diabetes management apps. • Diagnostic/Clinical Reference Apps: Use risk stratification algorithms or care guidelines to aid health assessments. Example SAMF App. • Pharmaceutical Supply Chain Apps: Focus on medication delivery prescribed through virtual/remote consultation and inventory tracking. Example PharmaGo. • Health Financing Apps: Facilitate insurance policy purchases, premium payments, and claims processing. Example Paymenow. • Public Health Management Apps: Streamline surveillance, outbreak predictions, and data visualization for responsive public health interventions. Example COVID Alert SA App.

2.5 Health Education

In this sub section education is considered within the health domain and specifically how it links to nurses' competencies. It is concluded with nursing education in South Africa.

2.5.1 Health Education Overview

Health education and health promotion are terms that have been used interchangeably, having the same meaning. However, health education differs from health promotion where according to the South African Department of Health 2015-2019 health promotion policy(Department of Health Republic of South Africa. 2014:6), health promotion has evolved into a program that "*includes education, training, research, legislation, policy coordination, and community development*". From this analysis, health education forms a component of health promotion and whose purpose is defined by WHO (2017:12) "*to increase knowledge about personal health behaviour but also to develop skills that "demonstrate the political feasibility and organizational possibilities of various forms of action to address social, economic and environmental determinants of health"*.

The characteristics that are pertinent to health education are that individuals are taught by a person who is qualified in a health profession, with experience in practice, and who specialised in education within the health domain, for example, a nurse educator. The aim of health education is to develop the necessary competencies that is congruent with the health needs of the individual to become competent in health delivery (Hwang and Kuo, 2018; Grimwood and Snell, 2020). According to Whitehead (2004) health education motivates an individual (or community) to accept a behavioural change by influencing the individual's values, beliefs and attitudes. This is noted where it is ascertained that the individual is at risk because they have been affected by an illness or a disability. The act of influencing is performed by a health practitioner who requires training in a particular illness/disease or disability (Hwang *et al.*,, 2018). This training is even more important when the health education also includes the health information technology aspect (Jacobs *et al.*, 2016; Nimkar, 2016).

Health IT-based interventions when used to promote health education have the potential to support and promote health behaviour change as well as to help prevent and manage diseases (Free *et al.*, 2013; de Sousa *et al.*, 2022). Health education can also be delivered over the Internet using several technologies such as mobile technology, wearable devices, virtual reality, simulation, gaming, and eLearning. (Edirippulige and Smith, 2018; Grimwood and Snell, 2020; Nimkar, 2016). These technologies, according to Broadbent, and Gasteiger (2025), are used in seven ways, i) namely for promoting health ii) self-management a health condition, iii) communicating with others about health mattes, iv) remote monitoring of a person's health, v) health data gathering, vi) improvement of self-adherence, and vii) health training or education. The advantages that IT offers is that it enables advancement, efficiency, accessibility, and convenience of storage of large amounts of data (Oussous *et al.*, 2018). This enables health records to be stored as Electronic Health Records on the clinical side as well as Personal Health Records used by the patients via health digital technology (Nimkar, 2016).

Health practitioners who have informatics skills are early adopters, evaluators, and innovators of HIS (Car *et al.*, 2019; Konttila *et al.*, 2019; Liu *et al.*, 2015). Training of health practitioners is important for the adoption of Health digital technologies as part of practices and can be translated to their patients.(Konttila *et al.*, 2019). Successful adoption requires education and training institutions to not only provide training in health education but to also integrate into the health curricula, health informatics knowledge.

2.5.2 Nursing Education

Literature on early Nursing indicates that nurses learned their trade through oral traditions passed along generations; observations of other nurses caring for the sick, and a process of trial and error (Egenes, 2009). The earliest record of formal education was in Guangdong, China, where a short nurse training program was introduced in 1837 (Young, 2016). It was in this paradigm that Florence Nightingale established St Thomas Hospital which became a model of nursing education (Yana and Turkowski, 2024). The introduction of Nightingales' Hospital meant that nurses were trained as apprentices within the hospital. Hospitals were then combined with higher education learning for nurses (Yana and Turkowski, 2024). Although this status meant that nurses were trained on-site, the academic standards of such a setup were disputed by others such as the Carnegie Foundation. In 1923 the Carnegie Foundation in America presented a report known as the Goldmark Report stating that nurses need to be trained in Universities adhering to academic standards (Sarkis *et al.*, 1986). This was followed by a series of Reports, such as the Burgress Report in 1928 which stated that the development of the educational philosophy was necessary, and this implied that there would be changes in the profession of nursing. This was expounded on further by the Brown Report in 1948, which advocates that practical nurses be given vocational studies and registered nurses be trained at Higher Learning Institutions (Sarkis *et al.*, 1986). World War 2, brought to the forefront the shortage of nurse practitioners, which was difficult as registered nurses took four years to train (Scheckel, 2016). At this time Montag, a doctoral nurse, proposes the creation of a 2-year program be created so that registered nurses are semitrained before becoming registered nurses, but could still perform their nursing practice (Harker, 2017). Nurses therefore have three options for training to become a nurse: hospital-based education earning a diploma; a community college route for awarding an associate degree or a 4-year Bachelor's degree (Morin, 2014). This was the start of the development of different levels of nursing with vocational, diploma, and Bachelor of Science in nursing, a post-graduate degrees such as a master's or doctoral degree. This seems to be the current model of nursing educational opportunities.

2.5.3 Nursing Education and Technology

Technology has become ubiquitous within health care, enabling the provision of better patient care (Skiba, 2017). Since the first use of computers in clinical settings in the 1970's when mainframes were created, there has been a rapid evolution of the type of technology that can be used in health care (Masic, 2014). Early health technologies were used for the automation of the admission process and financial processes within a hospital. Statistical processes were the closest to clinical use as they dealt with evidence-based analysis (Hussey, 2014; Mantas *et al.*, 2014). Education in Informatics during that era consisted of in-service training on hospital systems. The earliest record of an informatics training course was by Francois Gremy in 1969 (Mantas, 2016) which was titled as Medical Applications of Computer Techniques. In 1974, Anderson *et al*. (1974) recommended a 3-competency level course for healthcare professionals (Skiba, 2017). This course changed the Informatics training paradigm from institution-centred training to patient-centred training (Haux, 2010). With the evolution of technology within healthcare it became more evident that it was necessary for nurse practitioners to be trained in informatics. It was not only necessary for nurse practitioners to be able to use the technology, but to be able to analyse the technology and make a valued judgment on the design, development, or purchase of a health information system. (Thimbleby, 2013; Ückert *et al.*, 2014). As the field of nursing informatics developed and defined, theories were developed to build the epistemologies and paradigms that would shape the field. (Staggers and Thompson, 2002). Definitions by Graves and Corcoran (Staggers *et al.*, 2002) and later Staggers and Thompson laid the foundations that would shape the ontology of the discipline. Theoretical models that included interdisciplinary knowledge were developed, with the nursing process central to health knowledge (Effken, 2003). With the evolution of the discipline, Hübner *et al.*, (2018) observe that informatics training for nurses followed a silo approach, where training was tailored to the nursing process's contextual requirements and recommended that informatics courses be integrated into nursing curricula than in a separate course.

Since nurses worked in interdisciplinary teams, the nursing field needed to consider informatics education as this apply to health to ensure that nurses acquire the necessary knowledge to work as nurse practitioners with other healthcare practitioners using technologies (Kinnunen *et al.*, 2019). The informatics content in a courses, depends on the required outcomes of the programmes, and the needs obtained from nursing informaticians and nursing engineers (Costa *et al.*, 2023; Yao *et al.*, 2023). Course content maybe offered as short courses or integrated in the core nursing curriculum (Hubner *et al.*, 2018; Eldoushy and Soliman Behairy, 2023). Integrating the content would require it to be staggard with more familiar easier content in the beginning of the course and more complex nursing informatics content towards the end of the program (Hubner et al, 2018).

2.5.4 Nursing Education in South Africa

In South Africa, literature notes that Sister Henrietta Stockdale, played a similar role to that of Florence Nightingale in the Southern African Region (Scribante *et al.*, 2004). She is noted to have established a nursing school in Kimberly in the 1800's as well as being the first to establish professional training standards as part of the founding nursing charter (Dolamo and Olubiyi, 2013). In 1819 the first formal training of nurses was instituted. Within the Southern African region training of nurses was done by apprenticeship and all trained nurses and midwives were required to be registered with the Colonial Medical Council of the Cape Colony from 1904 (Kotze, 2012). Initially, nursing education was under the South African Medical and Dental Council and under these auspices, post-basic nursing courses were introduced in 1922 (Dolamo and Olubiyi, 2013). This was the case until 1944 when the South African Nursing Council (SANC) was formed by the Health Act of 1944 (SANC, 2022b). The first Baccalaureate degree was started in 1955 and Post Baccalaureate degree in 1967 (Dolamo and Olubiyi, 2013). Nursing education was initially offered at Public Nursing Colleges (PNCs), Universities, and Private Nursing Education Institutions (NEIs) (Dolamo and Olubiyi, 2013). Accreditation of courses within the Country in 2020 is done by SANC and the Council on Higher Education (CHE) for University-based courses. Courses offered by PNCs are accredited by SANC only. Educational provisions in 2020 are for a four-year Bachelor in Nursing and Midwifery Degree, a three-year Diploma in Nursing, a one-year Higher Certificate for Auxiliary Nurses, and one-year Post Graduate Diplomas. (Dolamo and Olubiyi, 2013; Ricks, 2018; SANC, 2022a). It is within this context that this study was conducted.

2.6 Informatics Education

In this sub section informatics education is considered globally and in South Africa to be concluded with the competencies associated with informatics training and education.

2.6.1 Informatics Education Globally

Early computing education was based on research, development, and maintenance, until the 1950's when academic institutions began to provide courses in computing or informatics education. (ACM and IEEE, 2020);(Berner, 2013). Computing is a term recommended by ACM and IEEE has evolved parallel to the flux in computing technologies influencing the competencies that information technology practitioners require (Nwokeji *et al.*, 2019). Not only has it influenced the circulation of informatics but has influenced the nature of non-Informatics disciplines.(Members *et al.*, 2016). This factor is especially important in the development of curricula for information technology practitioners where according to the ACM and IEEE, (2020) the sub-discipline competencies curricula within informatics originally were Computer Engineering (CE), Computer Science (CS)and Information Systems (IS).

One of the core fields of this study is computer science where the fundamental discipline as it contains all the theoretical software development components of computing. From the functioning of computer science and information systems, a sub-discipline Information Technology (IT) was derived which includes the theoretical components of computer science but with the addition of the maintenance and support components from interactions with users and the challenges they experience. It was only until the development of the information technology curricula that ACM and IEE decided to base the curricula on competency outcomes.(ACM and IEEE, 2020) This provided a means for shifting the focus of curricula away from the body of knowledge in terms of disciplines but instead channelled it towards practical student accomplishment and performance.

Informatics offers a wide range of knowledge and skills competencies, where the selection and combination to implement is dependent on the institution offering the course (Career Space Consortium, 2001; Takada *et al.*, 2020). The ACM and IEEE, (2020) acknowledge that amongst the combination of courses, there is a new trend of courses that are X-Computing or Computing-X. These are not unfamiliar as Informatics courses which have a business or finance lens that has been part of Institutional programs that have a specific domain focus, e.g. a business focus. The determination of these courses as sub-fields is influenced by the value that stakeholders place on the required competencies.

2.6.2 Informatics Education in South Africa

It is important to understand the needs and expectations of the relevant stakeholders for the development of Informatics courses that develop the competencies that informatics practitioners will need. At the micro-level the stakeholders are the students and the educators and informatics practitioners, at the meso-level the institution's goals and policies determine the outcome of competencies; while at the macro-level the guidelines are provided by the South African Council on Higher Education (CHE), the Department of Higher Education and the South African Qualifications Framework (SAQA) (South African Council on Higher Education, 2013). The South African Education System is governed by a National Qualifications Framework (NQF) which is run by the South African Qualifications Framework (SAQA). The latter governs all the higher education institutions within the country, and the courses that they are accredited to offer. For a higher education institution to have an informatics course accredited, they need to be registered with the Department of Higher Education and Training (DHET) and also need to be accredited by one of two relevant Quality Council (QC) organisations (SAQA, 2022). These are (1) Council for Quality Assurance in General and Further Education and Training (Umalusi) for or (2) Council on Higher Education (CHE) for higher education qualifications. Institutions develop their own curricula based on global guidelines and reference to South African skills as stated by the Institute of Information Technology Professionals South Africa (IITPSA) (Harmse and Wadee, 2020). Once they have developed their courses, these have to be approved by the Council on Higher Education (CHE) and the South African Qualifications Authority (SAQA) in South Africa. Once the course has been approved it is registered with SAQA to be available for administering to the students.

This study focuses on the stakeholders at the micro level, the educators, students and Informatics practitioners including expert who are familiar with the domain of health. It explores their perspectives on health informatics education for informatics students. An overview of other stakeholder influences helps in understanding the process of accrediting Informatics Courses.

2.6.3 Informatics Competencies

Domain knowledge, in this study, digital health, represents the context of the task in a specific situation, i.e., situated knowledge within the domain. According to the Association for Computing Machinery (ACM) and the Institute for Electrical and Electronics Engineers (IEEE), competency is comprised of three characteristics, Knowledge, skills, and dispositions (ACM and IEEE, 2017). Knowledge is defined as the "*Mastery of content which is the transfer of learning*". Skills are the "*Capabilities and strategies for higher-order thinking*" and Disposition is "*the personal qualities (socio-emotional skills, behaviours, attitudes) associated with success in college and career*" (ACM and IEEE, 2017). These are embodied within the context of a professional context (Clear *et al.*, 2020). Context is important because it defines the parameters that may influence the competencies in practice. For competencies in study programs and courses to be effective they have to be integrated into the environment where they will be used (Hübner *et al.*, 2018). For an informatics educational program, this is important to keep up with the evolution of technology, as it affects practice. This is especially important as the field of information technology is continuously evolving and the informatics practitioner needs to be well-equipped to be competent in developing, managing, and supporting information technology systems. (Career Space Consortium, 2001; Nwokeji *et al.*, 2019).

For IT students competencies to be relevant they should be capable of performing their tasks for, and with digital technologies in practice. Assyne *et al.*, (2022), in their study on the essential competencies of software professionals, identify that software professionals not only require hard skills in programming, software design, testing, project management and validation and verification management; but also need the following soft skills: interpersonal relation, cooperation and the ability to work in a team; handling and solving digital technologies; development in the job environment; and personal development. Wu (2022), in his study on the internship experiences of data science students, add to the soft skills indicating that the students also require the following skills: problem solving, critical thinking, creativity, leadership, communication and collaboration. He further identifies the following challenges that students experience within the work environment: communicating with co-workers; lack of domain knowledge; adapting to a new lifestyle; understanding existing work practices; understanding the real-world problem; finding solutions to new problems; obtaining new domain knowledge. These challenges indicate that, although the Information Technology programmes have a strong technological and humans grounding (Leidig *et al.*, 2020**),** they need to consider the context within which the students would be working, to cover the gap between industry and education (Clear *et al.*, 2020; Groeneveld *et al.*, 2021).

In this study, competency is considering the context of nursing Informatics. Thus, looking at both the competencies of the nurse and the informatics practitioners respectively.

2.7 Nursing Informatics

In this sub section the informatics aspect of nursing is considered within a global and South Africa context.

2.7.1 Nursing Informatics Globally

Nursing Informatics (NI) is said to have been founded by Florence Nightingale, the mother of Nursing. In 1857 she compiled and processed data for patients in Crimean War (Betts and

Wright, 2009). This was the earliest record of a database of information begins kept within the nursing field. Punch cards were used for capturing the data as part of the recording and storing of the data in mainframes instead of traditional files and filing cabinets. This paved the way for the need for more research to be conducted in the fields of nursing combined with Informatics as part of introducing digital technologies in nursing practices. In 1974 the first International BioMedical Informatics Association was formed (Mantas *et al.*, 2016) which formed an umbrella organisation from which other national organisations would reference. In 1982, the International Medical Informatics Association (IMIA) recognised health informatics as a unique integral sub-discipline component of Informatics (Kulikowski *et al.*, 2012).

In the same year, research on the epistemology, ontology, and axiology around nursing informatics was being conducted and definitions from Hannah(1985), Graves and Corchoran (1989) were being formulated (Staggers and Thompson, 2002; Peltronen *et al.*, 2021; Reid *et al.*, 2021). This was the start of the discipline of Nursing Informatics (NI) and the educating of nurses in informatics to equip them to benefit from digital technologies. Definitions and theories derived looked at the discipline through the paradigms of being as being either contextual in nature; as a tool; or praxis-oriented (Graves and Corcoran, 1989; Staggers and Thompson, 2002; Turley, 1996).

While the discipline was being formulated, a review of the working of technology within the field of healthcare was conducted and it was discovered that there were challenges with the Information Communication Technology (ICT) Systems in healthcare (Masic, 2014). Some of the reasons for these challenges were: the technology was unsustainable; the technology was disruptive in the work praxis of healthcare practitioners, and information communication technology practitioners did not know enough of the healthcare practices and processes (Masic, 2014. This emphasizes the importance of informatics knowledge relevant to their work as a competency for purse practitioners while the healthcare domain knowledge was an important competency for informatics practitioners.

The importance of both practitioners acquiring relevant knowledge has become more evident with the use of advanced digital technologies in healthcare (Kudinov *et al.*, 2021). Appropriate education became a large need as technology has become pervasive in the interactions between practitioners with each other as well as between practitioners and patients (Pears *et al.*, 2020). Technologies such as wearable devices and Internet of Things (IoT) technologies, Artificial Intelligence (AI) technologies, Telemedicine technologies, and Automation technologies have changed the landscape of healthcare in the provision of better care (Kudinov *et al.*, 2021). Nursing and informatics practitioners, although working collaboratively together, Martikainen *et al.*, (2020) note that when working on the design, development, and implementation of healthcare technologies, they have not been able to effectively work together due to lack of time and semantic knowledge of each other's practitioners praxis. Furthermore, they note that nursing practitioners preferred to collaborate with informatics practitioners who have some knowledge of healthcare. This is an indication that there is a knowledge gap that is required for both practitioners to be able to work together seamlessly in the evolving landscape of healthcare (Mantas and Hasman, 2017).

2.7.2 Nursing Informatics in South Africa

In the South African context, there are seven major stakeholders that influence the development of courses within the nursing domain. These are the government, SANC, nursing training providers, technology training providers, technology providers, health service providers and the community (Bhebe *et al.*, 2014). The relationship between these stakeholders, illustrated in Figure 2-7, assist with the development of nursing Informatics courses and associated competencies. The government provides the policies that govern the education sector through the following entities: The Department of Health (DoH); the Council on Higher Education (CHE) and the South African Qualifications Authority (SAQA). SANC is the governing body, which determines the macro curricula for nursing and accredits courses that are intended for the education and training of nurses (SANC, 2005). Nursing training providers, health services providers, technology training providers, technology providers and health service providers, conduct the meso- and micro-training that the nurses require (Horwitz, 2011). While Nursing training providers, and health service providers are responsible for training in the health domain, the technology education and training providers, educate and train the nurses on IT domain-specific topics, where they will specifically learn about applying IT competencies in healthcare, e.g. in health Informatics to be employed by technology providers. Training is also available to benefit the community where training is focused on community-related healthcare to equip practitioners working for technology providers and the health systems providers (Mostert-Phipps *et al.*, 2013).

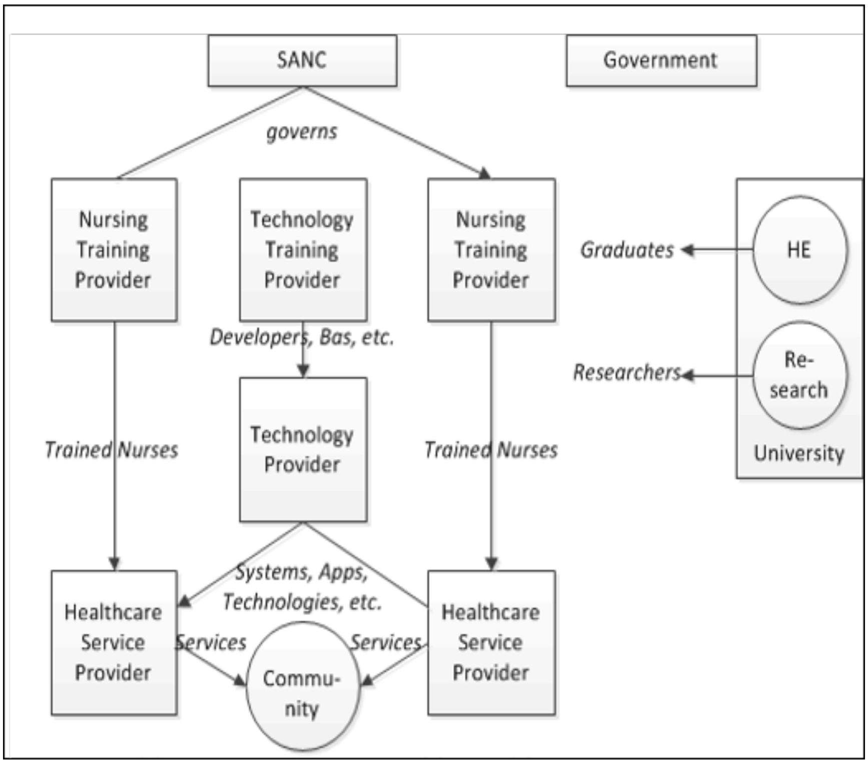

Figure 2-7: Nursing Informatics Stakeholders in South Africa (Bhebe and de la Harpe, 2014)

The training of nurses in informatics is particularly important in South Africa, as majority of nurses are digital migrants over 45 years old (SANC, 2022; Lekalakala-Mokgele *et al*., 2023) and as such their lack of digital literacy could result in losing opportunities for digital implementations in the South African Health context (Ramnund *et al.*, 2023). This state of digital migrants affects the course offerings for nurses, as digital migrants would require formal and training, integrated and short course offerings (Mantas and Hasman, 2017; Hubner et al, 2018; Eldoushy and Soliman Behairy, .2023).

Studies conducted in various contexts indicate that nurses have a positive attitude towards health services and technologies (Nkosi *et. al*, 2011; Wright *et al*., 2012). Additionally, Harerimana *et al*. (2019) reported that nurses have some "skills to use some ICT applications, and emphasis should be placed on the integration of computer literacy in the nursing curriculum". Chipps et al (2022) concluded that computer literacy skills, informatics literacy skills and information management skills were relevant to nursing practice, despite varying levels of competence in these skills among nurses. This was also confirmed by Le Roux *et al*. (2024) noting that practicing nurses have a limited level of nursing informatics competence, and reiterating that nursing informatics was still at the computer literacy stage as observed by Harerimana *et al (*2021)

2.8 Nursing Informatics Education

In this sub section the intersection of health (nursing), informatics and education is discussed as this represents the focus of this study.

2.8.1 Nursing Informatics Education Frameworks

In a panel discussion on theories (Mantas *et al.*, 2014), with health and nursing informaticians, it was noted that more middle-range theories applicable to the field are required. This would enable a deeper understanding of the underlying features that influence and shape the health and nursing informatics discipline. Macro theories and frameworks have been developed and used in the health and nursing informatics field, such as the Staggers and Parks nurse-computer interaction framework (Staggers and Parks., 1993b); the Effkens, informatics research organising model (Effken, 2003); and Kaminsky's, nursing informatics perspectives conceptual model (Kaminski, 2007). These models and frameworks have been used in various inquiries within health administration, clinical practice, education, IT systems design, development, implementation, and use, as well as within the various organisational structures that collaborate and influence the health field (De la Harpe, 2014; Korpela *et al.*, 2002).

Each of these frameworks approaches the field of Nursing Informatics from diverse perspectives. An exploration of the underlying factors that influence competencies formulation and affect the dimensions of design, implementation, and use of technology is considered by Staggers and Parks in their nurse-computer interaction framework (Staggers and Parks., 1993b). This framework considers the interaction that a nurse has with a computer including the nursing context, nurse behaviours, computer characteristics, information, the cycle of information exchange, and the trajectory of experience that the practitioner gains with time. Staggers and Miller (2001) reframe the nurse-computer interaction framework, illustrated in Figure 2-8 in an exploration of using a web-based platform as a patient care management system to rename it to the health human-computer interaction framework. The latter model includes information exchange, and collaboration activities of the nurse practitioner with other stakeholders. It considers the competencies that a nurse practitioner would acquire after interaction with a computer device over a period of time. In this study, the framework was used as a measure for understanding the use of health information technology by nurse practitioners. It provided a means for analysing the data as well as classifying the competencies.

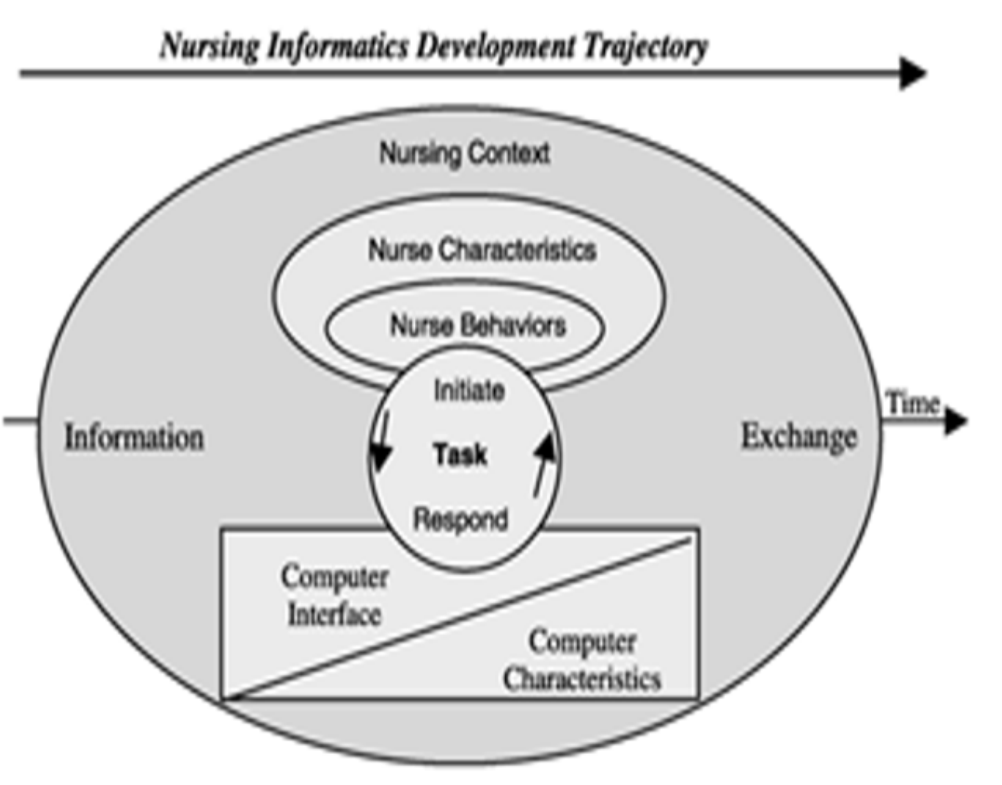

Figure 2-8: The Nurse Computer Interaction Framework (Staggers and Parks, 2002)

In 2003, Effken, in her conceptualisation of the informatics research organising model (IROM), illustrated in Figure 2-9 the initial nurse-Computer Interaction Framework by Staggers and Parks, drawing a parallel between the components found in the processes of the systems development life cycle and the nursing paradigm. The framework illustrates the interaction between the process of the systems development life cycle and the nursing paradigm, outlining research at three levels of sample participation, group, population, and Individual. At each stage of the cycle, evaluation is deemed necessary as a control measure. In this study, informatics research organising model (IROM) is used as a tool to analyse the outcomes from the inquiry for the derivation of a framework that may be used as a reference when approaching competency studies in nursing informatics.

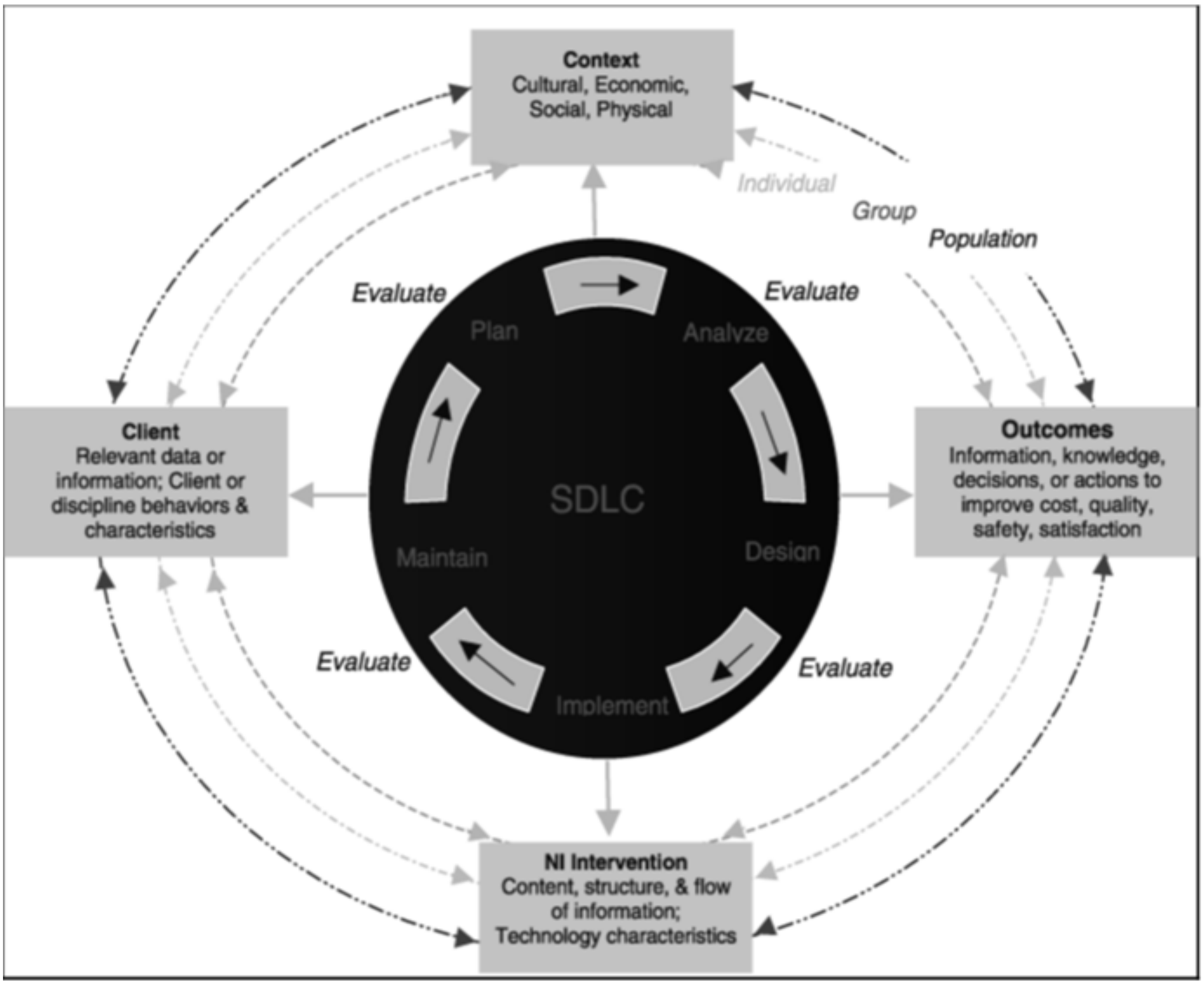

Figure 2-9: Effken's Informatics Research Organising Model (IROM) (Effken, 2003)

Key components in exploring competencies noted in the international health and nursing informatics frameworks are attitude, value, and judgement. These, according to Kaminsky (2007), form a critical measure of the perceptions of nurse practitioners, influencing their uptake of computer innovations. Kaminiski, in her doctoral thesis explores using grounded theory to determine the perceptions of nurse practitioners towards technology with the aim of understanding the factors that influence these perceptions. In her inquiry, Kaminsky derives a framework for exploring the perceptions of nurses on technology use within their work practice. Seven themes illustrated in Figure 2-10, were produced from the study, these were: (1) Network; (2) Artefact; (3) Agency; (4) Technique; (5) Utility; (6) Antithesis and (7) Power. Kaminsky links these themes to various philosophies, which are used in both the informatics and nursing health domains. Each of these perspectives provides a lens through which nurses view technology within their field. According to Kaminsky, this help to shape the "experience and adoption of informatics" within four domains of nursing: (1) practice; (2) administration; (3) education; and (4) research. The Staggers, Effken, and Kaminsky theories each offer different lenses through which one can design and develop nursing and health informatics training. An exploration of the attitudes of nurses towards computers is imperative as it provides a platform for determining the technological acceptance of health information technologies and the interest in learning more about informatics.

Figure 2-10: Nursing Informatics Perspectives (Kaminiski, 2007:7)

Staggers and Parks (1993) explore nurse competency interactions with informatics technologies while Kaminski (2007) proposes a model for understanding the characteristics that influence the attitudes, concerns and opportunities for outcomes that drive a positive adoption of technologies, and Effken (2003) proposes a framework for approaching research within the nursing informatics domain. In this study these frameworks were used as part of the data collection and data analysis.

2.8.1.1 Nursing Informatics and Health Informatics Education Competencies Frameworks

Competency frameworks: Competency frameworks should be living documents to cater for the continuous health and digital technology landscape changes influencing the dynamics of competencies that changes over time, experiences and settings (Davies *et al.*, 2022;

Purabdollah *et al.* 2023). Frameworks should also be regularly updated based on the digital health technologies relevant to lower and middle-income countries (Nazeha *et al.*, 2020). Duplications need to be avoided and competency frameworks need to be suitable for the relevant practices in the clinical work environments, specific contexts and also cater for different target groups whose competencies requirements may differ across practitioner group, role and level of seniority (Jarva *et al.*, 2024; Morris *et al.*, 2023; Nazeha *et al.* 2020) also considering their professional background of the practitioners (Purabdollah *et al.*, 2023). Successfully implemented competency frameworks need the following considerations as suggested by the study participants from different countries with a range of educational experiences: to enable design with scaffolding of digital health and technology capabilities; to develop interprofessional engagement experiences with digital health technologies capabilities; implementation strategies; evaluation by multi stakeholders (Lokmic-Tomkins *et al.*, 2024)

The topic of the lack of competence by nurses in nursing informatics has been ongoing discussion for decades and is still relevant today (Palamarek and Trieu, 2022). Having nurses and informatics practitioners who are knowledgeable in both informatics and health respectively enhances their confidence and overall preparedness to use digital health technologies in the context of patient care upon joining the workplace (Nagle *et al.*, 2020; Kleib *et al.*, 2021). For nurses to have informatics competencies enhance their attitudes towards computers and informatics tools so that they are able to implement new digital health solutions, and to improve on current digital health solutions. According to Kaihlanen *et al.*, (2021) in their study on nurse informatics competencies in a Finish context, nurses' attitudes towards informatics and the use of computers correlate with their informatics competencies. Ahmed *et al.*, 2020) in their study of attitudes toward electronic health records, note that nurses have a negative attitude because of a lack of the necessary competencies. Since attitudes are directly related to competency it is recommended that institutions should provide targeted education and training to address low digital literacy levels and/or confidence in using information systems (Kuek and Hakkennes, 2020).

2.8.1.2 Global Nursing Informatics and Health Informatics Education Competencies Frameworks

Since the use of the first computer in the health field and the evolution of technology in the developed world, it has become necessary for nurse practitioners to have informatics competencies as they are applied in healthcare practices (Saba, 2001; Wright *et al.*, 2012). The earliest recorded development of a broader domain of health informatics competencies was proposed by Staggers and Parks., (1993a). This was a study on the experiential competencies gained by nurses as they interact with computers within their context of practice. This inquiry led the way to the study by Staggers *et al.*, (2002) based on an international survey studying the informatics competencies for nurses at four levels of practice. Three major outcomes from the inquiry were derived of three levels of competencies as: basic computing skills; information skills; and informatics skills. These provided a reference point for the development of international health and nursing informatics competencies frameworks.

With the foundations from the Staggers and Thompson, (2002) study, in 2004 the Technology Informatics Guidance Education Reform (TIGER) Initiative was formed, bringing together a number of nursing stakeholders to evaluate how nurses are prepared to use Electronic Health Record (EHR) systems, which were the interest at the time (Technology Informatics Guiding Education Reform (TIGER), 2007). In 2007 the TIGER Initiative compiled tools, principles, and theories for nursing informatics using collaborative teams ((Technology Informatics Guiding Education Reform (TIGER) 2007). The TIGER at that stage selected a three-level competency structure that is based on the European Computer Driving Licence (ECDL) curricula for health practitioners (Technology Informatics Guiding Education Reform (TIGER), 2007).

As the body of literature expands on nursing and health informatics competencies, definitions, and epistemologies, Nazeha *et al.*, (2020) identify in their literature search between 2016 and 2019 of health and nursing Informatics frameworks, thirty frameworks. From these frameworks they identify twenty-eight digital health competency domains of which the health information technology competencies framework represents most of the competency domains. Of these frameworks historically, several international frameworks made a marked reference point such as the first by the International Medical Informatics Association (IMIA) which mandated a working group to inquire into the formulation of competencies in the field of health informatics (Mantas *et al.*, 2010). The working-group comprised of international health informatics experts, who conceptualised a framework illustrating the Interactions of disciplines within the holistic health informatics discipline. In addition to this, competencies for health practitioners and non-health practitioners were derived from the discipline competencies and combinations of competencies at different levels of course offerings were recommended. The formulation of these competencies influenced other developed countries in, Australia, America, and Canada to conceptualise competency frameworks and ascertain appropriate competencies suitable for their contexts (Kulikowski *et al.*, 2012; Moore and Shaw-Kokot, 2012).

In 2013, the EU and USA formed the EU-USA Work eHealth Project (Technology Informatics Guiding Education Reform (TIGER), 2017). The aim of the project was to derive competencies that would be suitable for the eHealth environment. Case studies were examined and international experts' opinions were considered via a survey. The results were published in 2018 and consisted of a database of health informatics competencies, HITComp, which could be developed according to either one of four roles of administration, direct patient care, engineering/information systems/ICT, informatics, or research/biomedicine. These could be considered at different levels, namely advanced, baseline, basic, expert, or intermediate; with a competency quadrant of interactions that a practitioner could have within their roles, which could be administrative, clinical, communication, health data, operational or patient interactions. The results of these selections represent thirty-three areas of competency from which competency choices could be made. ((Technology Informatics Guiding Education Reform (TIGER), 2017; Shaw *et al.*, 2017; Tiainen *et al.*, 2021). The TIGER organisation's involvement in the HITComp development, initiated a reconceptualization of the TIGER's competencies. The TIGER competencies published in 2018 changed the paradigm from a silo nursing informatics lens to a paradigm that incorporated the work of interdisciplinary teams of health practitioners (Hübner *et al.*, 2018; Thye *et al.*, 2019). The 2018 TIGER competency framework was nursing oriented and provided 24 competency areas for nursing informatists. In 2019 the TIGER organisation incorporated the HITComp competencies to derive a competency framework that was interdisciplinary and proposed competencies for 6 (six) roles that a nurse could take up. This competency framework had 33 competency areas, and proposed competencies for the six roles. In this study we look at the nurses' roles and the competencies recommended for them. The literature reviews conducted by Nazeha et al (2020) on Health Informatics frameworks looked searched frameworks up to 2019, a literature search from 2019 on Health Informatics frameworks, indicates that there is no update to the 2019 TIGER competency framework. The search also indicated that there was an update on the IMIA 2010 framework. The latter was done using reviews from the frameworks from Canada, Saudi Arabia, Europe, Australia, United Kingdom and United States. A comparison of the TIGER 2019 competencies for nurses and the IMIA competency framework (Bichel-Findlay *et al.*, 2023) is indicated in the Table 2-3 below, and outcomes indicate that the TIGER 2019 framework does not recommend any Health Informatics Core Principles, however there is a component of its competencies in the remaining domain knowledge areas of the IMIA 2023 framework.

Table 2-5: Health Informatics Competencies for Nurses based on the IMIA and TIGER frameworks discussed above.

Author	**Region Considered**	**Competency Domain Knowledge Areas**
IMIA Competencies 2022	International	• Computer, Data and Information Science • Health Sciences and Services • Management Science • Social and Behavioural Sciences • Biomedical and Health Informatics (BMHI) Core Principles
TIGER Competencies Knowledge areas for Direct patient care (DPC) (nurses/physicians/ therapists) 2019	International	• Information and communication technology (applications) • Teaching, training and education in healthcare • Care processes and IT integration • Communication Documentation • Quality and safety management • Leadership • Learning techniques • Ethics in health IT • Information and knowledge management in patient care
AMIA 2023 core competencies		• Health • Information Science and Technology • Social and Behavioural Science • Health Information Science and Technology • Human Factors and Socio-technical Systems • Social and Behavioural Aspects of Health • Social, Behavioural, and Information Science and Technology Applied to Health • Professionalism • Interprofessional Collaborative Practice • Leadership

2.8.1.3 Health Informatics Education Competencies

There is a lack of literature on Health informatics competencies for informatics practitioners. A look at informatics frameworks that provide competencies for informatics practitioners within a contextual domain were considered. The ACM and IEE, Information Technology Curricula 2017 (2017) provides a guideline for competencies for informatics practitioners working within a domain within a specific context. It focuses on competency-driven learning rather than delivery of knowledge in information technology programs. Sabin *et al.* (2018) explore this framework in their study on competencies for software developers. They propose six sub domain knowledge areas for which competencies maybe recommended. Another study by Frezza *et al.* (2018), consider competencies for first year and fourth year informatics students in practise. The competencies are indicated in Table 2-4 and grouped according to categories that were similar.

Table 2-6: Informatics Competencies in Practise for Informatics Practitioners (compiled from the above discussion)

ACM and IEE, Information Technology Curricula 2017	**Sabin *et al.* (2018) Software Development Domain Knowledge Areas**	**Frezza *et al.* (2018) 1st Year Student Competency Areas**	**Frezza *et al.* (2018) 4th t Year Student Competency Areas**
• Cybersecurity Principles • Information Management • Networking • Integrated Systems Technology • Platform Technologies • Web and Mobile Systems • Applied Networks • Internet of Things • Mobile Applications • Virtual Systems and Services • Cloud Computing	• Platform-based development Tools and services		
• Software Fundamentals • User Experience Design	• Process models and activities	• Develop and maintain programs and systems • Analyse and solve problems algorithmically	• Develop and maintain programs and systems of high quality • Analyse and solve complex computational problems • Develop and manage large IT systems
• Global Professional Practice • Software Development and Management • Social Responsibility	• Management	• Identify, analyse and solve problems in different settings • Plan and use your time wisely in a healthy way • Learn independently and efficiently	• Formulate, analyse and solve problems in different settings • Plan and use your time wisely in a structured and healthy way
	• Deployment	• Retrieve information in an effective way	

ACM and IEE, Information Technology Curricula 2017	Sabin *et al.* (2018) Software Development Domain Knowledge Areas	Frezza *et al.* (2018) 1st Year Student Competency Areas	Frezza *et al.* (2018) 4th t Year Student Competency Areas
• System Paradigm • Cybersecurity Emerging Challenge • Data Scalability and Analytics	• Operations	• Be versatile in programming • Work in groups in different settings • Writing in different settings • Communicate orally and in • Organize your work and take responsibility • Evaluate yourself and identify what you can improve and your limitations	• Work in groups in different settings • Communicate orally and in writing in different settings • Learn independently and efficiently • Learn from mistakes and hare knowledge • Reflect on and evaluate your work • Reflect on ethics, gender, and inclusiveness • Show self-discipline and take responsibility
	• Maintenance		

A look at the informatics competencies recommended by each author, the IT2017 curricula provides a comprehensive outline of competencies that are applicable in the informatics domain. This includes the informatics tools they use to create artefacts for a particular context. Sabin *et al.* (2018) and Frezzia *et al.* (2018) have recommendations are in alignment with the stages of the software development lifecycle. However, Sabin *et al.* (2018) include platform-based development tools and services as a necessary component aligning this with the IT2017 curricula. Frezzia *et al.* (2018) also include the following disposition competences: work in groups in different settings; communicate orally and in writing in different settings; learn independently and efficiently; learn from mistakes and share knowledge; reflect on and evaluate own work; reflect on ethics, gender, and inclusiveness; and show self-discipline and take responsibility. The three authors core competencies concentrate on the knowledge and skills aspects of competencies for each of these they are provided within a context setting.

2.8.1.4 African Nursing Informatics and Health Informatics Education Competencies

In the African context (Shopo *et al*., 2020) note that health information systems challenge the caring ethos of nursing as information technology (IT) infiltrates the caring presence between nurse and patient. They found that although nurses have a positive attitude toward digital technologies, there are gaps that needed to be addressed in terms of required competencies with many countries in the African region that have developed eHealth strategies that highlighting the need to train the digital health workforce (Kipturgo *et al.*, 2014; Munene *et al.*,2020). This was also indicated by Chipps et al (2022), that nursing students lacked computer literacy skills, informatics literacy skills and information management skills, despite varying levels of competence in these skills among nurses. Munene et al (2020) propose a framework for the African context for digital health workers, where they identify seven roles that a nurse with informatics skills can take up, these are Communicator, Collaborator, Professional, Data Analyst, Technology Expert, Health Advocate and Manager. Under each one of these Munene et al (2020) identified competencies which each role would fulfil. These are indicated below in Figure 2-11.

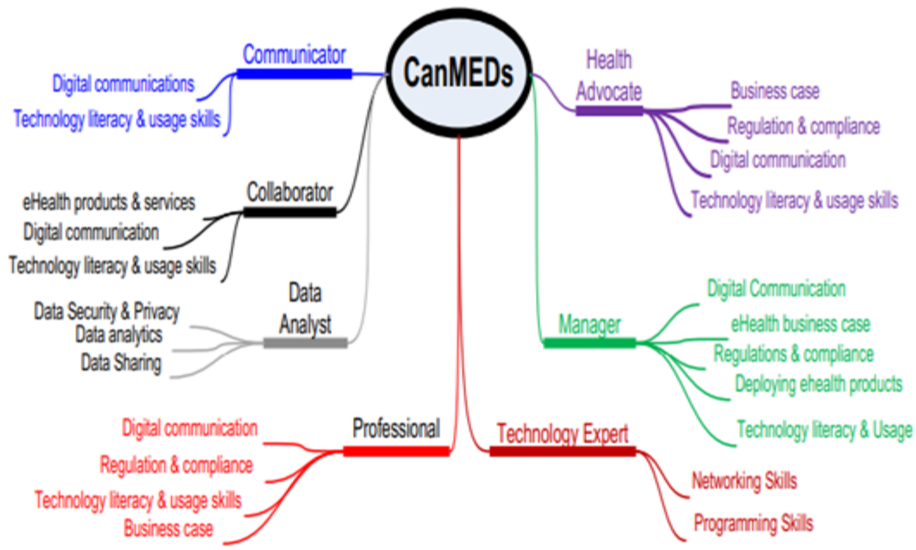

Figure 2-11: Proposed Learning Requirements for a Digital Health Worker for the African Region (adapted from Munene et al. (2020)

Chikware *et al.* (2024:10) in their scoping review of health informatics competencies for health professionals, identify fourteen program content areas of competency knowledge domains which they recommend. These are: (1) ICT user skills; (2) ICT and HI knowledge—Health Information Systems; (3) Fundamentals of Health informatics; (4) EHR education—including profession-biased concepts (BMI, Nursing Informatics, Pharmacoinformatic etc.); (5) EHR practical—simulations and live sessions; (6) Electronic Medical Records (EMR)—Practicum; (7) Academic Electronic Medical Records (AEMR)—Laboratory, classroom and simulations; (8) Telemedicine—Telehealth and Tele-pharmacy; (9) Practicum; (10) Decision support systems—Tools and strategies for biomedical information searching; (11) Databases and medical digital libraries; (12) Ethics and Legislation in Health Informatics; (13) Health Policy; and (14) Business/administration, and economics.

While each study looked at different health informatics competencies for health workers, they did this through different lenses. An overview of the two studies provides this study with a perspective of competencies that literature recommends as applicable in the African Context. This would enable this study to explore competencies which are relevant to the study context, and if there are gaps in recommended competencies.

2.8.1.5 South African Nursing Informatics and Health Informatics Education Competencies

There is a paucity of literature on informatics in nursing in South Africa, (Harerimana *et al.*, 2023; Ziqubu and Orton, 2023:11) with literature focusing on the adoption, use and application of e-learning technologies by nurse educators (Ravele, 2018; Sunnasy, 2020; Ziqubu and Orton, 2023). Results from their studies indicate that nurse educators had a positive attitude towards Informatics technology, but the challenges experienced are due to a lack of skills and there is therefore a need for capacity building in digital technologies.

Studies on nursing informatics competencies were conducted by Harerimana *et al.* (2019) and they discovered that nursing students had inadequate skills to use basic computing applications particularly word processing applications, reference manager, data analysis software, and plagiarism detecting software. Singh and Masango (2020) however, in their study found that nurses were significantly competent in general IT and in the use of IT for medical purposes or learning. Their participants recommend that informatics training be incorporated into the curriculum, and that a dedicated course be conducted for informatics. They further recommend that informatics training be extended to all healthcare personnel in clinical facilities; in order to improve the quality of care and reduce resistance that might arise through a gap in IT education between younger and older generations. In their analysis on the state of Nursing Informatics in South Africa, Harerimana *et al.* (2021) note that the focus of informatics education in nursing programmes in lower and middle-income countries, such as South Africa, were still in the initial stages with computer literacy being the focus. This was verified by Chipps *et al.* (2022) and later by Le Roux *et al.* (2024). The reason for this

Lekalakala-Mokgele *et al.* (2023) attribute to the lack of digital skills by first-entry students who were previously disadvantaged or poorly prepared in high schools, and digital emigrants who are from the older generation of nurses. They also recommend that research is needed to investigate and offer recommendations for the development of a nursing education curriculum that will improve digital literacy. Le Roux *et al.* (2024) concur with this indicating that nursing informatics be incorporated into the training and job requirements of nurses through short courses and in-service training.

2.8.1.6 Health Informatician Role

The identification and development of the competencies for health informatics are difficult because, even though the overlap between health sciences and informatics limits the competencies from the different fields, these still need to be focused and specific. There seems to be a gap between the digital capabilities of health practitioners and digital health technology-enabled delivery of healthcare services (Morris *et al.* 2023). It is also known that technology-oriented people may have limited understanding of healthcare practices (Mantas and Hasman, 2017). Likewise, health practitioners may have limited understanding of the role of digital health technologies that could benefit their practices. The engagements between health and informatics practitioners may therefore not be optimal (Mantas and Hasman, 2017, Martikainen et al, 2020). To resolve this, Mantas and Hasman (2017) suggest two health informatician roles to act as an intermediary between health and informatics practitioners, namely the health practitioner with additional health informatics knowledge and skills and the health informatics specialist who has specialised on some health informatics aspect. The one role is a health practitioner with additional obtained informatics competencies relevant to their health practices (specialised healthcare practitioner). This brings to the fore the need for nursing and health informatics competencies for four roles of practitioners: the nurse; the nursing informatics practitioner; the informatics practitioner and the health informatics practitioner. They further propose four domain areas for health informatics competencies, biomedical and health informatics; medicine, health and biosciences, health organisation, and nursing; informatics/computer sciences, mathematics, biometry, digital communication, etc.; optional modules from related fields. Education is an important enabler towards changes in society, science, and professional development.

The concept of health informatician refers to the intermediary role of a health informatics practitioner with competencies in both health and digital technologies. Health informatician and health informaticist are used interchangeably and Bain *et al.* (2024) concur that the related literature use both with the same meaning even though the “-ician” and “-ist” part of the word has different origins. Having this intermediary role to translate the needs of health practitioners to the informatics practitioner can benefit the development and use of digital technologies.

Health informaticians work in different healthcare settings in various roles and with different experiences that require unique abilities (Gadd *et al.* 2022). The different health informatician roles are beginner or user with relatively low digital health competencies; generalist with no specific health informatics background and intermediate health digital competencies, and specialist with health informatics including specialisation of some health informatics aspect with high digital health competencies (Jarva, 2024; Mannevaara *et al.*, 2024; Saranto and Kinnunen, 2022). It is important to consider the roles in the different qualification levels (Bichel-Findlay *et al.*, 2023). They recommend that for the user/beginner role it aligns to an undergraduate study in biomedical health informatics (BMHI) and Holden *et al.* (2018) suggest that the inclusion of a health informatician in inter-professional teams in healthcare services may contribute to addressing challenges experienced in healthcare services. An inter-professional team includes professionals from diverse health domains who use their expertise to holistically solve complex healthcare problems. Holden *et al.* (2018) suggest best practices for capitalising on the health informatician's knowledge, skills and tools to contribute to inter-professional teams' work in healthcare. These best practices focus on characteristics of effective teams; practice leadership and followship during well-designed team meetings; communicate using suitable tools, articulate and develop health informatics knowledge and skills as educational support and professional collaboration. Although Tang *et al.* (2023) refer to the informatician role within interprofessional teams with health practitioners and library informationists, they alert to the complex nature of health informatician's role within interprofessional professional teams that require an outward-facing mindset in complex settings. They suggest that a competent professional informatician has a combination of knowledge and skills informed by the attitudes and values needed for the interprofessional team practice.

2.9 Health Informatics Education

In this sub section health informatics education within a particular context is discussed. Firstly, the African context and the drivers for health informatics education is considered followed the South-African situation.

2.9.1 Health Informatics Education in Africa

Health Informatics is being adopted, adapted, and utilised by the lower and middle-income countries of the world simultaneously as the increasing growth in technologies and usage of the Internet provides unlimited possibilities for developing suitable healthcare systems. Undoubtedly benefits have been obtained from technology, offering service not only to the urban population but also to remote rural communities (Munene *et al.*, 2020). Several health institutions in various countries within Africa, recognise the benefits of upskilling practitioners with health informatics or nursing informatics competencies and have implemented health and nursing informatics formal and informal education and training courses (Braa and Sahay, 2017; Tilahun *et al.*,2014; Were *et al.*, 2020; Nyangena et al., 2022). However, the design and development of these courses are influenced by factors that are found within the context of lower and middle-income countries and require solutions that can be tailored to the features pertinent to such countries and contexts (Avgerou, 2008; Heeks, 2002; Ruhode *et al.*, 2013).

Informatics education within the health field initiatives in Africa has been noted in the literature as early as the 1960s when the first Health Information Systems were introduced in South Africa (Rienhoff *et al.*,1980). Like health ICT training evolution in developed countries, health informatics education began with training on the use of specific applications. Literature indicates the presence of the development of health informatics curricula within in the continent as emanating from praxis. One of the earliest forerunner influential articles was by Murray *et al.* (2009) in their inquiry on a health informatics masters online course. This has been a major reference point for the development of most course content for master's and doctoral-level courses (Achampong, 2017; Chastonay *et al.*, 2013; Wright *et al.*, 2015). At the post-doctoral level, health informatics initiatives have been research focus oriented in Institutions. However, there is a presence at undergraduate levels, health informatics courses, notably at institutions such as the University of South Africa (UNISA), the University of Gondor in Ghana, Debre Markos University in Ethiopia, which have developed course content, with prerequisites of having some basic computer literacy skills. Other initiatives have been collaborative with a North-South or a North-South-North program which involves the development of courses either at a modular undergraduate level or a short course certificate (Chastonay *et al.*, 2013; Ingelbeen *et al.*, 2013 ; Khalifa, 2014; Mars, 2010).

Activities of the development of these courses indicate a varied discipline focus. This is due to the specialisation skills intended for participants of the courses. Most master and doctorate courses have been developed within health departments and have an objective for health practitioners to provide them with essential Informatics skills to support, evaluate and make constructive judgments and recommendations on health information technology systems (Tilahun *et al.*, 2014; Wright *et al.*, 2015). The IMIA competency framework has been a key reference in most development and assessment initiatives in countries such as South Africa, Ethiopia, and Rwanda. Other frameworks considered, are the TIGER as reference competencies, and the AMIA competencies in Nigeria and Ethiopia. In courses, where practitioners from diverse specialties, for example, health, informatics, and business, different module paths are offered. Health courses on health information technology systems, terminology, and standards form part of the core content common for all practitioners in healthcare.

Murray *et al.* (2009), in their study, note that for a course to be relevant it must be adapted according to the students' needs. Most courses have been developed according to the needs of stakeholders within the health informatics field. Surveys, interviews, participatory methods as well as case studies have formed major activities to attain the expected outcomes for the courses. Although national objectives are considered, eHealth desired skills were explicit in the development of the master's course for the University of Gondor in Ethiopia therefore responding to student needs (Zeleke *et al.*, 2014). This forms part of the considerations that have influenced the development of health informatics courses within Africa.

2.9.2 Health Informatics Education Drivers in Africa

In the development of health informatics courses, there are factors that influence the shaping of the course focus and depth of content. In healthcare due to the sensitive nature of the field, the healthcare needs of the most vulnerable need to be considered to ensure that healthcare services reach all as stipulated in SDG 3. Activities of the WHO, on recommendations and strategies on eHealth and mHealth as well as country indicators, follow this culture of flow of information (Maina and Singh, 2020). African member states follow an eHealth Strategy where the contextual aspects of the country are considered. One of the key concerns in the strategies is the health informatics competencies of health practitioners to sustain the investment into eHealth (Department of Health Republic of South Africa, 2019; Department of Health Zimbabwe, 2017; Ministry of Health Ghana, 2009; Tanzania, 2019). The development of master's health informatics courses, Ethiopia followed the same process, but considering the country's national eHealth objectives (Tilahun *et al.*, 2014; Zeleke *et al.*, 2014). As course development requires funding, institutions are obliged to align their initiatives to the priorities of their funders as in the North-to-South and North-to-South-to-North initiatives. In the North-to-South collaboration, the north refers to the global north countries such as, for example, Europe, and Scandinavia, and the south refers to countries such as for example African countries. Since funding is limited to a specific period, program initiatives must align with the funding objectives. Early initiatives, for example, as part of the collaboration between the University of Western Cape and the University of Oslo to develop a master's programs in South Africa, Mozambique, and other Southern African development economic countries

(Braa and Muquinge, 2007; Murray *et al.*, 2009). This programme is based on the Health Information Systems Project (HISP) funded by Norway where a HIS relevant to the African context was developed and implemented. Another example of a North-South-South collaboration is the Informatics Development for Health in Africa (INDEHELA) network projects funded by different funding entities in Finland from the eighties until 2015 for research, capacity development, (courses and researchers), and exchange opportunities (Hisa et al.,, 2019). The countries that benefitted from these initiatives are Nigeria, South Africa and Mozambique. In another north-to-south courseware development, such as the AFRICA Build Project which ended in 2014, one of their aims was to develop online eLearning courses. These were implemented in Mali and Cameroon that led to the establishment of a health informatics course at the University of Yaounde in Cameroon (Bello *et al.*, 2013). Funding has not been limited to funders from the North. At the National level, funding for projects is availed as in the case of the development of the health informatics courses in the Eastern Cape, South Africa where the Department of Health in the Eastern Cape collaborated for the formation of the master's program (Murray *et al.*, 2009). As Tilahun *et al.* (2014); Mars (2010) and (de la Harpe *et al.* (2013), state, the development of courses provides a reference which other organizations may use as they collaborate with international stakeholders in curriculum design in health informatics education (Holden *et al.* ,2018; Thate and Brookshire, 2022). The success of the development of these interdisciplinary programs, artefacts and courses relied on the collaborative efforts of different stakeholders with different expertise (Issa-Salwe *et al.*, 2024; Samarah *et al.*, 2024).

Programs designed to meet national objectives such as the master's program in Rwanda by Wright *et al.* (2015), require international IMIA reviewers to guide the course alignment and content. Alignment with an international organisational framework, provides a means for accreditation of the course. In addition, collaboration including national objectives, provides potential input into the development of national standards and policies of the respective countries. These are also driven by the national and regional departments of the countries whose focus contributes towards national and regional programs in health informatics (Nyangena et al.,2022; Were *et al.*, 2020).

Socioeconomic and socio-technical factors have played an important role in influencing the design of courses in education. The political stability of a nation determines its development, for example in South Sudan (South Sudan Ministry of Health, 2015) the health system collapsed during the war (Garrib *et al.*, 2008). Other factors include the health needs of the people; having common language semantics for standards and identifiers; and the availability of job opportunities for the courses that are being developed (Department of Health Zimbabwe, 2017).

2.9.3 Health Informatics Education in South Africa

The earliest literature of health informatics education in South Africa was written in 1980, by Rienhoff *et al,* (1980) where a North-South relationship compared the development of the field between Germany and South Africa. Additional development of health informatics courses are within Universities in South Africa; the study by Murray *et al.* (2009) on the development of courses at the University of KwaZulu Natal (UKZN) and Walter Sisulu University (WSU). The latter studies considered the implementation of a Health Informatics degree in the Eastern Cape. Several articles involving telehealth education by Mars (2010, 2014), and eHealth (Mars, 2012) were then published. A later study by Ovwasa (2021) on the nursing informatics courses that are being offered in the different universities in South Africa, these included some health informatics courses and are indicated as shown in Table 2-5.

Table 2-7: Nursing Informatics Courses Offered in Universities in South Africa (Ovwasa, 2021)

Accredited University	Module name	NI Course component	Year/ Semester of Study
University of Stellenbosch	Praxis of Nursing and Midwifery Sciences taught under Essentials of Human Anatomy 171	Information and communication technology	1
Cape Peninsula University of Technology	Academic Literacy	Information literacy; Using and applying of information technology in theory and clinical practice	1 Sem. 1
University of Western Cape	Computer Literacy	Introduction to Windows; Microsoft Word; Microsoft PowerPoint; Microsoft Excel; Internet and GroupWise; e-Tools	1 Sems.1 and 2

Accredited University	Module name	NI Course component	Year/ Semester of Study
Nelson Mandela University	Computer Literacy	Not available	1 Sems.1 and 2
Tshwane University of Technology	Computer Literacy (1) Academic Literacy (2) **Health Information Management II (3) (prerequisite is Computer literacy) Health Information Management III (4) Health Information Management IV (5)	(1-2) Introduction of information literacy. Development of a search strategy and application of a search string to search engines and academic databases. Evaluation of information sources. Ethical and legal use of information. (3-4) This module introduces the student to basic principles of Health Information Management. Upon completion of this module, the student will be able to understand, apply, analyse and audit records, documents and processes as integral part of health information management. The student is also introduced to the eHealth strategy of South Africa, information sharing and collaboration	1. Sem.1 2. Sem. 2 3. Sem. 1 4. Sem. 2
University of Pretoria	***Academic Information Management	Not available	1 – Semester. 1 & 2
University of Limpopo Turfloop Campus	Health Care Systems		A year module under the postgraduate diploma in primary health care
University of KwaZulu-Nata	***Evaluation of Health Systems	Not available	3- Sem. 2

2.10 Conceptual Framework

According to Miles and Huberman, (1994), a conceptual framework explains, either graphically or in the narrative form the key factors or concepts, constructs or variables and presumed relationships between them. The elements of a conceptual framework should relate to each other exhibiting coherence, contributing to the main argument. The proposed conceptual framework is based on the findings derived from the literature review based on the current status of the concepts relevant to this study. A conceptual framework provides the basis for a researcher to conduct a scholarly study contributing to the body of knowledge based on an identified research gap (Trafford and Lesham, 2007). They further refer to the conceptual thinking of the research by identifying relevant concepts from the reviewed literature. Whereas a theoretical framework is derived from existing theory, a conceptual framework represents the researcher's understanding of the research, its concepts, and the relationships between the concepts (Grant and Osanloo, 2014). The conceptual framework also considers the focus and delineation of the study.

The context of nursing and informatics education can be categorised into two sections the education and the practice sections, as illustrated in the next figure (Figure 2-12). In this study, the education section is delimited to the micro and the nano education. The micro curricula include the nursing educators and the informatics educators, as they develop the competencies which they impart to the students. The nano curricula include the individuals who will be taking the courses, the nurse student practitioners as well as the IT practitioner.

In the practice section, the nurse practitioner, who should have nursing informatics competencies, is expected to make better use of health information systems and technologies as they practise their nursing at their workplace. The process of conducting the work practice is better enabled by using digital health technologies. The development of more digital skills and knowledge about digital technologies, enable nurse student practitioners to become more proficient in their work practices. This proficiency enables nurses to become more involved in the collaborative design, development, and implementation of health information systems and technologies, together with informatics practitioners.

The converse is also true for the informatics practitioners, as they gain domain informatics competencies within the domain of healthcare, they are better equipped to develop more resilient health information systems and technologies. They can better perceive the work practices of the nurse student practitioner and become more involved in the collaborative work with nurse student practitioners to gain an understanding of the needs and challenges experienced by nurses. This supports the aim of the study to gain an understanding of the required competencies to support the collaboration between nurses and ICT practitioners around context-sensitive needs-based digital development and support of nurses' use of these digital technologies in practice. All of these activities occur in this study in the African context.

This was described earlier as a unique setting as noted in the eHealth Strategies of the African countries.

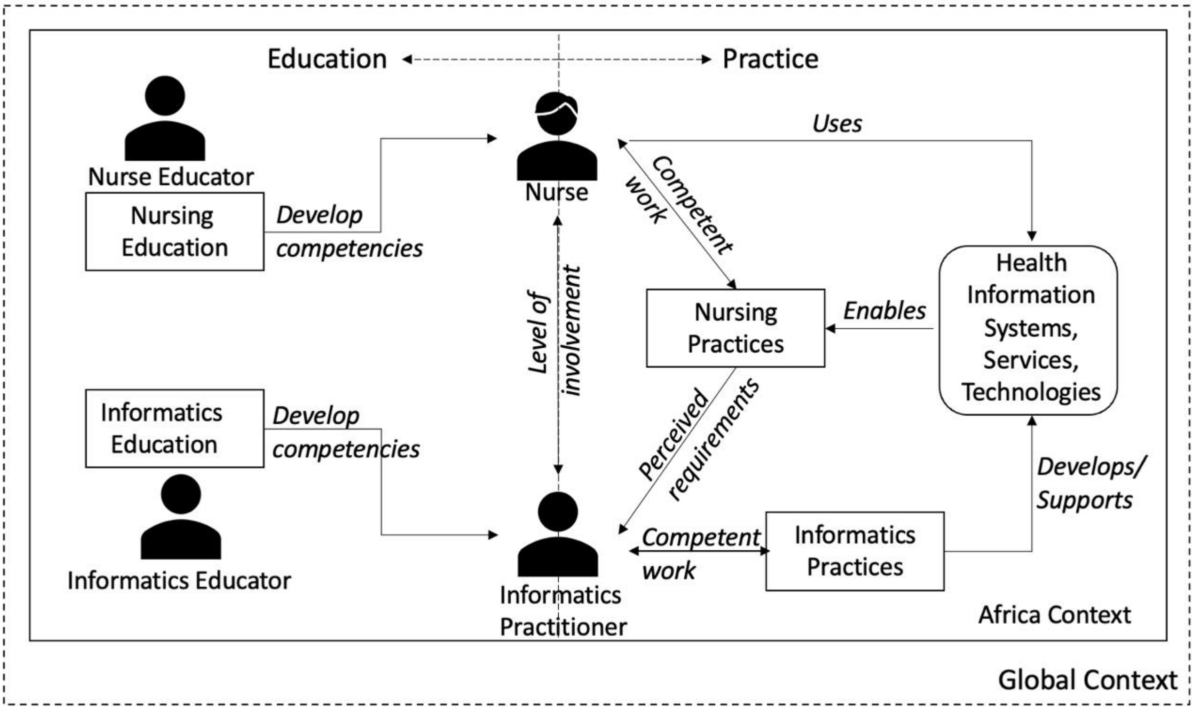

Figure 2-12: Proposed conceptual framework to guide this study based on the literature review.

2.11 Chapter Conclusion

In this chapter, an exploration of the structure of nursing and health informatics was conducted. This involved delving into the contextual paradigms of the three disciplines, health, informatics, and education sciences that are foundational to nursing and health Informatics. The related literature was reviewed to establish the current status of competencies within each field and based on that to identify the research gap to formulate the research problem to be addressed. This led to the positioning of the study as an inter-disciplinary inquiry. An exploration of the characteristics of the disciplines was conducted, and health and Nursing Informatics competency characteristics were noted.

Competencies were viewed in the international arena, with a special focus on the IMIA, TIGER, and HIT Comp frameworks. Consideration of these competencies was done through an understanding anchored in the African and South African contexts. Considerations of these pivotal disciplines, with special reference to the health and nursing Informatics development in African and South African context, led to the development of the initial conceptual framework which is used to guide this inquiry. Chapter Three will look at the research strategy and the philosophical Influences that determine the epistemology and axiology of the study and inform the conceptual framework.

CHAPTER 3 RESEARCH DESIGN AND PHILOSOPHICAL INFLUENCES

3.1 Introduction

In this Chapter the research philosophical Influences that directed the selection of the theoretical framework and research design are considered. The research paradigm forms the nature of "beliefs" as viewed by the researcher on the world and the role that the researcher takes within that world (Guba and Lincoln, 2000). The research paradigm, and its influence on the research ontology, epistemology, axiology and methodology are considered. The structure of the discussion starts with the research paradigm and philosophy, followed by Pragmatism and mixed methods selected for this study. Next, the research approach and design, followed by the delineation and context of the study are discussed. The ethical considerations discussion is followed by the data collection for the three perspectives of the study is discussed followed by the data analysis. The chapter is concluded with the proposed quality evaluation.

3.2 Research Paradigm and Philosophy

A paradigm is a theoretical framework made up of a set of basic beliefs that guide the research and influence the way knowledge is investigated and understood within a discipline. The term 'paradigm' considers the related assumptions, concepts, or propositions that orient thinking and research for a study (Saunders et al., 2015). The choice of paradigm is influenced by its ontology, epistemology, axiology, and methodology. These characteristics differentiate the different paradigms of choice within research.

Traditionally there are two leading thoughts of a research paradigm, namely it being quantitative or qualitative. The two dichotomies can be presented as a continuum with the research paradigm characteristics, that according to Saunders et al (2015) are being classified as on opposing ends. The quantitative paradigm has been associated with positivism while qualitative has been associated with interpretivism (Muhaise *et al.*, 2020). This has led to them adopting the paradigm characteristics of the two research philosophies. Quantitative inquiries have the characteristics of being confirmatory, generalisable and objective in nature, while qualitative inquiries are exploratory, descriptive, and subjective. Although positivism has been prominent on social science research, critics have censured it for its lack of robustness in conducting research as it ignores the fact that in the process of conducting research with subjective data may also be collected to reflect on human decisions and sense-making processes (Weber, 2004) . The interpretive paradigm posits that the world needs to be understood in relation to the subjective understanding of human experiences and behaviour and not be observed as an objective reality. Positivists and interpretivists have been criticized for their extreme position on research design. In an effort to deal with paradigm weaknesses linked by the two paradigm traditionalists, there has been a push for a pragmatic philosophical perspective as the middle ground between these two purists (Allemang *et al.*, 2022). The characteristics of the three paradigms are indicated in Table 3-1.

Table 3-1: Positivism, interpretivism, and pragmatism paradigm characteristics, (Adapted from Saunders et al., 2015:136-137)

	Positivism	**Interpretivism**	**Pragmatism**
Ontology	• Real, external, independent • Objective reality • Granular • Emperialistic	• Complex, • Rich Socially constructed • Multiple meanings, • interpretations, and realities	• Complex, rich external “Reality” is the practical consequences of ideas • Flux of processes, experiences and practices
Epistemology	• Scientific method • Observable and measurable facts • Law-like generalisations • Numbers, • Causal Explanation and prediction as contribution	• Theories and concepts too simplistic. • Focus on narratives, stories, perceptions and interpretations • New understandings and worldviews as contribution	• Practical meaning of knowledge in specific contexts. • “True” theories and knowledge are those that enable successful action . • Focus on problems, practices and relevance. • Problem solving and informed future practice as contribution.
Axiology	• Value-free research • Researcher is detached, neutral and independent of what is researched • Researcher maintains an objective stance	• Value-bound • Research. • Researchers are part of what is researched, subjective • Researcher interpretations key to contribution • Researcher • Reflexive	• Value-driven research • Research initiated and sustained by researchers doubts and beliefs. • Researcher reflexive

	Positivism	Interpretivism	Pragmatism
Methodology	• Typically deductive, • Highly structured, • Large samples, measurement, typically quantitative methods of analysis, but a range of data can be analysed	• Typically, inductive. • Small samples, in-depth investigations, • Qualitative methods of analysis, but a range of data can be interpreted	• Range of methods • Emphasis on practical solutions and outcomes

3.3 The Pragmatism Paradigm

The origins of pragmatism date back to the 1870's when theorists were questioning the practical use of a singular research design and methodology. Founding theorists Charles Sanders Peirce aimed to connect thought and action (Peirce, 1878). Thought produced beliefs, which Peirce defined as entities on which one is prepared to act and not just as a state of mind. It was further developed by the 19th- and 20th-century classical pragmatists William James (1907) and John Dewey (Levine, 1996). Dewey defines action as conducting experiments under controlled situations and thought as those theories guiding experiments.

Pragmatism's tenants lie in the ontology that research is not committed to one system of philosophy and reality (Creswell, 2009). It comprises a complex rich external 'reality' with practical outcomes of ideas, and a flux of processes, experiences, and practices. The essence of a pragmatist ontology is actions and change; humans act in a world that is in a constant state of becoming (Goldkuhl, 2012). Pragmatism according to Dewey (in Kelly and Cordeiro, 2020) lays beyond the human psychological perspective but it emphasises the aspect of shared human experiences. These experiences Dewey posits combined with interpreting belief and reflexive knowledge of experiences often lead to action, and reflection on the action leads to new knowledge and actions (Kelly and Cordeiro, 2020). Action cannot be separated from knowledge and is ever-evolving. For pragmatists, the only true ontology is the one which is most useful for achieving the goals of the study. This can be a useful way of thinking when applied to practical problems, but it can also lead to a form of relativism where anything can be considered true if it is useful to us.

Pragmatists' epistemology believes in obtaining the practical outcomes of knowledge in particular contexts. It advocates that 'true' theories and knowledge are those that enable successful action, with a focus on problem-solving and informed future practice as contributions (Mackenzie and Knipe, 2006). Pragmatism is an epistemological position that holds that knowledge is not passive but is instead actively constructed by humans in their engagement with the world. This means that knowledge is not simply a matter of representing reality but is instead a tool that we use to interact with the world. This position has important implications for education, as it suggests that learning is not simply a matter of acquiring information but is instead a process of actively constructing knowledge (Kaushik and Walsh, 2019; Kelly and Corderio,2020).

Pragmatism methodologies provide a platform for working with multiple methods, different worldviews, and different assumptions. as well as different forms of data collection and analysis (Frey, 2018). To overcome research strategies biases, researchers conceptualised methods that may include triangulation (Jick, 1979); mixed methods and other transformative methods (Creswell, 2009; Tashakkori and Teddllie1998). Pragmatism brought to the fore axioms that allowed researchers to conduct research that would maximise the use of the advantages of both quantitative and qualitative research designs, while the weaknesses that each can be overcome by the other.

Pragmatism comprises a philosophical tradition that emphasises the practical applications of ideas and theories (Kelly and Cordeiro, 2020) . In other words, pragmatists believe that the best way to assess the value of an idea is to see how well it works in practice. In research pragmatism emphasises that inquiry involves decisions about which goals are most meaningful and which methods are most suitable (Weaver, 2018) . Dewey was especially interested in the concept of *inquiry* as a form of experience that helps to resolve uncertainty (Morgan, 2017). Inquiry, therefore, becomes a conscious response to situations where, how one should act, is not immediately clear. Morgan (2017) challenges researchers when faced with such situations, to ask the question: what difference would it make to act in one way rather than another? The only way to answer this question is by following the likely consequences of different lines of action and finally decide on a way of acting that is likely to resolve the original uncertainty in the situation.

3.3.1 Pragmatism in Research Contexts

There are several studies in which pragmatism has been used. In organisational research, Kelly and Cordeiro (2020) in a doctoral study explored employees' activities within their organisation. In their study, they noted that pragmatism provides a guiding framework anchored in practicality. They then derived three principles of pragmatism: (1) an emphasis on actionable knowledge, (2) recognition of the interconnectedness between experience, knowing and acting, and (3) a view of inquiry as an experiential process. In information systems research, Goldkuhl (2008) and Da Silva *et al.* (2018) recommend the use of pragmatism as a research paradigm in information systems studies. They note three characteristics of pragmatism that make it suitable for information systems research: (1) pragmatism is a middle ground between the positivist and interpretivist paradigms, so the researcher is not bound to one of the extremes; (2) pragmatism connects knowledge to action since information systems (IS) is a practice-oriented field where the connection between knowledge and action is pertinent in IS research; (3) pragmatism makes use of both the qualitative and quantitative characteristics, making it appropriate for a mixed methods studies. This aids the IS researcher to select the best methodological approach in their studies.

Goldkuhl, (2008) identifies three different types of pragmatism, namely functional, referential and methodological. His study is based on the central pragmatic theme of knowledge and action. He identifies three relationships between knowledge and action, namely: knowledge for action; knowledge about action and knowledge through action. These three relationships are classified as functional pragmatism, referential pragmatism and methodological pragmatism respectively. Functional pragmatism is based on the perspective that the world is in a state of becoming, "*therefore knowledge should be useful for action and change*" (Goldkuhl, 2008:2) where it is concerned with how pragmatism can be useful in the world. Functional pragmatism looks at how knowledge and action can be used to facilitate knowledge transfer and knowledge use within local practice (Goldkuhl, 2012). Within local practices the researcher's role in pragmatism is: (1) that it is meaningful as local improvement; and (2) it is instrumental in creating knowledge that may be useful for local as well as general practices (Goldkuhl, 2012: 9). Referential pragmatism is concerned with describing the world using theories and in action-oriented ways (Goldkuhl, 2008). This allows actors, actions, action-objects, activities and practices to become the primary studied objects (knowledge *about* actions) (Goldkuhl, 2012). Referential pragmatism is concerned with how action-oriented theories are used in research. There are many action-oriented theories one can consider, for example, Gibbs saturation theory and Engestrom's activity theory amongst others. Methodological pragmatism is concerned with how knowledge is constructed (Goldkuhl, 2008). It emphasises the active role of the researcher in collecting data and using theories (Goldkuhl, 2012). Pragmatism is pluralistic in how it treats methodologies in research, it is not dogmatic in nature. Methodological pragmatism uses the methods and method combinations that work according to the research purpose and current empirical situation. These three types of pragmatism determine the type of IS research conducted within a pragmatic paradigm. In medical informatics research, Scott and Briggs (2009) discuss why pragmatism is suitable for research of this nature. They note that pragmatism looks at the practical actionable aspects of research, and medical informatics being a practical discipline in both the medical and the informatics disciplines, makes it a suitable research philosophy for the discipline (Voorheis *et al.*, 2023).

3.3.2 Pragmatism Alignment to the Study

In this study pragmatism is used as the framework that guides the philosophy of study and the methodology used in the study. The pragmatist characteristics of the connectivity of knowledge and action is in alignment with the philosophy of this study as the disciplines Nursing Informatics Education (NIE) and Health Informatics Education (HIE) including their sub disciplines of nursing, health, informatics, and education to solve practical problems within their contexts (Kaushik and Walsh, 2019; Voorheis et al, 2023). In solving these problems this study is not aligned to one form of paradigm but seeks to make use of the strengths found in both the quantitative and qualitative paradigms. In conducting the study, the interpreting beliefs and reflexive knowledge of the participants is of importance as these inform the attitudes and competencies that nursing and informatics practitioners should have aligned with nursing and health informatics outcomes. The study adopts a functional pragmatism paradigm, as it explores the creation of knowledge in nursing and health informatics for the nurse and informatics practitioners. In addition to looking at the creation of knowledge at the individual level, the study also considers the knowledge creation of the methodology within the context of practise.

3.4 Interdisciplinary Research Paradigm

As new knowledge occurs, it influences the evolution of practice in advertently affecting the nature of knowledge within disciplines. There is an increasing need to forge bridges between disciplines, as research attempts to solve complex problems and situations (McGregor, 2004). This has led to the rise of new disciplines whose nature comprises of paradigms from two or more disciplines. In Education, both teaching and learning are centred around the particular discipline's knowledge, as this provides the guidelines to theoretical and practical content (Effken, 2003). In delineating disciplines, Nicolescu (1999), identifies four types of discipline classifications for research inquiry, mono-disciplinary, multi-disciplinary, inter-disciplinary and trans-disciplinary. Each of these classifications, have differing worldviews of approaching research. Mono-disciplinary research comprises of inquiry done within one discipline. Research that involves more than one discipline is classified as either multidisciplinary, inter-disciplinary or trans-disciplinary. These terms address the use of two or more fields in different ways, which are described as follows:

- Multidisciplinary studies are described as involving parallel research of researchers in collaboration with backgrounds from different specialities, resulting in each researcher having an objective of advancing their own discipline research (Cronin, 2016). According to Choi and Pak (2006), multidisciplinary inquiry draws from knowledge from other disciplines, yet conceptualises and functions within its own disciplines, theories, tools, and concepts.
- Interdisciplinary studies involve collaboration of experts from different disciplines, connecting common characteristics with the objective of forming a complete outcome. Choi and Pak (2006:1) define it as "*Interdisciplinary analyses, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole*". Instead of compiling information separately, connections between the data are made.
- Transdisciplinary approaches are an extension of the interdisciplinary approach. They include influences from a greater variety of disciplines as well as acknowledging that practice-based knowledge is also important in addition to scientific knowledge (Hoffman *et al.*, 2019; Mitchell et al, 2015). In transdisciplinary research relevant stakeholders, representing the interest of societal groups influenced by the research, are actively involved in setting the research agenda and also contribute towards both scientific and practice-based new knowledge creation. These may be from the "*natural, social and health sciences in a humanities context*" (Choi and Pak, 2006:1). Transdisciplinary studies "*transcend boundaries*" to unpack theories, tools, methodologies, and concepts within diverse disciplines, in the creation of new epistemologies or disciplines (Cronin and Science Leader, 2008). A transdisciplinary approach, according to (Pohl and Hadorn, 2008), is a form of research that is driven by the need to solve societal problems. They further state that the aim of such an approach would be to "*contribute knowledge and practices that promote what is perceived to be the common good*". Since transdisciplinary projects deal with complex problems influenced by societal factors, it typically has more than one stakeholder representing the difference aspects of the realm of science, the realm of practice, and the overlap that represents the hybrid space of knowledge (both scientific and in-practice (Hoffman *et al.*, 2019). In transdisciplinary research societal actors are included to benefit from their in-practice knowledge in addition to scientific knowledge to result in three outcome spaces, situation, knowledge, and collaborative learning (Mitchell *et al.*, 2015) that represent knowledge co-production (Nordstrom *et al.*, 2022). Such projects may be more suitable for collaborative research, including researchers from different disciplines in addition of including non-academics in the research team. It may, therefore, have a scope that transcends in typical scope of a single PhD study.

In this study, the nexus of the health, with the case of nursing; informatics; and education disciplines have sub-fields relevant to this inquiry, illustrated in Figure 3-1, that contribute towards the context of the research. A pragmatic research paradigm was selected for this study as suitable to achieve the expected outcomes. This was due to the inquiry involving more than one discipline, health and clinical sciences, informatics, and education science. Each of the paradigms of the disciplines were considered, both scientifically as part of education as well as applied competencies needed in practice.

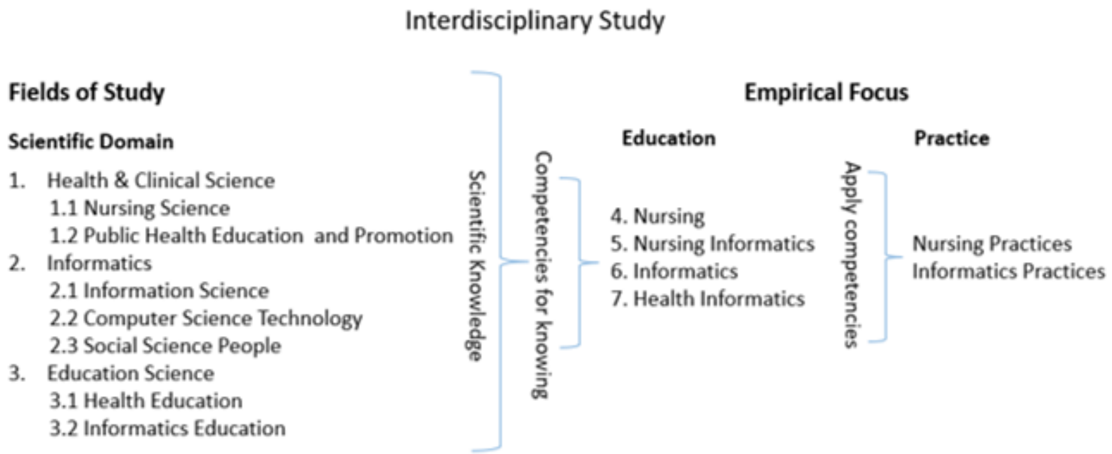

Figure 3-1: Fields of Inquiry

3.5 Pragmatism and Mixed Methods

As positivism and interpretivism are associated with quantitative and qualitative inquiry respectively (Muhaise *et al.*, 2020), pragmatism is associated with mixed methods (Tashakkori and Teddlie, 2003). Pragmatism, according to Tashakkori and Teddlie, (2003) provides the appropriate epistemology for mixed methods. For pragmatism, everyone is subject to their own interpretation of the real world that exists. Therefore, pragmatism adopts both the subjective nature and objective nature of qualitative and quantitative inquiry (Caetano *et al.*, 2018). Additionally, pragmatism is pluralistic in nature working with multiple methods, different worldviews, and different assumptions, as well as with different forms of data collection and analysis (Scott and Briggs, 2009). This is in alignment with mixed methodology as it does not subscribe to one form of methodology or worldview (Creswell, 2016). Mixed methods are described by Scott (Ammenwerth and Rigby, 2016:102) as " *the use of whatever methodological tools are required to answer the research questions under study*". In the process of selecting methods to mix, the research questions guide the researcher in deciding which characteristics would be suitable for the study. Thus, mixed methods take on the characteristics of pragmatism in that any methodological approach to research can apply as long as it answers the research questions (Leavy, 2017). Fàbregues *et al.*, (2021) argue in their criticism of mixed methods that the contribution that pragmatism makes to the epistemology of mixed methods is undervalued. In their study, they derived eleven criticisms categorised into four domains: the essence of mixed methods, philosophy, procedures, and politics, indicated in the next table. As this study makes use of mixed methods for its methodology these criticisms will be considered Table 3-2.

Table 3-2: Types of criticisms of mixed methods. (Fàbregues et al., 2021:21)

Domains	Criticism
Essence of mixed methods	1. The accepted definition of mixed methods research only considers the mixing of quantitative and qualitative methods. 2. The terminology used in mixed methods reflects a lack of agreement among its proponents. 3. Mixed methods research is not a new type of methods practise
Politics	1. Mixed methods research is not a third paradigm. 2. Current discussions of mixed methods research conceive quantitative and qualitative research as separate paradigms. 3. Superficiality of pragmatism 4. Mixed methods research aligns with positivism
Procedures	1. Limitations of typologies 2. Procedures described in the literature are not aligned with mixed methods practice
Politics	1. Mixed methods research is not better than monomethod research. 2. Homogenization of mixed methods research.

3.5.1 Mixed Methods

In this inquiry, mixed methods approach was implemented as the research methodology design. Creswell (2021) in his book on mixed methods, identifies design approaches that may be used. These approaches are classified into three categories of mixed method designs, the convergence design, the explanatory-sequential design and the exploratory-sequential design (Creswell, 2021). In the convergence design, also known as concurrent or parallel strategy, quantitative and qualitative results are collected at the same time and compared to validate the findings by triangulation and provide a holistic view of the findings. The exploratory-sequential design is sequential is implementation and is used in developmental research studies, where the researcher explores the context of the study by initially using qualitative methods and sequentially expands on this by implementing quantitative strategies. The third design, the explanatory-sequential design also implements a sequential strategy, where quantitative methods are implemented first and then qualitative strategies are implemented to provide foundational context for developing a quantitative instrument or intervention. Three main factors should be carefully considered while choosing a mixed method research design, these are outlined by Dawadi *et al.* (2021) as: (1) The priority of the quantitative and qualitative approaches; (2) The extent to which the quantitative and qualitative findings are collected, analysed, integrated and interpreted; and (3) The timing of the approaches, if they are occurring concurrently or sequentially.

3.5.2 Mixed Method Research Design

In this study the convergence design strategy was used to obtain answers to the research questions. This was in alignment with the research purpose for triangulation; seeking convergence of findings; complementarity; or examining different overlapping aspects of nursing informatics education and health informatics education; expansion, adding breath and scope to a study. The degree to which the researcher presents both the emic and etic perspectives (Onwuegbuzie and Johnson, 2006:58), balance was obtained through peer-review by the study supervisors.

Creswell and Pioano Clark, (2007), note that although there are challenges in implementing mixed method design with samples where different individuals are involved in the quantitative and qualitative strategies, this is not foreign to research. It is however dependant on the research question, the criteria of the participants and the outcomes from each sampling scheme and also validates one data set outcomes with another (Creswell and Clark, 2018); (Dawadi *et al.* 2021). This also forms a type of triangulation of the results from the research. Leech and Onwuegbuzie, (2009), provide an example of this while a study by Senne and Riekard (2009) collected data from both students and teachers to obtain a holistic outcome on the perspectives of both teachers and students.

In this study different inclusion criteria were used, for the nursing informatics education, samples from both nursing post basic practitioner students and nursing educators were taken and in the health informatics education samples from informatics educators and health informatics practitioners or Experts with an Informatics background were obtained. This provided an exhaustive and valid description of the attitudes, competencies and program design recommendations outcomes. The researcher took care not to make inferences from the quantitative data that was not confirmed in the qualitative data.

3.5.3 Mixed Method Data Integration

To make sense of the outcomes of the study, it is key to identify the method of integration of the data in mixed methods. Fetters *et al.*, (2013) in their study on integrating mixed methods, state that integration may occur at three levels of a study: The design level, the methods level and the interpretation and reporting level. Integration at the study design level occurs through three basic mixed method designs, which have been discussed prior, the exploratory sequential, the explanatory sequential, and the convergent designs. Integration at the methods level occurs through four approaches: By connecting, the data through sampling; by building, where the data informs the data collection approach of the other; by merging, where two data samples are brought together for analysis; by embedding, where the data collection and analysis link at multiple points. Integration at the interpretation and reporting level occurs through narrative where the study describes both the qualitative and quantitative outcomes in a single or series of reports; data transformation which happens in two steps. First, one type of data must be converted into the other type of data (i.e., qualitative into quantitative or quantitative into qualitative). Second, the transformed data are then integrated with the data that have not been transformed; and joint display, where researchers integrate the data by bringing the data together through a visual means to draw out new insights beyond the information gained from the separate quantitative and qualitative results (Moseholm and Fetters, 2017).

In this study the integration occurs at the design level, a convergence design is undertaken. In convergence design qualitative and quantitative data collection occurs at the same time and analysis for integration begins well after the data collection process (Moseholm and Fetters, 2017). The two forms of data are analysed separately and then the outcomes from both analyses are merged. On the methods level, the strategy used is merging, where two or more data samples are brought together for analysis (Testa *et al.*, 2011). In the interpretating and reporting of the integration a narrative approach is used (Fetters *et al.*, 2013) The narrative approach has three types of methods: the weaving approach involves writing both qualitative and quantitative findings together on a theme-by-theme or concept-by-concept basis. The contiguous approach to integration involves the presentation of findings within a single report, but the qualitative and quantitative findings are reported in different sections. The staged approach to integration often occurs in multistage mixed methods studies when the results of each step are reported in stages as the data are analysed and published separately (Moseholm and Fetters, 2017). In this study the contiguous approach was adopted to integrate the findings into a single report, with qualitative and quantitative findings being reported in different sections. Four target groups were approached to provide the data for the three perspectives of nurses; educators (nurse and informatics); and experts (health informatics). The study can be regarded as a nixed method study with small quantitative (quant) for the nurses' perspectives and big qualitative (QUAL) for the educators' and experts' perspectives. This formed the data collection samples.

3.6 Research Approach

The core aim of research is the generation of knowledge in a particular context. In fields where research is conducted within social contexts, it is important for the researcher to understand how people relate to their context and reality in which they generate knowledge.(Johnson and Christensen, 2014). In understanding this, the research design method of reasoning throughout the research process enables the researcher to build or test theory. Saunders *et al.* (2007), identifies three types of reasoning processes that can be used by a researcher, namely inductive, deductive and abductive reasoning. Deductive reasoning occurs when a conclusion can be logically derived from a premise from mental modes or a broad range of theories (Neville, 2007). For deductive reasoning to apply, the conditions and context of conclusion should be similar to that of the theory. This makes it a reasoning process that is suitable for use in quantitative studies. Inductive reasoning infers a premise, based on the mental modes and outcomes of a similar theory. Inductive reasoning refers to a particular premise in a certain state and extrapolates it onto the research condition, expecting similar outcomes, which makes it suitable for use in qualitative studies. Abductive reasoning is a process where the researcher moves between inductive and deductive reasoning as the research evolves (Morgan, 2007; Soiferman, 2010; Yu, 2006).

In this study deductive and inductive reasoning is employed separately as both quantitative and qualitative data is obtained in the study, this aligns with the ontology and epistemology of pragmatic paradigm (O'Reilly, 2016; Svennevig, 2001). Its application to the research process is illustrated in the Research Methodology and Choice process.

3.7 Research Design

In this section the research design is discussed to indicate how the research components are integrated to guide the research process. The research questions are aligned to the research problem; methods used; concepts relevant to the study; and research validity as delineated within a specific context. The elements of the research design are outlined as illustrated in the next figure (Figure 3-2).

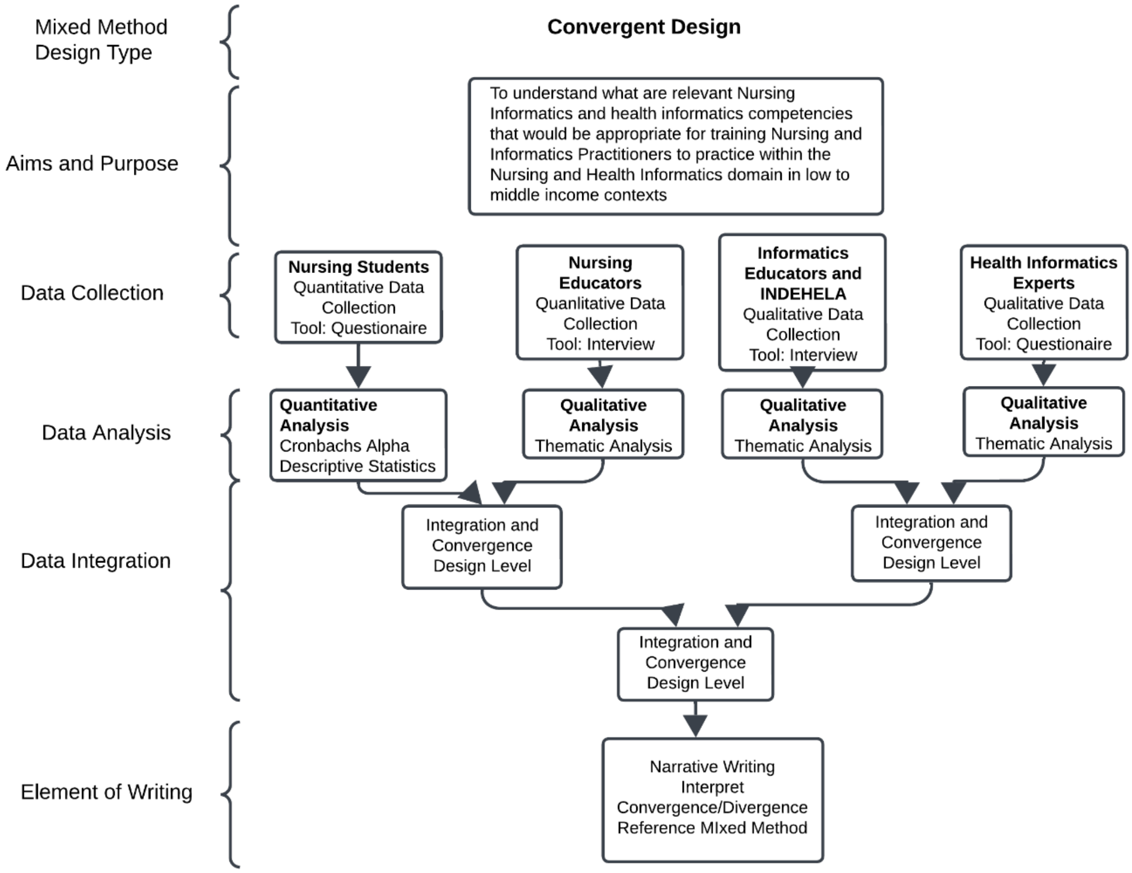

Figure 3-2: Research Design adapted from (Harrison et al., 2020)

In this study the literature review was used to establish the problem identification as the research gap and to understand the health and nursing informatics context globally, in Africa and South Africa. Once this was established, the Kaminsky P.A.T.C.H Assessment v3. Questionnaire was administered to post graduate nursing students to establish their competencies and attitudes towards nursing informatics in health. In parallel an interview was conducted with nursing educators and informatics educators to determine their perspectives on the topic as well as an open-ended questionnaire for health informatics experts. An outline of the research with outcomes is illustrated in Figure 3-3.

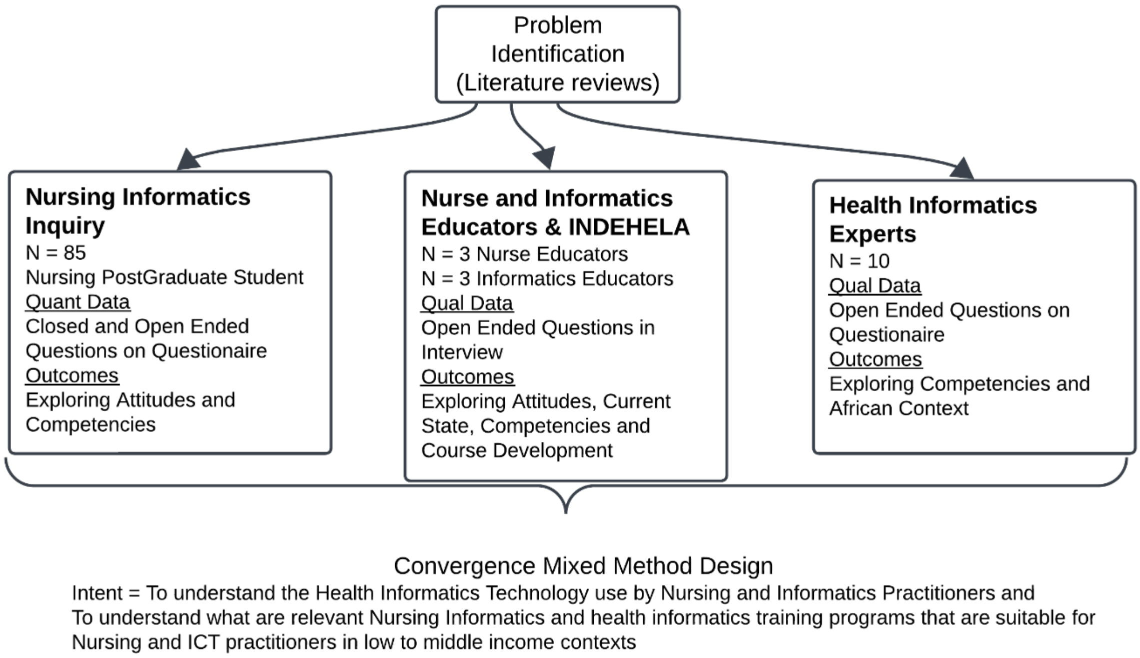

Figure 3-3: Research Process Components applied to study as per (Hirose and Creswell., 2023)

3.7.1 Units of Analysis

A unit of analysis is the entity of focal exploration in a study. (Lewis-Beck *et al.*, 2003) define this "*the most basic element of a scientific research project*." These may be categorised as aggregates, individuals, artefacts, interactions, periods of time, and geographical units. (Kumar, 2018; Jucker *et al.*, 2018). The unit of analysis for this study is the attitudes towards digital technologies and competencies to utilise digital technologies in practice of the individuals. A unit of observation is considered the entity which will be observed, measured, or collected to obtain outcomes from the exploration of the unit of analysis. The aim of the study is to determine relevant competencies for a Nursing or Health Informatics Education Program for Nurses and ICT practitioners. As the study's interest focused on nurses, nursing educators, informatics educators as well as health informatics experts, these provided the unit of observation,

3.7.2 Context of Study

One of the four Universities, the Cape Peninsula University of Technology is the largest university in the Western Cape. Historically dating back to 1920, when the foundation stone was laid in the Long market Street Building of the then Cape Technical College in Cape Town.

The institution was then established due to more than 10 years of advocacy by the community to provide for the upskilling of Coloured apprentices in various trades until its move to the Bellville Campus in 1967. These would be known as technikons as higher education institutions offering vocational training for practice as opposed to traditional universities that focused on academic studies creating knowledge. The Peninsula Technikon in Bellville and Cape Technikon in Cape Town were established after the enactment of the Technikons Act in 1976. The Minister of Education, Kader Asmal, in March 2001, announced the National Plan on Higher Education (HE) which changed the paradigm of HE in South Africa. This was followed by the announcement of the merger of Cape Technikon and Peninsula Technikon to be implemented in January 2005. In October 2003 a new name was announced Cape Peninsula University of Technology (CPUT) and technikons were incorporated into comprehensive university, merging with a traditional university or changed to a University of Technology (UoT). CPUT, is the only University of Technology in the Western Cape. In 2004 an Executive Interim Management was appointed and Professor L Vuyisa Mazwi-Tanga became the first Vice Chancellor in February 2006. Dr Trevor Manuel was elected in May 2008 as the first Chancellor of the University.

CPUT, in addition to the two main sites in Bellville and Cape Town has 6 sites where they offer instruction, and 2 hospital sites where students conduct their practicum. Having a vision, "*to be at the heart of technology education and innovation in Africa* ", CPUT offers more than 80 undergraduate and postgraduate courses in six faculties. These are offered in the fields of Applied Sciences, Business and Management Sciences, Education and Social Sciences, Engineering and the Built Environment, Informatics and Design, as well as Health and Wellness Sciences.".

In this inquiry data was collected from the Nursing Department in the Faculty of Health and Wellness, as well as the Information and Technology Department from the Faculty of Informatics and Design.

3.7.2.1 Faculty of Health and Wellness and the Nursing Department

The faculty of Health Wellness at CPUT is constituted of seven departments which are: Biomedical Sciences; Dental Sciences; Emergency Medical Sciences; Medical Imaging and Therapeutic Sciences (previously Radiography); Nursing; Ophthalmic Sciences; Wellness Sciences. Each of these departments' epistemology consists of unique tenants that incorporate hands on approaches. In 2003 Peninsula Technikon was granted approval by the Department of Education to offer a 4-year undergraduate BTech Nursing Science Degree under the Health and Wellness Faculty (Jeptha, 2008). Two years from then, in 2005, the

Nursing Degree was offered collaboratively with the Western Cape College of Nursing (WCCN). Currently the Department offers both BTech Nursing Midwifery Science, Post Basic courses in Public Health, Oncology, and Occupational Health as well as a Master's in Nursing Program (Cape Peninsula University of Technology, 2015). The Nursing Degrees offered by the Institution, are required to be in alignment with the macro requirements of the governing bodies SAQA, CHE and SANC.

The University in alignment with the regulations offers some informatics courses at all levels of offering. An overview of the 2019 online course content in the degrees being offered, indicates the presence of informatics content within the curricula. In the undergraduate course, the department offers a module academic literacy in the first year, in which the student is exposed to theoretical concepts and clinical practice on the use and application of information technology. In the post basic courses, the module health information systems is offered as three electives, which a student taking any one of the post basic courses may take. In addition, there is a master's course which is being offered.

3.7.2.2 Faculty of Informatics and Design and the Information and Technology Department

The Faculty of Informatics and Design is comprised of five departments, the Architectural Technology and Interior Design; the Town and Regional Planning; The Information Technology; The Design; and The Media Departments. The Information Technology Department offers both formal and Informal courses in specialities of Applications Development (Software Development); Communication Networks and Multimedia Technology. The Department, since 2012 has been offering a Health Informatics Course, as a BTech Elective Module in the Second Semester of the BTech Information Technology Course (CPUT, 2015) The learning outcomes and module content is outlined in Table 3-3.

Table 3-3: Learning outcomes and module content for Health Informatics Elective Module

Expected learning outcomes	The specific outcomes to achieve the above are: 1. Identify and describe the elements of the Health Informatics Field 2. Distinguish (comprehension – confirming use of knowledge) between the different health informatics knowledge areas 3. Explain the relevance of informatics in healthcare service provision in both global and local contexts 4. Indicate how ICT could facilitate healthcare service provision 5. Describe health informatics as a profession

In addition to this, the Department offers master's and doctoral Degrees to students whose research involves a health informatics focus (CPUT , 2015). Although both the Nursing and the Information Technology Departments offer courses with some Health Informatics, they differ in focus as the background specialities are different.

3.8 Data Collection for the Different Perspectives

Ethical clearance to conduct the study was obtained from the Department of Informatics and Design (Appendix A). Further clearance to conduct the study with students was obtained from the Office of the Vice Chancellor Teaching and Learning (Appendix B). The data collection section is discussed according to the three perspectives, nurses, educators, and experts.

3.8.1 Nurses' Perspectives (quantitative)

The objectives of the first perspective is to assess: (1) the health Informatics competency needs for Nurses. The post-graduate nursing students were identified for the first target group because they are busy with their education but also have experience in practice as nurse practitioners. Questionnaires were used as the instrument for the data collection method. the units of observation were their nursing informatics attitudes and competencies. Three expected outcomes should be (1) the current state of the attitudes of nurses; (2) In addition to this the current state of the competencies of nurses; (3) the desired nursing informatics education competencies that Nurses would prefer; and (4) the preferred program design according to the students.

3.8.1.1 Data collection tool – Questionnaire

Johnson and Christiansen (2014), define a questionnaire as an instrument that can be used to collect quantitative, qualitative and mixed data. A review of the literature identified a number of questionnaires that had previously been used to assess nurses' digital literacy levels. In some studies the researchers developed their own instruments: Khezri and Abdekhoda (2019) in their study to assess nursing informatics competency, and identify related factors in registered nurses; and Lysak *et al.*, (2022) in their inquiry which looked at exploring nursing students awareness and utilization of resources available to support nursing informatics competency development, and to compile a list of accessible resources to augment informatics learning at the undergraduate level. For some studies instruments that had a bias towards Information Technology and did not include the nursing context, were used, such as: Kuek and Hakkennes. (2020) who made use of the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT) model in their study looking into assessing the digital literacy levels and attitudes towards information systems. The participants were staff in a health service who were involved in the implementation of electronic health records to establish the barriers towards implementation that could be addressed; Harerimana and Mtshali (2019), who adapted the 2013 European Commission questionnaire as they explored the types of ICT applications used and the skills level of nursing students; and Shiferaw *et al.* (2020) who adapted the European commission's digital competency framework in order to assess digital competency of healthcare providers among seven public health centres. In some studies instruments assessing competencies were used but did not assess the attitudes of the nurses so the researchers developed their own instrument to assess the attitudes. Mohamed and Abouzaied (2020) made use of the SANIC assessment tool developed by the Technology Informatics Guiding Education Reform (Godsey, 2015) to inquiry on self-assessing nursing informatics competencies and attitudes among baccalaureate-nursing students; and Seo *et al.*, (2019) who adapted the SANIC questionnaire to develop a Korean SANIC as they inquired into the self-assessment of nursing informatics competencies scale. For this study a questionnaire was required that inquired into the attitudes and competencies of the nurses. The questionnaire needed to have a nursing context to provide a context for which the nurses could understand the questions as they did not have an IT background.

The questionnaire used in this study, was constructed in 1996 and has been iteratively updated twice, to a version 3 which had been in use since 2011 (Kaminsky, 2019) and is known as the Pre-test for Attitudes Towards Computers in Healthcare Assessment Scale (P.A.T.C.H) (Appendix C). The PATCH Assessment Tool was used to structure the questions that are addressed to a nursing audience. The questionnaire tests the following: (1) nurse attitudes towards computers; (2) current competencies as well as (3) desired competencies in computers; and (4) nursing informatics training program design preference. The questionnaire has been administered in United States of America, Turkey, India, Saudi Arabia, and Egypt. An analysis of the studies is indicated in Table 3-4 bellow. In all studies the participants were nurses, and the results were consistent in each of the study as per the validity and trustworthiness of the instrument.

Table 3-4: PATCH Questionnaire References

Title	**Year**	**Author(s)**	**Country**	**Use of PATCH Questionnaire**	Cronbach's alphas	**Summary of Findings**
Nursing Students' Computer Self-Efficacy and Attitudes toward Its Use in The Health Care Setting: A Comparative Study	2020	Hassona F M; Nageeb A.A.Z.F.	Egypt	To assess and compare nursing students' attitudes towards computer use in a health care setting	In Hail was (r=0.89) and (r=0.84) in Benha University	Nursing students in both universities have a positive attitude toward computer use.
Assessment of Undergraduate Nursing Students' Attitudes and Perceptions towards the Use of Computer Technology in Healthcare Settings	2020	Alaban A, Almakhaytah S, Almayouf L, Alduraib A, Althuyni A, Meshaileh L B	Saudi Arabia	The study aimed to assess the attitudes of undergraduate nursing students towards the use of computer technology in healthcare settings.	Not included	• only a small number of students (7.3%) had a very positive view of the potential use of computer technology in the healthcare • the undergraduate nursing students have limited computer exposure and may not be adequately prepared to work independently with the computers in the workplace once they graduate
Electronic health record instruction in first-semester nursing students: A comparative study.	2018	Ruckdeschel A.R.	USA	To investigate if the use of an AEHR improved self-efficacy, reduced anxiety, and enhanced competence compared to a traditional	Score was 0.92	Students had increased self-efficacy, less anxiety, and increased competency compared to peers who received the traditional instruction

Title	**Year**	**Author(s)**	**Country**	**Use of PATCH Questionnaire**	Cronbach's alphas	**Summary of Findings**
				PowerPoint presentation on EHR usage		
Development and Implementation of the Clinical Decision Support System for Patients With Cancer and Nurses' Experiences Regarding the System	2017	Yilmaz A.A. Ozedemir L.	Turkey	To develop and implement the clinical decision support system (CDSS) for oncology nurses in the care of patients with cancer and to explore the nurses' experiences about the system.	Score was 0.92	Nurses did not experience any problems during the implementation of the CDSS, and its usage facilitated the assessment of patients' needs and care management.
Nursing students' attitudes towards computers in health care: a comparative analysis	2014	Ramachandra P., Mat S.B.	India	To determine the effectiveness of basic computer course related to Nursing Students' attitudes towards usage of computers in health care	Not included	The findings suggest that integration of informatics throughout curriculum with increasing levels of difficulty is needed
Nurses' computer literacy and attitudes towards the use of computers in health care	2014	Topkaya S. G. Kaya N.	Turkey	To address nurses' computer literacy and attitudes towards the use of computers in health care and to determine the correlation between these two variables	the following coefficients were found: 0.93 for BS, 0.91 for ASS, 0.90 for CA and 0.95 for P. Kılınç and Salman9 calculated the alpha coefficients 0.91, 0.93, 0.94 and 0.91 for BS, ASS, CA and P, respectively. In the present study, the general reliability	The nurses, in general, had positive attitudes towards computers, and their computer literacy was good. Computer literacy in general had significant positive correlations with individual elements of computer competency and with attitudes towards computers

Title	Year	Author(s)	Country	Use of PATCH Questionnaire	Cronbach's alphas	Summary of Findings
					coefficient was 0.96; the coefficient varied between 0.88 and 0.94 for the subscales	

The structure of the questionnaire comprises of the four sections mentioned and an analysis tool for the questionnaire. The Analysis tool, known as the Assessment Scoring Tool for Interpretation was designed to enable ease of analysis of the questionnaire. Kaminski developed this tool for the analysis of the attitudes score for individuals who would take the test. This was on a two-variable component with allocation of values of 2 to 0 to each of the five options that a participant could select. Variables A and B inversely represented the attitudes of the participants' responses. Variable A reflected a positive response in the question for example "*I would love to be a proficient user of computers*" and Variable B reflected the inverse, "*I will never feel relaxed about using a computer*". The values assigned to variable A for responses on the Lickert Scale A to E were 2; 1.5; 1; 0.5; and 0 respectively. The inverse was assigned for variable B. This is a measure that consistently indicates a positive attitude or the inverse a cyberphobic attitude. An analysis of the sum-total of the student's responses was performed using the Kaminsky's PATCH Assessment Score Interpretation (Appendix D) illustrated in, Table 3-5 as the tool for Analysis.

3.8.1.2 The P.A.T.C.H assessment scale v. 3 (2011)

The Kaminsky's PATCH Assessment Score Interpretations Table is divided into six categories beginning with 0 points to 100 points. Each of these categories provides a description of the characteristics that a participant would have, with regards to their total obtained from the P.A.T.C.H Assessment Scale Version 3 Scoring Tool. These ranges are described as follows: (1) categories 0 -17 points show a positive indication of Cyber phobia; (2) 18 – 34 points, indicates some uneasiness on using a computer; (3) 35 – 52 points, means that the participant has moderate comfort in using a computer; (4) 53 – 69 points, suggests that the participant feels comfortable using a computer; (5) 70 – 86 points, indicates the participant is confident in using a variety of programs; and (6) 87 – 100 points, implies that the participant is very confident and can learn a computer to boost creativity. A more detailed description of each category is indicated in the next table. A calculation of each participant's score was conducted, and this was then summed for characteristic A and characteristic B and a sum total of both A and B was conducted. This was to view the perspectives of the participants according to the objectives of characteristic A which reflected a positive response and characteristic B which reflected an inverse negative response.

Scoring of the P.A.T.C.H assessment scale v. 3 (2011) was based on responses to positive and negatively worded statements. For the positive statements, (Items 1, 2, 4, 6, 7, 8, 11, 12, 16, 17, 18, 19, 21, 24, 29, 31, 33, 34, 36, 37, 42, 43, 46, 48, and 50) the score was based on the Likert rating chosen: 1 = 2 points, 2 = 1.5 points, 3 = 1 point, 4 = 0.5 point and 5 = 0 points.

For the negative statements, (Items 3, 5, 9, 10, 13, 14, 15, 20, 22, 23, 25, 26, 27, 28, 30, 32, 35, 38, 39, 40, 41, 44, 45, 47, and 49) the score was based on the Likert rating chosen: 1 = 0 points, 2 = 0.5 point, 3 = 1 point, 4= 1.5 points and 5 = 2 points . The sums of the two statements were added together to achieve a final total. The total of the sums ranked from 0-100 and was as follows:

Table 3-5: P.A.T.C.H. Assessment Scale v 3 Score Interpretations

Points Range	Interpretation
0-17 points	Positive Indication of Cyberphobia , Beginner Stage in experience
18-34 points	Indicate some uneasiness about using computers Very basic knowledge of computer basics and applications
35-52 points	Moderate comfort in using computers. Has basic knowledge of computers and applications
53-69 points	Feels comfortable using user-friendly computer applications
70-86 points	Confident of ability to use a variety of computer programs
87-100 points	Very confident that they can learn to use a computer to boost creativity and perform routine functions.

The questionnaire was administered with an objective of exploring the research context, for answers to sub-research questions (1): "*What are the competencies needed by nurses to use ICT as part of their work in practice in an African context?*" and (2) "*How can the required informatics competencies be incorporated in a Nursing informatics education program?*" A Piolet test was conducted with the questionnaire initially administered online via Google Forms. It was then administered face to face to the participants, where a greater participant number partook the questionnaire. Permission to use the questionnaire was obtained from Professor Kaminsky and is attached as Appendix E.

3.8.1.3 Rigour, Reliability and Validity of the Questionnaire

The rigour of a research Instrument is important for ensuring the reliability of the data in the inquiry. The design of the questionnaire should be relevant to the context of the study and be able to seek answers to data that will explain in response to the research questions. The questionnaire was administered for expert review to the research coordinator for the post-graduate studies to ascertain its relevancy within the South African Context and suitability for administration to the students. Queries on the question were repetitions of questions being stated in a different way yet requiring the same information. This was validated as one of the features of the rigour of a questionnaire is to ensure the reliability of the responses of the participants. A pilot test was conducted, with the students being requested to fill in the questionnaire online in Google Forms. Three students responded and a Cronbach's alpha coefficient was calculated. The three students indicated that they understood the questionnaire and had some queries over some nursing informatics terminologies, which they preferred to be addressed face to face using a paper instrument. When returning to the general student class, they indicated that they preferred a paper instrument instead of an online version. This was then administered during a class session, and 85 of the students filled in the forms, and another calculation of Cronbach's alpha was done.

3.8.1.4 Sampling Criteria of Participants

The convenience sampling technique was used as the sampling method for the selection of participants. This method was used for both the initial online in Google Docs and the face-to-face questionnaires. The questionnaire was administered to post-graduate nursing students. To collect data from the Nursing Students, consent was obtained from the University, and the nursing department of the university. Appendix B was used to obtain consent from the nursing students, permission was granted to attend the research post -graduate class to describe the study and request consent from the participants. The class register comprised of 110 Nursing Students, who were specialising in the fields of public health, occupational health, and oncology. The study considered the total population and eighty-five 85 (77%) students consented to participate in the research and indicated this by writing down their email addresses for further contact, with the link to the online questionnaire. An email was sent to the 85 participants and only 3 responses were obtained and analysed as a piolet test. It was then decided to administer the questionnaire face to face to those who consented to get a good response rate. All 85 respondents completed the questionnaire.

3.8.1.5 Participants Selection Criteria

The selection of participants to complete the questionnaire was guided by the need to explore the attitudes, and competencies of nursing practitioners. The P.A.T.C.H Assessment v3. The questionnaire was developed for nurse practitioners to pre-test their attitudes towards computers as well as explore their current skill set and desired skills in competency outcomes that are a hybrid of informatics and health. Since the questionnaire had a health focus, it was administered to post-graduate nursing students to meet the following three criteria: (1) They had foundational knowledge of their area of nursing; (2) they had some experiential praxis within their specialty, the minimum being 2 years full-time in-service training, and (3) they are conducting some academic research. They should have extended linkages between their theory and practice so they are able to make judgment on Health Informatics competencies within their domain.

3.8.2 Informatics and Nursing Educators' Perspectives

Further exploration of the context was required of the attitudes; current competencies; competency needs, and health informatics education and nursing informatics program design for the context of South Africa and South African Nursing Education. Interviews were then conducted with Educators from both the Nursing and Informatics Departments. Unstructured Interviews were conducted, to probe further into the study questions' requirements. This included a review of the International Health Organisations Definitions and Competencies from the TIGER and the HIT Comp (Hübner *et al.*, 2018).

3.8.2.1 Individual Interviews

Literature describes interviewing as having the characteristics enabling a researcher: (1) to be allowed to find out what is "*in and on someone's mind* " (Tisdell et al., 2025:136); (2) to obtain insights when s/he "*cannot observe, behaviour, feelings or how people interpret the world around them*" (Tisdell et al., 2025:136); (3) to inquire into an event, when it is impossible to replicate it; (4) to conduct sensitive case studies; (5) to investigate "*feelings, meanings and thinking*" (Knight, 2002); (6) when it is difficult to collect data from "*a large group of people, representing a broad range of ideas*." (Tisdell et al., 2025:137); and (7) to verify data when the reliability of it is in question (Knight, 2002). There are three common types of interviews identified in literature: (1) Structured Interviews; (2) Semi-Structured Interviews; and (3) Unstructured Interviews (Leavy, 2017). In addition to these, Mouton (2011) suggests four additional techniques of interviewing which are: (1) structured- self-administered questions; (2) structured telephone interviewing; (3) semi-structured focus groups and (4) free attitude interviewing methods.

Since this study involved two diverse disciplines (nursing for digital technologies use and ICT for digital technologies development and support), adopting a pragmatism epistemology to search for understanding from the participant's perspective, I used semi-structured interviews. These provided my inquiry with the characteristics of being able to (1) explore the participants' perspective on the topic of inquiry, (2) understand decisions that participants would have made; (3) understand reasons for attitudes and opinions; (4) infer causal relationships between variables and (5) ascribe meanings participants ascribe to health informatics education.

In unstructured Interviews an interview guide is used to probe the participant with them having the option to elaborate if needed. The interview is guided by the Interviewer and the participant can freely provide their perspectives on events, behaviour and beliefs on the topic. This provides insight into what Rubin and Rubin (2005:19) describe as seeing "*that which is not ordinarily in view and examine that which is looked at but seldom seen*". This is key to the study as the context of the study required perspectives from both Nursing and Informatics participants.

3.8.2.2 Interview Guide Development

The process for the development of the interview guide is followed by Rubin and Rubin, (2012), who describes the process as formulating the main questions around the research questions, and then follow-up questions seek to extract details around themes and probes seek to further elucidate meaning to the themes. According to (Roulston and Choi, 2018:222), preparing an interview guide involves "*generating a list of questions and topics that are likely to elicit descriptions that speak to the research questions posed*". They advise that one should begin with broader questions and then tailor to more specific questions, formulating open rather than closed questions. In an unstructured interview keeping the questions open is more important as it enables further follow-up questions and probing in the exploration of meanings.

In this study, the following framework studies were used to guide in the development of the interview guide. These were used to determine the current situation of heath informatics education for nurses and ICT practitioners in an African context. The Staggers and Parks Nurse-Computer Interaction Framework (Staggers and Parks, 1993a, 1993b) was used to explore the behaviour of nurses as they interact with computers. Kaminski's Nursing Informatics Perspectives Conceptual Model (Kaminski, 2007), considers the attitudes that nurses have towards computers. The Effken informatics research organizing (IRO) model (Effken, 2003) was used as the main framework to determine the competencies that either nurse practitioner or informatics practitioner would require.

In addition to the frameworks, the Tigers Competencies (Hübner *et al.*, 2018) and the HITComp Competencies (HITCOMP, 2022), were used to provide a baseline for which the educators could have an idea of what comprises of nursery Informatics and Health Informatics competencies.

3.8.2.3 Sampling Criteria of Participants

Purposive Convenience Sampling was used as the sampling method in the determination of the research participants. A request to conduct interviews was emailed to the participates, and consent was obtained from the participants. Request for permission to conduct interviews was required from the nursing department as the departmental policy requires the Faculty Research Committee (FRC) to approve health studies every year to ensure ethical protection of subjects that participate in those studies. When this was obtained from both the informatics and design faculty and the department of nursing, interviews with the lecturers were conducted.

Sampling Design involved sub-group sampling, with participant subgroups being from the nursing department and the information technology department. Using the recommendations proposed by Onwuegbuzie and Collins (2007), for participant sample size in Interviews and sub-groups, participants in each sub-group consisted of three practitioners. From the nursing department, three educators were interviewed and from the informatics department, two educators were interviewed. In both departments there was a shortage of lecturers who could teach the informatics aspects and hence the small number of participants.

3.8.2.4 Participants Selection Criteria

The selection of participants for interviews was dependent on the following criteria. (1) being an educator in one of the specialities, nursing, or informatics (within the health domain). The selection of the nursing educators was delineated by the research focus being conducted with post-graduate educators. Two educators were identified and consented to participate in the interview. The third educator was recommended as the participant was conducting her doctoral studies on a health informatics topic. Selection of the informatics educators depended on (1) lecturing within the information technology department and (2) involvement in health informatics curriculum development or research. Two lecturers consented to conduct interviews. The lecturers were interviewed using an unstructured interview guide, to probe and explore their perspectives on the results obtained from phase one. The lectures were interviewed in the next phase instead of the students, to obtain a holistic educational perspective of the competency needs of the students and the South African context.

3.8.2.5 Competency Frameworks Tools

As part of the data collection tools for the educators' perspectives, the interviews with the nursing educators and the informatics educators, an exploration into the competencies was conducted using the following international competency tools: the TIGER Health Informatics Competencies for Nurses (Hübner *et al.*, 2018) and the HIT Comp Framework Competencies for both nursing and informatics practitioners. The TIGER and the HIT-Comp, competencies were selected to use as the tools to provide a background on nursing informatics and health informatics competencies for conducting the interviews. These were selected because of the following characteristics: (1) the competencies considered both the European, United States and African countries' needs in their study, so they had greater international influence; (2) The competencies were developed in 2017 and 2018 after the first International Competencies by IMIA in 2010, thus the prior competencies from IMIA, CHIA, Digital Canada and the TIGER (2010) were referenced as sources for consideration and (3) The competencies, did not have a silo framework towards competencies only for health practitioners but were inclusive of a larger framework of practitioners.

3.8.2.6 Participant Member Checking of Results

Member-checking, also known as participant or respondent validation involves sharing findings with participants to ensure accuracy and credibility, allowing for feedback and validation of research data. After the interviews were transcribed and analysed, the results were validated by the participants.

3.9 INDEHELA case

The data source for this perspective was presentations that were based on formal project reports submitted. Details about the workshops were sourced from the different in-country workshop agendas. Sampling was convenient using the project members' contributions as captured in the reports and presentations. The Health Informatics Fundamental course outline was compared to the IMIA and IT2017 domains:

3.9.1 Health Informatics Expert Perspectives

The purpose of collecting data from health informatics experts was to represent the views and perspectives of IT practitioners. Expert perspectives are important to determine the content, design, and technical quality of the intervention. In addition to this, according to (Mafumiko, 2006), experts provide opinions on aspects of the intervention that need attention for improvement. An important consideration of expert review is the identification of the expert subjects. The participants should be considered within the community of the domain as experts. In this study participants should be considered as experts internationally, within Africa as well as in South Africa, for them to provide a comprehensive perspective on the framework.

3.9.2 Methodology

This phase was a qualitative study and included a semi-structured questionnaire/interview guide (Appendix G) which was administered to health informatics experts. The questionnaire was uploaded onto Google Forms to allow the experts to complete the form at their convenience. The survey was designed to be completed in approximately 30 minutes and was pre-tested for face validity by two health informatics experts. The questionnaire was administered online via Google Forms to the participants. Consent to participate in the survey was requested from respondents. This was then followed by sending an email invitation with a link to the survey. Convenience sampling of experts who had diverse experiences across the relevant domains of health informatics, was conducted. Thematic analysis was conducted on the results from the responses.

3.9.3 Data collection tool

The semi-structured questionnaire/interview guide (Appendix G) has two sections: (1) the demographics, the background and professional experience of the respondents; and (2) questions on topics and competencies in health informatics. Section 2 provides a contextual setting by providing a background for the competencies required from the students as well as the focus of the subject that the students would be taking. The background setting was:

> *"If you were asked to design a Health Informatics Course in an undergraduate programme to teach IT students to develop, implement and evaluate Health Information Systems, Health Information Technologies or Health Applications for the African context what topics would you suggest? Please list the five to ten most important topics?"*

Respondents were then asked the following, to: (1) list your suggested topics and add a short description for each; (2) indicate the proposed level of study for each of your suggested topics from a selection of 1st year Degree, Diploma, 3rd Year Degree or 4th Year Degree level of education; (3) indicate for each of the suggested topics what students would be expected to do; (4) indicated for each of the suggested topics the competencies that students should have; (5) suggest how IT practitioners already working in the field, can acquire the necessary healthcare competencies; and (6) anything you would like to add that may be useful to consider for the African context

3.9.4 Participant and Sampling Criteria

Selection of the participants was conducted, as per recommendations from domain practitioners. This removes four bias effects identified by Mouton (2011) that could affect the inquiry which are (1) biased interviewer; selectivity effect; (2) researcher distortion; (3) research expectancy and (4) demand characteristics. Sampling designs were purposive, implemented as recommended by Nieveen (1999) for three experts in paper-based assessments and six experts in computer-based assessments. Data collection from experts could lead to misrepresentation (purposeful, unintentional, subjective, or insufficient memory/knowledge) since they are influenced by their worldviews, experiences, and interests (Von Soest, 2023). It may be difficult to recruit enough experts who are willing to participate and therefore further research will be needed to address the limitations such as low sample size, low internal consistency, and difficulty to generalise the findings like for example, the study of Torres-Alzate *et al.* (2020) who used experts in their mixed methods Delphi study to determine the global health competencies in the USA.

Another distinct characteristic of an expert interview is defining who qualifies as expert and what knowledge is sought, which determines the sampling approach. The criteria for the the participants selection were that : (1) The experts have diverse experiences across the relevant domains of health informatics; (2) The experts have some education or training experience in health informatics; and (3) The experts have a postgraduate degree.

3.10 Data Analysis, Integration and Interpretation

Data Analysis strategies for the mixed methods data collection occurred at different points in the study. This combines the outcomes once each individual quantitative or qualitative data collection procedure occurrs, or when complementing the data from each of the strategies. In this inquiry, both strategies were used, where the data from the design strategies were analysed independently and in the nursing informatics education the quantitative data was extended complemented during the qualitative strategy. For this study the data collection philosophical paradigm used was pragmatism, the lens for integration analysis and interpretation used in the study was based on a subjectivist stance of an interpretive philosophical assumption is the interpretivist using a qualitative lens (Creswell and Clark, 2018), note several options for analysing data with a qualitative lens in mixed methodology studies, such as: data transformation; data comparison and data Integration. Data transformation is the conversion of qualitative to quantitative data or vice versa. The analysing of quantitative data using a qualitative lens was noted first by (Tashakkori and Teddlie, 1998), as they describe a study where a quantitative personal inventory was followed by qualitative interviews; and the data was qualitatively analysed. Andrew and Halcomb, (2009) provide several examples where data transformation was implemented in nursing and health mixed method research studies. Data comparison, also known as triangulation, is the process where data sets are compared from different sources to remove bias and ensure reliability of the findings. In the concurrent mixed analysis, an important consideration is the data integration. This occurs with the convergence mixed method design where both strategies have equal weighting (Dawadi *et al.*, 2021).

Integration of data during the process, is a key criteria of mixed methodology paradigm, including timing and weighting. It is the process of collating the data from both the quantitative and qualitative strategies for analysis and interpretation. Data Integration is well suited for the health informatics education for informatics students since the mixed method design was used to answer the research questions using a convergence mixed methods design. Creswell and Clark, (2018) discuss four possible stages for integrating two data sets: at the level of design, during data collection, during data analysis, and during data interpretation (Andrew and Halcomb, 2009).

In this study, in each of the sections data correlation was done with the purpose to maintain trustworthiness and research rigour. Data Integration of the quantitative nursing students data and the qualitative nursing and informatics educators and the health informatics experts were analysed concurrently and data was integrated and collated during the design.

3.10.1 Data Analysis Process

This section outlines the data analysis process for the quantitative and qualitative sections of the research for each of the participants.

3.10.1.1 Data Analysis Process of Nursing Results

The data collected from the quantitative questionnaire administered to Nursing Students was analysed using the PATCH ASSESSMENT SCORE which is described in section 3.9.1.2 detailing the questionnaire characteristics. The PATCH ASSESSMENT SCORE also included descriptive analysis which was conducted to understand the underlying elements of the students’ attitudes and competencies in informatics

3.10.1.2 Data Analysis Process of the Educators and Health Informatics Experts Results

The Interviews conducted with the educators and the semi-structured questionnaire administered to the health informatics experts was analysed using thematic analysis. In qualitative inquiry, thematic analysis is suitable for unpacking and analysing data to develop meaningful information in categories and themes (Hsieh and Shannon, 2005).

The thematic analysis procedure used was according to Creswell *et al.* (2012) who suggest six steps of data analysis and representation when conducting qualitative analysis. These are:

1. Manage data by creating and organising data files.
2. A thorough review of the data by reading and rereading the transcripts, making notes or memoing to identify or detect emerging themes to form baseline codes.
3. Describing the researcher's personal meaning of the phenomenon by using epoché or bracketing methods to prevent potential research bias, thereby promoting rigour of the research.
4. Identifying and classifying data from participants' statements and grouping or categorisation of the statements into meaning units.
5. Interpreting the textural description to answer the question what happened?" and structural description to answer the question "how it is experienced?" and then construct overall meaning or essence of the experience. As the researcher attempts to answer the questions, the core meanings of the individuals' experiences will be revealed.
6. Representing the essence of the experience by using tables and figures for visualisation of statements and themes for easy understanding of readers.

The thematic analysis process is further outlined in Chapters 5 and 6 when analysing the nursing and informatics educators as well as the health informatics experts' data.

3.10.2 Interpretation of Results

Interpretation of integration results was conducted by considering how the confirming, disconfirming and expanded results provide insight into the problem being studied and answer the mixed methods research question. Interpretation is the subjective meaning-making by the researcher of the qualitative data that represent the construction of the participants' sense-making from their responses (Walsham, 2006). Walsham further distinguishes between an outsider researcher (objective) and an involved researcher (subjective). While Munkvold and

Bygstad (2016), amongst other characteristics, refer to the multiple realities of the participants as well as multiple interpretations within their situated realities.

Interpretation of the results was conduction by collating the different mixed methods sections and hermeneutically identifying the different perspectives of the participants, combining similar perspectives and noting dissimilar and expanded perspectives.

3.11 Integration of Findings

Data integration in the study was conducted at the level of the study design. A convergence design was used in the study. Creswell and Clark (2018) propose a method of integrating findings at the design level of a study. This is by looking at the following factors: integration intent, integration data analysis procedures, representation of integration results, and interpretation of integration results. In the convergent design these factors would align to the following procedures:

3. Integration Intent should use simultaneous integration or merging to develop integrated results and interpretations that expand understanding to provide comprehensive results and or validate and confirm results.
4. Integration data analysis procedures are to be conducted as follows:
    a. Obtain results by analysing quantitative or qualitative data.
    b. Look for common concepts across the results.
    c. Compare the quantitative and qualitative results for each concept.
    d. Determine in what way the results confirm, disconfirm or expand each other.
    e. Interpret and resolve differences.
    f. Use different procedures for data transformation.
5. Representation of Integration Results is to be displayed as follows:
    a. Develop side by side comparisons of quantitative and qualitative results through a narrative or comparison joint display.
6. The integration of findings is outlined in Chapter 7.

Convergence was considered as it enabled gaining insight from perspectives of different participants by considering holistically the quantitative and qualitative results from the different participants and deriving outcomes that confirm, disconfirm, or expand the results.

3.12 Ethical Considerations

Ethical considerations are central in the health domain, in training, practice and research. In Informatics this is also key as the primary concern of Informatics is the capturing, transformation, sharing and storage of data. Health informatics combines the ethical considerations for health, informatics and education and is of primary importance for consideration in health informatics education and training. In all research that involves participants' ethical considerations are: (1) people have the right to privacy; (2) people should be treated with appropriate respect, have been one of the key characteristics that were put into consideration when conducting the research. Participants were informed about the objective of the research each time in the data collection process, and request for consent was asked of the subjects before collection of the data.

The research ethics practice adopted was that proposed by Mouton (2011) when conducting the inquiry. Four characteristics of research ethics were considered in terms of its relationship, namely: (1) to the practice of science; (2) to society; (3) to the subjects of science; and (4) to the environment. Each of these characteristics was put into consideration at each cycle of the research process.

Since the study involved participants from two departments at the university, permission to conduct the study with the participants from the respective departments, permission was required from both departments to collect data as proposed. This required approval from the ethical bodies of the university, the Faculty Research Committees of both Nursing and Information Technology, and the Research and Development Department. Final approval was granted by the Academic Pro-Vice Chancellor of the University, Appendix B. The Research spanned from 2015 and consent for study was required again. The respective Faculty of Research Committees and the Administrative and Departmental offices were approached and communication via email through the different offices for consent was forwarded. Approval was obtained and data was collected in 2019. The Nursing Department approved the research and data was collected from the post-graduate students and the nursing educators. Each participant had to give informed consent, after the purpose of the study and their role within it was explained, that their data may be used for the study. The following conditions were explained: that their participation is voluntarily and the participants could withdraw at any stage from the study; that their responses will be anonymised with all identifiable data being removed; that all the research data will be protected against unauthorised access and use; and that no compensation would be offered. Since the This satisfied the ethical requirements for proceeding with the study.

3.13 Research Quality and Rigour

Research rigour and quality in mixed methods research consider validity / trustworthiness criteria for both the quantitative and qualitative phases, including the integration, throughout all stages of the research design. This also applies to the research questions, units of analysis, and sampling strategies, not just the data collection phase (Tashakkori and Teddlie, 2003). Usually, finding what represents quality in mixed method research is dependent on the interpretation of different audiences such as academic journals, funding agencies, publishers, and professors (Clark and Ivankova, 2015).

In this study research quality and rigour will be looked at through three lenses: the quality criteria of mixed methods as outlined by Hirose and Creswell (2023); and quantitative research rigour and qualitative research rigour as described by Lincoln and Guba, (1985). This will provide a lens on the mixed method research quality applied in this study, ensuring the validity of the study and its results. These are outlined in the next sub sections.

3.13.1 Quality Criteria of Mixed Methods

Hirose and Creswell (2023) in their study on applying core quality criteria of mixed methods research to an empirical study, consider how quality in mixed methods can be assessed. They propose six quality criteria which may be used in studies where the elements are often too numerous for new researchers and do not incorporate diverse stakeholder perspectives. The quality criteria are: (1) advance a rationale for the use and appropriateness of mixed methods methodology; (2) write quantitative, qualitative, and mixed methods questions or aims; (3) report the quantitative and qualitative data separately; (4) name and identify the type of mixed methods design and present a diagram of it; (5) state the use of integration in a joint display and (6) discuss how meta-inferences and value resulted from the integration analysis. Hirose and Creswell (2023:17) state that "*It is not enough to advance a set of quality criteria. The new researcher, especially, needs a concrete illustration to demonstrate how an empirical study can incorporate the criteria.*"

Thus, the criteria are viewed in the context of this study to validate the implementation of a mixed method research approach. A discussion on whether the criteria were met is conducted in Chapter 8.

3.13.2 Quantitative Research Rigour

In quantitative studies research rigour is determined by looking at the following validity tests: internal validity, external validity, construct validity and statistical validity. refers to making inferences about whether a causal relationship exists between two variables (Johnson and Christenson., 2014; Mohajan.,2017). External validity is the extent to which the causal relationships can be generalized to distinct samples of the population, settings, and outcomes (Johnson *et al.*, 2014; Mohajan.,2017). Construct validity is the degree to which the evidence accumulated supports the intended objectives of the study (Johnson *et al.*, 2014; Mohajan.,2017). Statistical conclusion validity infers whether the predicted cause and effect covary and the magnitude of their relationship (Johnson *et al.*, 2014).

3.13.3 Qualitative Research Rigour

In qualitative studies, research quality is verified by looking at the following trustworthiness criteria: credibility, dependability, confirmability, and transferability (Lincoln and Guba, 1985). The next table provides a list of Lincoln and Guba's trustworthiness criteria and summarises the techniques for achieving them.

Table 3-6: Lincoln and Guba's (1985) trustworthiness criteria and techniques

Criteria	Techniques	Page
Credibility **(internal validity)**	1. Prolonged engagement 2. Persistent observation 3. Triangulation (sources, methods, investigators) 4. Peer debriefing 5. Negative case analysis 6. Referential adequacy (archiving of data) 7. Member checks	(pp. 301-304) (pp. 304-305) (pp. 305-307) (pp. 308-309) (pp. 309-313) (pp. 313-314) (pp. 314-316)
Transferability **(external validity)**	8. Thick description	(p. 316)
Dependability **(reliability)**	9. Overlap methods (Triangulation of methods) 10. Dependability audit examining the process of the inquiry (how data was collected; how data was kept; accuracy of data)	(p. 317) (pp. 317-318)
Confirmability **(objectivity)**	11. Confirmability audit examines the product to attest that the findings, interpretations and recommendations are supported by data	(pp. 318-327)

Both quantitative and qualitative criteria were considered in the study and a review of how these were met is discussed in Chapter 8.

3.14 Chapter Conclusion

This chapter provided a detailed description of the research philosophy that was used to conduct the study. The purpose of this mixed method study was to understand the Health Informatics Technology use by nursing and informatics practitioners; and to understand what are relevant nursing informatics training programs that are suitable for nursing and ICT practitioners in lower to middle-income contexts. This chapter also discussed the research design, philosophy and approach, methodological choice, data collection, data analysis, sample and setting, recruitment of the sample and unit of analysis. Ethical considerations were outlined as well as data collection procedures, questionnaire, interview questions and data analysis. Research quality and rigour was discussed with the criteria for achieving them in a mixed method study. The ensuing chapters will outline the results for the questionnaire data collection from the Nursing Students.

CHAPTER 4 POST GRADUATE NURSE PERSPECTIVES

4.1 Introduction

In Chapter 3 the research design and philosophical Influences were discussed. Pragmatism was discussed as the research philosophy and mixed methods as the methodological framework guiding the study and influenced the axioms of the research inquiry. In this chapter, the perspectives of the post graduate nurses were explored. The characteristics of the participants were first generated, and the associations of the characteristics with the results were then produced. The objectives of phase one was to seek answers to the following sub questions: (1) *what is the current state of nursing practitioners attitude towards nursing informatics*? and (2) *what is the current state of competencies in nursing informatics do nurses have*?

4.2 Participants Characteristics

Of the 85 participants who completed the questionnaire, 18 participants did not give consent without providing a reason, and a total of 25 respondents failed to answer all baseline (P.A.T.C.H.) questions. Those 43 respondents were omitted from the analysis, leaving a usable sample size of N=42. The participants' ages ranged from 20 years old to 59 years old. Participant demographics were generated and are outlined in the next.

Table 4-1: Participant Characteristics

Age range	**20-29**		**30-39**		**40-49**		**50-59**	
Age (no of students in the age range above)	n	%	n	%	n	%	n	%
	7	17%	20	48%	9	21%	6	14%

The demographics profile of the nursing participants indicates a representation of mostly between 30 and 59 years old. The results indicate a finding that 16% of participants were digital natives, within the age categories of 20 to 29 years. The digital emigrants age groups were 30-39, 40-49 years and 50-59 years were 8.

4.1 "A" average and "B" average Scores

The Data Analysis tool for the PATCH assessment Questionnaire is the PATCH Assessment Scale Score described in the PATCH Assessment Questionnaire Section of Chapter 3; the points obtained from the analysis are displayed as percentages as findings in Table 4.2 below. Indicating the percentage scores for a positive response towards computers as the A average and the percentage score for the negative response towards computers as the B responses.

Table 4-2: Responses per age group

Age range	20-29	30-39	40-49	50-59
A (average) - positive response	39 %	42 %	33 %	33 %
B (average) - negative response	31 %	36 %	36 %	33 %
A+B (average)	74 %	77 %	68 %	66 %

4.3 Results

The results are indicated in the following sections.

4.4 Attitude (A+B) Average Scores Interpretation

The Kaminsky's PATCH Assessment Score Interpretations Table is divided into six categories starting with 0 points to a maximum of 100 points. Each of these categories provides a description of the characteristics that a participant would have, with regards to their total obtained from the P.A.T.C.H Assessment Scale Version 3 Scoring Tool. These ranges are described as follows:

(1) categories 0 -17 points show a positive indication of cyber phobia.

(2) 18 – 34 points, indicates some uneasiness on using a computer.

(3) 35 – 52 points, means that the participant has moderate comfort in using a computer.

(4) 53 – 69 points, suggests that the participant feels comfortable using a computer, and the user has a realistic view of current computer capabilities in health care.

(5) 70 – 86 points, indicates the participant is confident in using a variety of programs; and (6) 87 – 100 points, implies that the participant is very confident and can learn a computer to boost creativity.

A score for each participant was computed, which is the sum-total of both A and B. The totals per category are indicated in Table 4.3 below and represented as percentages.

Table 4-3: Summary of Responses per category in relations to the Statements on the PATCH Assessment v3 Score Interpretation of June Kaminsky 1996 – 2019

Interpretation	Range of Scores	Composite A and B
Indicates signs of cyberphobia	0-17	0
Indicates the user is unsure of the usefulness of computers in health care	18-34	0
Indicates limited awareness of the applications of computer technology in health care	35-52	5%
Indicates the user has a realistic view of current computer capabilities in health care	53-69	56%
Indicates the user has an enthusiastic view of the potential of computer use in health care	70-86	32%
Indicates a very positive view of the potential of computer use in health car	87-100	7%

4.4.1 Attitude - Anxiety

The outcomes from the PATCH Assessment Score Analysis indicate that none of the participants showed any cyberphobia, the lowest level of attitude towards computers was that 5% of the participants indicated limited awareness of the application of computers in healthcare and have moderate comfort using a computer. Of the participants, 56% are comfortable using a computer and had a realistic view of the capabilities of computers in healthcare. There are some participants, 7% who have a positive view of computers in healthcare. The results indicate that there is an overall positive attitude towards the use of computers with most participants comfortable in using computers.

4.4.2 Validity of Questionnaire -Cronbach Alpha Coefficient

A single administration was conducted, and according to Mertens and Wilson (2018:361), when participants take one test to determine the reliability of the test, there is need to test for the consistency of the test using a statistical method. This was necessary in the inquiry as only one paper administration of the questionnaire could be done. In this inquiry a Cronbach's alpha coefficient test was conducted. The formula for the Cronbach's alpha has three components required for its calculation. These are the number of items, the variance of the observed total scores, and the variance of item i for person y. The test was conducted on the variables that were used in the calculation of Kaminsky's Score. These were used as the two, attitudinal categories required to conduct a test on the Cronbach's alpha coefficient. The calculations produced a result of the alpha coefficient equivalent to 0.76584. This was an acceptable alignment with literature for a range of 0.7 to 0.9 (Tavakol and Dennick, 2011), indicating acceptable reliability in the administration of the questionnaire to the students.

4.4.3 Competency – Skill – PATCH Assessment Scale

Competency is defined as comprising of attitudes, knowledge and skills. The PATCH Assessment Scale provided some skills self-assessment questions such as: "*I feel I am a skilled typi*st", of which 32% of participants agree that they are skilled typists; "*I like to use the Internet to research health and nursing information*" of which 98% of participants indicate strongly that they use the internet; "*I enjoy using technology to communicate with colleagues (email, etc.)*"; 85% of the participants indicate that they use technology for communication "*Computers help me to keep up to date with nursing issues, knowledge, research*"; 93% of the participants agree that they use computers when seeking nursing information for various reasons; and "*I use health care apps on my cell phone or SMART phone*"; 73% agree that they use healthcare applications.

This is a finding that indicates that participants have some skill sets in computer use and to utilise the basic computer applications for typing, the Internet and mobile healthcare apps.

4.4.4 Computer Literacy

The participants were then asked to rate their experience in using some informatics tools. They were asked to rate themselves as either: (1) no experience or were novices; (2) have some experience or were advanced beginners; (3) were comfortable users and were competent or (5) were skilled, proficient users. Although 42.1 percent of the participants were comfortable using Word Processing packages, participants were not experienced or were novices with regards to Spreadsheets (53.1 percent), PowerPoint Presentations (37.8 percent) and Databases (45.5 percent). In the latter competencies where participants indicate that they are novices, they express their interest in acquiring the competency and stating the following for their plan of action in acquiring the skills.

‘Not competent, yet would like to know more’ [Student 2]

‘Would benefit more on further course on computers’ [Student 37]

‘Learn how to create calculations on Excel for statistical purposes and reports’ [Student 29]

‘Comfortable and competent in it. Use it for monthly outcome for my presentations’ [Student 29]

‘Develop mock presentations to improve my skills. This is a skill I need for my employment’ [Student 41]

Of note is that the participants scored highly as comfortable or competent users on Cell phone, Smart Phone, Tablets, Chat Room Forums and Social Media competencies. Further to indicate their self-rating of competency, the participants were also requested to indicate five competencies that they are interested to develop as skills. Responses from the participants were categorised into subthemes and themes as per Saldana (2016) and are illustrated in the Figure 4-1.

Participant No	Participant Name	Goal	Sub Theme	Theme
28	student29@cput.ac.za	To do an advanced computer course to enable me to be a proficient computer user	Advanced Computers	Advanced Computer Literacy
28	student30@cput.ac.za	Advanced Excel	Advanced Excel	Advanced Computer Literacy
29	student32@cput.ac.za	Basic and Advanced Literacy	Basic Computer Skills	Basic Computer Literacy
27	student27@cput.ac.za	To be more computer competent	Basic Computer Skills	Basic Computer Literacy
29	student30@cput.ac.za	To know computers better	Basic Computer Skills	Basic Computer Literacy
23	student24@cput.ac.za	Master all the basic functions on the PC	Basic Functions of PC	Basic Computer Literacy
23	student23@cput.ac.za	Master basics in computers within a year	Computer Basics	Basic Computer Literacy
31	student31@cput.ac.za	Learn more on computer hardware	Computer Hardware	Basic Computer Literacy
21	student22@cput.ac.za	To use the computer quickly and effectively I both excel etc	Computer Literacy	Basic Computer Literacy
29	student31@cput.ac.za	To know how to help others to use computers	Computer Support	Basic Computer Literacy
29	student30@cput.ac.za	To be able to email	Emailing	Basic Computer Literacy
19	student19@cput.ac.za	To be well versed in using Microsoft word to its full extent	Microsoft Word	Basic Computer Literacy
21	student21@cput.ac.za	To use PowerPoint presentations in may e health education to make it more understandable	Powepoint	Basic Computer Literacy
23	student25@cput.ac.za	Become a good typist within 1year	Typing	Basic Computer Literacy
23	student26@cput.ac.za	Be able to use the programes	Use programmes	Basic Computer Literacy

Figure 4-1: An excerpt of the thematic analysis of the desired competencies

Seven (7) themes of competencies were derived from the participants' selections and are indicated in Figure 4-2. These codes were derived from a grouping and categorisation of thirty (30) sub-themes. The sub-themes were considered in terms of similar and duplicate theme names and descriptions that resulted into the final seven (7) themes. These themes are a representation of the participants' perceptions on competencies they would like to take up as part of their upskilling.

	A	B	C
1	*Theme*	*Sub Theme*	COUNTA of Goal
2	Advanced Computer Literacy	Advanced Computers	1
3		Advanced Excel	1
4	Advanced Computer Literacy Total		2
5	Basic Computer Literacy		1
6		Basic Computer Skills	3
7		Basic Functions of PC	1
8		Computer Basics	1
9		Computer Hardware	1
10		Computer Literacy	1
11		Computer Support	1
12		Emailing	1
13		Microsoft Word	1
14		Powepoint	1
15		Typing	1
16		Use programmes	1
17	Basic Computer Literacy Total		14
18	Data Management	Data Capture	1
19		Database Use	1
20	Data Management Total		2
21	Education and Research	E-learning	1
22		Education	1
23		Research	2
24	Education and Research Total		4
25	Social Media	Communication Platform	1
26	Social Media Total		1
27	Software Design and Development	Create an app	2
28		Design	1
29		Graphic Design	1
30		Website Development	1
31	Software Design and Development Total		5
32	Technical Writing	Blogging forum	1
33		Vlogging	1
34	Technical Writing Total		2

Figure 4-2 Themes from the Competencies Responses

4.4.4.1 Theme One: Advanced Computer Literacy

Theme one looked at upskilling the nurses with advanced computer literacy skills. The participants stated an interest in gaining advanced computer skills, this they indicated would enable them to be a proficient user. The topic of interest in this advanced computer literacy was Microsoft Excel.

The key finding for this theme is that participants are interested in developing advanced computer skills. They especially indicated Excel as a software of interest.

4.4.4.2 Theme Two: Basic Computer Literacy

Theme two included the upskilling of nurses in basic computer literacy. This considered topics like Microsoft Word, Excel, PowerPoint and being able to email. In addition, participants indicated they were interested in improving their typing skills as well as learn more programs and computer hardware. The participants said the following about their goals:

> *"To be well versed in using Microsoft word to its full extent" [Participant 19]*

> *"To use the computer quickly and effectively I both excel etc" [Participant 21]*

> *"To use PowerPoint presentations in e health education to make it more understandable" [Participant 21]*

> *"Become a good typist within 1year" [Participant 23]*

> *"Be able to use the programmes" [Participant 23]*

> *"To be able to email" [Participant 29]*

> *"Learn more on computer hardware" [Participant 31]*

The key finding for this theme is that participants would like to be upskilled in digital technology applications but use as examples only software they know instead of considering more recent technologies. Additionally, they would like to learn computer hardware.

4.4.4.3 Theme Three: Data Management

In theme three, the participants expressed interest in data management skills. They considered data capturing and accessing databases as primary goals and said the following:

> *"To be able to access databases effectively" [Participant 31]*

The key finding for this theme is that participants would like to learn data management skills for their data capturing and database accessing needs.

4.4.4.4 Theme Four: Education and Research

Theme four, education and Research looks at the education of the nurses in being able to make use of eLearning Learner Management Software, being able to structure an assignment in a software and being able to conduct information search to conduct research. The participants expressed this by saying:

> *"I need to learn how to work on a computer correctly to stay up to date with the latest nursing research" [Participant 25]*

> *"Be proficient in aligning my Assignments" [Participant 31]*

The key finding for this theme is that participants would like to be able to make use of eLearning Learner Management Software and be proficient in conducting information search from databases for research.

4.4.4.5 Theme Five: Social-Media

Theme five, social media expects the nurses to be able to use social media for communication. This maybe to communicate texts or images between nurses and other health practitioners. The participants indicated this by saying:

> *"Communication platform -electronically between doctors and nurses" [Participant 17]*

The key finding for this theme is that participants would like to be competent in the use of social media for communication purposes between the nurses and doctors.

4.4.4.6 Theme Six: Software Design and Development

In theme six, software design and development the nurses would be creators of digital health technologies. They would have the skills to design and develop applications for their contextual needs. This was expressed by the participants who said:

> *"Create my own website" [Participant 16]*

> *"Create an app for nursing personal education" [Participant 17]*

> *"To be proficient on Design" [Participant 33]*

The key finding for this theme is that participants would like to be creators of their own digital health technologies, especially developing websites and applications development.

4.4.4.7 Theme Seven: Technical Writing

In theme seven, technical writing the participants would be content creators. They would have technical writing skills in blogging and vlogging. Participants expressed interest in this saying:

> *"Start a blogging forum" [Participant 33]*

The key finding for this theme is that participants would like to be content creators, especially to post blogs and vlogs.

4.4.5 Methods of Skilling

The participants were further asked for a plan an action for equipping themselves with nursing informatics skills. The key finding for skills development methods is that they prefer self-study, to attend workshops, and to enrol in college and in service training.

4.5 Main Findings for the Nurse Practitioner Perspective

- The majority of participants (84%) were digital emigrants aged 30 to 59 years. Sixteen percent of participants were digital natives aged 20 to 29 years.
- Nurses' attitudes are positive towards the use of computers as most participants were comfortable in using computers.
- In addition, nurses indicate:
- They were competent in computer use and to utilise the basic computer applications for typing and using the internet and mobile healthcare apps.
- They are interested in the seven knowledge areas related to digital health that have the potential to improve their nursing practices.
- They would prefer to develop their nursing informatics competencies through the following methods such as: self-study, to attend workshops, and to enrol in a college for an in-service training.

This Chapter considered the initial phase of the study and the perspective of nursing practitioner students. Outcomes from the study indicate that nurse student practitioners have a good attitude towards computers, they are comfortable using computers. They have some skills in computer use with the ability to type, search and synthesise information from the internet and use health apps. Although participants indicated efficiency in Microsoft Word, they noted that they needed training in seven (7) knowledge areas. A discussion on how the participants could be trained was also noted with options provided by the participants. The next chapter will look at the perspectives of the Educators both Nursing and Information Technology.

CHAPTER 5 EDUCATOR PERSPECTIVES

5.1 Introduction

In this chapter the perspectives of the educators of both nurse and informatics educators were considered. In addition, the IDEHELA experience is outlined. This was to provide a broader view of the education lens through which the study was being considered. The results from the study were analysed as part of the mixed methods convergence design. This chapter serves to highlight the data collection process, the number of research participants, Furthermore, this chapter presents the data analysis process, emergent themes, interpretation of results and the subsequent findings.

5.2 Participant Interviewing

Chapter 3 introduced the research methodology implemented for interviewing the Educators. Purposive sampling was implemented in the selection of participants. Emails were sent to the participants requesting permission for a date and time when the interview could be conducted.

A consent form was sent to the participants with a summary of the purpose of the interview and copies of the TIGER and HIT competencies frameworks. The interview questions were derived from the research questions according to Rubin and Rubin (2005), to ensure that data collected can be used to address the identified research gap. The research question (RQ) key concept refers to the specific theoretical concepts related to each sub-research question. The interview questions were open-ended to allow the participants to elaborate their perspectives. In the next table, the research questions, research objectives, interview questions for data collection and the RQ key concept are outlined in the next table.

Table 5-1: Interview Questions mapped to the Research Questions

Research Question (RQ1): What are the competencies of appropriate education programs that integrate applied competencies with the work activities of Nursing and ICT Practitioners in Africa?			
Research sub-questions	**Research objectives**	**Interview questions for data collection**	**RQ key concept**
SRQ 1: What is the current status of informatics in nursing and ICT courses?	To determine the current status of the respective programmes globally and in a specific context	What do you know about Nursing Informatics or Health Informatics?	Awareness of Nursing Informatics or Health Informatics
		How have informatics competencies been integrated in your nursing program?	Current state of Informatics in Nursing Programs
		How has health domain knowledge been integrated into informatics program?	Current state of health domain knowledge in Informatics Programs
SRQ2: How are the informatics competencies applied in practice in healthcare?	To establish the attitude and competencies for digital technology use in practice	Where do nurses utilise informatics competencies in their work practise?	Use of Informatics in Nursing Practice
Research Question (RQ2): Why is the intersection between health sciences and informatics complicating the design of relevant courses for required competencies in the two respective disciplines?			
SRQ 3: How do nursing informatics courses develop competencies to equip nurses' involvement in digital health technologies development and support?	To determine how nursing informatics courses develop domain competencies to involve nurses in digital health technologies development and support	What are the challenges of developing informatics courses for nurses?	Complications of intersection between health sciences and informatics
		How can nursing informatics courses enable nurses to develop digital health technologies?	Training needs
SRQ4: How do health informatics courses develop/prepare ICT practitioners to involve nurses in the development and support of digital technologies to enable nursing practices?	To determine how informatics courses develop ICT practitioners to involve nurses in the development and support of digital technologies to enable nursing practices?	What are the challenges of developing health domain knowledge courses for ICT practitioners?	Complications of intersection between health sciences and informatics
		How can health informatics courses enable ICT practitioners to involve nurses in the development of digital health technologies?	Training needs

Next the participant characteristics are discussed.

5.3 Participant Characteristics

Six participants were interviewed to collect data on their perspectives on health and nursing informatics education. These were the only ones involved in health informatics-related education or post graduate research in a health informatics-related topic. Three participants were nursing educators and three were informatics educators. The participants had a minimum of masters' degrees and were currently working as educators. The selection criteria were that these educators must be involved in informatics education and have a good understanding and experience of informatics competencies. The participant profiles are indicated in Table 5.2 below. At that stage nurse educators with a PhD were scarce and having a formal qualification and experience in health informatics was not yet well established in South Africa. Through the INDEHELA collaborative network, there were a few research studies in health informatics to build the necessary capacity.

Table 5-2: Nursing and Informatics Educators Participant Profiles

Participant	Role in Organisation	Highest Qualification
Participant 1	Nurse Educator	PhD
Participant 2	Nurse Educator	Masters
Participant 3	Nurse Educator	Masters
Participant 4	Informatics Educator	Masters
Participant 5	Informatics Educator	PhD
Participant 6	Informatics Educator	PhD

5.4 The Thematic Analysis Process

The interviews were transcribed, and the researcher examined the raw textual data line by line to identify distinct, ideas, actions, and perceptions of relevance that were coded as concepts. A coding process was applied whereby the words or phrases were assigned descriptive codes. The researcher made use of the descriptive codes to tag the emerging keywords or phrases and thereafter, to categorise the themes. According to Saldana (2009:8), "*To codify is to arrange things in a systematic order, to make something part of a system or* *classification, to categorise*”. There are several different types of coding: open coding, axial coding and selective coding (Neuman (2015).

Open coding is a method where the transcribed data is first broken down and analysed to identify concepts, categories, or themes. It involves producing initial codes that capture the main ideas or concepts found in the data. It aims to identify key ideas that are hidden in in the data. Axial coding involves a more detailed and systematic exploration of the data to identify relationships between categories and subcategories identified during the open coding phase (Bhattacherjee, 2012).

Whilst open coding is distinct from axial coding, both can be performed simultaneously (Bhattacherjee, 2012). For this study, open and axial coding were applied, ultimately providing the researcher with the ability to sort and organise the data from the interviews and arrive at the concomitant themes.

According to Saldana (2016) themes generated from the coding can be linked to categories and subcategories, and as such, every sub-theme that emanated was broken into its categories and subcategories and this was interpreted to point to a certain theme. The Interviews were transcribed and captured. Participant Member checking was conducted to validate the results. Thematic analysis of the outcomes was conducted as indicated in Figure 5-1.

RSQ	Descriptive Code	RQ Key Concept	Key Concept	Category	SubTheme	Theme
1.2	*know the possibilities and the potentials'*	Nursing Course	Opportunities for Integration	Workflows	Business Process Workflows	Context of Practice
1.2	*It's going to apply to all. The degree to which it applies is the type of data that you are going to enter that is going to be different between Undergrad and Postgrad*	Integration of Informatics in Nursing Course	Data is different for different levels	Data Management	Data Analysis and Management	Context of Practice
1.2	*I don't think it would be possible to do the short courses, and also if you do a short course you write all those competencies for the person there are going to be totally lost because they can't apply as defiantly integrated as they go through the curriculum*	Integration of Informatics in Nursing Course	Course Application for students	Short Course	Integrated Course or Short Course	Course Structure
1.2	*lesson in how to use the Learner Management System (LMS) is the only computerised content*	Integration of Informatics in Nursing Course	Current Informatics Content	Workflows	Business Process Workflows	Context of Practice
1.2	*I think the integrated works best now, because we have so many different types of technology that different hospitals user and because the students are exposed to, in practical in different sense throughout their 4 years of their courses*	Integration of Informatics in Nursing Course	Course Structure for Nursing Program	Integrated Course	Integrated Course or Short Course	Course Structure
1.3	*"Most of the IT courses the IT students should have gone through them during the course of their study, a short course or dedicated course would be appropriate*	Integration of Health in Informatics Course	Short or dedicated Course	Short or Dedicated Course	Integrated Course or Short Course	Course Structure
1.3	*I think some of the topics should be taken as a short course and some can be integrated in the main course*	Integration of Health in Informatics Course	Short Course or Integrated	Short Course	Integrated Course or Short Course	Course Structure
1.3	What is the aim of the course…the IT students need the Health component, that is what they are lacking	Integration of Health in Informatics Course	Need for Health Domain	Content	Course Content	Course Structure
2.1	*"if the Sister is not in and take the doctor around and be able to say look the sister in charge is not here, to the students who are around, this is how you can decided the work schedule*	Use of Informatics in Practise	Work Schedule Data Management	Data Management	Data Analysis and Management	Context of Practice
2.1	*Data doesn't necessarily mean statistics… they have to go through a site, analyse and identify the risks*	Use of Informatics in Practise	Data Statistics and Analysis	Data Analysis	Data Analysis and Management	Context of Practice
2.1	like the IVF thing, that type of thing it's not the same any more in Wards in Hospitals	Use of Informatics in Practise	Data Capturing	Data	Data Analysis and Management	Context of Practice

Figure 5-1 An excerpt to illustrate the data analysis of the educators' interview responses

5.5 Results

Three themes arose from the interviews, under these, seven subthemes were derived. These are illustrated in Table 5.4 below. Each theme and its related sub-themes are discussed from both health and informatics domains.

Table 5-3: Interview Results Themes

Themes	Sub-themes
Context of Practice	Awareness of Context
	Business Process Workflows
	Data Analysis and Management
Course Structure	Integrated Course or Short Course
	Course Content
Mental Maps	Student Mental Maps
	Collaboration

5.5.1 Theme One: Context of Practice

The fields nursing and health informatics are derived from a combination of other fields with the nursing and informatics being the core fields. Due to the amalgamation of fields, it was important to ascertain the perspectives of the educators of both nursing and informatics on the context of the fields. This theme has three sub-themes.

5.5.1.1 Sub-Theme one: Awareness of Context

Nurse Educators Perspectives

To determine the current situation of nursing and health informatics, the nursing educators were asked if they were aware of nursing or health informatics respectively. This was asked to determine how much knowledge the educators had about nursing informatics.

The nursing educators were not sure about what was entailed in the discipline of nursing informatics. This was voiced by a participant who stated:

"I am aware of it not that in depth, I've never actually worked with that " [Participant 2].

When asked what they thought about Nursing Informatics or Health informatics in terms of practice and Nursing education the participants voiced the importance of the nursing informatics discipline. One participant in describing the importance stated the following:

"… it's important for every sphere of Nursing , whether it's Undergrad Studies or for students also, I mean socially , personally its interrelated into everyday living , so there is no way that you can avoid it " [Participant 3].

Informatics Educators Perspectives

To determine the current situation of health informatics education, IT educators indicate that they were involved in some health informatics activities. Participant 4 indicates that they had been involved with organisations that developed and maintained health information systems. The educators were involved in health informatics studies as they were taking further advanced studies in a post-graduate course with health informatics as the domain of study. The IT department was more knowledgeable about the disciplines of nursing and health informatics. When asked if there were any courses being offered within the IT department that were health oriented, the response was that a fourth-year elective course is being offered for Bachelor of Technology Honours in IT. This is taken over a period of a semester which comprises of 6 months. In addition to the elective course, an honours research project, masters, and doctoral research studies in health informatics by thesis were being offered.

When the IT educators were asked about their opinion on health informatics, they indicate that they do not see the disciplines as two separate fields coming together to form another discipline, they saw it as one discipline differing from the health and the informatics.

5.5.1.2 Sub-Theme two: Business Process Workflows

Nurse Educators Perspectives

The nursing educators, although aware of nursing informatics, were not well versed with the discipline. This was emphasised by one participant, mentioning that the educators are not able to teach nursing informatics, because they are not familiar with the theories and concepts that are found in the field. The main reason for this is that as digital immigrants, they have not been exposed to Informatics possibilities within the nursing field, and they are not aware of how nursing informatics can be utilised or taught. As a solution to this problem the participant suggested that training of educators be done to equip them with the knowledge and skills:

> *"They will be able to find the opportunities, that are there within the courses, because the opportunities are there, opportunities are there … I need to know it before I can actually look for it to expose my students, and most of us have trained before this so we don't even know the possibilities and the potentials" [Participant 1].*

When asked if there were any informatics courses that were being offered, the nursing educators indicate that a lesson on how to use the Learner Management System (LMS) was the only computerised content that they were taught. This meant that the students were taught how to retrieve assignments, conduct assignments, and upload assignments that are required by their lecturer. Simulation models, which the students are exposed to, were for training the students, simulating the heart sounds and respirator sounds. None of the models were computerised and were therefore not available on the LMS or any online system. Nursing Informatics was of interest to them as the educators mentioned that within practice there was introduction of a clinical health information system, where practitioners captured the vitals of the patient, and students would need to be proficient in using the system.

Informatics Educators Perspectives

When considering the nature of knowledge that would be required for informatics students, the IT educators were concerned that IT students are not familiar with the context of health. IT students feel that they are already familiar with the IT courses in the design, development, and implementation of software and hardware information technologies but they lack the contextual domain knowledge. They need to acquire competencies in understanding, analysing and synthesising data from the business workflow processes and workflow processes of the participants. This was stated by the participants indicating the following in practice.

> *…problem probably for the IT people to create the right solutions that will work in practice, if they don't understand how the practice works out." [Participant 5].*

> *" … you would need to know about the Hospital Environment or the and the broader health care system…. For an IT person this whole concept of continuity of care needs to be linked with the records in other words, highly structure records so that you can get continuity of care or sharing right," [Participant 5].*

"… Would be the eHealth records [okay] the health records the personal health records of individuals how do you deal with them?" [Participant 6].

"I would visit the centres, for example you are dealing with health I would take a group of students, visit a health centre. We go there for the week and observe what is happening there. So, the students get first-hand information from the people who work with health" [Participant 6].

In addition to learning about the context of health, educators indicate that students need to learn about digital technologies enabling health practices. They indicate that these are integral for an IT student to know as IT practitioners make recommendations on the hardware and software that is used within a health information system. This was stated by the educators saying:

"there is the technology and there is the workflow, when you look at the system you are looking at all of that…" [Participant 4].

5.5.1.3 Sub-Theme three: Data Analysis and Management

<u>Nurse Educators Perspectives</u>

When shown the Tiger and the HIT Comp competencies, the nursing educators were initially surprised that they were structured on a Blooms competency scaling and identified competencies that were already being taught within the current curricula. The data information and knowledge domain competencies are all necessary for all the nursing students to know. This involved knowledge of the following topics: principles of nursing informatics; information and knowledge management in patient care; nursing documentation (including terminologies); decision support by IT; information management in informatics research; information management in teaching, training and education and resource planning and logistics. They indicated that these competencies are important as base knowledge for the students and some of these aspects are already being taught. On closer inspection of the competencies, they concurred that all the competencies are relevant to their context. One of the participants commenting on the competencies said:

"… It's going to apply to all. The degree to which it applies is the type of data that you are going to enter that is going to be different between Undergrad and Postgrad" [Participant 2].

Key examples in practices that were used, underlined the need for competencies that enabled the practitioner to be able to capturer, analyse and manage data. The capturing of the data, conducted at source is done in various contexts of practice, for example:

"if the Sister is not in and take the doctor around and be able to say look the sister in charge is not here, to the students who are around, this is how you can decide the work schedule" [Participant 1].

"for example, if you qualify you might at a high level start integrating and developing a care plan, whereas at undergrad level you might just be entering say vital signs… Undergrad has a lot of procedures than Postgrad, you have to enter data before even after doing a procedure…" [Participant 2].

"Data doesn't necessarily mean statistics… they have to go through a site, analyse and identify the risks…" [Participant 2].

"…like the IVF thing, that type of thing it's not the same any more in Wards in Hospitals [Participant 3].

An additional competency that nurse practitioners need is decision support. Decision support occurs at all levels of education of the nurse practitioner. According to the educators at the undergraduate level, for example in praxis:

"…you need to keep track of who has got the flu and who is diabetic… and see who is able to provide the food" [Participant 2].

For the post-graduate student, educators noted that they are not limited in the amount of information they access and use. This includes the type of information that they use. The nature of their work is more information intensive and as such decisions made at that level are for example:

"Data doesn't necessarily mean statistics… they have to go through a site, analyse and identify the risks…" [Participant 2].

"Allocation of staff, allocation of responsibilities, getting or ordering of stuff" [Participant 2].

5.5.1.4 Context of Practice Findings

Key findings for the nurse educators are that there is a paucity of knowledge of nursing informatics by nursing educators. In addition, educators need training to be able to lecture content of the nursing informatics discipline. The latter was important to the educators as it would enable them to see relevant areas in the context which they could use as examples within their classrooms. An exploration of the TIGER competencies with the nurse educators indicated that they were not aware of the framework or any international framework and could not conceptualise competencies for the nurse practitioners. The exploration provided the nurse educators with a perspective of areas within the context of practise where students make use of informatics. Thus, the training of educators would enable them to transfer that knowledge to their students; understanding informatics and its application in practise.

Understanding how nurses use informatics tools in their practice, is key to knowing what content to lecture. Key findings indicate that there are various areas where nurses use informatics tools for example, nurses use information systems for data capturing for their workflow processes; for patient vitals and statistics; decision-support; evidence-based practice; and patient data recording and capturing; data analysis; and to identify and ascertain patient risks. This context knowledge indicates that nurses often use their knowledge, intuition, and experience to make decisions, based on their awareness of a particular situation with informatics tools providing that information.

Key findings for the informatics educators indicate that informatics students lacked contextual health domain knowledge. In addition, students need to know the workflows of the health domain for each practitioner, as well as the use of digital health technologies. It was noted that informatics students already have the informatics domain knowledge, however they had challenges in the development of relevant informatics tools, because they did not have contextual knowledge of the health domain, and to understand the decision-making processes in the workflows and health technologies use.

The main findings in the context of practise theme are: (1) There is a paucity of knowledge on the nursing informatics and health informatics disciplines and even of the International Competency Frameworks, thus there is a need for advocacy of nursing informatics and health informatics for their inclusion in the nursing and informatics curriculum; (2) Nurse educators need skilling in informatics so that they can be able to find examples which they may use in their course content; (3) Nurses use informatics tools to aid them with data capturing, decision support and data analysis within their practise; (4) Informatics students lack the contextual health domain knowledge and need to know the decision making processes in the workflows and health technological use.

Therefore, from these findings we can indicate that there is a lack of knowledge on Nursing Informatics by nurse educators, hindering them from including competencies in their courses even though there is evidence of nurses using informatics competencies in practice. Findings also indicate that Informatics students need health domain knowledge with a particular focus on workflows and decision-making processes.

5.5.2 Theme Two: Course Structure

The course structure was a key concern of the educators. The course structure determines the competencies required for the course, the outcomes, and the content of the course. This theme has two associated sub themes.

5.5.2.1 Sub-Theme one: Integrated Course or Short Course

<u>Nurse Educators Perspectives</u>

One of the key concerns that the educators have is whether to have a separate course or to integrate the informatics or health knowledge into the course curricula as it is taught. The challenge that the educators have is the conceptualising the content of the course. To overcome this challenge, the educators were shown the TIGER and the HITComp competencies. After taking a look at the TIGER and HITComp recommended competencies, the nurse educators recommend that the competencies should be integrated into the course curricula that the nursing students would be doing. This, participants said would be ideal for the following reasons:

> *"I don't think it would be possible to do the short courses, and also if you do a short course you write all those competencies for the person there are going to be totally lost because they can't apply as defiantly integrated as they go through the curriculum" [Participant 2].*

> *"I think the integrated works best now, because we have so many different types of technology that different hospitals user and because the students are exposed to, in practical in different sense throughout their 4 years of their courses "[Participant 3].*

<u>Informatics Educators Perspectives</u>

The informatics educators also went through the TIGER and HITCompetencies frameworks to understand the nature of courses that could possibly be offered. They indicate that their students would benefit from a short course being taught, or an integration of health informatics into an IT course. This would be ideal for the following reasons:

> *"Most of the IT courses the IT students should have gone through them during the course of their study, a short course or dedicated course would be appropriate" [Participant 4].*

> *"I think some of the topics should be taken as a short course and some can be integrated in the main course" [Participant 5].*

5.5.2.2 Sub-Theme one: Course Content

<u>Nurse Educators Perspectives</u>

The educators for both nursing and informatics indicate that the offering of a health informatics course would depend on the course content. In voicing their concerns, the nursing educators note that whatever the course may be, it should lean on instructing informatics knowledge more than the health knowledge.

> *"It depends on the objective of the course… the offering for nurses should have more IT than Health" [Participant 1].*

<u>Informatics Educators Perspectives</u>

The Informatics Educators indicate that their course should lean on the health knowledge rather than the informatics knowledge. This was voiced by the following participants.

> *"What is the aim of the course…the IT students need the Health component, that is what they are lacking" [Participant 4].*

5.5.2.3 Course Structure Findings

Key findings in determining the course structure are that educators recommended that the competencies be integrated within the course curricula that the nursing students would be doing. Having looked at the competencies recommended by the TIGER; nurse educators felt it was possible to lecture the content integrated within the current course structure so that the students gain a holistic picture of informatics within their practise.

Another key finding is that the current skills of nurses within the context of South Africa lack the required digital health technology skills to benefit from such technologies in their practices. It was recommended that in the current situation, there is a need for both, an integrated, as well as a dedicated course. As there are still a large number of digital immigrants within the domain of nursing, they would need to be upskilled using a short course of computing basic skills, whilst the current students who are digital natives would go through the integrated course.

A key finding on course structure was that the course content depends on who the course is being offered to. If it is the nursing students, they are interested in the informatics content and the informatics students would require a course with health content. This was crucial in determining the competencies of a course and the outcomes that the participants would require.

A main key finding for the course structure theme is: (1) Given the current situation in South Africa where there are a large number of digital emigrant nurses, informatics courses offered should be both integrated within the curriculum as well as having short courses for digital emigrants; (2) Course content depends on who the program is intended for, nurses require a program with an informatics focus and informatics practitioners require a program with a health focus.

Therefore, we may indicate that there is a need for offering both an integrated and short course in Nursing Informatics in South Africa. Findings also indicate that courses should be offered to upskill the practitioner in the domain they lack.

5.5.3 Theme Three Mental Maps

This theme had two related sub-themes. A mental map in this study refers to the thoughts, experiences, and perceptions of the participants' relationships with digital technologies in practice. The application of informatics competencies in practice, provide, for example, the nurse with the means to observe, act, consider frequency, use technologies, record and manage patient-related information, to support a diagnoses (Cubas *et al.*, 2023). They refer to such a mental maps as the sense-making of the nurse's approach in dealing with the complexity of care aimed at improving the health state of a patient.

5.5.3.1 Sub-Theme one: Student Mental Maps

When looking at the mental maps of the nursing students, the educators note that there are two different types of students, digital natives, and the digital immigrants. Educators noted that digital natives, were younger, were comfortable with the use of technology and easily adopted the skills taught to them in the LMS. The digital immigrant students, who were older, were more cautious with technology use.

The Digital Immigrant students did not readily adopt to technology as noted in their use of the LMS. This, educators also noted, was the same in practice, as they said:

> *"The younger students because they are used to working with smart devices, they are used to working with smart devices. Your older students are a little same with your e-learning, your younger students are happier to work with a smart phone or with eLearning. or computers and al the older students feel very threatened because they feel like they haven't got the skills and they don't have enough faith in it." [Participant 1]*

> *"There are methods, methods in the clinic, the government has introduced, an application where they can access patient's data and stuff like that…. (The Older students) are seeing it as a burden, because they are not comfortable." [Participant 1]*

> *"…my feeling from working in Hospital is, the older nurse-midwifes like before technology was so used, the older nurse-midwife have issues with tech, they are very resistant to change, they are resistant to working on computers, that is what I've experienced everywhere that I have worked" [Participant 3]*

To counter these mental maps, the educators felt that scaffolding a course content would be suitable. The "*younger students*" could then take the more comprehensive courses, while the digital immigrant students could begin with the basics and then built on it.

> *"Starting with the basics not the basics only…. you want to move people from what they know to what they don't know, when they are able to see the link, so starting with small stuff simple things. Then they can gain confidence from small things at a time" [Participant 1]*

5.5.3.2 Sub-Theme two: Collaboration

The IT Educators felt that their students as they were already involved in the design, development, and implementation of health information systems, they need to have collaborative skills. These they felt, would allow the student to be able to understand the context of practice. The nature of IT practices is based on collaborative as they implement solutions in diverse contexts. This is not different within the health context, and students needed the soft skills for collaboration. This was their reason for saying this:

> *"IT students should have that knowledge…they need to work with the domain experts to develop the apps" [Participant 5]*
>
> *"For the IT students to gain domain knowledge they need to work collaboratively with domain experts" [Participant 6].*

5.5.3.3 Mental Maps Findings

There is a digital gap between generations of nurses and key findings indicate that the older generation of nurses are digital emigrants, unfamiliar with information technology while the younger nurses are digital natives already using digital technologies with their social connections. This is indicated by the fact that the older nurses have an aversion of digital products pose a challenge even when introduced to an informatics tool by the Department of Health which is meant to be part of their workflow. This indicates that there are two mental maps for which a course to provide for digital immigrants and digital natives.

When looking at how to empower the digital emigrants with informatics knowledge key findings need to cover the technology gap with a staggered approach to teaching and learning. This could be conducted by constructive knowledge, where the more familiar content is covered first and then more content is built on the familiar until all the content is covered. In this way the students may relate to the material and be able to connect the content to their work practise or life.

Looking at the mental maps of the IT students, the key finding is that IT students have been trained to develop, design, and implement IT solutions, and for them to develop these solutions, their key need is in developing collaborative skills. Collaborative skills will enable them to work with domain knowledge experts to produce relevant digital technologies for that domain.

The main key findings from the mental maps theme are: (1) There are two mental maps which have to provisioned for in a course for the digital emigrants and digital natives; (2) To cover the gap between nursing and informatics it is advisable to constructively build the knowledge, where the more familiar content is covered first and then more content is built on the familiar until all the content is covered and (3) IT students need to develop collaborative skills to enable them to work with domain knowledge experts.

Therefore, the findings indicate that there is need to constructively implement courses for both digital emigrants and natives. In addition, the findings indicate that collaborative skills are important for informatics students.

5.6 The INDEHELA Case

Not only is this study part of a larger collaborative project, but many other person, specifically student, lecturing staff and administrators also benefit from these funded projects that would otherwise not be possible. The principal researcher and project leader was Dr Mikko Korpela (Researcher Director, University of Eastern Finland, Finland; adjunct professor, Cape Peninsula University of Technology, South Africa at the time of the projects. The projects continued from his doctoral research that was done in Nigeria, hosted by the Obafemi Awolowo University in Ile Ife, Nigeria during the 1980s. In addition, it was also a continuation of work already done in health informatics education that helped to provide a meaningful baseline to guide the projects (Saranto *et al.* 2001) This project was funded by the academy of Finland (Korpela et al., 1998). The information about the INDEHELA activities, collaborations and experiences (Figure 5-2) is sourced from a personal reflection presented by Dr Mikko Korpela, at a public networking event on 16 October 2018 at CPUT (Korpela, 2018). All the results form part of the different reports submitted to the funding organisations to support the reflections.

INDEHELA (**In**formatics **De**velopment for **Hel**th in **A**frica) is a long-term initiative to strengthen the capacity of the participating African higher education institutions to **contribute to the socio-economic and human development** in their countries, particularly in the **scientific field of Health Informatics** (HI) and the **practice of e-health**.

… by means of **international collaboration**.

Figure 5-2: INDEHELA Collaboration

The first project was: *Methods for informatics development for health in Africa* (1998-2001) with partner institutions HIS R&D Unit, University of Kuopio (later to become the University of Eastern Finland - UEF) and the Department of Science and Engineering, Obafemi Awolowo University (AOU), Nigeria. An important focus was that any development, education, and research must ultimately benefit the communities and their citizens with the aim of a positive impact. In addition, the importance of contextual factors, appropriate methods, and sustainable solutions need to be considered to commit to positive outcomes.

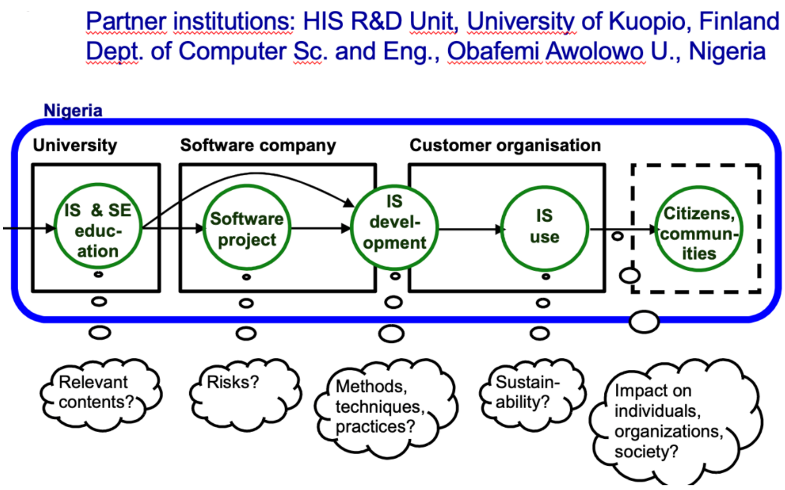

Figure 5-3: INDEHELA Methods

The universities from Mozambique and South Africa became part of the INDEHELA network for the INDEHELA-Context (2004-2007) research project funded by the Academy of Finland.

The participating universities were University of Eastern Finland (UEF), Savonia University of Applied Sciences (SUAS, Finland); Cape Peninsula University of Technology (CPUT, South Africa), Abofemi Awolowo University (AOU, Nigeria) and Eduardo Mondlane University (EMU, Mozambique).

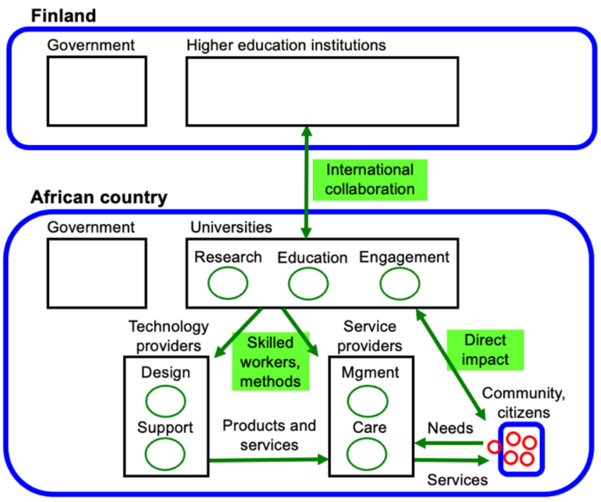

Figure 5-4: Universities and communities networked through activities, services, organizations, countries

An important focus of the INDEHELA projects was the emphasis on the needs of the beneficiaries from their communities to consider the impact of the initiatives on their situation. This framework became the basis for all the INDEHELA activities as well as the post-graduate studies. The aim was to consider context-sensitive methods suitable for the local contexts.

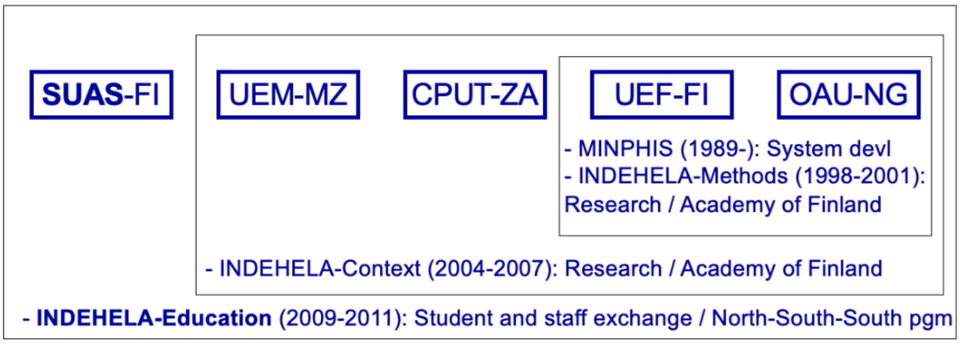

Figure 5-5: The INDEHELA-Context project and partners

During 2009-2011 staff and student exchanges took place between the participating universities as part of the INDEHELA-Education collaboration funded by the North-South-South programme. This was followed by the INDEHELA-Exchange collaboration from 2012-2014, and INDEHELA-Access from 2014-2015. The Higher Education Institutions Institutional Cooperation Instrument (HEI ICI) supported cooperation projects between higher education institutions in Finland and funded the INDEHELA-ICI for eighteen months from 2011-2012. The INDEHELA-ISD4D research project (2011-2015) funded by the Academy of Finland focused on Information Systems Development for (human) Development (ISD4D). There were also other collaborations that had different objectives and activities, but all aligned to the same priorities. The Kujali Innovation Hub was established at CPUT in 2012, funded by the South African Finland Partnership (SAFIPA) to pay interns and researchers to develop innovative solutions in healthcare. Unfortunately, the funding was only until 2015 but the Kujali Hub continued its operation until 2018 when the lead researcher resigned. Even though the Kujali Hub was regarded as a success for the university, there was unfortunately any funding allocated to sustain its operation. There were other collaborative projects outside INDEHELA but still well-aligned to the INDEHELA priorities. These collaborations and participating universities are depicted in Figure 5-6.

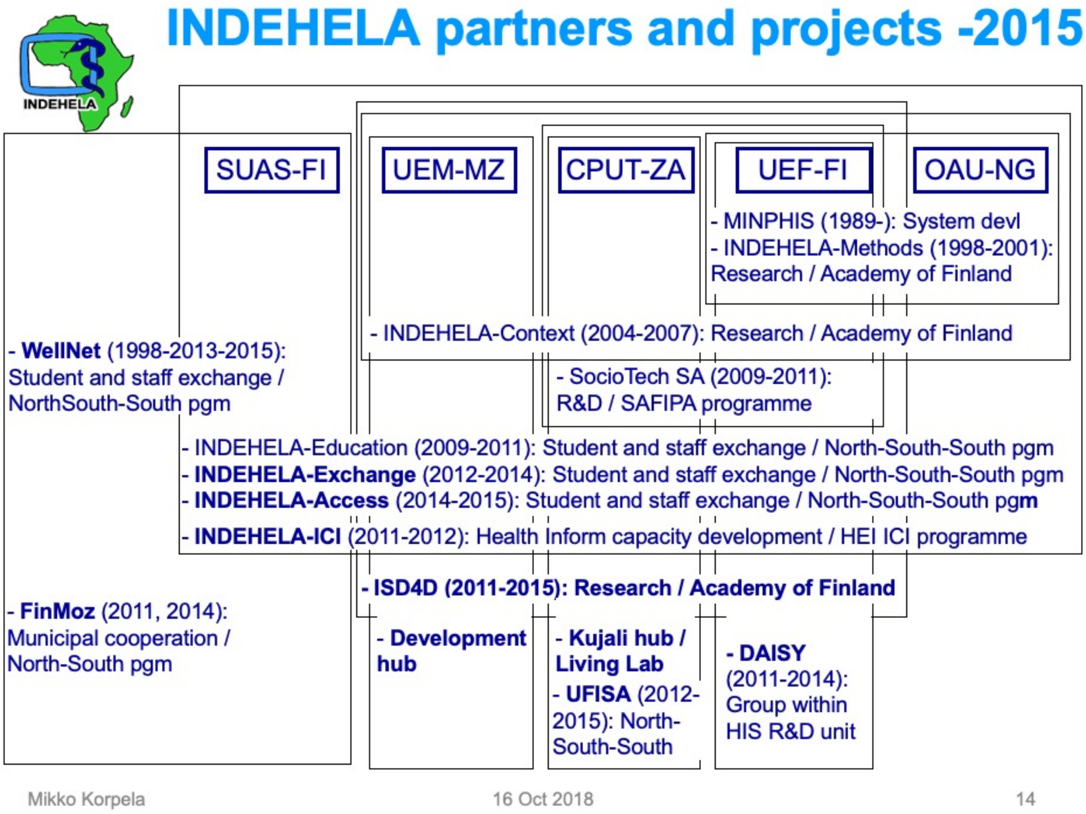

Figure 5-6: Overview of all the INDEHELA and related initiatives

Since this study is part of the HEI-ICI outcomes to build capacity, Figure 5-7 provides a summary of the details of the collaboration and the involvement of the partners.

Figure 5-7: INDEHELA-ICI collaboration

The INDEHELA-ICI project resulted in tangible outcomes (Figure 5-8).

Expected results by end of 2012 (received funding):

- Staff development:
  - 6-10 junior and 3-5 senior academic staff have been identified
  - Each junior member with a feasible postgraduate degree plan / proposal
  - Supervisors appointed, African-Finnish co-supervision / mentoring groups
- Educational capacity development:
  - Each African partner HEI has the curriculum and a timed plan for implementing its Masters and/or certificate programme
  - First modules have been designed, the teaching / learning methods set, and at least one pilot module implemented in each African partner HEI
- Administrative capacity development:
  - Project Coordinator / Project Officer / Administrator with good organizing skills has been identified and employed in each African partner HEI
  - Legal and financial project administration practices created within each HEI and at the international level
  - Personal development plans approved for each project officer

Figure 5-8: INDEHELA-ICI outcomes

In Figure 5-9 all the results of the INDEHELA collaborative projects are given. Not only is this an indication of the benefits that post-graduate students, researchers, teachers, research administrators, and under-graduate students as interns have received, but it also provided a strong foundation for further collaborations, regardless of funding. It can therefore be claimed as a sustainable stable network that provide a strong foundation for researchers in Africa to develop themselves to continue capacity development in Africa.

Results by August 2015 (received funding) + 9 months:

- Contributed to 72 **publications**: 20 journal, 21 conference papers
- **Degrees**: 16 doctoral (6 FI, 10 Afr), 15 Masters (1 FI)
- Holistic **ISD4D approach**:
  - '**Guidelines for Information Systems Development in a Community Development Context**', draft for a living document
  - Main papers summarizing lessons learnt: de la Harpe et al. 2015, Ruhode et al. 2015, Tswane et al. 2015, Grobbelaar et al. submitted
- **Action research** in case projects → Relevant socio-tech IS → Societal development in communities:
  - On-going action in Grabouw
- International multidisciplinary **research group**:
  - Strong research at CPUT, with national and international relations
  - Development hub at UEM
  - UEF terminated ISD4D research areas and dismissed its researchers

Figure 5-9: Outcomes of all the INDHELA Projects

Next, the outcomes of the INDEHELA funded projects that benefit CPUT staff and students are indicated in Figure 5-10.

- 6 Intensive courses (hosting & participating – Cape Town, Mozambique, Nigeria, Finland)
- 14 Teacher exchanges (including to other African countries – Mozambique & Nigeria)
- 15 Student exchanges
- 6 Post graduate student exchanges (up to 5 months)
- 16 Interns (R381,000.00)
- Administrator training (R104,000.00)
- 2 Courses
  - Health Informatics Fundamentals (offered since 2012)
  - Health Informatics Masters (basis curriculum)

Figure 5-10: Outcomes from the INDEHELA collaborations since 2019 (de la Harpe, 2023)

The INDEHELA outcomes were noted at the end of 2018 even though funding was only for the period 2004-2015. This means that although the different funded projects ended, and the formal INDEHELA network collaboration ceased to exist, the individual activities continued.

In addition, the outcomes of activities since 2018 were presented at a network event in 2023 as reflections and possible future collaboration networks (de la Harpe, 2023). Since 2019, five PhDs completed their studies, all five specialising in a digital health topic, and there are currently six PhD students (five from South Africa, one from Kenya and one from Ethiopia – four specialising with a digital health topic). Five masters' students (two specialising with digital health topics) completed their studies with twelve journal articles and two book chapters published.

The spin-off projects that continued from the INDEHELA collaborative network was: NRF/Namibia joint research project. Live Design, Transform Life: Mobile education and service design to promote gifted youth development for innovation. 2014-2016; Live Design, Transform Life: Relevant technologies and digital services for the wellbeing of the youth@risk (Phase 2 – 2017-2019); EU: Marie Skłodowska-Curie Actions (MSCA). Research and Innovation Staff Exchange (RISE) PARTY (Participatory Tools for Human Development with the Youth) 2015-2018 with partners from Finland, UK, Italy, Namibia and South Africa; Africa Internal Collaboration (established in 2022) with experienced researchers, post doc fellows, PhD students from the UK (lead from University of Leeds); South Africa, Kenya, Ethiopia, Namibia and Ghana (de la Harpe, 2023).

This study draws from all the activities as a participant and beneficiary to specifically capitalise on the HEI-ICI project that informed this study and using the health informatics course as the informatics education for IT practitioners who will work as IT practitioners within the domain of health.

5.6.1 INDEHELA Outcome – Health Informatics Fundamentals Course

It must be noted that this subject was developed based on the knowledge at the time of the project, 2011-2012. It will therefore not reflect the most recent health and digital technologies trends and uses. It must also be noted that this subject was one of 10 subjects of the BTech Qualification that has since been phased out to align with the new national qualification structure. The structure of the IT BTech qualification is as follows:

- Specialisation (select 1 specialisation for 2 credits)
    - Information and Technology Management and advanced information and technology management
    - Software Development and advanced software development
    - Communication Network and advanced communication networks.
- Professional Development (5 credits)
    - Business Fundamentals
    - Project Management
    - Research Methodology
    - Project (2)
- Electives (2-4 credits)
    - Database systems, computer security, data administration, health informatics fundamentals, software engineering

The process of forming the curricula was done on a national level with all the participating universities involved. There were more specialisation options but the IT Department at CPUT decided to offer three specialisations as indicated above. The IT Management specialisation was a popular option for IT practitioners who wanted to prepare for their career development. These students already worked as IT practitioners and studied part-time. The structure of this specialisation is:

<u>Specialisation:</u> (2): IT Management and Advanced IT Management

<u>Professional development</u> (5): Business Fundamentals, Project Management, Research Methodology and Project (2 credits with an opportunity to specialize in one of the subject areas.

Electives (3): Database Systems, Computer Security, Data Administration, Health Informatics Fundamentals

The health informatics fundamentals subject was a popular choice for the students. Details about its structure is indicated in Figure 5-11.

Table 5-4 SATN subject/module information template (Developed by DUT and adapted by CPUT)

Subject/Module Information	
Name of programme	BTECH: INFORMATION TECHNOLOGY
Name of responsible department	INFORMATION TECHNOLOGY
Name of Head of Department or programme coordinator and contact details	Course Coordinator: Prof Retha de la Harpe HOD : Prof Bennett Alexander
Suggested name of the subject/module	SUBJECT NAME: HEALTH INFORMATICS FUNDAMENTALS SAPSO SUBJECT NAME: APPLICATION TECHNOLOGY IV (SAPSO CODE: 69900306)
Suggested CPUT subject code	HIF400S
Level of subject within the programme	4th Year (BTech)
SAQA Credit value	12 (1 SAQA credit = 10 notional hours) = 3 ECTS
HEQF level	7
Pre-requisites	Any NQF Level 6 or 7 qualification
Co- requisites	None
Compulsory or elective	Elective
Major subject	No
Notional hours	120 (1 SAQA credit = 10 notional hours)
Contact time	1.5 - 2 Hours per week contact time (12-15 weeks)
Expected learning outcomes	At the end of this subject the student should have the basic knowledge and skills in ICT as it is needed and used in medicine and healthcare to be prepared for a career in Health Informatics in academic, healthcare, government or industrial settings. The specific outcomes to achieve the above are:

Subject/Module Information	
	1. Identify and describe the elements of the Health Informatics Field 2. Distinguish (comprehension – confirming use of knowledge) between the different health informatics knowledge areas 3. Explain the relevance of informatics in healthcare service provision in both global and local contexts 4. Indicate how ICT could facilitate healthcare service provision 5. Describe health informatics as a profession
Summary of subject/module content	1. Basic terms and concepts in Health Informatics 2. Health care systems 3. Information recording in healthcare 4. Using information for healthcare professional 5. Using Health Information for patients and communities 6. Information systems in healthcare 7. Using information technologies in Healthcare 8. Socio-technical issues in healthcare 9. Integration of service, work and information flows in practice 10. Legal and ethical issues 11. Principles of project management
Prescribed books or recommended reading list	Reading list of identified and relevant academic and applied articles Online content
Teaching and learning strategy	Once a week contact session supported by online content materials and activities. A blended learning model will be used with combining face-to-face formal instruction with computer mediated instruction; web-based content with simulation examples; and group work to apply the course content to real-life situations. The focus of the teaching will be on the application of informatics in healthcare settings. The nature of this course is inter-disciplinary, and this aspect will be central to the offering. The learning and teaching strategies have been designed to teach the identified topics in local and global contexts with an emphasis on the learning process for the candidates to develop their knowledge, competencies, skills and attitude to the requirement on this level.

Subject/Module Information	
Assessment strategy	Group assignments Report(s) Essay Summative tests Personal portfolio The final mark will be calculated with the following weights: Assessment 1 (20%): 1 group assignment to cover the first few topics. Assessment 2 (20%): 1 Summative test to cover the content of topics 1–5 Assessment 3 (20%): Group assignments to cover the remaining topics Assessment 4 (10%): An individual essay (2,500 words) about the research of any of the topics Assessment 5 (30%): Final summative 3-hour exam to cover all the material All the assessments will cover the required knowledge, competencies, skills and attitude required on NQF level 7

Figure 5-11: Health Informatics Fundamentals Subject offered at CPUT

5.6.2 Health Informatics Fundamentals Course Structure

There were eight topics that formed part of the implementation of the approved fundamentals subject. Each topic was taught by a domain knowledge expert. Each lecturer was supported by the other members of the INDEHELA collaboration representing the four participating countries and experts from Health, Nursing, Public Health, Anthropology and Informatics covering Computer Science, Information Technology and Information Systems. The names of the lecturers and INDEHELA collaborators were anonymised to remove identifiable privacy data. The structure of the course is indicated in the next table. The disposition competencies were addressed in the project work and assignments that focused on group work based on a given real-life health situation. Each topic was also presented as it would apply to health practice. Many IT students decided to continue with post-graduate studies with health-related specialisation-topics and thus increase the capacity of specialised health informaticians. The schedule of the first offering is presented next.

Table 5-5: Health informatics Fundamentals Subject Topics and Schedule

	Health Informatics – Fundamentals					
	Topic	**Credits**	**Hours/Contact Hrs**	**Week**	**Dates**	**CPUT Lecturer**
1	Basic terms and concepts in Health Informatics	1	4/2 hrs	1	23-Jul	IT lecturer with a PhD in IT
2	Legal and ethical issues	1	4/2 hrs	2	30-Jul	IT lecturer with several years of practice experience
3	Information recording in healthcare	1.5	8/4 hrs	3-4	6-Aug 13-Aug	IT Professor with a PhD in a health related topic and a junior IT lecturer to be mentored
4	Health care systems	1	4/2 hrs	5	20-Aug	Health Informatics practitioner with a masters in Health Information Management
5	Using information for healthcare professional	1.5	8/4 hrs	6-7	27-Aug 3-Sep	Prof in Advanced Midwifery with a PhD in Health Informatics
6	Using Health Information for patients and communities	1.5	8/4 hrs	8-9	17-Sep 24-Sep	IT Lecturer a PhD in Information Communication and a master’s in Anthropology
7	Information systems in healthcare	1	4/2 hrs	10	1-Oct	IT lecturer with several years of informatics practice experience
8	Using information technologies in Healthcare	1	4/2 hrs	11	8-Oct	IT lecturer with a PhD in Health Information Technologies

	Health Informatics – Fundamentals					
9	Socio-technical issues in healthcare	1	4/2 hrs	12	15-Oct	IT Professor with a PhD in a health related topic
10	Integration of service, work and information flows in practice	1.5	8/4 hrs	13-14	22-Oct 29-Oct	Heath Informatics Professor with expertise in Health Systems Development

5.6.3 Analysis of the Health Informatics Fundamentals Course

Analysis of the Health Informatics Course was done to understand the domain areas of the course as covered in the IT2017 Curricula and the AMIA Foundational domains. Colour mapping was done based on the definitions and descriptions given for the respective topics and domains. The results are indicated in the next table. The course covered most of the core knowledge areas of the IT2017 Curricula and the health domain knowledge areas with technology of the AMIA foundational domains. Apart from the AMIA Health domain, the other links were with the intersection between health information science and technology ($F4 = F1 \cap F2$); human factors and socio-technical systems ($F5 = F2 \cap F3$); social, behavioural and information science and technology applied to health ($F7 = F1 \cap F4 \cap F5$). This means that these domains already provide for the integration of domains. The last three domains, professionalism, interprofessional practice and leadership refer to disposition competencies and are covered by the professional competencies in the IT2017 and AMIA linked with legal and ethical issues in HIF4. Most of the domains in the IT2017 competency framework deal with digital technology-related topics that are specific for IT practitioners. However, it provides an option to specialise in specific topics, e.g., cyber security and also offer the possibility to specialize in a new areas, e.g., machine learning, AI, etc.

The key finding for the jointly developed fundamentals course is that it covers most of the health informatics competencies identified and suggested by global health informatics advisors.

Table 5-6: Health Informatics Topics and Domains Comparison

HIF 4	IT2017	AMIA Foundational Domains	IMIA Foundational Domains
1. Basic terms and concepts in Health Informatics	IT1: Information Management	F! Health	BMHI Core Principles
2. Health care systems	IT2: Integrated Systems	F2 Information Science and Technology	Health Sciences and Services
3. Information recording in healthcare	IT3: Technology	F3: Social and behavioural science	Computer, Data and Information Science
4. Using information for healthcare professional	IT4: Platform Technologies	F4: Health Information Science and Technology	Social and Behavioral Sciences
5. Using Health Information for patients and communities	IT5: System Paradigms	F5: Human Factors and Socio-technical Systems	Management Science
6. Information systems in healthcare	IT6: User Experience Design	F6: Social and Behavioural Aspects of Health	
7. Using information technologies in Healthcare	**Essential**	F7: Social, Behavioural, and Information Science and Technology Applied to Health	
8. Socio-technical issues in healthcare	IT7: Cybersecurity Principles	F8: Professionalism	
9. Integration of service, work and information flows in practice	IT8: Global Professional Practice	F9: Interprofessional Collaborative Practice	
10. Legal and ethical issues	IT9: Networking	F10: Leadership	
11. Principles of project management	IT10: Software Fundamentals		
	IT 11: Web and Mobile Systems		
	Supplemental		
	IT12: Cybersecurity Challenges		
	IT13: Global Professional Practice Social Responsibility		
	IT14: Applied Networks		
	IT15:Software Fundamentals Software Devel. & Mgmt.		
	IT16: Web and Mobile Systems Mobile Applications		
	Supplemental Only		
	IT17:Cloud Computing		
	IT18: Data Scalability and Analytics		
	IT19: Internet of Things		
	IT20 Virtual Systems and Services		

5.6.4 INDEHELA Case Findings

Four key findings were derived from the INDEHELA capacity building project. The first key finding is that the health informatics fundamentals course covers most areas of health practices using digital health technologies as indicated in the coverage of the AMIA foundational knowledge domains. Every topic of the health informatics fundamentals subject was aligned to at least one competency domain of IT2017 or AMIA 2022 and in some cases to both. In addition to the health informatics fundamentals subject, the other eight subjects specifically of the Qualification dealt with information technology competencies needed by informatics practitioners. It also had an option to specialise in the Project subject. This enables the student to have competencies in a specialised health informatics topic that are aligned to the required competencies expected of a specialised health informatician.

The second finding deals with the collaborative nature of the competencies' identification. The collaborations of the health and informatics domain representatives resulted in identified suitable context-sensitive health informatics topics based on an aligned negotiated understanding. Everyone in the collaboration were encouraged to contribute to the discussions resulting in the outcome of a refined and aligned topic. The collaborators were from nursing, public health, health informatics specialist, anthropology, and informatics looking at computer science, information technology and information systems in addition to the health domains. This ensured a wide coverage of domain perspectives contributing towards the development of the course. It therefore means that the competencies were considered from an inter-disciplinary perspective, for example the heath informatics topics were considered collaboratively with the input from both health and informatics experts. The design of a suitable health informatics course took place during week-long face-to-face workshops rotating between the different participating countries. This provided the participants with an opportunity to be exposed to that country's healthcare context.

The third finding is that teaching was done by domain experts. The health topics were covered by health experts and the informatics topics by informatics experts. This means that students had the opportunity to learn from an expert in that topic. The topic educators were also supported by experts within the INDEHELA team to provide for additional contextual insights.

The fourth finding was that there was a combination of activities that supported the INDEHELA capacity development project that provided different perspectives to the project. A collaborative network of inter-disciplinary members on different levels can produce meaningful outcomes by leveraging individual expertise, diverse experiences, and building upon existing research, teaching, and other practices. These included teaching, research, an innovation hub for developing artefacts, and participation of diverse practitioners. Additionally, there were spin offs to the project which included student projects; post graduate research; development of specific focus areas; and. The benefit of such an inter-disciplinary collaborative network is evident in the outcomes achieved. The INDEHELA network consistently expanded attracting new members which resulted in novice researchers having the opportunity to be mentored by the senior students and professors.

5.7 Main Findings for the Educator Perspective

A summary of the key findings for the educators' perspectives on health informatics education is presented below.

Table 5-7: Summary of Educators' Findings

Theme	Findings
Context of Practice	• There is a paucity of knowledge on the nursing informatics and health informatics disciplines, thus there is a need for advocacy of nursing informatics and health informatics. • Nurse educators need skilling in informatics so that they can be able to find examples which they may use in their course content. • Nurses use informatics tools to aid them with data capturing, decision support and data analysis within their practise. • Informatics students lack the contextual health domain knowledge and need to know the decision-making processes in the workflows and health technological use.
Course Structure	• Given the current situation in South Africa where there are a large number of digital emigrant nurses, informatics courses offered should be both integrated within the curriculum as well as having short courses for digital emigrants. • Course content depends on who the program is intended for, nurses require a program with an informatics focus and informatics practitioners require a program with a health focus.
Mental Maps	• There are two mental maps which have to provisioned for in a course for the digital immigrants and digital natives. • To cover the gap between nursing and informatics it was advised to constructively build the knowledge, where the more familiar content is covered first and then more content is built on the familiar until all the content is covered. • IT students need to develop collaborative skills to enable them to work with domain knowledge experts

Theme	Findings
INDEHELA case	• The health informatics fundamentals course covers most areas of health practices using digital health technologies as indicated in the coverage of the AMIA foundational knowledge domains. • The collaborations of the health and informatics domain representatives resulted in identified suitable context-sensitive health informatics topics based on an aligned negotiated understanding. • Teaching was done by domain experts. The health topics were covered by health experts and the informatics topics by informatics experts. • A collaborative network of inter-disciplinary members on different levels can produce meaningful outcomes by leveraging individual expertise, diverse experiences, and building upon existing research, teaching, and other practices.

5.8 Chapter Conclusion

This chapter explored the domain of nursing informatics and health informatics from the perspectives of nurse and informatics educators. Three themes arose from the exploration: Context of Practice; Course Structure and Mental Maps. Several findings emanated from the exploration, these were: Nurse educators lacked competency in the topic of nursing informatics and required training ; In the South African context training of nursing informatics needs to consider both digital natives and emigrants, this would mean offering both integrated and short courses; and Informatics students though well versed in hard information technology competencies they lacked health domain knowledge which enabled them to understand problem contexts. The researcher can conclude that although there is a positive interest in the nursing informatics and health informatics disciplines by the educators, training would be required for the educators for them to integrate or provide short courses that are relevant for the nurses and informatics students. In addition, a collaborative course would be ideal to offer as a course that caters to both nurses and informatics students as their competency needs are in each other’s disciplines. The INDEHELA story was explored to indicate the relevance of informatics practitioners having health domain knowledge.

The ensuing chapter will look at health informatics experts’ perspectives.

CHAPTER 6 HEALTH INFORMATICS EXPERTS

6.1 Introduction

Chapter five discussed the perceptions of informatics educators on health informatics. In addition, the chapter also considered the health knowledge that informatics students would need to gain necessary domain knowledge of the health field. This chapter will, look further into the health informatics knowledge that informatics students would require from the perspectives of health informatics experts. The expert perspectives specifically focus on the competencies that IT practitioners will need to design, develop, implement, and support digital technologies to support health professionals providing healthcare services. The perspectives of experts have been used in studies to obtain a greater paradigm of the discipline in question. Experts are defined by Bogner *et al.* (2009:221) as "*someone who is responsible in some way or another for the development, implementation or monitoring of a problem or who has privileged access to information about people or decision processes*." Thus, experts are better able at synthesising relevant details from large sets of information, and have spent more time analysing problems, therefore are better at identifying interdisciplinary knowledge for other domains (Bruggeman *et al.*, 2018; Mothupi *et al.*, 2020).The chapter will initially outline the methodology and then the characteristics of the data collection tool for the semi-structured questionnaire, it will then look into the participant profiles. The chapter will then present the results from the collected and analysed to discuss the results the expert perspectives.

6.2 Participant Profiles

The respondents represented a wide variety of different roles and backgrounds and ranged from early career professionals to retirement age. The respondents selected had both informatics and health professional expertise to gain a wide perspective from both disciplines. All experts have experience working in South Africa or similar lower and middle-income countries (LMIC) contexts. Twenty invitations were sent out to health informatics experts, and ten responded positively. For their highest qualification, five of the respondents have Master's degrees and five have PhDs. One respondent was retired and some respondents came from organisations in the UK, Finland, South Africa, and Mozambique.

Participant profiles are indicated in the next table.

Table 6-1: Health Informatics Experts – Participant Profiles

Participant	Country	Role in Organisation	Highest Qualification
Participant 1	South Africa	Provincial Secretary/ Provincial Manager	MComm (MIM)
Participant 2	United Kingdom	Various in Development and Communication	PhD Health Informatics
Participant 3	Finland	Retired	Doctor of Technology
Participant 4	South Africa	Technical Advisor	Masters
Participant 5	South Africa	Executive director	PhD MPH
Participant 6	South Africa	CSIR	PhD
Participant 7	South Africa	Lecturer and Researcher	Master of Technology: Information Technology
Participant 8	Mozambique	Assistant Professor	PhD
Participant 9	Finland	UX researcher in Lifecare Application	PhD
Participant 10	United Kingdom	Professor of Nursing Informatics	MBA

6.3 Data Analysis

Thematic analysis was conducted on the data for the health informatics experts. The data was placed in an excel worksheet as indicated in the extract illustrated by Table 6.2 below. Categories were inductively derived from the explanation according to the experts. Thirty-eight (38) categories were derived that were further analysed comparing the category and explanation according to the experts to derive a sub theme and then the final themes.

Table 6-2: Thematic Analysis of Health Informatics Experts Data

Participant	Topic No	Topic	Explanation according to experts	Fund	Dip	Degree	Y4	Categories	Sub-theme	Themes
P8	5	Patient empowerment	Teaching patients and endorsing informatics resources to enforce patient uptake of informatics resources			1	1	Patient empowerment	Digital Health Records	Community-based Healtrh & Wellbeing Services
P2	7	Personal Health Records/Patient Access and Engagement	Facilitate and promote patient/consumer use of health information and related technologies	1		1		Personal health Records	Digital Health Records	Community-based Healtrh & Wellbeing Services
P3	4	Patient, citizen and community centered healthcare and information modeling	Human vs. organization centred views of healthcare, communities' and individuals' needs and roles as actors, health information and ICT for communities and individuals			1		Community-based Health	Digital Health	Digital Health
P3	7	Examples of current and future ICT applications in healthcare	A contemporary hospital information system, a radiology system, a community health system, a mobil health system, artificial intelligence in health care	1		1		Digital Health Systems	Digital Health	Digital Health
P11	1	Digital technologies	moving to digital technologies	1				Digital Health Transformation	Digital Health	Digital Health
P6	2	Healthcare knowledge in HI	The structure and function of healthcare systems	1	1	1	1	Healthcare Systems Functioning	Digital Health	Digital Health
P4	1	Introduction to Public health:	The science of protecting and improving the health of people and their communities. This work is			1	1	Public Community Health & Wellbeing	Digital Health	Digital Health

6.4 Results of Knowledge Area Themes

6.4.1 Introduction of Expert Results

The competencies were considered for different years of study, starting with first year of an under-graduate tertiary qualification after completing their High School. Students entering higher education for their first year are typically novices in terms of formal digital competencies but may have been exposed to such technologies in their school, private and social lives. Next, the key competencies expected from students who completed their third year of study, typically completing a national diploma or three-year degree, should be sufficient to enter the job market as an IT practitioner. This level is focusing on vocational competencies and provides the practical aspects of a course with less theory. Vocational qualifications focus on practical knowledge that is embedded in a specific context and industry and may therefore be less condensed (Winberg, 2012).

A fourth-year qualification is typically on an honours or post graduate level (the BTech degree was the alternative qualification on a fourth level offered by universities of technology until 2021 when it was phased out). In this instance the student is considered as working in practise and has started to specialise in specific knowledge domains of the discipline. In addition to relevant knowledge areas on a more advanced level the student is expected to have the necessary knowledge to apply in practice. The form of knowledge at this level is considered as professional knowledge relevant to a specific profession and discipline that also includes procedural, theoretical, and practical knowledge. Such a qualification also considers theoretical knowledge that is context independent and stronger condensed. Skills development changes from job and task-oriented skills on the lower-level post-school qualifications to the development of cognitive skills that are professional and practice-oriented. A sense of self, role and identity develop from generic competencies and behavioural skills to advanced capabilities with critical self-reflection for the higher-level qualifications.

6.4.2 Knowledge Area Themes

Results from the thematic analysis resulted in eleven (11) derived themes. These are: (1) Community-based Health and Wellbeing Services; (2) Digital Health; (3) Digital Health Development and Implementation; (4) Digital Health Ecosystem, (5) Digital Health Management; (6) Digital Health Monitoring and Evaluation; (7) Emerging Digital Health; (8) Health Informatics Education and Research; (9) Health Informatics Fundamentals; (10) Health Information Management and Interoperability and (11) Health Professional Work Practise. These codes were derived from a grouping and categorisation of sixty-eight (68) categories and from these categories into nineteen (19) sub-themes. The sub-themes were considered in terms of similar and duplicate theme names and descriptions that resulted into the final 11 themes. The themes are a representation of the participants' perceptions on competencies in health informatics education for Informatics Practitioners. A conceptual representation of the themes is illustrated in the Table 6.3 below. It is important to note that each participant's perspective was unique and individual and was in no way restricted to one single theme. To some extent, all themes were expressed in each of the individual participant perceptions. Themes are supported by excerpts from the questionnaire in the ensuing discussions of each theme.

Table 6-3: Main themes with associated initial themes and counts

Themes	Sub-Themes	Categories	Codes (n)
1. Community-based Health and Wellbeing Services	• Digital Health Records	• Patient empowerment • Personal health records • Community-based health • Public community health and wellbeing	5
	• Public Health	• Epidemiology public health	
2. Digital Health	• Digital Health	• Digital health systems • Digital health transformation • Healthcare systems functioning	3
3. Digital Health Development and Implementation	• Digital Health Design	• Design • User-centred design	15
	• Digital Health Development and Implementation	• Digital technologies utility • Health • Health technologies • Health informatics fundamentals • Systems development life cycle • Telehealth/MHealth/EHealth • Telehealth/MHealth/EHealth • Usability testing • User-centred design	
4. Digital Health Ecosystem	• Digital Health Ecosystem	• Health systems • Healthcare systems • Healthcare work practice	3
5. Digital Health Management	• Digital Health Management	• Management of change • Multi-professional project work	
	• Digital Health Risk Management	• Security/confidentiality/risk	

Themes	Sub-Themes	Categories	Codes (n)
6. Digital Health Monitoring, Evaluation	• Digital Health Monitoring and Evaluation	• Health information systems • Impact assessment • Systems maintenance and evaluation	
7. Emerging Digital Health	• Emerging Digital Health	• Health ICT technologies • Trends in health informatics • User experience	4
8. Health Informatics Education and Research	• Health Informatics Education and Research	• Applied digital health knowledge • Education and research	3
9. Health Informatics Fundamentals	• Data Utilisation and Management	• Data management	4
	• Health Informatics Knowledge	• Health informatics history fundamentals	
	• Healthcare Services	• Health	
10. Health Information Management and Interoperability	• Data Standards and Interoperability	• Data standards and interoperability • Information technology, architecture and infrastructure, digital decision-making and communication	19
	• Data Utilisation and Management	• Data management • Data recording • Data science • Digital communication	
	• Digital Health Records	• Electronic health records	
	• Governance, ethics and regulations	• Ethics • Governance • Security/confidentiality/risk	
11. Health Professional Work Practice	• Health Professional Work Practice	• Health professional roles • Healthcare work practice	4

6.4.2.1 Theme 1: Community-based Health and Wellbeing Services

The community-based health and wellbeing services theme is the first theme. This theme includes the use of digital technologies in Public Health. It involves issues that deal with patient empowerment, personal health records and epidemiology. Issues of consideration as per the participants description of the topics related to the interaction and uptake of digital technologies by individuals and communities for their education, as well as health institutions research on disease and injury prevention. The participants described the topics in this theme as including the following:

> *"Facilitate and promote patient/consumer use of health information and related technologies" [Participant 2].*

> *"Human vs. organization centred views of healthcare, communities' and individuals' needs and roles as actors, health information and ICT for communities and individuals" [Participant 3].*

> *"The science of protecting and improving the health of people and their communities. This work is achieved by promoting healthy lifestyles, researching disease and injury prevention, and detecting, preventing and responding to infectious diseases." [Participant 4].*

> *"Teaching patients and endorsing informatics resources to enforce patient uptake of informatics resources" [Participant 8].*

The key finding of this theme is that this was the only health discipline field that was recommended by the health informatics experts. It entailed issues that involved individuals and the community, including concepts like public health, epidemiology and personal health records.

6.4.2.2 Theme 2: Digital Health

Theme two, Digital Health, considered having a knowledge of the diverse digital health systems that are available in the health domain. It also includes having a knowledge of how these digital health systems function in the health domain in the provision of care, as well as how they transform the provision of care by the health workers. Participants described this theme topics by saying they should include the following:

> *"A contemporary hospital information system, a radiology system, a community health system, a mobile health system, artificial intelligence in health care" [Participant 3]*

"The structure and function of healthcare systems" [Participant 6].

The key finding for theme two is that informatics practitioners should have a knowledge of the diverse digital health systems. They should understand their structure, function and how they impact the health domain.

6.4.2.3 Theme 3: Digital Health Development and Implementation

Digital health development and implementation is the third theme. This theme involves the design, development, and implementation of health information technologies. It includes the activities done during the development of health information technologies as conducted in the systems development lifecycle. This involves activities such as record management, collaboration of practitioners and identifying features that make up a digital health information system. In describing what the topics in the theme entail the participants said the following:

"Ensure that records management issues for specific collaboration and networking activities are addressed in in health IT/eHealth system development" [Participant 2].

"History of information system design, waterfall and iterative models, user participation in IS design, system lifecycle from design through acquisition and implementation to adaptation and assessment" [Participant 3].

"Collaboration with frontline users (doctors and nurses) on how to design systems fit for executing work activities" [Participant 7].

"(including telemedicine and teleconsulting): identify common solutions, identify their features and application in the SA context, motivate others to implement" [Participant 8]

"How to make intuitive solutions" [Participant 9].

"IT in different healthcare organisations, units, and environments in different treatment/administrative situations: this would take some time" [Participant 9]

"the development of digital solutions that ensure the centrality of the patient not the professional, this is different to the 'control' concept as shown in Patient Empowerment" [Participant 10].

Key findings for theme three are that informatics practitioners should develop the skills to design develop and implement digital health technologies and they should be able to identify features that make up a digital health information system.

6.4.2.4 Theme 4: Digital Health Ecosystem

The Digital Health Ecosystem theme considered having some knowledge about the diverse Health Systems, international and the one implemented in the local context. It considers the healthcare systems with the informatics practitioners understanding the culture and working practices within all areas of primary, acute and tertiary healthcare. It included the application of digital health technologies to address needs instead of just implementing artefacts. Participants said the following describing the topics in this theme:

> *"tertiary care, specialties in health care, referrals, public and private service providers, funding models (out-of-pocket, private insurance, national insurance, taxation), examples (own country, UK NHS, Germany, USA" [Participant 3]*

> *"Digital health connects and empowers people and populations to manage health and wellness, augmented by accessible and supportive provider teams working within flexible, integrated, interoperable and digitally enabled care environments that strategically leverage digital tools, technologies and services to transform care delivery" [Participant 4]*

> *"General practice and specialized services, health promotion and disease prevention, social services and healthcare, levels of health care from community services to*

> *to provide an understanding of the culture and working practices within all areas of healthcare (primary, acute and tertiary) so as to ensure that any development is need led not technology led." [Participant 10].*

Key findings for the digital health ecosystem theme are that informatics practitioners should understand the different healthcare systems, both internationally and what is applied locally. They should understand the health systems, primary, acute, and secondary so they can develop digital health technologies that are relevant to the needs.

6.4.1.1 *Theme 5: Digital Health Management*

Theme 5, Digital Health Management looked at the professional practise of practitioners in the management of digital health. Areas of consideration are change management; multi-professional project work; security; confidentiality and risk. Participants had the following to say describing the topics:

> *"Respond appropriately in order to minimize risks that exist related to health IT/eHealth data and technology, including risks in relation to obtaining, holding, recording, sharing*

and using data and information, as well as in relation to confidentiality, integrity, availability and transmission of information" [Participant 2]

"ICT students and health students work in teams, identify a need for improved ICT facilitation to provide improved work and services in a restricted setup, identify stakeholders, iteratively design a prototype, record process and outcome, assess the outcome with stakeholders" [Participant 3]

"*system design, development, implementation and evaluation (re-design) all require high levels of change management knowledge and skills using a combination of IT future-proofing and workforce capability." [Participant 10].*

A key finding for this theme is that informatics practitioners should develop digital health management skills in their professional practice. These include being able to manage change, projects, security and risk.

6.4.2.5 Theme 6: Digital Health Monitoring and Evaluation

Digital health monitoring and evaluation, theme six, involves the impact assessment, monitoring and evaluation of Health Information Systems. It also includes critical appraisal of such systems. Participants described topics in the theme as follows:

"Assess the implications of relevant office systems, such as workflow and image processing, for records and internal information management" [Participant 2].

"Monitoring and evaluation models and frameworks that are applied to evaluate quality and efficiency of health systems" [Participant 6].

"management and optimization of implemented health information technologies" [Participant 7]

"Critical appraisal new technologies in terms of "good"/" bad" system design. Appraisal of hardware, e.g. handheld devices" [Participant 8].

Key findings for this theme are that informatics practitioners should learn the skills to be able to conduct impact assessment, monitoring and evaluation of digital health systems. They should be able to critically appraise digital health technologies and optimise existing digital health systems.

6.4.2.6 Theme 7: Emerging Digital Health

Theme 7, emerging digital health, considers the trends of digital technologies in health informatics. It looks at the impact emerging digital health technologies such as artificial intelligence, have in the health environment for the provision of support to health and care. Participants described topics in the theme as follows:

> *"This course will examine trends impacting the health informatics field and their impact on the structure, behaviour, and interactions of natural and artificial systems that store, process and communicate information." [Participant 6].*

> *"Where artificial intelligence is being/will be used to provide support to health and social care allowing practitioners to have time to provide the compassion in care and patients to live to their optimal level of life quality." [Participant 10].*

Key findings for this theme are that informatics practitioners should have a knowledge of emerging digital technologies. They should understand the impact and the use that these technologies will have on the health domain and their applicability in health contexts.

6.4.2.7 Theme 8: Health Informatics Education and Research

Theme eight was the Health Informatics Education and Research. This theme included having some knowledge about the epistemology, ontology, methods and theories that entail the Health Informatics discipline with respect to learning and research. It involves equipping the practitioner with skills to enable them to apply scientific knowledge to resolve case studies, complete a project or discover new knowledge. Participants had the following to say describing the topics:

> *"Applicable to public health, research, and learning. You must integrate and apply knowledge, principles, theories, concepts, methods, techniques, skills, competencies, values and professional viewpoints developed throughout the curriculum to resolve complex case studies and to complete an applied health informatics project." [Participant 6].*

> *"apply scientific methods to discover new knowledge in health informatics." [Participant 7].*

Key findings for this theme are that informatics practitioners should have some knowledge on the epistemology, ontology, methods, and theories in the health informatics discipline. They should be able to apply scientific knowledge to resolve case studies, complete a project or discover new knowledge.

6.4.2.8 Theme 9: Health Informatics Fundamentals

Theme 9 is Health Informatics Fundamentals. This theme considers having foundational knowledge about health informatics which includes the history of health informatics; concepts such as communication processes, health informatics organisations internationally and locally as well as sources of health informatics knowledge. Participants had the following to say describing what the topics in this theme should entail:

> *"History of the multidisciplinary field of HI and involves transformative technologies, communication processes and information practices in healthcare. Definition of health informatics, discussion of related terms like ICT in healthcare, health informatics as a profession, health informatics research, health informatics organizations globally and locally, sources of health informatics knowledge (journals, conferences, web"* [*Participant 3].*

> *"History of the multidisciplinary field of HI and involves transformative technologies, communication processes and information practices in healthcare" [Participant 6].*

Key findings for this theme are that informatics practitioners should have knowledge of the history of health informatics. They should understand concepts such as communication processes, health informatics organisations internationally and locally as well as sources of health informatics knowledge that make up the field.

6.4.2.9 Theme 10: Health Information Management and Interoperability

Health information management and interoperability is theme ten. This theme includes the following concepts: data standards and interoperability; information technology architecture and Infrastructure; Digital Decision-making and Communication Data Management; Electronic Health Records; governance; security; confidentiality and risk. Participants had the following to say describing what the topics in this theme should entail:

> *"Appropriately apply data and IT standards in a healthcare setting" [Participant 2].*

> *"Locate and retrieve information in the electronic health record" [Participant 2].*

> *"Reasons for privacy and security issues in health care, legislation and regulation, methods for privacy protection, methods for data security, methods for information*

quality insurance, ethical permissions for research in health informatics" [Participant 3].

"information technology infrastructure and architecture, systems interoperability, interface and integration, information assurance, knowledge management and decision support systems, and technology for communication." [*Participant 8].*

"Understand the properties of different media • Decision-support – digital information. Secondary use of data; nuances of digital recording; use of digital recorded data; data analysis" [Participant 8].

"Clinical relevant governance procedures, e.g. use of personal mobile devices to communicate patient information Practical cybersecurity knowledge" [Participant 8].

"nurses to receive useful data from information systems to help improve their care delivery, to include evidence in support of practice." [Participant 10].

Key findings for this theme are that informatics practitioners should be able to manage health information such as health data, electronic health records, governance, security, confidentiality and risks. They should understand the processes of data recording, decision making and data analysis. They should also understand health systems architecture and how health systems are impacted by interoperability.

6.4.2.10 Theme 11: Health Professional Work Practice

Theme eleven, health professional work practice considers developing the skill to analyse and design digitally supported services by understanding the information, workflows and activities of the health practitioners. It also includes having a knowledge of the different health professional roles in healthcare and how they use digital health technologies. Participants had the following to say describing what the topics in this theme should entail:

"Utilize personal knowledge, experience and advanced informatics skills to enable transformation of paper-based workflows into electronic clinical decision support" [Participant 2].

"The roles of nurses, physicians, midwives, community care providers, laboratory technicians etc. in healthcare, multiprofessional work, types of information and ICT use by professional groups" [Participant 3].

"Positive and negative impacts of ICT systems on healthcare professionals' work, impacts on services, analysing and developing work activities, analysing and designing services, the potentials of ICT systems for improvements in work and services" [Participant 3].

"Suggestions on any processes to be digitalised" [Participant 10].

A key finding for this theme is that informatics practitioners should be able to analyse and design digitally supported services that are in alignment with the workflows and activities of health practitioners.

6.4.3 Methods of Upskilling

Respondents were asked to recommend ways in which IT Practitioners who are already practising could acquire their recommended competencies in the form of upskilling or reskilling. The following methods indicated in Table 6.6 were suggested by the experts as means by which the practitioners could upskill themselves.

Table 6-4: Methods of Upskilling

Methods of Upskilling
• Staggered 3/4 year course • Short Online Course • Summer/Winter schools • Hands-on experiences • Reading • Shared learning experiences with health practitioners

When looking at how the informatics students could be skilled with health domain knowledge, the key findings are the six methods recommended by the experts, namely: staggered 3/4 year course; short online course; summer/winter schools; hands-on experiences; reading; and shared learning experiences with health practitioners.

6.4.4 African Context Perspectives

When asked for useful suggestions for the African context some of the responses are:

" The international situation is fast-moving and eclectic. Keeping a watching brief on both political national / international situations and priorities; academics must establish development of high-level contacts or getting involved in international, governmental and local policy bodies and initiatives relating to informatics deployment in health, academic goals and capacity and capability. [Participant 2].

"Health informatics must be a recognised speciality in Health "[Participant 5].

"Through their hands-on experiences and y reader wider on the topic - prescribing a prerequisite list of articles on topics that have to be read and analysed and presented before admission can be gained. Focus and apply African type of case studies and examples on all course materials. Focus on visionary documents on health and wellbeing – National Development Plan and Digital Health Strategy." [Participant 7].

"It is important not to apply one size fits all to the African context because of the peculiar context and varying economies" [Participant 8].

'Practitioners should not lose sight of paper-based components of systems and work in hybrid environments' [Participant 11].

'Much emphasis is on what happens when the students do not have the infrastructure. Offline resources should be considered, podcasts, flash drives, paper not real-time learning'[Participant 11].

Key findings on the experts' perspectives on health informatics in the African context are: Institutions need to be involved in international collaboration to gain a holistic view of health informatics from the governmental to the academic perspective; A hybrid context, where paper-based systems are used together with informatics systems needs to be considered since nurse practitioners work with both systems; African context considerations need to be taken into account such as African policies and examples, a one size fits all does not apply to the African context; In line with the African Context's lack of infrastructure needs to be considered as resources for learning and implementing the health informatics systems is at times not available.

6.5 Main Key Findings

A summary of all the findings based on the experts' perspectives are summarised in the following table.

Table 6-5: Summary of Experts' Key Findings

	Key Findings
Competencies Topics Themes	• **Community-based Health and Wellbeing Services** This theme considered the use of digital technologies in Public Health with consideration on the areas of patient empowerment, personal health records and epidemiology. • **Digital Health** This theme focused on the knowledge of digital health systems that are available in the health domain. It includes knowing their structure, function and how they impact the health domain. • **Digital Health Development and Implementation** This theme includes activities that involve the design, development, and implementation of health information technologies. It considers record management, collaboration of practitioners and identifying features that make up a digital health information system. • **Digital Health Ecosystem** This theme involved understanding the different Health Systems, international and the one implemented in the local context primary. It considered knowing the different types of healthcare, primary acute and tertiary. • **Digital Health Management** This theme looked at the professional practice of informatics practitioners with a focus on change management; multi-professional project work; security; confidentiality and risk. • **Digital Health Monitoring and Evaluation** This theme considered the impact assessment, monitoring and evaluation of Health Information Systems. • **Emerging Digital Health** This theme looked at the impact emerging digital health technologies such as artificial intelligence and other technologies have on the health domain • **Health Informatics Education and Research** This theme looks at equipping the practitioner with skills to enable them to apply scientific knowledge to resolve case studies, complete a project or discover new knowledge. • **Health Informatics Fundamentals** This theme looks at having foundational knowledge in health informatics. It includes areas such as the history of health informatics; concepts such as communication processes, health informatics organisations internationally and locally as well as sources of health informatics knowledge. • **Health Information Management and Interoperability** This theme looks at appropriately applying data and its standards in the health domain. It considers areas such as data standards and interoperability; information technology architecture and Infrastructure; Digital Decision-making and Communication Data Management; Electronic Health Records; governance; security; confidentiality and risk. • **Health Professional Work Practise** This theme involves understanding the information, workflows and activities of the health practitioners.

	Key Findings
Competencies finding	Findings indicate that Health Informatics Experts suggest topic themes where informatics practitioners gain competencies in having some knowledge about the different functioning of the health domain and an understanding the impact and application of digital health systems and technologies in health practice.
Method of Skilling	• Staggered 3/4 year course; • Short Online Course; • Summer/Winter schools; • Hands-on experiences; • Reading; and Shared learning experiences with health practitioners
African context	• Institutions need to be involved in International Collaboration to gain a holistic view of health informatics from the governmental to the academic perspective. • A hybrid context where paper-based systems are used with informatics systems needs to be considered since nurse practitioners work with both systems. • African context considerations need to be considered such as African policies and examples, a one size fits all does not apply to the African Context. • In line with the African Context's lack of infrastructure needs to be considered as resources for learning and implementing the health informatics systems is at times not available. • Infrastructure needs to be considered as resources for learning and implementing the health informatics systems is at times not available.

6.6 Chapter Conclusion

This chapter presented and discussed the perspectives of health informatics experts on competencies that could be taught to IT Students to enable them practice having some domain knowledge in the health field. From the competency topics suggested by the health informatics experts eleven (11) themes were identified. Experts proposed two main ways for practising IT professionals to gain health domain knowledge. This was either through in-service training or by taking a short course. Suggestions that would be useful for the African context are also presented to gain their perspectives of the lower and middle-income countries' context. This chapter provided a perspective of competencies that IT Students may acquire necessary within Health informatics.

CHAPTER 7 DISCUSSION

7.1 Introduction

This chapter discusses the results from the study conducted with the nursing students, both nurse and informatics educators and the health informatics experts. The study begins by summarising the results and discussing them. As the mixed method study design used in this research is convergence, the integration of the results, and a combination of the results is discussed. The findings are then mapped to the conceptual framework. Significant findings are indicated and outlined at the end of the chapter.

Next, the researcher summarises the findings based on the perspectives of the nurses, educators, INDEHELA case, and experts explored.

7.2 Summary of Results and Discussion of Nursing Students Outcomes

The following sections provide a summary of the nursing students results and then a discussion of the results is conducted.

7.2.1 Key Findings based on the Nurses' Perspectives

The key findings from the study are repeated in the following table as it appears also in Chapter 4.

Table 7-1: Summary Findings for the Nurse Practitioners Perspective

Summary Main Findings for the Nurse Practitioner Perspective
• Majority of participants (84%) are digital emigrants aged 30 to 59 years. Sixteen percent of participants are digital natives aged 20 to 29 years. • Nurses' attitudes are positive towards the use of computers as most participants were comfortable in using computers. • In addition, nurses indicate: • They are competent in computer use and to utilise the basic computer applications for typing and using the internet and mobile healthcare apps. • Their interest in seven knowledge areas related to digital health that have the potential to improve their nursing practices. • They would prefer to develop their nursing informatics competencies through the following methods such as: self-study, to attend workshops, and to enrol in a college for an in-service training.

7.2.2 Discussion of Results of Nursing Students

Findings indicate that the majority 84% of the nursing students were older participants aged 30 to 59 and only 16% were younger 20 to 29 years. This indicates the demographic status of the nursing practitioners age groups that are currently active in practice. This finding is also indicated by the annual statistics of SANC (2022). This finding indicates that the majority of participants were digital emigrants and as such competencies in informatics are not their strong point unlike the digital native younger nurses (Lekalakala-Mokgele *et al.*, 2023).

In determining whether the nursing students saw value in computers, it was important to assess their attitudes towards computers and information technology. The analysis indicates that nursing students view computers and their usage in healthcare generally favourably. This is independent of age, level of experience, or nursing specialty. This was consistent with the findings of Nkosi *et al.* (2011), Wright *et al.* (2012) and Ruxwana *et al.* (2010), as well as other investigations. The score results also show that some nurses have a realistic view of current computer capabilities in health care, which indicated that they were familiar with the use of HIS within their work practice. This indicates that they could identify areas of use for computers and information technology and make recommendations. This was indicated by them stating that they would need spreadsheet competencies for statistical and reporting, and presentations for monthly reporting.

The participants identified themselves as competent in word processing programs, which was consistent with the findings from Harerimana and Mtshali (2019). However, this study differs in that the participants identified themselves as novices or without experience in Excel, PowerPoint presentations, and Databases. The nurses indicated that these competencies are important for their practice and are a requirement for work competency. The participants also state that they are proficient with social media, smartphones, tablets, and cell phones. Seven themes:(1) advanced computer skills; (2) basic computer skills; (3) software design and development; (4) education and research; (5) technical writing; (6) data management and (7) social media, were generated from the capabilities that participants felt they should take. These competencies were being used as follows: the basic computing competencies included Word Processing for reporting; Power Point for monthly presentations; Excel for statistical purposes; software design and development to develop websites and applications; education and research to be more proficient applying higher-level knowledge in their assignments; technical writing for blogging; data management for evidence-based practice and social media to enhance communication between nurses and doctors. From the outcomes of desired competencies, the current state of competencies is in its computer literacy stage. This is in alignment with the studies from Harerimana *et al.* (2021) and Le Roux *et al.* (2024). This study differs from these two studies by indicating further competencies that the nurses would like to take, which are currently outside of the computer literacy scope. When analysing the desired competencies in comparison to the TIGER (Hubner et al.,2018), AMIA (Valenta *et al.*, 2018) and the IMIA (Bichel-Findlay *et al.*, 2023) knowledge areas proposed by these authors, the results indicate that the nurses concern was on gaining informatics knowledge. This was evident in the competencies that focus on computers, technology, data and information science. The competencies desired were more than computer literacy, which is an indication that nurses are aware of more uses of health informatics technologies. Although the current state of informatics is in its computer literacy stage as stated by Harerimana *et al.* (2021) and Le Roux *et al.* (2024), nurses are ready to advance in their informatics skills.

Four methods of attaining the competencies were derived from the responses. These are: (1) self -study, some participants indicated that they could read on the competencies or take an online MOOCs (an online learner management system) course. (2) Participation in workshops where specific competencies are developed, with a recommended time frame is mostly 2-3-day workshops, this was recommended as nurses have limited time to attend a workshop that is more than 2-3 days. (3) in-service training of practitioners as they are at their places of work. The competencies should be integrated within the nursing praxis. This is a recommendation that the Hübner *et al.* (2018) as well as Mantas and Hasman (2017) propose in their discussion of the TIGER and IMIA competency frameworks for nurses; and (4) registration at a college that provides training that is in alignment with the competencies. The method of incorporating informatics competencies into nursing informatics preferred by most was the integration of competencies within the nursing curricula. This would be also in alignment with the SANC macro curricula which has integrated computer skills competencies into the curricula.

7.2.3 Results Mapped to the Related Literature

The following section is a mapping of the findings to Literature.

Table 7-2: Nurse Practitioners Perspectives

Findings for the Nurse Practitioner Perspective	**Mapping to Literature**
1. Most of the participants are digital emigrants aged 30 to 59 years. 84 percent and sixteen percent of participants are digital natives aged 20 to 29 years.	Nursing Informatics in South Africa SANC (2022) Lekalakala-Mokgele et al (2023)
2. The nurses' attitudes are positive towards the use of computers as most participants are comfortable in using computers.	Nursing Informatics in South Africa Nkosi *et al.,* (2011), Wright *et al.,* (2012) Ruxwana *et al.* (2010),

3. They were competent in computer use and to utilise the basic computer applications for typing and using the internet and mobile healthcare apps	Nursing Informatics in South Africa Harerimana and Mtshali (2019)
4. Their interest in seven knowledge areas related to digital health that have the potential to improve their nursing practices	Global Nursing Informatics and Health Informatics Education Competencies Frameworks TIGER (Hubner et al.,2018), AMIA (Valenta *et al.*, 2018) IMIA (Bichel-Findlay *et al.*, 2023)
5. They would prefer to develop their nursing informatics competencies through the following methods such as: self-study, to attend workshops, and to enrol in a college for an in-service training	Nursing Informatics in South Africa Hübner *et al.* (2018) Mantas and Hasman (2017)

An outline of empirical findings similarities and differences with literature indicate that finding number one, the indication that majority of nurses are digital emigrants is similar to what has been found in literature. This is from the writings of SANC (2022) and Lekalakala-Mokgele *et al*. (2023). Finding number two, the positive attitudes of the nurses is similar to a number of studies that have been conducted with nurses in different contexts in South Africa and validates these studies for postgraduate nursing students. Finding number three is similar to studies conducted by Harerimana and Mtshali (2019), they indicate that nurses are competent in word processing application, however this study differs from their study by indicating that the nurses were not competent in Excel, PowerPoint and Database software. This study differs further in finding number four by exploring desired competencies by the nurses and outlines seven knowledge area themes that have not been indicated in literature. Literature currently indicates that nursing informatics is at the computer literacy stage and literature by Harerimana et al (2021) and Le Roux et al (2024) explore the current competency assessment of nurses. This study indicates that nurses are willing to gain more informatics competencies as the competencies they indicated fell in the information technology knowledge areas outline in the TIGER, AMIA and IMIA frameworks. There is a paucity of literature on the methods of training in the African context, however in the international context finding number five differs from the findings from Hubner *et al,* (2018) and Mantas and Hasman (2017) as they suggest nursing informatics should be integrated in the nursing course, yet the nurses provide training methods that are external to integrating.

7.3 Summary of Results of Nurse and Informatics Educators; and INDEHELA Case and Discussion

A summary of the Nurse and Informatics educators is repeated in the following section. This is followed by a summary of the INDEHELA case summary as indicated in Chapter 5.

7.3.1 Key Findings based on the Educators' Perspectives

Table 7-3 Themes and findings - educators' perspectives

Theme	Findings
Context of Practise	• There is a paucity of knowledge on the nursing informatics and health informatics disciplines, thus there is a need for advocacy of nursing informatics and health informatics. • Nurse educators need skilling in informatics so that they can be able to find examples which they may use in their course content. • Nurses use informatics tools to aid them with data capturing, decision support and data analysis within their practise. • Informatics students lack the contextual health domain knowledge and need to know the decision making processes in the workflows and health technological use.
Course Structure	• Given the current situation in South Africa where there are a large number of digital emigrant nurses, informatics courses offered should be both integrated within the curriculum as well as having short courses for digital emigrants. • Course content depends on who the program is intended for, nurses require a program with an informatics focus and informatics practitioners require a program with a health focus.
Mental Maps	• There are two mental maps which have to provisioned for in a course for the digital immigrants and digital natives. • To cover the gap between nursing and informatics it was advised to constructively build the knowledge, where the more familiar content is covered first and then more content is built on the familiar until all the content is covered. • IT students need to develop collaborative skills to enable them to work with domain knowledge experts

The next section discusses findings of educators' perspectives.

7.3.1.1 Discussion of Theme 1: Context of Practice

Literature indicates that nurse educators have a positive attitude towards information technology (Ravele, 2019; Sunnasy, 2020; Ziqubu and Orton, 2023). However, challenges they faced with the implementation of information technology in their practise was that they lacked informatics skills (Harerimana *et al.*, 2021) which would enable them to understand the content and context of informatics within the context of nursing. This paucity of skills by the lecturers results in a lack of teaching strategies (Harerimana *et al.*, 2021; Harerimana *et al.*, 2023) This correlated with the study as key findings indicated that nurse educators indicated that they had no informatics knowledge and if they had information technology skills, they would be able to synthesise relevant content which they can integrate into the curriculum and teach their students. Nurse educators acknowledge that the opportunities for integration are present, however because they are digital migrants they are not aware of the opportunities and therefore require training to equip them. This is also concurred by literature (Ravele, 2018; Sunnasy, 2020; Ziqubu and Orton, 2023). This indicated that educators need training to be able to lecture content of the nursing informatics discipline. The latter was important to the educators as it would enable them to see relevant areas in the context which they could use as examples within their classrooms.

According to literature there are several opportunities for the use of informatics within the nursing domain. (Ahmad *et al.*, 2018 ; Mahoney, 2011) These have been noted as beneficial to the practice and entail nurses using their knowledge, intuition and experience for promoting the ease of documentation; quick retrieval of required information; prevention of medication errors; monitoring alerts, and increasing the use of Evidence-Based practice. Contexts where nurses use informatics tools are in the capturing of clinical documentation or EHR at the point of care (Vehko *et al.*, 2019; Brown *et al.*, 2020) This entails electronic patient charting of the medical history, diagnosis, treatment plans, medications, radiology images, and lab results for each patient. (Portilho, 2018). Competencies that are required for this are decision support and data analysis, when nurses synthesise, the data produced by the informatics tools. (Ahmad *et al.* 2018). Key findings corelated with literature indicating that nurses use Information Systems for Data Capturing for capturing data for their workflow processes, for patient vitals and statistics; Decision Support, for evidence-based practice from patient data captured; Data Analysis, to identify and determine patient risks. Nurses often use their knowledge, intuition, and experience to make decisions, based on their awareness of a particular situation with informatics tools providing that information. The informatics tools they use in practice provide the data and information, that they would use to inform their knowledge. A knowledge of the way nurses use informatics tools provides the context areas where examples nurses can relate to may be drawn.

Context is one of the dimensions noted by the ACM an IEE in their definition of competencies for Informatics students (Clear *et al.*, 2020) and as such it is to be incorporated in the courseware for Informatics students. However, literature notes that while informatics students have the hard skills of coding, and data analysis, one of the skills they lacked was domain knowledge of the context in which they would be practising (Wu, 2022). This as Wu (2022) indicates is a challenge as most problems are domain specific with the business rules that govern how a problem is approached. Key findings according to the informatics educators their students already have the hard skills and require knowledge in the health domain as well as knowledge of the workflows of the health practitioners. This would enable them to understand the domain knowledge and analyse, develop and implement applications that are relevant and sustainable.

Four key findings were found from the INDEHELA case. The first was that the Health Informatics Course covered knowledge areas in the IT2017 and the IMIA Foundational domains and had competencies for a Health Informatician. Holden *et al.*, (2018) suggest that the inclusion of a health informatician in inter-professional teams in healthcare services may contribute to addressing challenges experienced in healthcare services. The second finding is that a collaborative approach was conducted. The third finding is that teaching was conducted by domain knowledge experts. The fourth finding is that the INDEHELA had various activities that provided diverse perspectives to the project.

7.3.1.2 Discussion of Theme 2: Course Structure

According to Skiba (2017), the evolution of nursing informatics as a discipline corelated with the evolution of information technology. As information technology was being developed courses for nurses were structured in a silo format where the course is aligned to training only on the information technology use (Mantas, 2016). Hubner et al (2018) however noted this and recommended that courses change from a silo structure to an integrated format. This would mean that as the nurses go through their 3- or 4-year nursing degree, nursing informatics topics are taught to them as part of their curriculum. This too was recommended in key findings by the nurse educators as they felt that there are many different technologies available in practise, that training in one informatics tool would disadvantage competencies in the other tools. Having looked at the competencies recommended by the TIGER; nurse educators felt it was possible to lecture the content integrated within the current course structure so that the students gain a holistic picture of informatics within their practise

While training maybe integrated into the nursing curriculum, this would cater for the digital native nurses that are going through the course and not the nurses that have already done their training especially the digital migrants. According to SANC (2022) most of the nurses within South Africa are nurses over 45years old. These would be classified as digital migrant, and they lack digital literacy skills. Considering that integrating the course content into nursing degree or diploma would not cater for the digital migrant nurses, these nurses, would require formal and informal training in the form of short courses that are tailored to upskill them in informatics (Eldoushy and Soliman Behairy, 2023; Ramnund *et al.*, 2023). This correlated with the key findings that in the current skills context of nurses within South Africa it was recommended that there was a need for both, an integrated, as well as a dedicated course. This was because there was still a large number of digital immigrants within the domain of nursing, these would need to be upskilled using a short course of computing basic skills, whilst the current students who are digital natives would go through the integrated course This would mean that both Integrated and short course would be an option for the South African context for training of nurses in informatics.

Finding a universal course of informatics applied to the nursing and healthcare domain is a complex and challenging task, not only because of the distinct fields it entails but also because of the multitude of existing definitions of the sub-disciplines within the domain (Staggers and Thompson, 2002; Peltonen *et al.* ,2021; Reid *et al.* 2021) The domain of Nursing Informatics and Health informatics lie in the intersection of multiple disciplines, making it difficult to define and, consequently, characterise the training needs and requirements in this domain. (Costa *et al.*, 2023; Yao *et al.*, 2023). Thus, literature indicates that the content for Nursing Informatics and Health informatics in the courses, is dependent on the required outcomes of the program and the needs obtained from the nurses and informatics students (Costa *et al.*, 2023; Yao *et al.*, 2023). Therefore, that the course content would depend on who the course is being offered to. (Costa *et al.*, 2023). Key findings on course structure concurred with literature indicating that if the course is to be offered to nursing students, they would be interested in the informatics content, and the informatics students would require a course with health content. This was crucial in determining the competencies of a course and the outcomes that the participants would require.

7.3.1.3 Discussion of Theme 3: Mental Maps

According to literature a lack of digital competencies in nurses that are practising would result in losing opportunities for digital implementations in the South African Health context (Ramnund *et al.*, 2023). Digital migrants who comprise most of nurses in practise contribute towards this as they lack the digital competencies to use informatics tools. In addition to lacking competencies digital migrants are not comfortable with the use of informatics tools and have an aversion towards the tools (Ramnund *et al.*, 2023). Thus, the older nurses do not readily adopt technologies introduced to them unlike the younger digital native nurses. Key findings also indicate that the older generation of nurses which are digital emigrants, unfamiliar with information technology while the younger nurses are digital natives. In addition, the digital emigrants are not comfortable with the use of informatics tools even within practice when dealing with a tool implemented by the Department of Health. This indicates that there is a need to cater for different competency levels should a course be offered.

To increase adoption of informatics technologies by digital native nurses, integrating informatics topics into the nursing curricula was recommended in literature (Hubner *et al.*, 2018). An approach for integrating the content would be to stagger the topics, with more familiar easier content in the beginning of the course and more complex nursing informatics content towards the end of the program (Hubner et al, 2018). This was the recommendation according to the course recommendations from the TIGER (Hubner *et al.*, 2018). Staggering the course content would enable the nurses to constructively learn informatics competencies, developing from novices to experts (Staggers *et al.*, 1993). Key findings concurred with literature on having a staggered approach to teaching and learning. In this approach it was recommended that the content that students are more familiar with is covered first and then more content is built on the familiar until all the content is covered. This would ensure that the students may relate to the material and be able to connect the content to their work practise or life.

According to Wu (2022), in his study on the Internship experiences of Data Science students, one of the soft skills that IT students required was Communication and Collaboration. IT students have been trained to develop, design, and implement IT solutions; their need is in developing collaborative skills which enable them to work with Domain Knowledge experts to produce relevant artefacts (Wu, 2022). Martikainen *et al.*, (2020) also note that collaboration between Informatics practitioners and nurses is a necessity, as nurses do not have the time to analyse, design, develop and implement informatics artefacts. Collaboration would enable the interdisciplinary transfer of knowledge between the IT practitioners and nurses, upskilling them informally. The need for collaborative skills by informatics students was one of the key findings. IT students have been trained to develop, design and implement IT solutions and their challenge is to develop relevant and sustainable solutions for nurse practitioners. Since they are not familiar with the domain of health, their key need is in developing collaborative skills which will enable them to work with domain knowledge experts to produce relevant artefacts.

7.3.1.4 Results of Nurse and Informatics Educators mapped to the related literature.

A summary of the Nurse and Informatics educators is detailed in the next table.

Table 7-4: Summary of Educators Inquiry

<table>
<tr><th colspan="4">Themes, Findings and Evidence From The Data</th></tr>
<tr><th>Themes</th><th>Key Findings</th><th>Evidence</th><th>Mapped To The Literature</th></tr>
<tr><td rowspan="2">Context of Practice</td><td>Nurse Educators
Paucity of knowledge of Nursing Informatics by nursing educators. Educators need training to be able to lecture content of the nursing informatics discipline</td><td>“I am aware of it not that in depth, I’ve never actually worked with that “ [Participant 2]

“They will be able to find the opportunities, that are there within the courses, because the opportunities are there, opportunities are there … I need to know it before I can actually look for it to expose my students, and most of us have trained before this so we don’t even know the possibilities and the potentials” [Participant 1]</td><td>2.7.2 Nursing Informatics in South Africa
Ziqubu and Orton, 2023
Ravele, 2018</td></tr>
<tr><td>Nurses often use their knowledge, intuition and experience to make decisions, based on their awareness of a particular situation. Nurses use Information Systems for
Data Capturing - For capturing data for their workflow processes, for patient vitals and statistics,
Decision Support - For evidence-based practice from patient data captured,
Data Analysis - To identify and ascertain patient risks</td><td>“… if you qualify you might at a high-level start integrating and developing a care plan, whereas at undergrad level you might just be entering say vital signs… Undergrad has a lot of procedures than Postgrad, you have to enter data before even after doing a procedure…” [Participant 2]

“…you need to keep track of who has got the flu and who is diabetic… and see who is able to provide the food” [Participant 2]

“Data doesn’t necessarily mean statistics… they have to go through a site, analyse and identify the risks…” [Participant 2]</td><td>2,4,6 Digital Use
(Ahmad et al., 2018);
(Mahoney and Faan, 2011)</td></tr>
</table>

Themes, Findings and Evidence From The Data			
Themes	**Key Findings**	**Evidence**	**Mapped To The Literature**
	Informatics Educators Informatics Students lack contextual health domain knowledge. In addition to the workflows of the Health domain for each practitioner, Informatics Students need to know Health Technologies	"…problem probably for the IT people to create the right solutions that will work in practice, if they don't understand how the practice works out." [Participant 5] "there is the technology and there is the workflow, when you look at the system you are looking at all of that…" [Participant 4]	2.6.3 Informatics Competencies Wu (2022)
Course Structure	**Nurse Educators** Educators recommended that the competencies be integrated within the Course Curricula that the Nursing Students would be doing	"I think the integrated works best now, because we have so many different types of technology that different hospitals user and because the students are exposed to, in practical in different sense throughout their 4 years of their courses "[Participant 3]	2.5.3 Nursing Education and Technology Hübner *et al.*, (2018)
	Nurse Educators In the current situation of the context of health, there was a need for integrated and short courses. As there was still a large number of digital immigrants within the domain of Nursing and these would need to be upskilled using a short course of computing basic skills.	"Most of the IT courses the IT students should have gone through them during the course of their study, a short course or dedicated course would be appropriate" [Participant 4] "I think some of the topics should be taken as a short course and some can be integrated in the main course" [Participant 5]	2.7.2 Nursing Informatics in South Africa SANC, 2022 Ramnund *et al.*, 2023 Eldoushy and Soliman Behairy, 2023
	Nurse and Informatics Educators Course content depends on who the course is being offered to. If it is the Nursing Students are interested in the Informatics Content and the Informatics Students would require a course with Health Content,	"It depends on the objective of the course… the offering for nurses should have more IT than Health" [Participant 1] "What is the aim of the course…the IT students need the Health component, that is what they are lacking" [Participant 4]	2.5.3 Nursing Education and Technology Costa *et al.*, 2023 Krive *et al.*, 2023 Yao *et al.*, 2023

Themes, Findings and Evidence From The Data			
Themes	**Key Findings**	**Evidence**	**Mapped To The Literature**
Mental Maps	**Nurse Educators** There is a digital gap between generations of nurses. The older generation of nurses are digital emigrants, and the younger nurses are digital natives. The older nurses have an aversion of digital products even when introduced by the Department as part of their workflow. Younger nurses adopt the digital products more readily	"… your younger students are happier to work with a smart phone or with eLearning. or computers and al the older students feel very threatened because they feel like they haven't got the skills and they don't have enough faith in it." [Participant 1] "There are methods, methods in the clinic, the government has introduced, an application where they can access patient's data and stuff like that…. (The Older students) are seeing it as a burden, because they are not comfortable." [Participant 1]	2.7.2 Nursing Informatics in South Africa SANC, 2022 Ramnund *et al.*, 2023
	Nurse Educators Advised approach to covering the gap is to have a staggered approach to teaching and learning which is constructive in nature with material that the students can relate to their work practise or life	"Starting with the basics not the basics only…. you want to move people from what they know to what they don't know, when they are able to see the link, so starting with small stuff simple things. Then they can gain confidence from small things at a time" [Participant 1]	2.5.3 Nursing Education and Technology Hubner *et al.*, 2018
	Informatics Educators IT students have been trained to develop, design and implement IT solutions, their need is in developing collaborative skills which enable them to work with Domain Knowledge experts to produce relevant artefacts,	"For the IT students to gain domain knowledge they need to work collaboratively with domain experts" [Participant 6]	2.6.3 Informatics Competencies Wu (2022)

7.3.2 Key Findings from the INDEHELA Case

The following key findings were derived as described in Chapter 5, sub-section 5.6.

Table 7-5: Key Findings from the INDEHELA Case

Theme	Findings
Health Informatics Course Coverage	The health informatics fundamentals course covers most areas of health practices using digital health technologies as indicated in the coverage of the AMIA and IMIA foundational knowledge domains.
Collaborative competencies' topics	The collaborations of the health and informatics domain representatives resulted in identified suitable context-sensitive health informatics topics based on an aligned negotiated understanding.
Domain teachers	Teaching was done by domain experts. The health topics were covered by health experts and the informatics topics by informatics experts.
Collaborative network	A collaborative network of inter-disciplinary members on different levels can produce meaningful outcomes by leveraging individual expertise, diverse experiences, and building upon existing research, teaching, and other practices.
Main finding	The development and implementation of a Health Informatics course by INDEHELA network collaborators can be regarded as a success due to the collaborative expertise of practitioners from various disciplines that included Health and Informatics, in crafting the topics, and teaching them. This collaborative effort produced a course which content was comparable with the International competencies of AMIA, IMIA and IT2017 frameworks.

The meaning of the findings is discussed next.

7.3.2.1 Discussion of the INDEHELA Case

The INDEHELA case outlines the collaboration of various universities from the global North and the South in the exploration of the health informatics domain. Findings from the project show that the success of the project was due to its collaborative nature. Perspectives from practitioners from health, informatics and anthropology were brough together to produce the outcomes. Collaborative approaches have been used in interdisciplinary studies as they bring domain experts from both the health and informatics disciplines, who collaboratively integrated their knowledge and skills. This approach was adopted in the development of International Frameworks for example the IMIA in 2010 and in 2017 (Mantas *et al.*, 2010; Bichel-Findlay *et al.*, 2023), and the TIGER in 2018 (Hübner *et al.*, 2018).

Additional findings from the study were that the Health Informatics Course was in alignment with the core IT2017 Curricula recommendations and the IMIA foundational domains. This indicated that the course was in alignment with the standards from the Informatics domain. The topics that were in alignment with the IMIA foundational domains, indicated that the necessary health domain knowledge was covered in the course. The coverage of informatics and health domain knowledge signified that the topics proposed are adequate for competencies for a health informatician. This is in alignment with Holden *et al.* (2018) who propose that a health informatician should have skills that communicate using suitable tools, articulate and develop health informatics knowledge and skills. Other findings is that the course was taught by domain experts. This provided a platform for the transfer of domain knowledge as there is a lack of health informatics experts who are well versed in both domains (Thate and Brookshire, 2022). The lack of health informatics domain knowledge by nurse educators and informatics educators was reported by the educators, indicating that because of this they are not conversant in what to teach the students.

A final finding was that the project produced many outcomes due to the collaboration. These were research, an innovation hub for developing artefacts, participation of diverse practitioners and spin offs in terms of student projects and post graduate research and development. These outcomes are in alignment with research projects of such nature as they are meant to contribute physically as well as to the body of knowledge (Issa-Salwe *et al.*, 2024; Samarah *et al.*, 2024).

7.3.2.2 INDEHELA Summary Results Mapped to Related Literature

Table 7-6: INDEHELA Summary Results mapped to the Literature.

Theme	Finding	Mapping to Literature
Health Informatics Course Coverage	The health informatics fundamentals course covers most areas of health practices using digital health technologies as indicated in the coverage of the AMIA foundational knowledge domains.	2.8.2.1 Global Nursing Informatics and Health Informatics Education Competencies Frameworks Mantas et al., (2010); Bichel-Findlay et al., (2023), Hübner *et al.,* (2018)
Collaborative competencies' topics	The collaborations of the health and informatics domain representatives resulted in identified suitable context-sensitive health informatics topics based on an aligned negotiated understanding.	Health Informatics Education Drivers in Africa Holden *et al.,* (2018) Thate and Brookshire, 2022
Domain teachers	Teaching was done by domain experts. The health topics were covered by health experts and the informatics topics by informatics experts.	1.1.1 Health Informatics Education Drivers in Africa Thate and Brookshire, (2022)
Collaborative network	A collaborative network of inter-disciplinary members on different levels can produce meaningful outcomes by leveraging individual expertise, diverse	1.1.1 Health Informatics Education Drivers in Africa Issa-Salwe et al., (2024) Samarah et al., (2024)

Theme	Finding	Mapping to Literature
	experiences, and building upon existing research, teaching, and other practices.	
Main finding	The development and implementation of a Health Informatics course by INDEHELA network collaborators can be regarded as a success due to the collaborative expertise of practitioners from various disciplines that included health and informatics, in crafting the topics, and teaching them. This collaborative effort produced a course which content was comparable with the international competency AMIA, IMIA and IT2017 frameworks.	1.1.1 Health Informatics Education Drivers in Africa Issa-Salwe *et al.*, 2024; Samarah et al., 2024 Bichel-Findlay *et al.*, (2023), Hübner *et al.,* (2018)

7.4 Summary of Results of Health Informatics Experts and Discussion

The following section provides a summary of the results of the Health informatics Experts, and a discussion of the results.

7.4.1 Key findings based on the experts' perspectives

The summary findings as derived in Chapter 6 repeated here in Table 7-7.

Table 7-7: Key Findings from the Experts

Key Findings	
Competencies Topics Themes	• **Community-based Health and Wellbeing Services** This theme considered the use of digital technologies in Public Health with consideration on the areas of patient empowerment, personal health records and epidemiology. • **Digital Health** This theme focused on the knowledge of digital health systems that are available in the health domain. It includes knowing their structure, function and how they impact the health domain. • **Digital Health Development and Implementation** This theme includes activities that involve the design, development and implementation of health information technologies. It considers record management, collaboration of practitioners and identifying features that make up a digital health information system. • **Digital Health Ecosystem** This theme involved understanding the different Health Systems, international and the one implemented in the local context primary. It considered knowing the different types of healthcare, primary acute and tertiary. • **Digital Health Management** This theme looked at the professional practice of informatics practitioners with a focus on change management; multi-professional project work; security; confidentiality and risk. • **Digital Health Monitoring and Evaluation** This theme considered the impact assessment, monitoring and evaluation of Health Information Systems. • **Emerging Digital Health** This theme looked at the impact emerging digital health technologies such as artificial intelligence and other technologies have on the health domain. • **Health Informatics Education and Research** This theme looks at equipping the practitioner with skills to enable them to apply scientific knowledge to resolve case studies, complete a project or discover new knowledge. • **Health Informatics Fundamentals** This theme looks at having foundational knowledge in health informatics. It includes areas such as the history of health informatics; concepts such as communication processes, health informatics organisations internationally and locally as well as sources of health informatics knowledge. • **Health Information Management and Interoperability** This theme looks at appropriately applying data and its standards in the health domain. It considers areas such as data standards and interoperability; information technology architecture and Infrastructure; Digital Decision-making and Communication Data Management; Electronic Health Records; governance; security; confidentiality and risk.

	• **Health Professional Work Practise** This theme involves understanding the information, workflows and activities of the health practitioners.
Competencies finding	Findings indicate that Health Informatics Experts suggest eleven topic themes where informatics practitioners gain competencies in having some knowledge about the different functioning of the health domain and an understanding the impact and application of digital health systems and technologies in health practice.
Method of Skilling	• Staggered 3/4 year course; • Short Online Course; • Summer/Winter schools; • Hands-on experiences; • Reading; and Shared learning experiences with health practitioners
African context	• Institutions need to be involved in International Collaboration to gain a holistic view of health informatics from the governmental to the academic perspective. • A hybrid context where paper-based systems are used with informatics systems needs to be considered since nurse practitioners work with both systems. • African context considerations need to be considered such as African policies and examples, a one size fits all does not apply to the African Context. • In line with the African Context's lack of infrastructure needs to be considered as resources for learning and implementing the health informatics systems is at times not available. • Infrastructure needs to be considered as resources for learning and implementing the health informatics systems is at times not available.

7.4.2 Discussion on Results of Health Informatics Experts

The Health Informatics Experts recommended topics for informatics practitioners which they will take in year 1,3 ,4 and diploma levels. Eleven (11) themes were derived from an analysis of the topics. Health information Management and Interoperability is the theme that had the most counts, indicating a focus on sub themes such as Data Standards and Interoperability; Data utilisation and management; Digital Health Records and Governance, ethics and regulations. Most of the topics were covered in the IT2017 and IMIA frameworks (Bichel-Findlay *et al.*, 2023), however the Data Standards and Interoperability was a topic not indicated in either framework. The second theme was the Digital Health Development and Implementation theme, that participants described as the need to design, development and implement digital health technologies. This topic is included in all the frameworks as core to the competencies that Informatics practitioners should have. These two themes have an informatics domain knowledge focus and had representation in the IT2017 framework, which focused on informatics competencies. The following theme was health focused as Community-based Health and Wellbeing Services; these participants indicate that informatics practitioners need to gain knowledge on public health and digital health records dealing with personal health records and electronic health records. The remaining themes each had the same count of topics and were Digital Health Management; Digital Health Monitoring and Evaluation; Emerging Digital Health; Health Informatics Fundamentals; Health Professional Work Practice and Health Informatics Education and Research. The latter themes have a health focus and are included in the IMIA framework than the IT2017 framework.

Contextual orientation of the content of the competencies according to suggestions from the experts is health oriented. The competencies suggested had three characteristics: (1) A broad overview of the health domain context; (2) An overview of the Health System of the context, for example the Road to Health System that is used in South Africa; and (3) Health ICT Systems Software Modules. The competencies suggested are centred around Health informatics Data, and Data Management. These competencies characteristics complement the Informatics practitioner's domain knowledge, for developing systems for a context, and domain knowledge on the data and the decisions made on that data. Mantas and Hasman (2017) note that having this knowledge in the health context would ensure implementation of resilient Health ICT Systems.

For problem-based education such as in Health informatics Education, especially in Africa where contexts differ greatly, it is important to tailor courses to the context (Baayd et al, 2023). As one expert noted that the notion of one size fits all does would not apply for Health informatics Education, as there are varying needs, the "particular context and economies" (Adeniyi et al, 2024). When asked to recommend a method of administering a Health informatics Course for Informatics practitioner, experts suggested six methods. These were: (1) Through a regulated 3- or 4-year course; (2) Short Online Course; (3) Winter or Summer School; (4) Hands on Experience; (5) Reading; (6) Shared learning experience with experts. Other than the regulated course and Winter and Summer Schools, the other four methods accommodate the Informatics practitioner, whose work practice does not allow for time off (Blanchard and Thacker, 2023). This provides Informatics practitioners who are working with opportunities to upskill themselves within a particular domain.

On the focus, objective and depth of content of a course, it is noted that the following contextual characteristics are of importance: (1) Keeping a note of both national and international political situations and priorities as countries are at various levels of development, (2) keeping abreast with the contextual changes that affect the domain and relevancy of the health informatics education offering (Baayd et al, 2023).

In the African Context, course content should “focus and apply African type of case studies and examples", this makes the content visually meaningful and relevant to the students. The African health context provides a platform for the development of Health Information Systems and Technologies artefacts that can be used in remote areas. In the African context eHealth, telehealth and mHealth are the common systems that Informatics practitioners implement especially for remote area contexts. Kokol *et al.* (2018) notes that this is the strength domain of Informatics practitioners working Health contexts, while Health informatics is a strength for Health practitioners. Case study examples provide Informatics Students with an understanding of the process of implementing relevant artefacts within the context of Health. (Tiihonen et al,2008).

It is important for informatics students to know and understand the ‘paper-based components’ used within their context of health. These would aid the students in understanding the context of health, the type of data that health practitioners capture as they conduct their praxis and enable them to gain an overview of the activity workflow touch points, the stakeholders that use that data, the user rights to the data, the decisions made using that data and security measures that need to be implemented to protect that data. Content should also include the health documents from the country or context in which the course is to be administered. (Mahoney, 2011) suggest that a hands-on experience is important, and involvement in an initiative either governmental or non-governmental aids in providing platforms from which students can practice their competencies (Ruhode *et al*., 2013).

For content that is focused on the development of Health Systems, it is important to note that Health IT artefacts have domain specific data standards that they implement for the Systems databases. It is important that Informatics students learn the data standards, and backend components. These differ according to national context as well as context of practice. Common data standards that are particularly used within Africa are the DHIS2, HL7, SNOMED and other components that are used in the development of Health Information Systems Architecture.

7.4.3 Results mapped to related literature

Table 7-8: Key Findings from Experts Mapped to the Literature

Key Findings		**Mapping to Literature**
Competencies themes finding	Findings indicate that Health Informatics Experts suggest eleven topic themes where informatics practitioners gain competencies in having some knowledge about the different functioning of the health domain and an	2.8.2.1 Global Nursing Informatics and Health Informatics Education Competencies Frameworks

	understanding the impact and application of digital health systems and technologies in health practice.	IT2017 AMIA (Valenta *et al.*, 2018) IMIA (Bichel-Findlay *et al.*, 2023) Mantas and Hasman 2017
Method of Skilling	• Staggered 3/4 year course; • Short Online Course; • Summer/Winter schools; • Hands-on experiences; • Reading; and Shared learning experiences with health practitioners	2.4.2 Informatics Practitioners Praxis in the Health Field Baayd et al, 2023 Adeniyi et al, 2024 Blanchard and Thacker, 2023
African context	• Institutions need to be involved in International Collaboration to gain a holistic view of health informatics from the governmental to the academic perspective. • A hybrid context where paper-based systems are used with informatics systems needs to be considered since nurse practitioners work with both systems. • African context considerations need to be considered such as African policies and examples, a one size fits all does not apply to the African Context. • In line with the African Context's lack of infrastructure needs to be considered as resources for learning and implementing the health informatics systems is at times not available. • Infrastructure needs to be considered as resources for learning and implementing the health informatics systems is at times not available.	2.4.6 Informatics in lower and middle-income countries (LMIC) / Digital Health in Africa Kokol *et al.* 2018 Tiihonen *et al*., 2008 Mahoney and Faan, 2011 Ruhode *et al*., 2013;

7.1 Integration of Nursing Results

In this section the results from the nursing students and the nurse educators are integrated. This is done to find any convergence in the data or any conflicts for the digital technologies from the outcomes. Findings from the results show that both nurse students and nurse educators indicate that there is a paucity of knowledge on informatics. Nursing students indicate that although they are literate in MS Word, they lack knowledge in other software packages such as Spreadsheets, Presentation and Databases. This paucity is reflected in the nurse educator’s knowledge as they indicate that if they had informatics knowledge, they would transfer this to their students.

Despite the paucity, both students and educators indicate areas in their use of technology that could be topics that the students could be trained in. The nursing students indicate they used Spreadsheets, Presentation for statistics, reporting and presentations. This was expanded on by the educators as they indicated that nurses use informatics tools for capturing data for example for nursing care plan and vitals; for data analysis for risk analysis; for decision support in statistics and evidence-based practice. Although currently South Africa is in the Computer Literacy stage, results from the nurses indicate they would like training in informatics focused competencies, this would be possible if the educators were trained as they were willing to look at areas where they could implement informatics in their courses.

On methods of training the students provided a broader choice of training methods. Educators felt that informatics should be integrated into the course curriculum and a point that short course should be offered for digital emigrant nurses. The nurse students agreed with the educators and offered other options such as Self Study, and In Service Training.

Conflicts from the results are in the mental maps of the students. Findings indicated that the nursing students’ results indicate that they had a positive attitude towards computers, however the nurse educators state that the older nurses were resistant to computers and had a fear of learning the technology. This was of interest as the participants were aged 30 to 59 which is the age for digital emigrants. This fear by the nurses, according to the educators, is evident in their practises where they are not confident using the Health Information Systems Services and Technologies that are provided by the Department of Health.

7.5 Integration of Informatics Results + INDEHELA

In this section the integration of the results from the informatics educators and the health informatics experts are considered. Informatics practitioners’ aim in industry is to implement tools that are relevant to the context of practise. Findings from the informatics educators and the health informatics experts indicate that they agree that for the informatics practitioners to implement these tools they need to understand the health context and the workflows of health practitioners. The health informatics experts recommend that these topics should be covered in the foundational stages of the informatics practitioners’ course in the first year. They also recommend other topics which are interdisciplinary in combining aspects of the health domain and informatics domain.

When considering the structure of course offerings, the informatics educators and the health informatics experts agree that to apply one size fits all is not appropriate in the informatics African context. The informatics educators indicate that informatics practitioners would need health knowledge to complement the informatics knowledge they would already have. Of note is that the informatics educators indicate that the informatics practitioners would need to have collaborative skills, this was however, not noted by the health informatics experts. The health informatics experts provided comprehensive topic suggestions that would enable an informatics practitioner to become a hybrid practitioner.

7.6 Combined Discussion

Findings from the nursing and informatics participants indicate that considerations for training in nursing informatics and health informatics in the current context of South Africa, there is need for advocacy of informatics training to the nursing profession and health training to the informatics profession. As one health informatics expert indicated there is a need for health informatics to be recognised as a speciality in health.

Currently the findings indicate that the nursing profession requires training in Basic Computer Literacy from the nurse educators to the nursing students. A course would need to be structured that addresses that need. Findings from the nursing participants also indicate that they have an interest in developing of applications, this is a topic which provides them with competencies for developing applications within their practise. Findings from the informatics participants indicate that informatics practitioner require training in digital health especially in the following topics: data management, data standards and interoperability, digital records and governance and ethics. To design a training course that would involve both practitioners would require provision of the course in stages with the fundamentals being taught in informatics to the nursing practitioners and the health to the informatics practitioners, then interdisciplinary courses which cover the context of health informatics and nursing informatics would be provided.

7.6.1 The Health Informatician Role / interaction moment / collaboration

Results from the study show that the skilling in health informatics competencies results in a practitioner called a health informatician. This practitioner acts as an intermediary and represents both the health and digital technology domains (Gadd *et al.* 2022). The health informatician therefore translates the health domain knowledge to the informatics practitioner and the informatics domain knowledge to the health practitioner.

It can be noted that nurses do not use digital health technologies continuously but interact with them briefly to accomplishing a task for a specific purpose. It is therefore necessary to consider what happens at that point where the health practitioner interacts with the digital technologies to gain insights in the challenges and gains experienced by the health practitioner. A person with competencies in both health and informatics, in the role as health informatician, will be best suited to observe the interaction to establish to what extent the informatics practitioner understood the needs of the health practitioner to incorporate these in the digital health technologies development. The concept of an interaction moment can be an important addition to the concepts identified from the literature to pinpoint the moment when the use of digital technologies is enabled or constrained.

A touchpoint is where the health practitioner connects with the health digital technologies that facilitate the healthcare service for a specific task. Such a touchpoint can also be referred to as an interaction moment, a temporary connection within a specific space (physical or virtual) at a specific time. The health practitioner interacts with the digital health technologies for that moment. Using that interaction moment as the unit of analysis provides an opportunity to the informatics practitioner, in the role of health informatician, to observe the practices of the health practitioners as they experience challenges, gain and pain points that the digital health technologies enable or constrain the interaction. The required competencies at the interaction moment reflect the knowledge and skills and right mindset of the health practitioner to perform the task using digital health technologies. These interaction moments were indicated by the statements by the educators, saying nurses use technologies for "integrating and developing a care plan"; "entering say vital signs"; entering data before even after doing a procedure"; "keep track of who has got the flu and who is diabetic"; "see who is able to provide the food"; "statistics"; "analyse and identify the risks". In addition, a competent informatics practitioner will have sufficient knowledge, skills, and mindset within the health domain to develop and maintain the digital health technologies that enable the interaction moment for the specific task.

As reported in literature, the design-reality gap remains where digital technologies are often designed based on a perceived understanding of the health practitioners' requirements without understanding the implication of it actually being used in practice versus its expected use. According to the informatics educators for the informatics practitioner to design and develop relevant digital health services and technologies they need to have knowledge of the workflows and decision-making practices of the nurse practitioner. This requires an understanding of the various touch points where nurses have an interaction moment with digital health services and technologies.

This is illustrated in Figure 7-1.

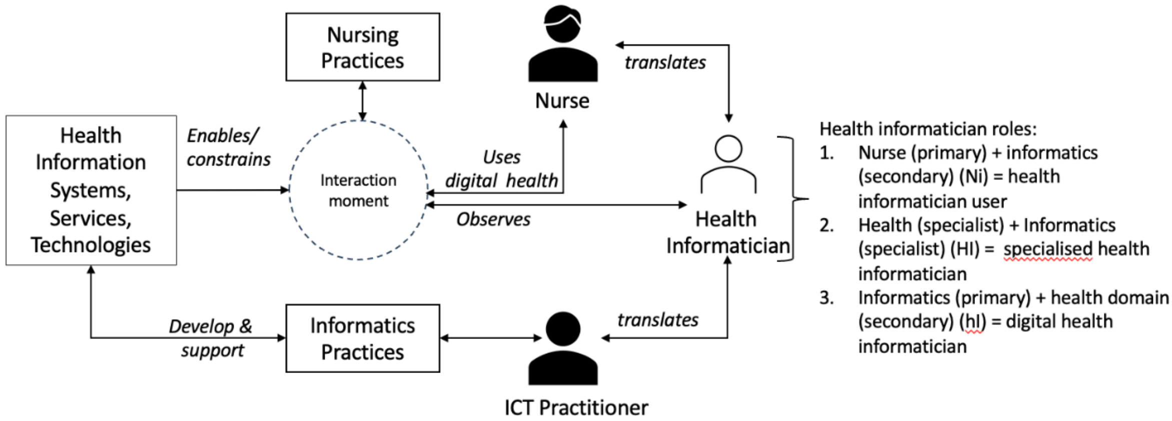

Figure 7-1: Health and informatics practitioners, and health informatician involvement during the interaction moment derived from the study

An outline of the empirical findings indicates there are three roles of a health informatician that is an expansion of the informatician roles suggested by Mantas and Hasman (2017**).** In this study the following health informatician roles are suggested: a health informatician user, a digital health informatician and a dedicated health informatician (Figure 7-2).

A health informatician can be:

- A health practitioner, as a *health informatician user*, needs informatics competencies to enable their work tasks through digital technologies. The levels of such a person could be as an end-user of digital health technologies, or as a generalist (advanced user) with competencies to integrate and apply different aspects of digital health technologies in their practices.
- A *digital health informatician*, is an IT practitioner needing competencies in healthcare to enable them to develop appropriate digital technologies for healthcare and can either be a generalist, having a relatively broad range of health competencies needed for digital health technologies development and support,
- A *dedicated health informatician* has the competencies to act as an intermediary between the health and informatics practitioners to facilitate the development and support of digital health systems, services, and artifacts. This person would be competent in specific areas of both health and informatics and can therefore be regarded as a dedicated health informatician with a deeper understanding of how informatics integrates with clinical practice or healthcare operations. The dedicated health informatician has specialised health competencies for advanced digital health technologies development and support.

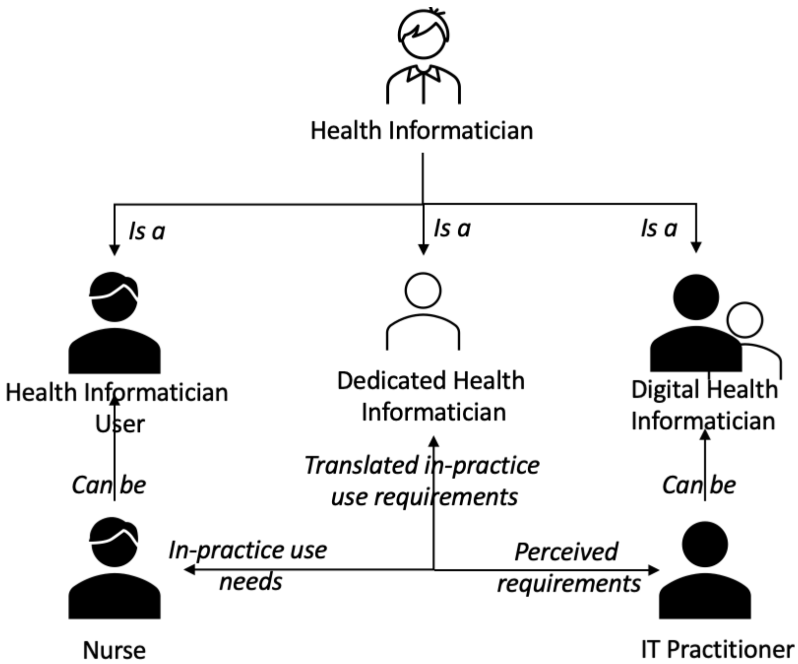

Figure 7-2: Health Informatician Roles

However, it is important to note that the health information role can be part of the health or informatics practitioner work responsibilities or a separate person who is then the intermediary between the health and informatics practitioners.

Each health informatician role is on a level of a continuum, from a beginner to a generalist, to a specialist health informatician as suggested by the literature (Jarva, 2024; Mannevaara *et al.*, 2024; Saranto and Kinnunen, 2022). The level will depend on the complexity of the task; different healthcare settings; and experiences; that confirms with the suggestion of Gadd *et al.* (2022) that such a role need to have unique abilities.

For the health informaticians to be involved in the design, development and maintenance of digital health services and technologies, educators mentioned that they would need to have collaborative skills. The nurses would have enough informatics knowledge to communicate their practices, digital health informatician would have enough knowledge to synthesise requirements into systems and the health informatician can be an intermediary that translates requirements between the two practitioners.

7.7 Results mapped to the Conceptual Framework

In this sub-section, the findings are mapped with the conceptual framework to establish to what extent the data supports the focus of the study. The research questions are formulated to address the identified research gap and each question addresses a specific aspect of the study.

Research Question 1: How suitable is the global Health informatics and its competencies for the training of nurse and ICT practitioners in a health domain in an African context?

> **Research question 1** maps to the Education partition of the framework, how the Nurse Educators and the Informatics Educators develop competencies for their students in the African context given the Global competencies.
>
> **Theoretical Lens:** The suitability of Global competencies in the development of competencies for Healthcare Practitioners and ICT practitioners in the African context.

Research Question 2: Why is the intersection between health sciences and informatics complicating the design of relevant education for the required competencies in the two respective disciplines?

> **Research question 2** maps to the Practise partition of the framework, the competencies of Nursing practitioners influence their use of ICTs in their work activities in practice and competences needed by Informatics practitioners to develop ICTs with the involvement of healthcare practitioners to use the ICT as part of their work activities in practice.
>
> **Theoretical Lens:** The competencies of nursing and informatics practitioners relevance in their work activities in practice.

The conceptual framework proposed for this study (Figure 7-3) is repeated here for easier referencing (refer to sub section 2.10).

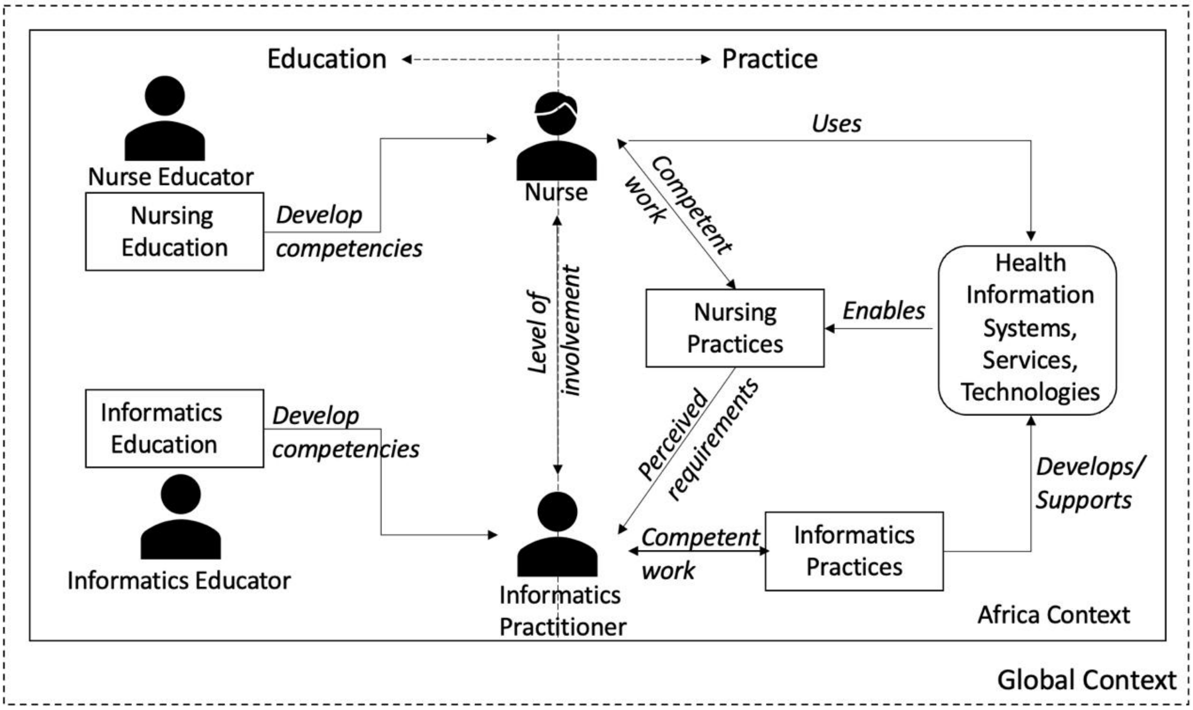

Figure 7-3: Proposed conceptual framework to guide this study referenced from Figure 2.12 in Chapter 2

Next the findings as they are mapped with the conceptual framework are discussed according to the different partitions illustrated in the framework.

7.7.1 Education

In this section of the framework, the role of nurse and the informatics educators in developing and teaching competencies based on the needs of nurses and IT practitioners to be competent in interacting with digital health technologies in practice. The contextual influences seem to also be an important consideration in competencies education. Findings from the nursing education context indicate that currently there is a paucity of informatics competencies in the nursing programs. This may be due to the lack of drive for informatics competencies from SANC the governing body. Another reason based on the findings is that nurse educators, indicate that they have little knowledge of nursing informatics and of the international competency frameworks and do not know how it may fit in nursing education. Although they indicated an interest they were not versed in informatics. However, they state that if they know more about informatics, they would be able to include such aspects in their courses. When shown the competencies from the TIGER and HTComp, they could see which competencies may be included in their courses. They even realised that without knowing, some of the competencies are already being taught. The educators indicate that the staggard approach of the TIGER competencies was appealing as it followed a Blooms Taxonomy structure of which they were familiar, in addition it includes some of the competencies were topics they already knew. They therefore indicate that the international competencies may be used to guide the development of nursing informatics competencies. An advocacy of nursing informatics is necessary for the inclusion of informatics competencies in the curriculum from SANC to provide a platform for the training of nurse educators to equip them with the required informatics knowledge. This would further enable them to include informatics examples in their courses.

One of the findings indicate that there is a need for considering varying course deliveries to cater for different target groups, e.g., for the digital natives, and digital emigrants. Statistics from SANC indicate that most nurses in practise are older, digital emigrants and as such would need programs tailored to their base knowledge. Upskilling the nurses would need advocacy from SANC as it dictates the curriculum from the undergraduate to the postgraduate, where the undergraduate nurses are mainly younger, digital natives and the postgraduate nurses are the older, digital emigrants. This advocacy would enable institutions to develop short courses that are tailored with examples from practise which older nurses can relate to, thus alleviating their fear of information technology.

The findings from the informatics education indicate that there is a need for informatics practitioners to gain domain knowledge of the health context. The informatics educators indicate that informatics practitioners would need to have knowledge of the work practice of health practitioners, including their workflows and the decision-making process. According to the health informatics experts' responses, eleven (11) themes were derived that cover the knowledge areas they deem as important competencies needed by informatics practitioners. Although the IT2017 international competency framework was used to compare the suggestions of experts, the identified topics could be used as a guideline for the development of a course for informatics practitioners specifically in the African context. The international competencies may need to be adjusted to be appropriate for the context of practice.

The development of a health informatics fundamentals course can be regarded as an example of how a collaboration between experts from both health and informatics familiar with the international informatics competency and the African context can result in the successful implemented of an informatics course within the health domain.

An analysis of the competencies desired by the nurses indicates a focus on informatics competencies. An analysis of the themes from the health informatics experts indicates an alignment of the themes to the IMIA framework which has both a health focus and an informatics focus. The skilling of the practitioner in each other's domains enable them to become health informaticians, who can represent either the health or the informatics domain in a collaborative context.

7.7.2 Practise

When considering the in-practice part of the framework, the utilisation of health information systems services and technologies is considered to establish how these enable the work practise of nurse practitioners and what work knowledge they would need to be able to use digital technologies to enable their practices. Digital health technologies are increasingly becoming pervasive within the health domain. Within South Africa there are already several digital health technologies in use within healthcare facilities. The South Africa Department of Health introduced some digital services and technologies expecting the nurses to use in their practice. Some examples are: 1) continuity of care between hospitals with the electronic continuity of care record (eCCR); (2) the provincial health data centre system that stores data from all the provinces; and (3) a single patient viewer system that ensures continuity of care for a patient where several health practitioners need to access the patient's record at the different points of care that are at different levels. However, it is not clear to what extend these technologies are accepted by the health practitioners. Additionally, within each health institution, there are diverse tools from different manufacturers in practise for example the tools for taking vital signs. These provide the artefacts which nurse practitioners use for their practise.

7.7.2.1 Nurse Practices

Findings from the nursing practise indicate that nurses use digital health technologies in various ways and find these that they have accepted relevant to their nursing practices.

The relevance of the services and technologies in practise makes it important to equip nurses with the competencies they need to use these services and technologies. The use of these services and technologies prescribes their work knowledge and skills determining the competencies that need to be developed. The nurse educators suggest they can use examples of tools they are familiar with expand this to concepts they would need in practice. This method of training would enable the digital emigrant nurses to also have skills that would give them confidence in using the services and technologies implemented by the Department of Health.

7.8.2.1 *Informatics Practices*

According to the framework the informatics practitioner develops and supports digital health technologies as part of their informatics practices, based on their perception of how these should be used by the health practitioners. The Informatics domain provides informatics tools that aid health practitioners to provide better service in their praxis. The Informatics domain however must create informatics tools that are relevant to the health practitioner and sustainable in praxis. In the provision of digital services, relevancy and sustainability need to be considered. Informatics practitioners are already familiar with the design, development, implementation, and support of informatics technologies where informatics courses already focus on informatics competencies relevant to the latest trends in digital technologies development. However, they may lack the context-specific domain application knowledge and expertise needed in their practices. Thus, according to the perspective of the informatics educators the practitioners would need to understand, for example, the workflows and decision-making process of health practitioners. These maybe translated into digital technologies and techniques that informatics practitioners use in their practices. According to the health informatics experts the informatics practitioners would need additional competencies for a more comprehensive perspective of the digital health domain.

7.7.2.2 Nurse and Informatics Practitioner Engagements

In the practise and education parts of the framework the level of involvement of the nurse and informatics practitioner as they engage with each other in practise, is considered. This level of involvement is influenced by the intersection between health sciences and informatics that is complicating the design of relevant education for the required competencies in the two respective disciplines. The level of involvement looks at the interdisciplinary perspectives of the participants towards the intersection between the health and the informatics disciplines. Outcomes from these perspectives are indicated in the study. These are there is some ignorance about the intersection, where the nurse educators indicate that they were aware of nursing informatics but did not know much about it. This made it difficult for them to ascertain the informatics competencies that would be required, as they were not aware of the international competencies frameworks that could be used as a source to guide them. In practise the nursing students are making use of informatics tools and have a positive attitude towards these, however the digital emigrant nurses were noted by the educators as being hesitant to use the services and technologies that are unfamiliar to them.

One of the recommendations that informatics educators noted is that informatics practitioners need to collaborate with health practitioners for the design, development and implementation of health information systems services and technologies. As noted by Martikainen *et al.*, (2020), health practitioners may not have the time to set aside for collaboration in the design, development and implementation of health information systems services and technologies processes. Even if they have time to participate in the development process, they may lack the ability to convey their digital technologies use needs in a form that could be understood by informatics practitioners. Having a better understanding of each other's domain could assist in a better collaboration between them. Thus, the interest in gaining a skill in programming by the nurses and the recommended skills by the health informatics experts justify an additional health informatician role that allows health and informatics practitioners to become proficient in health informatics. It is even possible that a health information can be a dedicated role where such a person specialises in the combined competencies represented by the overlap between health and informatics to fulfil an intermediary role between health and informatics practitioners.

7.7.2.3 Disciplinary Influences on Competencies

Complexities of course content are influenced also by other disciplines that make up a health or nursing informatics course. This is because in structuring a course, the content is not only informed by the inter-disciplinarity of health and informatics but also need to consider the disciplines that informed these disciplines, such as, social sciences, information sciences and management sciences, to name a few. The degree to which each of these are placed within the course content forms part of the complexities in the determination of appropriate competencies. Competencies require a description of some action to occur. This may be the description of an attitude, value, or judgement. These characteristics are not empirical in their nature, but their variability translates into complexities in the determination of appropriate competencies. The health participants value informatics competencies as their prior knowledge consisted of the health discipline. The inverse is true for the informatics participants as well. The same factor characteristics bring about complexities in framing appropriate competencies in training method, capacity building and the configuration of academic ICT tools such as the Learner Management System.

The health domain considerations of competencies can also be viewed in terms of the definition of competencies which considers the aggregate knowledge, skill job performance and ultimately the organisational success. These are the factors that are greatly influenced by the health domain considerations. There are many sub fields in the health domain, each with their own epistemologies, ontologies and methodology. An interdisciplinary field such as health informatics would be a challenge to ascertain as due to the diverse paradigms in the sub health fields. Additionally, in the words of one participant the level of responsibility and level of difficulty are key considerations in the determination of key competencies. This emerged in the explanation of the need to stagger competencies from undergraduate students to the post graduate students. In addition to this, local policy, procedures, rules of governance and ethics affect the nature of and combination of competencies, thus, complicating the selection of appropriate competencies.

DTs comprise all technologies for the creation, processing, transmission, and use of digital goods that can be summarised under the term information, communication, and media technologies.

The nature of digital technologies is varied within the computing field where its focus could be informed by informatics, computer science, information technology and information systems, etc. as well as overlaps between these subfields of computing. When considering the computing sub fields, it is important to consider the positioning of the subfields horizontally for development from theoretical, application, deployment and on the highest a transformed organisation where the digital heath technologies use is infused in practices. Vertically the computing sub-fields appear from the hardware and architecture on the lowest level followed by systems and infrastructure, software methods and techniques, application technologies, organisational, and on the highest level, societal aspects. The intersection between health and informatics is challenged by the sub disciplines, and the derivation of competencies is dependent on the selection of sub discipline. It is also not possible to cover all the aspects of each discipline, and further challenges could occur based on the delineation of content in the disciplines and their importance to the practitioner and their work practise.

Typically, the health informatician user will need digital health technologies that are associated with application, deployment and use rather than with the theory of computing or very technological. Whereas the specialised health informatician would have expertise and is competent in one of the more specialised computing topics that form part of the computing subfield. The scope of informatics is just too wide and complex to easily become an expert in several topics.

7.7.2.4 Course Accreditation

There are accreditation considerations and course structure considerations. Accreditation provides validation of a program. This validation may be external and/or internal. Externally the accreditation of the program is recognisable nationally and internationally as a viable program. Internally the accreditation provides validation of the skill set that practitioners require therefore providing a measure of comparison. This provides confidence in the course by stakeholders including the students, faculty, and the public. In addition to accreditation participants, preferred three forms of structure for nursing informatics course content. These are: (1) Integration within the current course content; (2) Implementation of a short course for essential courses content that cannot be integrated; and (3) Staggering of short courses. According to one participant these types of implementations in the interdisciplinary field could be considered as work integrated learning. This is because their content included discussions on procedures in context, and contextual observations.

7.7.3 Global and African Health Informatics Context

Findings from the participants indicate that there is an imbalance between ICT development and the use of health information systems, services, and Technologies. Nurse students indicate that they lack computer literacy skills and informatics practitioners need to develop relevant services and technologies. When considering characteristics for appropriate education programs according to the educators to determine the competencies for a program for nurses and informatics practitioners the objective of the course must be considered. They indicate that nurses would require a program with informatics content and informatics practitioners with health content. This program would be staggard beginning with competencies that were familiar and advancing to more complex competencies. In the African context this would be appropriate since the disciplines of nursing informatics and health informatics are not prevalent and according to Harerimana *et al.*, (2021) and Le Roux *et al.*, (2024) this is still in the computer literacy stage. According to the health informatics experts the design of a program would also need to take into consideration the fact that because of the peculiarity of the African context the policy that one size fits all cannot apply, hybrid pen and paper and electronic based practises are still prevalent because of lack of infrastructure, these would need to be considered when looking at tools for training. Additionally, health informatics experts recommend that the students be taught through hands-on experiences and reading wider on the topic with educators prescribing a prerequisite list of articles on topics that must be read and analysed. Recommendations also include that educators focus and apply African type of case studies and examples on all course materials, including focusing on visionary documents on health and wellbeing such as the South African National Development Plan and Digital Health Strategy.

7.7.4 Main findings

Based on the empirical findings the following changes are incorporated in the proposed conceptual framework based on the literature reviewed (Figure 7-4).

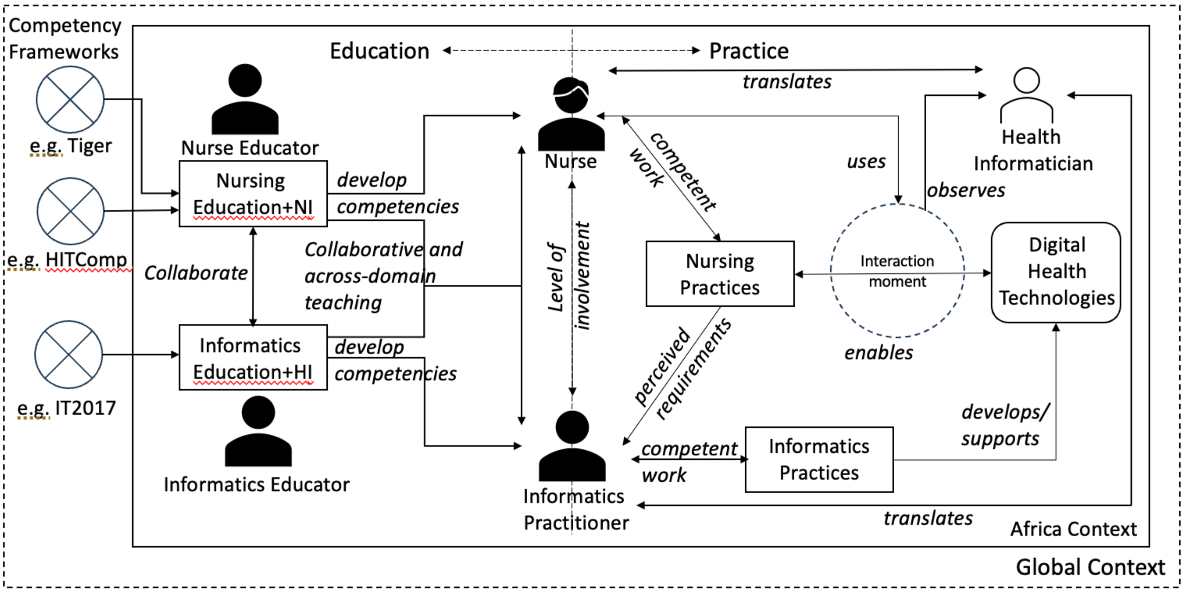

Figure 7-4: Proposed Refined Conceptual Framework for aligning informatics and health education with the competencies required in the respective domain practices.

Firstly, the inclusion of international competency frameworks to guide the identification and development of context-specific competencies aligned to the international competencies. This should assist educators in developing new courses or revise current courses to include health/nurse informatics competencies.

Secondly, it is important for nurse and informatics educators and their advisors to collaboratively develop health/nurse informatics knowledge-areas and course content, and where possible to appoint domain experts to teach the different topics.

Thirdly, the inclusion of an interaction moment to represent the moment when the health practitioner interacts with the digital technologies that enable or constrain their ability to execute a specific task as part of their care practices. The interaction moment could indicate the intricacies of the connection between human and technology influenced by many factors that result in the difficulty to inscribe the perceived use in the design of digital technologies that caters for all possible users, with different competencies, levels of expertise, attitudes, etc.

Fourthly, the inclusion of a health informatician role to act as an intermediary between the health and informatics practitioners by translating the needs based on the health practitioner's ability to use digital technologies for a specific task. These observations can be translated to digital technology requirements for the informatics practitioners to ensure that the design of the digital technologies aligns closely to the in-practice use.

7.8 Conclusion

The aim of this chapter was to discuss the findings of the study and address the research questions. The latter were mapped to the conceptual framework and a discussion of the findings with regards to the conceptual framework was conducted.

Significant findings from the study included: (1) recommended competencies which nurse students felt they lacked competency in; competencies for informatics practitioners; (2) additional findings were the need for educators to be trained in nursing informatics and health informatics;(3) The current state of awareness and knowledge of nursing informatics and health informatics knowledge by nursing and informatics practitioners requires a staggard approach for developing a course that caters to combined practitioners. and (4) having a health informatician versed in both health and informatics would reduce the conflict dissonance in the intersection between the health and the informatics discipline.

The ensuing chapter will conclude the study and provide recommendations for further research.

CHAPTER 8 CONCLUSION AND FURTHER RESEARCH

8.1 Introduction

This last chapter revisits the research aims and objectives while highlighting the important conclusions from the mixed methods studies. The chapter further illuminates the contributions made by the study in terms of knowledge in the related fields. The study addresses the objectives of the study and although the study looks at Nursing Informatics Education and Health Informatics Education considering the competencies required in both fields, the study cannot claim to have addressed all the issues relating to Nursing Informatics Education and Health Informatics Education. The study limitations and recommendations for further research are presented for further consideration.

The quality of the study is considered by including a genuine account of the study, limitations and expressing the challenges encountered with a practical evaluation to the authenticity of the research. In proposing the contributions that the study makes to the field I begin with an overview of the research, then a review of the research questions, followed by an evaluation of the mixed methods research, reflection of the research, contributions, limitations, and further research recommendations.

8.2 Overview of Research

The aim of this mixed method study was to understand the relevant nursing and health informatics competencies that would be appropriate for educating nursing and informatics practitioners to practice within the nursing and health informatics domain in lower to middle-income country contexts. The study's approach was to explore the perspectives of those stakeholders involved in health informatics education, as educators or learners. Learners could be full time students or those already working as health or informatics practitioners. Whereas health practitioners are using digital health technologies, informatics practitioners are responsible for the designing, developing, implementing, and maintaining of such digital technologies within the health domain. It is this different engagement foci of user versus developer that informed the need for this study to consider to what extend the health informatics competency education needs to consider these differences. Therefore, the study explored the two main groups of stakeholders the nursing and the informatics groups. In the nursing group, the study considered the perspectives of nursing students who are post graduate students, therefore already having in-practice experiences of using digital health technologies. Additionally, the nurse educators' perspectives were taken considered to provide an education perspective on the competencies required for training. In the informatics group, the informatics educators' perspectives were considered to provide an education perspective on the competencies that informatics practitioners would require and health informatics experts, with a background of both health and informatics perspectives were then considered to provide the practitioner perspective of health informatics.

This study adopted a pragmatic approach to achieve the aim of this study, and to answer the following research questions: (1) How suitable is the global Health Informatics and its competencies for the training of nurse and ICT practitioners in a health domain in an African context? and (2) Why is the intersection between health sciences and informatics complicating the design of relevant education for the required competencies in the two respective disciplines? Furthermore, the approach addressed the stated research problem as the identified research gap, and provided the researcher with an in-depth, detailed understanding of the role of health informatics technologies in the nurses' and informatics.

In-depth interviews and questionnaires were used to engage the selected participants to collect data. The data collection method for this study was mixed method, and as a result, the researcher used non-probability sampling, via convenience sampling of the nursing students, and purposeful sampling, to identify and select the educators and health informatics experts. This technique assisted the researcher in identifying a sample size that would provide in-depth information aligned to the research objectives of this study. The target population for this study consisted of nursing students, nurse educators, informatics educators and health informatics experts.

This study comprised a total of 85 nursing student participants, 3 nurse educators and 3 informatics educators and 10 health informatics experts. A questionnaire was administered to the nursing students, and another was administered to the health informatics experts. In depth interviews were conducted with the nurse and informatics educators. Thematic analysis was conducted to organise the data acquired from the participants. The units of analysis were the attitudes of the nurses and the competencies of the participants. The units of observation were the nursing students, the nurses and informatics educators and the health informatics experts, in other words what competencies do these practitioners require in nursing informatics and health informatics.

The following section will revisit the research questions for this study.

8.3 Research Questions Revisited

In the ensuing sections, the researcher answers the research and sub research questions.

Research Question 1: How suitable is the global Health Informatics and its competencies for the training of nurse and ICT practitioners in a health domain in an African context? This question is based on how the Nurse Educators and the Informatics Educators develop competencies for their students in the African context given the global health informatics competencies.

Sub Research Question 1: What are the competencies needed by nurses to use ICT as part of their work in practice in an African context?

As the end user of the health information systems services and technologies, the study findings are that nursing students use MS Office tools for statistics, reporting and presentations. The nurse educators expanded the use by adding that nurses use technologies also for data capturing for their workflow processes, for preparing the nursing plan patient vitals and statistics; decision support, for evidence-based practice from patient data captured and data analysis, to identify and ascertain patient risks. When looking at the global nursing informatics competencies nurse educators indicate that they are suitable for use in their context as some of the competencies were currently being taught. From the results of the study, it is evident that health information systems services and technologies are integral in the practice of nurses and competencies in MS Office, Data Capturing, Decision Support and Data Analysis are needed by nurses as part of their work practice. The competencies they need to utilise digital health technologies are still mainly related to basic digital literacy. They indicate a positive attitude to learn more about digital health technologies but are not sure what these should be or how to utilise these in their work practices.

Sub Research Question 2: What is the current situation of Heath Informatics Education for Nurses and ICT Practitioners in an African context?

Findings from literature indicate that there is a paucity of health informatics education for nurses and ICT practitioners in the African context. There are some efforts being conducted in higher education institutions within countries for nurses, with literature recording efforts evidenced from South Africa, Ethiopia, and Nigeria. For ICT practitioners the literature indicate the inclusion computing such as computer sciences, software engineering, information systems, information technology in most universities and other training organisations with less applied computing courses and even less digital health courses. South African and Ethiopian Universities offer health-related informatics courses. Findings from the study indicate that health informatics is not considered a speciality in Africa as per health informatics experts' perspective. In addition, the nurse educators indicate that they are aware of the discipline but did not know much about it. The paucity of health informatics education stems from the fact that at the macro level of education there is no advocacy of the discipline, this means that although at the micro level of education and at the health institutions there is a need for the discipline, it is not factored into the curriculum.

The answer to research question one is informed by the answers its sub-research questions. It is not possible to establish the suitability of global health informatics competencies since there is insufficient evidence of the use of the international health or nurse informatics competency frameworks. However, the nurse educators and students are keen to become more competent in utilising digital health technologies in their practices. They indicated that this could be possible by capitalising on international identified health informatics competencies that they were unaware of. Apart from the health informatics fundamentals subject, developed by the INDEHELA collaboration, taught as an elective of an information technology qualification, there was no evidence of other computing courses that specifically include health informatics topics. The experts confirmed the importance for informatics practitioners to be competent in informatics if they are practicing in a health-related domain. The health informatician role is not clear and therefore it is difficult for the nurse and informatics practitioners to envisaged how their domain expertise can be enhanced by the competencies of the other discipline, e.g., health enhanced with informatics or informatics enhanced with health (refer to sub section 7.7.1). Furthermore, these informatician roles can be further developed to specialise in specific advanced health and informatics areas.

Research Question 2: Why is the intersection between health sciences and informatics complicating the design of relevant education for the required competencies in the two respective disciplines? This question is based on how the competencies of Nursing practitioners influence their use of ICTs in their work activities in practice and competences needed by ICT practitioners to develop ICTs with the involvement of healthcare practitioners to use the ICT as part of their work activities in practice.

Sub Research Question 3: How do the competencies of nursing practitioners influence their use of ICTs in their work activities in practice?

As digital technologies evolve, the implementation of these in the health context will become more prevalent, as the technology may be used in resource restricted areas. Findings from the study indicate that the Department of Health of South Africa introduced some health information systems, services, and technologies in health institutions with the expectation that these digital health technologies need to be infused in the work practices. For nurse practitioners to have competencies in nursing informatics will allow them to confidently use these digital health technologies as part of their work practise to contribute towards the government's vision to digitise health institutions. It is evident that nurse practitioners require nursing informatics competencies, and that they require training in informatics. The nurses know that they can improve their work and that the use of digital health technologies will enable this, but they are not clear on what competencies are needed and how to develop these. They further indicate that the competencies they would like to develop, that seem to be more advanced, such as advanced computer skills; software design and development to create applications for their work context; education and research for enhancing their assignments; data management to be able to access databases and social media to enable communication between doctors and nurses. Their indicated desire to learn more about software development may be an indication that they acknowledge that the difficulties experienced when using digital health technologies, may be a result of the informatics practitioner’s perceived misunderstanding of their needs related to their in-practice use. By developing their informatics competencies could enhance their informatics knowledge to better apply digital technologies in their practices. This in turn may allow them to enhance their current healthcare competencies by developing a health informatician role with a major domain knowledge of health and a minor domain knowledge of informatics.

Sub Research Question 4: What are the competences needed by ICT practitioners to develop ICTs with the involvement of healthcare practitioners to use the ICT as part of their work activities in practice?

Findings from the study indicate that according to the informatics educators, informatics practitioners have the informatics skills to develop ICTs, however they lack the health domain knowledge to develop useful, relevant, and sustainable ICTs. To resolve this informatics educators, suggest that: (1) informatics practitioners should be trained to develop their collaborative skills in addition to the required health domain knowledge for meaningful engagement with healthcare practitioners during the digital health technologies development; and (2) informatics practitioners need to be trained on the workflows of health practitioners and their decision-making processes. This should enable them to work more efficiently with healthcare practitioners as they would have the required domain knowledge. Validating the latter outcome, the health informatics experts also recommended that informatics practitioners get knowledge with a greater focus on health information management, interoperability, and digital health development and implementation. These themes have an informatics focus which is set in the context of digital health. Other themes had a health focus, augmenting the health domain knowledge that informatics practitioners would need to have to be able to collaboratively work with health practitioners in developing digital health technologies. Informatics practitioners may develop their health informatician role with major informatics domain knowledge enhanced by some basic health domain knowledge and eventually advanced health domain knowledge.

The second research question is answered informed by the answers to its related sub research questions. The intersection between health sciences and informatics is not just an identified overlap of competencies that form part of both the health and informatics domains but instead will depend on the ability of the digital technologies to enable a task that form part of the health practitioner's practices. Therefore, the combined health and informatics competencies that will appear in the overlap between the health and informatics fields will depend on the digital health technologies needed at that point of healthcare. The combined set of competencies needed is dynamic and will change for the different health practitioners' practices. Another contributing factor related to the complexity of health informatics as a field, is it being divergent with different orientations and interests that requires a negotiated process of exploring similar, different, and even competing perspectives by both the healthcare and informatics practitioners towards a common understanding. This could justify the role of health informatician to act as intermediary between the two disciplines. This person should also consider the influences of the cultural, organisational, and other contextual aspects on the health practitioners' experience when interacting with digital technologies to translate these for the informatics practitioner. In addition to the health and informatics fields, the additional consideration of the education field increases the complexity of the health informatics field even more. In Africa it seems that health informatics education is dominated by either health or informatics experts, not denying that health experts may already be competent in informatics, especially those developing international competency frameworks. There seems to be little to no collaboration between the respective educators in deciding the content and delivery of health informatics. In conclusion, the findings of this study, indicates a lack of understanding by the health and informatics practitioners of what happens at the interaction moment of using the digital technologies that is further complicated by the lack of understanding by the respective educators of the competencies needed to enable the interaction moment.

8.4 Summary of Research Questions

A summary of the research questions, the sub-research questions associated objectives, and respective answers appear in the following table.

Table 8-1: Research Questions Revisited

Research Question 1: How suitable is the global Health Informatics and its competencies for the training of nurse and ICT practitioners in a health domain in an African context?	
Sub Research Questions	**Objectives**
SRQ 1: What are the competencies needed by nurses to use ICT as part of their work in practice in an African context?	To ascertain the use of ICT technologies by nurses for the purpose of determining competencies they would need
SRQ2: What is the current situation of Heath Informatics Education for Nurses and ICT Practitioners in an African context?	To ascertain the current situation of Health Informatics Globally, In Africa and South Africa?

Research Question 1 Answered The answer to research question one is informed by the answers its sub-research questions. It is not possible to establish the suitability of global health informatics competencies since there is insufficient evidence of the use of the international health or nurse informatics competency frameworks. However, the nurse educators and students are keen to become more competent in utilising digital health technologies in their practices. They indicated that this could be possible by capitalising on international identified health informatics competencies that they were unaware of. Apart from the health informatics fundamentals subject, developed by the INDEHELA collaboration, taught as an elective of an information technology qualification, there was no evidence of other computing courses that specifically include health informatics topics. The experts confirmed the importance for informatics practitioners to be competent in informatics if they are practicing in a health-related domain. The health informatician role is not clear and therefore it is difficult for the nurse and informatics practitioners to envisaged how their domain expertise can be enhanced by the competencies of the other discipline, e.g., health enhanced with informatics or informatics enhanced with health (refer to sub section 7.7.1). Furthermore, these informatician roles can be further developed to specialise in specific advanced health and informatics areas.	
Research Question 2: Why is the intersection between health sciences and informatics complicating the design of relevant education for the required competencies in the two respective disciplines?	
Sub Research Questions	**Objectives**
SRQ 3: How do the competencies of Nursing practitioners influence their use of ICTs in their work activities in practice?	To ascertain the scope of effect of epistemological inquiries between nursing praxis and informatics
SRQ4: What are the competences needed by ICT practitioners to develop ICTs with the involvement of healthcare practitioners to use the ICT as part of their work activities in practice?	To determine factors that shape ICT practitioners' ability to adapt to Health Technologies
Research Question 2 Answered The second research question is answered informed by the answers to its related sub research questions. The intersection between health sciences and informatics is not just an identified overlap of competencies that form part of both the health and informatics domains but instead will depend on the ability of the digital technologies to enable a task that form part of the health practitioner's practices. Therefore, the combined health and informatics competencies that will appear in the overlap between the health and informatics fields will depend on the digital health technologies needed at that point of healthcare. The combined set of competencies needed is dynamic and will change for the different health practitioners' practices. Another contributing factor related to the complexity of health informatics as a field, is it being divergent with different orientations and interests that requires a negotiated process of exploring similar, different, and even competing perspectives by both the healthcare and informatics practitioners towards a common understanding. This could justify the role of health informatician to act as intermediary between the two disciplines. This person should also consider the influences of the cultural, organisational, and other contextual aspects on the health practitioners' experience when interacting with digital technologies to translate these for the informatics practitioner. In addition to the health and informatics fields, the additional consideration of the education field increases the complexity of the health informatics field even more. In Africa it seems that health informatics education is dominated by either health or informatics experts, not denying that health experts may already be competent in informatics, especially those developing international competency frameworks. There seems to be little to no collaboration between the respective educators in deciding the content and delivery of health informatics. In conclusion, the findings of this study, indicates a lack of understanding by the health and informatics practitioners of what happens at the interaction moment of using the digital technologies that is further complicated by the lack of understanding by the respective educators of the competencies needed to enable the interaction moment.	

8.5 Evaluating Mixed Method Research

Mixed Methods Research involves the implementation of research designs that involve quantitative and qualitative phases and the integration of those phases. The field of mixed methods has developed quality standards; however, the components are frequently too numerous for novice researchers, do not consider a variety of perspectives, and apply quality criteria. Hirose and Creswell (2023) propose 5 quality criteria for assessing the use and appropriateness of mixed methods methodology. These are: (1) Advance a rationale for the use and appropriateness of mixed methods methodology; (2) Write quantitative, qualitative, and mixed methods questions or aims; (3) Report the quantitative and qualitative data separately; (4) Name and identify the type of mixed methods design and present a diagram of it; and (5) State the use of integration in a joint display. This section looks at each of these criteria in light to the study.

8.5.1 Advance a rationale for the use and appropriateness of mixed methods methodology Mixed Methods

A mixed method approach was appropriate for this study because it was likely to yield rich insights into the studied phenomenon that could not be fully comprehended by using only qualitative or quantitative approaches, combining two methods were preferable to utilising just one. This enables the researcher to view the phenomenon from multiple perspectives and research lenses. The rationale of using a mixed methods approach in this study was to triangulate the data. In mixed-methods research, data triangulation is well recognised as a technique for confirming findings from the individual approach (Bergman, 2008). For example, a researcher seeks to gain a more accurate understanding of a study problem by directly contrasting the results obtained from one method (qualitative or quantitative) to those for convergence and/or divergence derived from another (quantitative or qualitative) approach (Plano Clark and Ivankova, 2015). Since the study was interdisciplinary to gain a deeper understanding of nursing informatics and health informatics education gathering data from various stakeholder sources provides deeper understanding of a phenomenon than any one method alone could, leading to more reliable and robust conclusions than a single method alone as indicated by Tashakkori and Teddlie (2009). Accordingly, data triangulation increased the validity of conclusions on the current situation of the nursing informatics and health informatics education in Africa; use of ICTs in health by nurses; competencies in the disciplines for nurses and ICT practitioners; and African context characteristics to be considered when implementing a training program.

8.5.2 Write quantitative, qualitative, and mixed methods questions or aims Mixed Methods

Mixed method approaches are used when qualitative research or quantitative research is insufficient to fully understand the problem. The aims of this study were: (1) to understand the health informatics technology use by nursing and informatics practitioners and (2) to understand the required competencies relevant to nursing informatics and health informatics training programs, suitable for nursing and informatics practitioners in lower to middle-income country contexts. To address these aims a quantitative perspective was required to gather data on the current use of health informatics technology by nurses and informatics practitioners and the current competencies of the practitioners for the characteristics of training programs that are relevant to the practitioners, this also answered research question 1: "*How suitable is the global Health Informatics and its competencies for the training of nurse and ICT practitioners in a health domain in an African context?*". Qualitative data was collected to respond to the aim for understanding the relevant training programs from the perspectives of the educators and health informatics experts with research questions 2: "*Why is the intersection between health sciences and informatics complicating the design of relevant education for the required competencies in the two respective disciplines?*"

A detailed description of the methodology is outlined in Chapter 3. The quantitative and qualitative components are indicated in Table 8.4 and Table 8.5. The research design was Convergence Design with the intent of triangulating the outcomes to gain a better understanding of the context of nursing and health informatics education in lower to middle-income countries.

Table 8-2: Quantitative Data Table.

Quantitative Data Table				
Phase of Study	**General Type**	**Specific Measures**	**n**	**Data Analysis**
Nursing Postgraduate Students	Closed and Open-ended responses	Responses to questions on the quantitative instrument	85	Descriptive analysis

Table 8-3: Qualitative Data Table

Qualitative Data Table				
Phase of Study	**General Type**	**Specific Measures**	**n**	**Data Analysis**
Nursing Educators	Interviews	One-on-one interviews	3	Thematic
Informatics Educators	Interviews	One-on-one interviews	3	Thematic
Health Informatics Experts	Open-ended responses	Responses to questions on the quantitative instrument	10	Thematic

8.5.3 Name and identify the type of mixed methods design and present a diagram of it Mixed Methods

The research design was convergence design, and results were triangulated. A summary of the mixed methods is depicted in the next diagram (Figure 8-1).

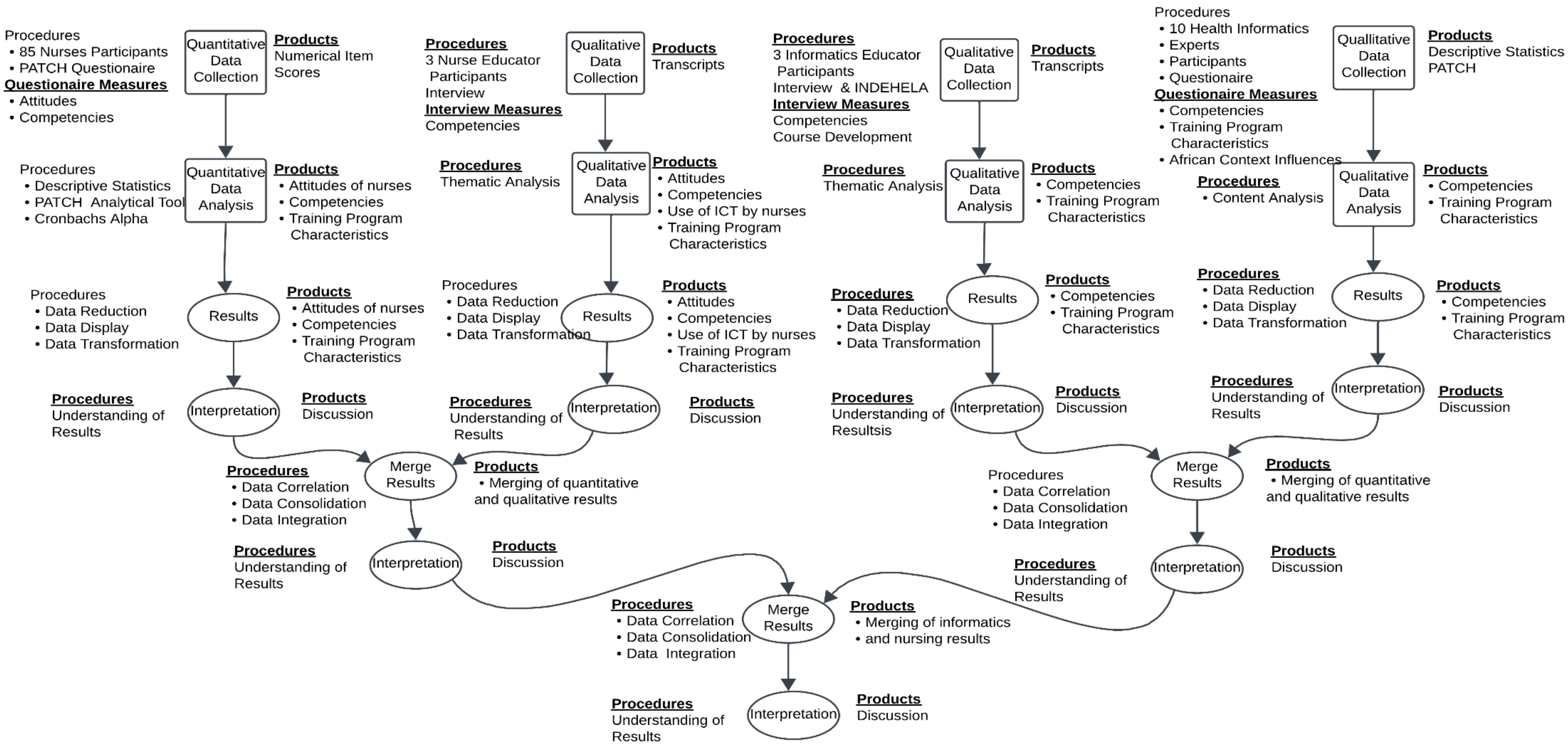

Figure 8-1: Mixed Methods Summary

8.5.4 Mixed Methods: Integration in a joint display

Data triangulation was implemented in the study, this was to gain insight from perspectives of different stakeholders. The following Joint Displays indicate the integration between the nursing perspectives, the informatics perspectives and the combination of perspectives.

Table 8-4: Joint Display Integrating Nursing Perspectives

Integration of Nursing Perspectives		
Nursing Students – QUANT N=85	**Nursing Educators – QUAL N=3**	**Integration: Inferences drawn from Comparison of Results**
• Positive attitude towards the use digital technologies • Comfortable using Digital technologies they are familiar with • Current use of digital technologies for reporting and presenting • Competencies Desired: MS Excel, Databases, Presentation Software, Programming, Training suggestions – workshops, Enrol in College, In Service Training, Self-Study	• Lack of knowledge of nursing Informatics as a field • Older digital emigrant nurses are afraid to use digital technologies because they lack the necessary digital skills. • They use Digital technologies to develop care plans, record vitals, record procedure, Track patients, track feeding program, analyse and identify risks. • Competencies identified by educators: data capturing, decision support, data analysis. • Training Program: integrated in core curriculum, short courses • Courses should be staggard starting with familiar concepts proceed to more complex concepts. • Course content depends on who the course is being offered to. Nursing students, they are interested in the informatics content.	• Positive attitude indicated by nurses and educators. • Lack of knowledge in informatics is hinderance to develop required competencies. • Conflict of findings as nurses indicate they are comfortable, yet educators indicate they fear to use digital technologies because of lack of skills. • Educators presented a broader perspective of use of digital technologies indicating more understanding of application of digital technologies in practice. • Both nurses and the educators indicate similar competencies needed. • Competencies from educators encompassed a broader perspective of uses as they related to the use of digital technologies in practise. • Nurses could only attend training programs that were in alignment with their availability from work. Educators consider the

Integration of Nursing Perspectives		
		current competencies of students, providing courses that are applicable for both digital natives and digital emigrants. • Educators propose that courses should be staggard to cater for training nurses, constructively building their knowledge from their current knowledge. • Nurses have health domain knowledge and for them to be adept in nursing informatics, they require Informatics knowledge.
Main finding from nurses	**Main finding from nurse educators**	**Combined main finding for nurse informatics**
Nurses have a positive attitude and agree with the need for digital technology competencies but are not familiar with what these should be.	Nurse educators agree with the need to develop digital technology competencies and have a good idea about how such technologies could be used in practice. They are not familiar with international health informatics frameworks and were surprised by how these frameworks could assist them to design courses for nurses at different levels.	The nurses and nurse educators are well aligned with their understanding of digital technologies needed in their practice but are unable to comprehend the competencies that could benefit them beyond their use in their current practices. Currently they develop these competencies reactively without consideration of their future needs.

Table 8-5: PART A – Joint Display Integrating Informatics Perspectives

Integration of Informatics Perspectives		
Informatics Educators - QUAL **n=3**	**Health informatics experts- QUAL** **n=10**	**Integration: Inferences drawn from the comparison of the results**
Informatics students lack contextual health domain knowledge. In addition to a better understanding of the workflows of the health domain they need to know more about digital health technologies, and their application possibilities within the health domain. IT students have been trained to develop, design, and implement IT solutions; their need is in developing collaborative skills which will enable them to work with domain Knowledge experts to produce relevant digital technologies. Health informatics course content depends on who the course is being offered to and should have an application orientation to expose informatics students to real-life health scenarios. It is possible to develop a course through a collaborative approach that could develop the relevant digital technologies competencies for context-specific healthcare digitisation.	Several health topics were suggested with varied focuses that reflect the complexities associated with the health domain to develop competencies for informatics practitioners in the health domain. Several skilling and reskilling training options need to be available to provide for progression towards advanced topics applied in digital healthcare. The importance of considering contextual factors was emphasised, especially in the African context.	Competency Topics from the educators were mentioned by the Health Informatics Experts, and the Experts extended these by adding other topics. Informatics Students have informatics skills and to implement ICT solutions they need to work with domain experts. Working with these requires collaborative skills. Informatics Students require health domain knowledge and its offerings in the African context.

Table 8-6 PART B – Joint Display Integrating Informatics Perspectives

Main finding for informatics education to prepare for informatics practice in a health domain	**Main findings from health informatics experts**	**Combined main finding for informatics competencies in the health domain**
The offering of informatics courses with an application to a specific domain is a preferred teaching approach of informatics educators since computing is an applied field where theory and practice are combined to solve real-life problems. Through a collaborative process the relevant competencies and levels can be identified.	The extensive suggestions of the health informatics experts provide for sufficient depth and breadth of the competencies that informatics practitioners need now, and in the future, to develop relevant context-sensitive digital health technologies.	The findings of the educators and experts are well-aligned and confirm the need for informatics to be competent with the application of informatics competencies in real-life healthcare situations. The competencies education should also focus on the need to collaborate with others, especially to understand the use of such technologies in practice as expected by the health practitioner.

Table 8-7: Joint display integrating the combined perspectives

Integration of Nursing and Informatics Perspectives		
Nursing Perspectives	**Informatics Perspectives**	**Integration: Inferences drawn from Comparison of Results**
• Positive attitude indicated by nurses and educators. • Lack of knowledge in informatics is hinderance to develop required competencies. • Conflict of findings as nurses indicate they are comfortable, yet educators indicate they fear to use digital technologies because of lack of skills. • Educators presented a broader perspective of use of digital technologies indicating more understanding of	• Competency Topics from the educators were mentioned by the Health Informatics Experts, and the Experts extended these by adding other topics. • Informatics Students have informatics skills and to implement ICT solutions they need to work with domain experts. Working with these requires collaborative skills. • Informatics Students require health domain	• Currently health informatics education is considered by the respective disciplines in isolation without any collaboration to benefit from each other's perspectives. • There is need for advocacy of informatics training to the nursing profession and health training to the informatics profession at macro and micro levels in both domains. • Currently the findings indicate that informatics is an add-on to their existing

application of digital technologies in practice. • Both nurses and the educators indicate similar competencies needed. • Competencies from educators encompassed a broader perspective of uses as they related to the use of digital technologies in practise. • Nurses could only attend training programs that were in alignment with their availability from work. Educators consider the current competencies of students, providing courses that are applicable for both digital natives and digital emigrants. • Educators propose that courses should be staggard to cater for training nurses, constructively building their knowledge from their current knowledge. • Nurses have health domain knowledge and for them to be adept in nursing informatics, they require Informatics knowledge.	knowledge and its offerings in the African context.	courses with a focus on basic digital literacy. • The inter-disciplinary nature of health informatics is not fully considered also without acknowledging their respective sub-fields to address the human aspect in relation to digital technologies use practice in a specific domain. • Currently there is not a specific intermediary role to assist with inter-disciplinary translations for health and informatics .
Combined main finding for nurse informatics	**Combined main finding for informatics competencies in the health domain**	**Main finding for all perspectives**
The nurses and nurse educators are well aligned with their understanding of digital technologies needed in their practice but are unable to comprehend the competencies that could benefit them beyond their use in their current practices. Currently they develop these competencies reactively without consideration of their future needs.	The findings of the educators and experts are well-aligned and confirm the need for informatics to be competent with the application of informatics competencies in real-life healthcare situations. The competencies education should also focus on the need to collaborate with others, especially to understand the use of such technologies in practice as expected by the health practitioner.	Although there is some understanding of the other discipline, it is not the result of a collaborative negotiated process to reach a common understanding of the combined health and informatics competency that enables the use of digital technologies by health practitioners.

8.5.5 Discuss how meta-inferences and value resulted from the integration analysis

Meta inferences can be drawn from the integration procedures in joint displays as they are the inferences that transcend the databases. Harrison and Creswell (2022) describe meta inferences as the process of transferring the inferences from the databases to other settings or contexts. This involves seeing how the inferences derived relate to the existing literature. Areas where meta inferences from the study and literature are: (1) Advocacy of nursing informatics and health informatics education in African contexts; (2) Transferability of Health Informatics Experts topic competencies to other African contexts; (3) Training of educators in African contexts; (4) The three roles of Health Informaticians.

The nursing quantitative data shows that nurses agree that they require digital technology competencies, but they are not conversant with what these should be. The nursing qualitative data shows nurse educators see the need of digital technology competencies and understand how these technologies may be used in practice; however, they are not familiar with international health informatics frameworks and how these may assist them to design courses for nurses at different levels. A cross-validation of the informatics results show that the educators recommend that a collaborative approach with stakeholders can enhance relevant competencies and levels can be identified, the experts also identified the need for relevant context-sensitive digital health technologies requiring relevant competencies. The meta-inference from this is that there is need for advocacy of nursing informatics and health informatics education in African contexts.

Further meta-inference results from the cross-validation of the informatics results show that the collaborative approach to developing competencies for implementation of digital health systems and technologies in health practice may enable transferability of Health Informatics Experts topic competencies to other African contexts.

A complementarity exploration of the educators and experts data, provided different dimensions of understanding the context of nursing informatics and health informatics education as they indicated the need for competencies in informatics and health respectfully. The meta-inference from this is that there is need for training of educators in African contexts

A meta-inference development that arose from exploring perspectives from the different stakeholders was the how the development of the competencies would influence the role the practitioners would play in practise. A outcome of this resulted in the identification of the three roles of Health Informaticians.

8.6 Research Rigour and Validity

This mixed method study included the implementation of quantitative and qualitative designs. To ensure research rigour, the following tests were done.

8.6.1 Quantitative Research Rigour

In quantitative studies research rigour is determined by looking at the principles of internal validity, external validity, and reliability. Internal validity could not be established as the study involved one group of participants and there was no pre-test or post-test conducted on the study group. External validity could not be established as the samples of participants were based on participants at one University and cannot be generalised to be said to represent the nursing population. Reliability was conducted on the questionnaire by the supervisors of the researcher in addition by the lecturer of the nursing students. Further a Piolet was conducted where two participants completed the questionnaire.

8.7 Qualitative Research Rigour

In the qualitative studies the recommendations of Lincoln and Guba's trustworthiness criteria were followed, and results are indicated in the next table.

Table 8-8: Research Quality Assessment

Criteria	Research Steps Conducted
Credibility (internal validity)	To ensure credibility of the research, the following steps were taken: 1. The researcher recognises her affiliation with the field of study and the experiences thereof. 2. Consent from all participants was taken that the researcher may confirm her interpretation of their accounts and verify their contributions. 3. The use of multiple data sources in the study allowed for analysis of various themes while the triangulation contributed to a search for convergence among multiple data sources. 4. The development of research questions while using a theoretical lens to carry out the research allowed the research to be grounded in theory. The deduction of data allowed the research questions answered to be matched with the relevant data sources that were inductively analysed. 5. Debriefing sessions and peer review sessions with experts in the field including regular supervision sessions during the period of the study kept the researcher accountable to the process. 6. Two Supervisors were assigned to the research, one with an informatics background to review the informatics perspective and the other with a health background to provide the health focus.
Transferability (external validity)	The thick description of the research context, study participants, transactions and processes allow this study to be carried out in a similar context.
Dependability (reliability)	Triangulation of methods was conducted, with questionnaires and interviews being administered to the participants. Nursing students' data was collected face to face with a paper questionnaire administered, this allowed the participants to question any section of the questionnaire for clarification. The responses were captured in a google form and imported to STSS for analysis. Paper responses were kept in a safety box. Interviews of the educators were recorded and uploaded to the researchers google drive for storage. Interviews were transcribed and themes and data analysis conducted. Health Informatics Experts were presented with a google forms questionnaire to complete. The data was analysed for content.
Confirmability (objectivity)	Findings and interpretations were reviewed through peer review and supervisory sessions, to confirm that recommendations are supported by data.

8.8 Reflection on Research

A challenging part of this journey was the tedious process of obtaining ethical clearance. The researcher first had to apply for clearance via the Faculty of Informatics and Design (where the researcher is registered), thereafter from the Registerer Academics then from the Faculty of Health and Wellness and the Department of Nursing. This process started in 2014, and as a result, and because of the various processes that had to be undertaken to obtain the necessary ethical clearance and permission the necessary clearances were only available in 2019. Further challenges include the difficulty in securing a data collection time with nurse students, due to their busy schedules. The researcher initially administered the use of an online questionnaire; however, the nurses could not find time to complete it. Thus, it was recommended that a class time that would be suitable for the lecturer and students would be allocated for data collection via paper and pen. A further challenge was having to work in isolation due to the lockdown measures imposed as a result of the Covid-19 pandemic. It was extremely difficult to remain focused in the absence of interaction and motivation from peers. However, because the researcher was determined to complete the thesis, she persevered. As the researcher was working full time, there were challenges with finances, and health, the research process took long and could only be completed in 2024.

There were notable highlights, the nursing students had a positive attitude and showed keen interest in the study and in advancing their computer competencies. The nurse educators indicated that they would like to know more about informatics and the competencies that they could teach. The informatics educators showed interest in the study as they were either doing Post graduate studies in health informatics or teaching the module at Cape Peninsula University of Technology.

Through the study of the three disciplines the Researcher gained a broader insight into the nursing informatics and health informatics competencies that are relevant for the practitioners, The Researcher better understood the health domain and obtain health domain knowledge. Additionally the researcher obtained competencies that can identify critical technical skills required to implement in strategies as well as institute career paths, from basic courses through to higher education.

8.9 Contributions of Research

In this study nursing informatics and health informatics education were studied in a low resource setting within a lower and middle-income country context. The state of health informatics education within the African context was considered. The uses of health information systems services and technologies by nurses was indicated. The current competencies of nurses were identified. Perspectives on competency topics that were appropriate for nurses and informatics practitioners were ascertained.

8.9.1 Methodological Contributions

Since nursing informatics is an inter-disciplinary course, methodological contributions are on the approach towards implementation of research in the discipline are necessary as a one size fits all policy does not produce relevant training. Guidelines for approaching the development of nursing informatics and health informatics competencies within situated work practice contexts in lower and middle-income countries in a mixed method inquiry are outlined according to Hirose and Creswell (2023) were followed. Lessons from the use of mixed methods were:

(1) The use of a questionnaire dispensed to the nurses. enabled data collection from a larger extensive representation of the nurse population than interviews would have provided. This aided in acquiring a more comprehensive understanding of the competencies that the two categories of practitioners would require in the African context. The method also, in its use of closed and open-ended questions, permitted for collection of both quantitative and qualitative data simultaneously. Where the quantitative data allowed for quantifying the attitudes and current competency state of the nurses. This also allowed for comparison between demographic data and non-demographic questions, making possible the identification of characteristics of digital natives and digital emigrants. This enabled exploration for a broader understanding of the current status of nursing informatics within South Africa at the nano level of education. A constraining factor was that sampling was conducted for one institution due to the challenges of acquiring ethical clearances, limiting generalisation and saturation of the data. However, the methodology could guide a possible transfer to other institutions. In addition, a constraint was that the nurses did not have the necessary knowledge and computing infrastructure to complete a Google Form, so a face-to-face distribution of the questionnaire was conducted. While there were many nurse participants for the questionnaire a challenge was that further probing was not possible due to the lack of availability of the nurses.

(2) Interviews were a selected qualitative method of collecting data from the educators as they enabled, through extensive probing, a deeper exploration of informatics competencies for nurses and health knowledge for informatics practitioners from an education perspective. The nurses could not provide this perspective as they did not have the broader knowledge of nursing curricula in academic and health institutions. This brought to the fore the interaction moments of nurses with information technology and the practises of informatics practitioners in the design, development and implementation of digital health technologies. The probing in the interviews resulted in revealing knowledge gaps in the educators regarding the international competency frameworks. This led to exposing the educators to the frameworks and a view of the frameworks expanded their conception of the applicability of nursing and health informatics in the nursing and informatics curricula. This enabled them to identify competencies within practise that nurses and informatics practitioners would require.

The INDEHELA project provided a perspective of the elements that would be necessary for the development of a health informatics course. The collaborative nature of the members of INDEHELA with diverse academic expertise, contributed to the crafting of the course, so that it is aligned with international criteria on competency frameworks.

(3) An open-ended questionnaire was conducted with health informatics experts as it facilitated a more far reaching investigation from the experiences of the experts on competencies for informatics practitioners. The inclusion of experts was necessary to provide a holistic perspective of both disciplines in a domain where there is a small number of African health informatics practitioners with foundational informatics competency as observed in chapter 6 and 7.

An amalgam of these different methods made it possible to derive nursing and health informatics competencies for nurses and informatics practitioners in the African context. In addition, the study’s discovery of health informatician roles that the practitioners may take.

8.9.2 Theoretical Contributions

The theoretical contributions of this inquiry lie in the following sciences: education sciences; informatics sciences, and health sciences. Contributions towards the health sciences was knowledge on praxis interaction with technology of the nurses, this was identified as an interaction moment in the touchpoint of the nurse’s work activities. The interaction moment was ascertained as brief and not continuous thus requiring the nurses to have competencies in the use of health information services and technologies. Theoretical contributions towards the education science were the knowledge of a collaborative working of health and informatics personnel in the developing of nursing and health informatics education competencies for nursing students and informatics practitioners for African contexts. In addition, the necessity for the engagement of domain experts to teach the different topics. Theoretical contributions towards the informatics sciences were knowledge about the use of information in digital technologies in the African context, as nurses indicated knowledge and interest in design and development of technologies for use in their practice, stating the use of social media for communication between doctors and nurses, and programming to develop applications. The latter implies that nurses are keen on gaining informatics competencies more than computer literacy.

8.9.3 Practical Contributions

Five practical contributions were produced from the inquiry: (1) Suggested nursing informatics competencies aligned to their nursing practice needs for the African context, and supported by international competency frameworks; (2) Suggested health informatics competencies needed to develop digital technologies for health practices in the Africa context by informatics practitioners, which are aligned with international competency criteria; (3) Best practises that may be utilised in the crafting of a health informatics course in Africa as outlined in the development of the INDEHELA Health Informatics Course; (4) The different health informatician roles that practitioners may play in practise; and (5) A proposed competencies framework that can be applied for the development of nursing and health informatics competencies for nursing and informatics practitioners in the African context.

8.10 Assumptions and Limitations

Assumptions that were made in the study were: (1) Nursing students have some computer literacy skills as they were taught computers in high school; (2) Informatics students have a positive attitude towards learning health informatics domain knowledge, since their activities include designing, developing, implementation and maintenance of Health Information Systems Services and Technologies.

Limitations to the study were: (1) The study was delineated to one institution nursing students and nurse and informatics educators were from this institution there generalisation of outcomes beyond this institution cannot be done; (2) The nature of self-rating instruments may have resulted in respondents over or underestimating their competencies in nursing informatics domains; (3)There is a paucity of advocacy of nursing informatics and health informatics hence little is known about the fields such that support for inquiry in the disciplines is low; (4) There is a paucity of literature in nursing informatics and health informatics for the middle to low income countries in Africa.

8.11 Further Research

Recommendations and further research include the following:

- There is need for research on the development of health informatics courses that:
  - Target group: Identifies the target groups that need to develop their health informatics competencies. Since the health informatics field is so wide with many aspects on different levels of complexity, it is important to first determine the profile of the target group. This will assist in analysing their specific needs to develop courses that address the competencies needed in practice. It may be necessary to consider the needs of health and informatics practitioners separately to ensure that their respective existing domain knowledge is considered. More research is needed to consider the above aspects of the target groups to gain health informatics competencies.
  - Considers the appropriate levels to provide for a continuation from basic health informatics competencies to more specialised competencies. This means that more research is needed to consider the development a series of courses based on identified needs of the target groups to provide for increasing and varying complexities of required competencies.
  - Course type: more research is needed to decide the type of course, whether it should be part of formal degree course or continuing professional development, or both, to provide for new health practitioners or for continuing development of existing practitioners. It is also important to decide on the form of different short courses such as intensive short courses, workshops, network events, etc. More research is needed to better understand how the competency needs can be addressed considering, especially, the time availability of the target groups.

- Mode of delivery, more research is needed to determine which mode of course delivery will be more appropriate for the different target groups considering especially the availability of the practitioners (face-to-face, virtual, hybrid, e-learning, blended, etc.).

- Context-sensitive competencies: more research is needed to establish the contextual influences on the practices of health and informatics practitioners and how these should be considered in developing the necessary competencies for a specific context. At the same time, it is important to align these context-specific competencies to the global identified competencies to ensure international relevancy of courses. At all times the human aspect should be considered.

- Training of educators is necessary, for them to have the necessary health informatics expertise and to be aware of areas where they may integrate health domain or informatics content in their health informatics courses.
  - More research is needed to establish how the health and informatics educators should collaborate to contribute from their domain expertise as they reach a common understanding of health informatics knowledge areas. Such research should also focus on the collaboration process to establish how inter-disciplinary knowledge is co-created.
  - More research is also required to advise health and informatics educators on including domain topic experts to teach specific topic aspects to expose health informatics learners to experts.
- Health informatician – more research is needed to unpack the different health informatician roles as health informatician user; digital health informatician; and dedicated health informatician. There may be a need to differentiate between these different roles based on a basic, generalist and/or specialist focus. There may even be more roles or combined roles to better understand their contribution as intermediaries between health and informatics practitioners in practice. By having an idea of the different health informatician profiles will assist in determining the competency needs associated with each role. An exploration on the depth of knowledge that would be required for nurses and informatics practitioners to be expert health informaticians.
- Interacting with digital health – more research is needed to determine what happens at the point of care where the health practitioner interacts with the digital health technology. Insights in such an interaction moment will assist in a better alignment between health practitioners

use of technology in practice versus the development of the health technology based on perceived requirements. More research is required to advance the human-computer interaction considerations in the different related fields from a healthcare perspective.

- The African context – more research is needed to determine the health informatics competencies relevant to the African context. The outcomes of such research could be used to build and maintain a repository of relevant competencies to be shared amongst health informatics educators. A repository with a compilation of relevant competencies could also be a useful resource for other lower and middle-income countries to serve as a shared health informatics learning platform. In addition, the results of research studies reporting on health informatics course development could report on lessons learnt and best practices.

8.12 Conclusion

This interdisciplinary study focussed on the perspectives of nurse, nurse educators, informatics educators and health informatics experts towards nursing informatics and health informatics education. Data gathering and presentation strove to: (1) Ascertain the attitudes and desired IT competencies of Postgrad Nursing Students; (2) Discover the perspectives of the Nursing and Informatics Educators; (3) Obtain the perspectives of Health Informatics Experts. These provided an understanding of the Health Informatics field and informed the Research Questions. Answers to the Research Questions and sub questions revealed the component elements that are critical for consideration in any Health and Nursing Informatics training program. This also showed how these elements are embedded in the disciplines constitutive of the two fields.

The formulated praxis and theoretical landscape, as literature and the Health Informatics Experts suggest is affected by the level of development of the country where these are applied. This study focused at the lower to middle-income context of Africa with special emphasis on the South African context. Accordingly, outcomes from the inquiry were: (1) competencies for consideration for both Health and Nursing Informatics programs; (2) the roles of the Health Informatician; and (3) knowledge of the attitudes towards Informatics by Nursing Practitioners. The study explored the context of Health Informatics as a domain that is not clearly understood as the demarcation where Health, Information Technology and Informatics is not clear so as to understand the usage of Health ICT Tools and the training characteristics that would be relevant for both Nursing and Informatics Practitioners.

Applicability of the programme and framework were not investigated in this study, though available evidence in the study strongly suggests the usability of these. These aspects, together with the limitations of the study cited above could be subjects for consideration in future research.

REFERENCES

Abernethy, A., Adams, L., Barrett, M., Bechtel, C., Brennan, P., Butte, A., Faulkner, J., Fontaine, E., Friedhoff, S., Halamka, J., Howell, M., Johnson, K., Long, P., McGraw, D., Miller, R., Lee, P., Perlin, J., Rucker, D., Sandy, L., Savage, L., Stump, L., Tang, P., Topol, E., Tuckson, R. & Valdes, K. 2022. The promise of digital health: then, now, and the future. *NAM perspectives.* https://doi.org/10.31478/202206e.

Abulencia, C. 2021. Why is education important and how does it affect one's future? https://www.worldvision.ca/stories/education/why-is-education-important#What-is-education [15 December 2024].

Achampong, E.K. 2017. Assessing the Current Curriculum of the Nursing and Midwifery Informatics Course at All Nursing and Midwifery Institutions in Ghana. *Journal of Medical Education and Curricular Development*. *4*. https://doi.org/10.1177/2382120517706890

ACM & IEEE. 2006. *ACM Computing Curricula 2005. The overview Report covering undergraduate degree programs in Computer Engineering, Computer Science, Information Systems, Information Technology & Software Engineering.* https://www.acm.org/binaries/content/assets/education/curricula-recommendations/cc2005-march06final.pdf. [15 December 2024].

ACM & IEEE. 2017. *Information Technology Curricula 2017: Curriculum Guidelines for Baccalaureate Degree Programs in Information Technology*. https://www.acm.org/binaries/content/assets/education/curricula-recommendations/it2017.pdf [15 December 2024].

ACM & IEEE. 2021. *Computing Curricula 2020: Paradigms for Global Computing Education* https://www.acm.org/binaries/content/assets/education/curricula-recommendations/cc2020.pdf [15 December 2024].

Adeniyi, I.S., Al Hamad, N.M., Adewusi, O.E., Unachukwu, C.C., Osawaru, B., Onyebuchi, C.N., Omolawal, S.A., Aliu, A.O. & David, I.O. 2024. Educational reforms and their impact on student performance: A review in African Countries. *World Journal of Advanced Research and Reviews*, 21(2):750-762.

Ahmad, M.M., Musallam, R. & Allah, A.H., 2018. Nurses and internet health-related information: review on access and utility. *Clujul medical*, 91(3):266-273.

Ahmed, M., Elaziz, E. & Mohamed, N. 2020. Nurse's knowledge, skills, and attitude toward electronic health records. *Journal of Nursing and Health Science*, 9*(5)*:53-60.

Alaban, A., Almakhaytah, S., Almayouf, L., Alduraib, A., Althuyni, A. & Meshaileh, L.B. 2020. Assessment of Undergraduate Nursing Students' Attitudes and Perceptions towards the Use of Computer Technology in Healthcare Settings. *Iris Journal of Nursing and Care*, 3(3):1-3.

Ali Mahmoud, A., Mostafa Ragheb, M., Said Mohamed, S. and Ali Ibrahim, R., 2022. Effect of implementing nursing care protocol on critical patients' safety outcomes. *Journal of Nursing Science Benha University*, *3*(1): 770-790.

Aljaber, K.S., AlOtaibi, M.J., AlOtaibi, N.M., Almutairi, R.G., Almutairi, D.S., Almutairi, N.S., Alkwekbi, S.M., Abuattiyh, M.M., Alsulman, F.A., Almutairi, M.M., Almutairi, J.M. & Alqurnas, A.A. 2021. Impact of health information technology (HIT) on nursing practices and performance. *Social Science.* https://sjr-publishing.com/wp-content/uploads/2019/03/Impact-of-health-information-technology-HIT-on-nursing-practices-and-performance-3.pdf [27 January 2025]

Allemang, B., Sitter, K. & Dimitropoulos, G. 2022. Pragmatism as a paradigm for patient-oriented research. *Health Expectations*, 25(1):38–47.

Almunawar, M.N. & Anshari, M. 2012. Health information systems (HIS): Concept and technology. *arXiv preprint arXiv,*1203.3923.

American Nurses Association. 2019. *Nursing Informatics : Scope and Standards of Practice*. 3rd ed. Silver Spring, MD: American Nurses Association.

Ammenwerth, E. & Rigby, M. (eds.). 2016. Evidence-based health informatics: Promoting safety and efficiency through scientific methods and ethical policy. Amsterdam: IOS press.

Anderson, J., Gremy, F & Pages, J. 1974. Education in informatics of health professionals New York: Elsevier Publishing.

Andrew, S. & Halcomb, E.J. (eds.). 2009. *Mixed methods research for nursing and the health sciences*. Wiley-Blackwell

Asah, F.N. & Kaasbøll, J.J. 2023. Challenges and Strategies for Enhancing eHealth Capacity Building Programs in African Nations. *Journal of Personalized Medicine*, 13(10):1463.

Association of Registered Nurses of Newfoundland and Labrador. 2006. Scope of nursing practice: definition, decision-making and delegation. *Association of Registered Nurses of Newfoundland and Labrador*: 26.

Assyne, N., Ghanbari, H. & Pulkkinen, M. 2022. The state of research on software engineering competencies: A systematic mapping study. *Journal of Systems and Software*, 185:111183.

Ataguba, J.E. 2021. The Impact of Financing Health Services on Income Inequality in an Unequal Society: The Case of South Africa. *Applied Health Economics and Health Policy*. 19(5):721–733.

Attallah, D. & Hasan, A.A. 2022. Approach to Developing a Core Competency Framework for Student Nurses in Saudi Arabia: Results from Delphi Technique. *Nursing Reports*, 12(1):29–38.

Attinger, E.O. & Panerai, R.B. 1988. Transferability of Health Technology Assessment with Particular Emphasis on Developing Countries. *International journal of technology assessment in health care*, 4(4):545-554.

Avgerou, C. 2008. Information systems in developing countries: A critical research review. *Journal of Information Technology*, 23(3):133–146.

Baayd, J., Heins, Z., Walker, D., Afulani, P., Sterling, M., Sanders, J.N. & Cohen, S. 2023. Context matters: Factors affecting implementation of simulation training in nursing and midwifery schools in North America, Africa and Asia. *Clinical Simulation in Nursing*, *75*:1-10.

Bader, F. & Hamada, H. 2015. Competency based approach between theory and practice. *Journal of Human Sciences,* 7-19.

Bailey, C. & Pang, T. 2004. Health Information for all by 2015? *The Lancet*, 364(9430):223-224

Bain, A.P., McDonald, S.A., Lehmann, C.U. and Turer, R.W., 2024. Informaticist or Informatician? A Literary Perspective. *Applied Clinical Informatics*, *15*(05): 939-941.

Beaumont, R. 2011. Types of health information systems (IS). *Introduction to health Informatics*, 1-15

Bello, F., de Paul Djientcheu, V., Tchemgui, N.N., Boli, A., Alima, R. & Amvene, S.N.O. 2013. Health Informatics and Education: An Example of Multilateral e-learning Program for

Post Graduate Trainees. In Korpela, M., Pottas, D., Tchuitcheu, G.K & Kemloh Wagoum, A.U. (eds.). Proceedings of the 8th International Conference, HELINA 2013, Eldoret, Kenya, 7-8 October 2013, 192.

Bergey, M.R., Goldsack, J.C. & Robinson, E.J. 2019. Invisible work and changing roles : Health information technology implementation and reorganization of work practices for the inpatient nursing team. *Social Science & Medicine*, 235:112387.

Berner, E.S. 2013. Informatics education in healthcare: lessons learned. In Berner, E. (ed.). *Informatics Education in Healthcare: Lessons Learned*. London: Springer, 225-235.

Betts, H.J. & Wright, G. 2009. Observations on sustainable and ubiquitous healthcare informatics from Florence Nightingale. *Connecting Health and Humans*, 91-95.

Bhattacherjee, A. 2012. *Social science research: Principles, methods, and practices*. (Textbooks Collection. Book 3). University of South Florida. http://scholarcommons.usf.edu/oa_textbooks/3.

Bhebe, S. V & de la Harpe, R. 2014. Nursing Informatics Education Stakeholder Analysis in South Africa, 1–5.

Bichel-Findlay, J., Koch, S., Mantas, J., Abdul, S.S., Al-Shorbaji, N., Ammenwerth, E., Baum, A., Borycki, E.M., Demiris, G., Hasman, A. & Hersh, W. 2023. Recommendations of the International Medical Informatics Association (IMIA) on education in biomedical and health informatics: second revision. *International Journal of Medical Informatics*, *170*:104908.

Bickford, C.J. 2017. The Professional Association's perspective on nursing informatics and competencies in the US. In Murphy, J., William Goossen, W. & Weber, P. (eds.). *Forecasting Informatics Competencies for Nurses in the Future of Connected Health.* IOS Press, 62-68.

Blanchard, P.N. & Thacker, J.W. 2023. *Effective training: Systems, strategies, and practices*: SAGE Publications.

Blumenthal D. & Glaser J.P. 2007 Information technology comes to medicine. *The New England Journal of Medicine,* 356(24):2527-34. PMID: 17568035. https://doi.org/10.1056/NEJMhpr066212

Boell, S.K. & Cecez-Kecmanovic, D. 2015. What is an information system? *Proceedings of the 48th Annual Hawaii International Conference on System Sciences*, March 2015. Kauai, Hawaii, USA: IEEE, 4959–4968.

Bogdan, R. & Biklen, S.K. 1998. *Qualitative Research for Education: An introduction to theories and methods*. Boston: Allyn and Bacon, Inc.

Bogner, A., Littig, B. & Menz, W. 2009. Introduction: Expert interviews-An introduction to a new methodological debate. *Interviewing experts.* London: Palgrave Macmillan UK, 1-13.

Borges do Nascimento, I.J., Abdulazeem, H., Vasanthan, L.T., Martinez, E.Z., Zucoloto, M.L., Østengaard, L., Azzopardi-Muscat, N., Zapata, T. & Novillo-Ortiz, D. 2023. Barriers and facilitators to utilizing digital health technologies by healthcare professionals. *NPJ digital medicine*, 6(1):161

Braa, J. & Sahay, S. 2017. The DHIS2 Open Source Software Platform: Evolution over time and space. In Celi, L.A.G., Fraser, H. S. F., Nikore, V., Osorio, J. S. & Paik, K, (eds.).*Global Health Informatics: Principles of eHealth and mHealth to improve Quality of Care.* 6:67–72.

Braa, J.J. & Muquinge, H. 2007. Building collaborative networks in Africa on health information systems and open source software development-experiences from the HISP/BEANISH Network. *IST Africa,* 1–5.

Braithwaite, J. 2018. Changing how we think about healthcare improvement. *The BMJ,* 361. https://doi.org/10.1136/bmj.k2014

Brandao, P. 2018. History Of Informatics : The Beginning Of Commercial Computers Research Article History Of Informatics : The Beginning Of Commercial Computers * Pedro. *International Journal of Current Research*:70216-70218.

Bredenkamp, C., Burger, R., Jourdan, A. & Van Doorslaer, E. 2021. Changing inequalities in health-adjusted life expectancy by income and race in South Africa. *Health Systems & Reform*, 7(2), e1909303. https://doi.org/10.1080/23288604.2021.1909303.

Broadbent, E. and Gasteiger, N., 2025. Technology-enabled approaches to remote intervention delivery in health psychology.

Brown, J., Pope, N., Bosco, A.M., Mason, J. & Morgan, A. 2020. Issues affecting nurses' capability to use digital technology at work. An integrative review. *Journal of Clinical Nursing*, 1–19. https://doi.org/10.1111/jocn.15321

Bruggeman, B., Tondeur, J., Pynoo, B. & Struyven, K. 2019. Experts' Insights About Blended Learning Implementation: What Teacher Attributes are Relevant?. In Orngreen, R., Buhl, M. & Meyer, B. (eds.). *Proceedings of the 18th European Conference on e-Learning,* 7-8 November 2019. Copenhagen, Denmark: Academic Conferences International Limited, 639-648.

Buntin, M.B., Burke, M.F., Hoaglin, M.C. & Blumenthal, D. 2011. The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health affairs*, 30(3):464-471.

Busse, R., Blümel, M., Knieps, F. & Bärnighausen, T. 2017. Statutory health insurance in Germany: a health system shaped by 135 years of solidarity, self-governance, and competition. *The Lancet,* 390(10097):882-897. http://dx.doi.org/10.1016/S0140-6736(17)31280-1.

Caetano, H., Siqueira, Oliveira, A., Augusto Vasconcelos Araújo, M. & Simião Dornelas, J. 2018. Let's be Pragmatic : Research in Information Systems with Relevance and Rigor. *International Journal of Business Management and Economic Research*, 9(4):1314–1321

Caligtan, C.A., Carroll, D.L., Hurley, A.C., Gersh-Zaremski, R. & Dykes, P.C. 2012. Bedside information technology to support patient-centered care. *International Journal of Medical Informatics*, 81(7):442–451.

Canadian Association of Schools of Nursing. 2012. *Nursing Informatics Entry-to-Practice Competencies for Registered Nurses*. https://www.casn.ca/wp-content/uploads/2014/12/Nursing-Informatics-Entry-to-Practice-Competencies-for-RNs_updated-June-4-2015.pdf [26 January 2025].

Cape Peninsula University of Technology. 2015. *Faculty Handbook.* https://www.cput.ac.za/storage/study_at_cput/prospectus_and_handbook/fid_handbook_2015.pdf. [2 December 2024].

Car, J., Carlstedt-Duke, J., Car, L.T., Posadzki P., Whiting P., Zary N., Atun R., Majeed A., Campbell J.; & Digital Health Education Collaboration. 2019. Digital Education in Health

Professions : The Need for Overarching Evidence Synthesis Corresponding *Journal of Medical Internet Research* , **21(2):e12913.** https://doi.org/10.2196/12913.

Carroll, L.S.L. 2017. A comprehensive definition of technology from an ethological perspective. *Social Sciences,* 6(4):126.

Caspersen, M.E., Gal-Ezer, J., McGettrick, A. & Nardelli, E. 2018. *Informatics for All The strategy.* https://www.acm.org/binaries/content/assets/public-policy/acm-europe-ie-i4all-strategy-2018.pdf. [2 December 2024].

Chastonay, P., Moretti, R., Zesiger, V., Cremaschini, M., Bailey, R., Pariyo, G. & Kabengele, E.M. 2013. Health workforce development: A needs assessment study in French speaking African countries. *Advances in Health Sciences Education*, 18(2):265–277.

Chikware, A.B., Roman, N.V., & Davids, E.L. 2024. Improving Health Informatics Competencies: A Scoping Review of the Components of Health Informatics Academic Programs. *Sage Open*, 14(4). https://doi.org/10.1177/21582440241293259.

Chipps, J., Le Roux, L., Agabus, J. & Bimerew, M. 2022. Nursing informatics skills relevance and competence for final year nursing students. C*urationis*, 45(1):2277.

Choi, B. C. & Pak, A. W. 2006. Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clinical and Investigative Medicine*, 29(6):351–364.

CIHI. 2009. *Health Informatics and Health Information Management Human Resources Report.* https://technationcanada.ca/wp-content/uploads/2021/02/J14-3447_HR_Report_WEB2.pdf [15 December 2024].

Clark, V.L.P. & Ivankova, N.V. 2015. *Mixed methods research: A guide to the field.* (3 Mixed Methods Research Series). Los Angeles, United States of America: Sage publications.

Clear, A., Clear, T., Vichare, A., Charles, T., Frezza, S., Gutica, M., Lunt, B., Maiorana, F., Pears, A., Pitt, F., Reidesel, C. & Szynkiewicz, J. 2020. Developing Competency Statements for Computer Science Curricula: The Way Ahead. In Giannakos, M., Sindre, G., Luxton-Reilly, A. & Divitini, M. (eds.). *Proceedings of the 2020 ACM Conference on Innovation and Technology in Computer Science Education*, 15-19 June 2020. Trondheim Norway: Association for Computing Machinery, 515-516.

Coovadia, H., Jewkes, R., Barron, P., Sanders, D. & McIntyre, D. 2009. The health and health system of South Africa: historical roots of current public health challenges. *The Lancet*, 374(9692):817–834.

Costa, P.D., Almeida, J., Araujo, S.M., Alves, P., Cruz-Correia, R., Saranto, K. & Mantas, J. 2023. Biomedical and health informatics teaching in Portugal: Current status. *Heliyon*, 9(3).

Creswell, J.W. 2009. *Research Design: Qualitative, Quantitative and Mixed methods approaches. 3rd ed.* Thousand Oaks, California: Sage Publications.

Creswell, J.W. 2015. *Educational research: Planning, conducting, and evaluating quantitative and qualitative research.* Pearson.

Creswell, J.W. 2016. Research Design, Qualitative, Quantitative and Mixed Methods Approaches. 3rded. Thousand Oaks, California: Sage Publications.

Creswell, J.W. 2021. *A Concise Introduction to Mixed Methods Research.* Thousand Oaks, California: Sage Publications.

Creswell, K.M., Bates, D.W. & Sheikh, A. 2013. Ten key considerations for the successful implementation and adoption of large-scale health information technology. *Journal of the American Medical Informatics Association*, 20(1):e9–e13. https://doi.org/10.1136/amiajnl-2013-001684

Cronin, K. 2016. *Transdisciplinary Research (Tdr) and Sustainability.* Wellington: Ministry of Research, Science and Technology. *http://learningforsustainability.com/pubs/Transdisciplinary_Research_and_Sustainability.pdf* [12 December 2024].

Da Silva, H.C.C., de Oliveira Siqueira, A., Araújo, M.A.V.& Dornelas, J.S. 2018. Let's be Pragmatic: Research in Information Systems with Relevance and Rigor. *International Journal of Business Management & Economic Research*, *9*(4):1315-1321.

Davhana-Maselesele, M. & Direko, K. 2017. A model of collaboration between nursing education institutions in the North West Province of South Africa. C*urationis*, *40*(1):1-10.

Davies, A., Hassey, A., Williams, J. & Moulton, G. 2022. Creation of a core competency framework for clinical informatics: From genesis to maintaining relevance. *International Journal of Medical Informatics*, 168:104905

Davies, A., Mueller, J. & Moulton, G. 2020. Core competencies for clinical informaticians: a systematic review. *International Journal of Medical Informatics*, 141:104237.

Dawadi, S., Shrestha, S. & Giri, R.A. 2021. Mixed-methods research: A discussion on its types, challenges, and criticisms. *Journal of Practical Studies in Education*, 2(2):25-36.

De la Harpe, R. 2014. The level of participation during the development of a mobile care data application for home-based healthcare in a developing context: An actor-network theory perspective. *South African Computer Journal*, 54(54):20–33.

De la Harpe, R., Korpela, M. & van Zyl, I. 2013. The collaborative design of a health informatics fundamentals curriculum for the South African context. *Journal of Health Informatics in Africa*, 1(1):1–7.

De la Harpe, A. and Van Zyl, I., 2012. Prioritising University-Community engagement in North-South research partnerships

DeMarrais, K.B. and Lapan, S.D. eds., 2003. *Foundations for research: Methods of inquiry in education and the social sciences*. Routledge

De Sousa, D., Fogel, A., Azevedo, J. & Padrao, P. 2022. The effectiveness of web-based interventions to promote health behaviour change in adolescents: a systematic review. *Nutrients*, 14(6):1258.

Department of Health Republic of South Africa. 2024. THE EMERGING SOUTH AFRICAN NATIONAL HEALTH INFORMATION SYSTEM: Strategies, Approaches And Experiences. https://www.csir.co.za/emerging-south-african-national-health-information-system-strategies-approaches-and-experiences [6 August 2025].

Department of Health Republic of South Africa. 2014. The National Health Promotion Policy and Strategy. https://knowledgehub.health.gov.za/system/files/elibdownloads/2023-04/National%252520health%252520promotion%252520policy%252520and%252520strategy%2525202015%252520-%2525202019.pdf [2 December 2024].

Department of Health Republic of South Africa. 2019. National Digital Health Strategy for South Africa 2019 – 2024: Pretoria South Africa.

Department of Health Zimbabwe. 2017. Zimbabwe ' s E -Health Strategy Ministry of Health and Child Welfare: 1–27.

Dewey J .1916. Democracy and education. In Boydston JA (ed) The Middle Works, Vol 9 Carbondale: SIU Press: 1-402

DOH South Africa & CSIR. 2014. Health Normative Standards Framework for Interoperability in eHealth in South Africa. *National Health Normative Standards Framework for Interoperability in eHealth in South Africa*. https://www.gov.za/sites/default/files/gcis_document/201409/37583gen314.pdf [20 March 2021].

DOH South Africa. 2012. Development of a National Ehealth Strategy for South. (July):1–25.

DOH South Africa. 2015. The National Health Promotion Policy and Strategy. https://knowledgehub.health.gov.za/system/files/elibdownloads/2023-04/National%252520health%252520promotion%252520policy%252520and%252520strategy%2525202015%252520-%2525202019.pdf [2 December 2024].

Dolamo, B.L. & Olubiyi, S.K. 2013. Nursing education in Africa : South Africa , Nigeria , and Ethiopia experiences. *International journal of Nursing and Midwifery*, 5(2):14–21.

Dreyfus, Phillipe. 1962. *L'informatique.* Gestion, Paris: 240–41

Duma, S., Dippenaar, J., Bhengu, B., Oosthuizen, A., Middleton, L., Phillips, M., Naude, S. & Uys, L. 2014. Specialist and Advanced Specialist Nursing and Midwifery Practice. *Trends in Nursing*, 1(1):102-119.

Edirippulige, S., Smith, A.C., Wickramasinghe, S. & Armfield, N.R. 2018. Examining the influence of e-health education on professional practice. *Journal of Medical Systems*, 42:1-6.

Effken, J.A. 2003. An organizing framework for nursing informatics research. *CIN: Computers, Informatics, Nursing,* 21(6):316–323.

Egenes J. 2009. History of Nursing. In Roux G., Halstead J. A. (Eds.). *Issues and trends in nursing: Essential knowledge for today and tomorrow*. Jones & Bartlett Learning.

Eldoushy, E.E. & Behairy, A.S. 2023. Effect of Nursing Informatics' Training Program on Nurses' Proficiency in Remote Follow-Up for Liver Transplant Recipients. *International Egyptian Journal of Nursing Sciences and Research*, 4(1):307-327.

Elsayed, L.A., El-Nagger, N. & Mohamed, H.A.A. 2016. Evolution of Nursing Informatics: A key to Improving Nursing Practice. *Research Journal of Medicine and Medical Sciences*, 11(1):X1-X7.

Erdmann, A.L., Andrade, S.R.D., Mello, A.L.S.F.D. & Drago, L.C. 2013. Secondary Health Care: best practices in the health services network. *Revista latino-americana de enfermagem*, 21*:*131-139.

Esterhuizen, J.M. & van Rensburg, G.H. 2021. The historical influence of nursing organisations on the development of the nursing profession in South Africa. *International Journal of Africa Nursing Sciences*, 14:100290.

European Commission. 2007. *EU*US eHealth Work Project; Mapping Skills and Competencies; Providing Access to Knowledge, Tools and Platforms; and strengthening, Disseminating and Exploiting Success Outcomes for a Transatlantic eHealth Workforce.* https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5ba68e643&appId=PPGMS [2 February 2022].

Fàbregues, S., Escalante-Barrios, E.L., Molina-Azorin, J.F., Hong, Q.N. & Verd, J.M. 2021. Taking a critical stance towards mixed methods research: A cross-disciplinary qualitative secondary analysis of researchers' views. *PLoS ONE*, 16(7):e0252014. https://doi.org/10.1371/journal.pone.0252014

Fernández, E. 2017. Innovation in healthcare: harnessing new technologies. *Journal of the Midwest Association for Information Systems (JMWAIS)*, *2017*(2):8.

Fetters, M.D., Curry, L.A. & Creswell, J.W. 2013. Achieving integration in mixed methods designs-principles and practices. *Health Services Research*, 48(6pt2):2134-2156.

Findley, M.G., Kikuta, K. & Denly, M. 2021. External validity. *Annual Review of Political Science*, 24(1):365-393.

Fiordelli, M., Diviani, N.& Schulz, P.J., 2013. Mapping mHealth research: a decade of evolution. *Journal of medical Internet research*, *15*(5), p.e2430.

Fong, D.Y., Ho, S.Y. & Lam, T.H. 2010. Evaluation of internal reliability in the presence of inconsistent responses. *Health and Quality of Life Outcomes*, 8:1-10.

Fourman, M. & Fourman, M. 2002. *Division of Informatics , University of Edinburgh by informatics*. https://www.inf.ed.ac.uk/publications/online/0139.pdf [12 December 2024].

Free, C., Phillips, G., Galli, L., Watson, L., Felix, L., Edwards, P., Patel, V. & Haines, A. 2013. The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review. *PLoS Medicine*, 10(1):e1001362.

Freeman, R.E. 2011. *Strategic management: A stakeholder approach.* Cambridge University Press.

Frenk, J., Chen, L., Bhutta, Z.A., Cohen, J., Crisp, N., Evans, T., Fineberg, H., Garcia, P., Ke, Y., Kelley, P. & Kistnasamy, B. 2010. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *The Lancet*, 376(9756):1923-1958.

Frenk, J., Chen, L.C., Chandran, L., Groff, E.O., King, R., Meleis, A. & Fineberg, H.V. 2022. Challenges and opportunities for educating health professionals after the COVID-19 pandemic. *The Lancet*, 400(10362):1539-1556.

Frey, B.B. (ed.). 2018. *The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation*. Sage publications.

Frezza, S., Daniels, M., Pears, A., Cajander, Å., Kann, V., Kapoor, A., McDermott, R., Peters, A.K., Sabin, M. & Wallace, C. 2018. Modelling competencies for computing education beyond 2020: A research based approach to defining competencies in the computing disciplines. In *Proceedings Companion of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education*. *ITiCSE,* 148–174.

Friedman, C.P. 2009. A “fundamental theorem” of biomedical informatics. *Journal of the American Medical Informatics Association*, 16(2):169-170.

Fry, E.C., Toste, J.R., Feuer, B.R. and Espin, C.A., 2024. A systematic review of CBM content in practitioner-focused journals: Do we talk about instructional decision-making?. *Journal of Learning Disabilities*, *57*(5): 275-290.

Gadd, C.S., Steen, E.B., Caro, C.M., Greenberg, S., Williamson, J.J. & Fridsma, D.B. 2020. Domains, tasks, and knowledge for health informatics practice: Results of a practice analysis. *Journal of the American Medical Informatics Association*, 27(6):845–852.

Garrib, A., Stoops, N., Dlamini, L., Govender, T., Rohde, J. & Herbst, K. 2008. An evaluation of the District Health Information System in rural South Africa. *South African Medical Journal*, 98(7):522–549.

Gaumer, G.L., Koeniger-Donohue, R., Friel, C. & Sudbay, M.B. 2007. Use of information technology by advanced practice nurses. *CIN: Computers, Informatics, Nursing*, 25(6):344-352.

Global Health Security Index. 2019. Global Health Security Index: Building Collective Action and Accountability: 324. *Nuclear Threat Initiative (NTI) and John Hopkins Bloomberg School of Public Health Centre for Health Security.* https://ghsindex.org/wp-content/uploads/2019/10/2019-Global-Health-Security-Index.pdf. [29 January 2025]

Godsey, J.A. 2015. *Towards an informatics competent nursing profession: validation of the self-assessment of nursing informatics competency scale (SANICS) before and after online informatics training*. Doctoral Thesis, University of Hawai'i at Manoa. https://scholarspace.manoa.hawaii.edu/items/5ee0be10-16b5-415b-bbce-b3976b117a1b/full (29 January 2025).

Goldkuhl, G. 2008. What kind of pragmatism in information systems research. In *AIS SIG Prag Inaugural meeting,* 14:3-8. https://www.researchgate.net/publication/279411549_Proceedings_of_the_Inaugural_Meeting_of_AIS_SIGPrag. (29 January 2025).

Goldkuhl, G. 2012. Pragmatism vs interpretivism in qualitative information systems research. *European Journal of Information Systems*, 21(2):135–146.

González-Pérez, L.I. & Ramírez-Montoya, M.S. 2022. Components of Education 4.0 in 21st century skills frameworks: systematic review. *Sustainability*, 14(3):1493.

González-Salamanca, J.C., Agudelo, O.L. & Salinas, J. 2020. Key competences, education for sustainable development and strategies for the development of 21st century skills. A systematic literature review. *Sustainability*, 12(24):10366.

Goossen-Baremans, A., Collins, S. & Park, H.A. 2017. Semanticification in Connected Health. In *Forecasting Informatics Competencies for Nurses in the Future of Connected Health*. IOS Press. https://doi.org/10.3233/978-1-61499-738-2-133.

Gordon, T., Booysen, F. & Mbonigaba, J. 2020. Socio-economic inequalities in the multiple dimensions of access to healthcare: The case of South Africa. *BMC Public Health*, 20(1):1–13.

Grandia, B.L. 2017. Healthcare Information Systems : A Look at the Past , Present , and Future. *Health Catalyst*, 1-6.

Grant, C. & Osanloo, A. 2014. Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your “house”. *Administrative Issues Journal*, 4(2):4.

Grant, M.J. & Booth, A. 2009. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health information & Libraries Journal*, 26(2):91-108.

Graves, B.A., O’Neal, P. V., Roussel, L. & Polancich, S. 2018. EBP Design and Translation: Teaching How to Begin a Scholarly Practice Project. *Worldviews on Evidence-Based Nursing*, 15(2):152–154.

Graves, J. & Corcoran, S. 1989. The study of nursing informatics. *The Journal of Nursing Scholarship*, 21(4):227–231.

Grimwood, T. & Snell, L. 2020. The use of technology in healthcare education : a literature review. *MedEdPublish*, 9:137. https://doi.org/10.15694/mep.2020.000137.1.

Groeneveld, W., Vennekens, J. & Aerts, K. 2021. Identifying non-technical skill gaps in software engineering education: What experts expect but students don’t learn. *ACM Transactions on Computing Education (TOCE)*, 22(1):1-21.

Gruppen, L.D., Burkhardt, J.C., Fitzgerald, J.T., Funnell, M., Haftel, H.M., Lypson, M.L., Mullan, P.B., Santen, S.A., Sheets, K.J., Stalburg, C.M. & Vasquez, J.A. 2016. Competency-based education: programme design and challenges to implementation. *Medical Education*, 50(5):532-539.

Gruppen, L.D., Irby, D.M., Durning, S.J. & Maggio, L.A. 2019. Conceptualizing learning environments in the health professions. *Academic Medicine*, 94(7):969-974.

Gruppen, L.D., Mangrulkar, R.S. & Kolars, J.C. 2012. The promise of competency-based education in the health professions for improving global health. *Human Resources for Health*, 10:1-7.

Guba, E.G. & Lincoln, T.S. 2000. Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (eds.). The SAGE Handbook of Qualitative Research. *Thousand Oaks, CA. Sage Publications,* 105–117.

Gürdaş Topkaya, S. & Kaya, N. 2015. Nurses' computer literacy and attitudes towards the use of computers in health care. *International Journal of Nursing Practice*, 21:141-149.

Hadar, I., Soffer, P. & Kenzi, K. 2014. The role of domain knowledge in requirements elicitation via interviews: an exploratory study. *Requirements Engineering*, 19(2):143-159.

Hanmer, L.A. 1989. The postgraduate medical informatics programme at the University of Cape Town. *Methods of Information in Medicine,* 28(04):321-323.

Hannah, K. J., Guillemin, E. J. & Conklin, D. N. (eds.). 1985. *Nursing Uses of Computers and Information Science.* North-Holland

Hannah, K.J., Hussey, P., Kennedy, M.A. & Ball, M.J. (eds.). 2014. *Introduction to Nursing Informatics* 4th ed. Springer.

Harerimana, A. & Mtshali, N.G. 2019. Types of ICT applications used and the skills ' level of nursing students in higher education : A cross-sectional survey. *International Journal of Africa Nursing Sciences*, 11:100163

Harerimana, A., Wicking, K., Biedermann, N. & Yates, K. 2021. Integrating nursing informatics into undergraduate nursing education in Africa: A scoping review. *International Nursing Review*, 68(3):420-433.

Harerimana, A., Wicking, K., Biedermann, N. & Yates, K. 2023. Ready, Set, Go! Fostering nursing informatics integration into our curricula. In *Abstracts from the National Nursing Forum (NNF) 2023*. 9-11 August 2023. Adelaide Convention Centre, Adelaide, Australia: National Nursing Forum.

Harker, M. 2017. History of Nursing Education Evolution Mildred Montag. *Teaching and Learning in Nursing*, 12(4):295–297.

Harmse, A. & Wadee, A.A. 2020. Competency Frameworks as Activators for curriculum development in ICT courses: A comparative study. In *Proceedings* of the *2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems, icABCD 2020.* 6-7 Aug. 2020. IEEE. https://doi.org/10.1109/icABCD49160.2020

Harrison, R.L., Reilly, T.M. & Creswell, J.W. 2020. Methodological rigor in mixed methods: An application in management studies. *Journal of Mixed Methods Research*, 14(4):473-495.

Hassona, F.M., Ali, A.Z. & Nageeb, S.M. 2019. Nursing students' computer self-efficacy and attitudes toward its use in the health care setting: A comparative study. *Evidence-Based Nursing Research*, 1(4):9-9

Haux, R. 2010. Medical informatics: Past, present, future. *International Journal of Medical Informatics*, 79(9):599–610.

Health Systems Trust. 2021. *Health Indicators.* https://www.hst.org.za/healthindicators [2 December 2024].

Heeks, R. 2002. Information Systems and Developing Countries: Failure, Success and Local Improvisations. *The Information Society*, 18(2):101–112.

Heeks, R. 2006. Health information systems: Failure, success and improvisation. *International Journal of Medical Informatics*, 75(2):125-137.

Hersh, W. 2009. A stimulus to define informatics and health information technology. *BMC Medical Informatics and Decision Making*, 9(1):1–6.

Hirose, M. & Creswell, J.W. 2023. Applying core quality criteria of mixed methods research to an empirical study. *Journal of Mixed Methods Research*, 17(1):12-28.

Hisa, I., Jami, K. and Pikin, P., 2019. Information on IMIA Regional Groups.

HITCOMP. 2022. Health Information Technology Competencies. http://hitcomp.org/. [2 December 2022].

Hoffman, S.J. & Cole, C.B. 2018. Defining the global health system and systematically mapping its network of actors. *Globalization and Health*, 14: 1-19.

Hoffmann, S., Klein, J.T. & Pohl, C. 2019. Linking transdisciplinary research projects with science and practice at large: Introducing insights from knowledge utilization. *Environmental Science & Policy*, 102: 36-42.

Holden, R.J., Binkheder, S., Patel, J. & Viernes, S.H.P. 2018. Best practices for health informatician involvement in interprofessional health care teams. *Applied Clinical Informatics*, *9*(01):141-148.

Horwitz, S. 2011. The nurse in the university: A history of university education for South African nurses: A case study of the University of the Witwatersrand. *Nursing Research and Practice*, 2011(1):813270.

Hovenga, E. & Grain, H. 2013. Developing a common reference model for the health informatics discipline. In Lehmann, C.U., Ammenwerth, E. & Nøhr, C. *MEDINFO 2013.* (Studies in Health Technology and Informatics). IOS Press, 192:122-126. https://doi.org/10.3233/978-1-61499-289-9-122

Hsieh, H.F. & Shannon, S.E. 2005. Three approaches to qualitative content analysis. *Qualitative Health Research*, 15(9):1277-1288.

Hübner, U., Shaw, T., Thye, J., Egbert, N., Marin, H. & Ball, M. 2016. Towards an international framework for recommendations of core competencies in nursing & inter-professional informatics: The TIGER competency synthesis project. *Studies in Health Technology and Informatics*, 228:655–659.

Hübner, U., Shaw, T., Thye, J., Egbert, N., Marin, H., Chang, P., O'Connor, S., Day, K., Honey, M., Blake, R., Hovenga, E., Skiba, D. & Ball, M. 2018. Technology Informatics Guiding Education Reform-TIGER. *Methods of Information in Medicine*, 57(S01):e30–e42.

Hwang, H. & Kuo, T. 2018. Competency in delivering health education : A concept analysis. *Journal of Interprofessional Education & Practice*, 11:20–25.

Hwang, H.H.L., Kuo, M.L. & Tu, C.T. 2018. Health education and competency scale : Development and testing. *Journal of Clinical Nursing*, 27(3):e658-e667.

Hwang, H.L., Kuo, M.L. & Tu, C.T. 2018. Health education and competency scale: Development and testing. *Journal of Clinical Nursing*, 27(3-4):e658-e667.

Impagliazzo, J. & Pears, A.N. 2018 The CC2020 project — computing curricula guidelines for the 2020s. In *Proceedings of 2018 IEEE Global Engineering Education Conference (EDUCON),* 17-20 April 2018. Santa Cruz de Tenerife, Spain: IEEE. https://doi.org/10.1109/EDUCON.2018.8363484.

Ingelbeen, B., Anne, A., de Paul Djientcheu, V., Jimenez-Castellanos, A., Khanna, J. & Zolfo, M. 2013. Building Capacity Through a Social Network for African Researchers: Piloting two eLearning Courses on Evidence Based Medicine and Research within the AFRICA BUILD Project. *Journal of Health Informatics in Africa,* 1(1).

International Medical Informatics Association 2016. *IMIA NI Education Working Group.* https://imia-medinfo.org/wp/ni-education/. [2 December 2024].

Issa-Salwe, A.M., Khilji, N.K. & Roberts, S.A. 2024. Transitions in Information Systems education: confronting technological and societal change in the face of global realities and disparities. In Hwang, M. (ed.). *Teaching Information Systems*. Cheltenham: Edward Elgar Publishing, 264-298.

Jabali, A.K., Waris, A., Khan, D.I., Ahmed, S. & Hourani, R.J. 2022. Electronic health records: Three decades of bibliometric research productivity analysis and some insights. *Informatics in Medicine Unlocked*, *29*:100872.

Jacobs, R.J., Lou, J.Q., Ownby, R.L. & Caballero, J. 2016. A systematic review of eHealth interventions to improve health literacy. *Health Informatics Journal*, *22*(2):81-98.

James, W. 1907. Pragmatism: A new name for some old ways of thinking. https://open.library.okstate.edu/introphilosophy/chapter/william-james-on-pragmatism/ [29 January 2025].

Jarva, E. 2024. *Digital health competence of healthcare professionals in healthcare settings*. Doctoral thesis presentation to the Programme Committee of Health and Biosciences of the University of Oulu for public defence in the Markku Larmas auditorium in Dentopolis, on 24 May 2024. https://oulurepo.oulu.fi/bitstream/handle/10024/49647/nbnfioulu-202404152739.pdf?sequence=1 [2 December 2024].

Jarva, E., Oikarinen, A., Andersson, J., Pramila-Savukoski, S., Hammarén, M. & Mikkonen, K. 2024. Healthcare professionals' digital health competence profiles and associated factors: A cross-sectional study. *Journal of Advanced Nursing.* https://doi.org/10.1111/jan.16096.

Jeptha, 2008.*Throughput rate of nursing students in the Faculty of Health and Wellness Sciences at a university of technology*. Masters thesis, Cape Peninsula University of Technology. https://etd.cput.ac.za/handle/20.500.11838/1204 [2 December 2024].

Jick, T.D. 1979. Mixing qualitative and quantitative Methods: Triangulation in action. *Administrative Science Quarterly,* 24(4):602-611.

Jidkov, L., Alexander, M., Bark, P., Williams, J.G., Kay, J., Taylor, P., Hemingway, H. & Banerjee, A. 2019. Health informatics competencies in postgraduate medical education and training in the UK: a mixed methods study. *BMJ open*, *9*(3):e025460.

Johnson, R.B. & Christensen, L.B. 2014. *Educational Research, Quantitative, Qualitative, and Mixed Approaches*. Sage Publications.

Jones, J., Valenta, A.L., Borbolla, D., Deckard, G. & Manos, L. 2023. Mapping the delineation of practice to the AMIA foundational domains for applied health informatics. *Journal of the American Medical Informatics Association*, 30(10):1593-1598.

Jouparinejad, S., Foroughameri, G., Khajouei, R. & Farokhzadian, J. 2020. Improving the informatics competency of critical care nurses: Results of an interventional study in the southeast of Iran. *BMC Medical Informatics and Decision Making*, 20(1):1–24.

Jucker, A.H., Schneider, K.P. & Bublitz, W. (eds.) 2018. Data in pragmatic research. *Handbooks of Pragmatics [HOPS].* De Gruyter Mouton, (10):3-36.

Kaihlanen, A., Gluschkoff, K., Kinnunen, U., Saranto, K., Ahonen, O. & Heponiemi, T. 2021. Nursing informatics competences of Finnish registered nurses after national educational initiatives : A cross-sectional study. *Nurse Education Today*, 106:105060.

Kaminski, J. 2007. *The revealing of nursing informatics: Exploring the field.* Manuscript submitted to supervisory committee, University of British Columbia, British Columbia, Canada. https://www.nursing-informatics.com/revealing/NI_comp2.pdf [12 December 2025].

Kaminski J. 2019. *P.A.T.C.H. Assessment Scale. V.3.* https://nursing-informatics.com/niassess/plan.html [2 December 2022].

Katurura, M.C. & Cilliers, L. 2018. Electronic health record system in the public health care sector of South Africa: A systematic literature review. *African Journal of Primary Health Care & Family Medicine*, 10(1):1–8.

Kaushik, V. & Walsh, C.A. 2019. Pragmatism as a research paradigm and its implications for social work research. *Social Sciences*, 8(9):255.

Kautzky, K. & Tollman, S.M. 2008. A Perspective on Primary Health Care in South Africa. *South African Health Review, 2008*:17–30.

Kelly, L.M. & Cordeiro, M. 2020. Three principles of pragmatism for research on organizational processes. *Methodological Innovations*, 13(2).

Kenya Ministry of Health & Health, M.O.F. 2016. KENYA NATIONAL eHEALTH POLICY 2016-2030.

Khalifa, M. 2014. Technical and Human Challenges of Implementing Hospital Information Systems in Saudi Arabia. *Journal of Health Informatics in Developing Countries*, 8(1):12–25.

Khezri, H. & Abdekhoda, M. 2019. Assessing nurses' informatics competency and identifying its related factors. *Journal of Research in Nursing*, 24(7):529-538.

Kim, J. 2015. Competency-based curriculum: An effective approach to digital curation education. *Journal. of Education for Library and Information Science*, 56(4):283-297.

Kim, K.T. 2019. The structural relationship among digital literacy, learning strategies, and core competencies among South Korean college students. *Educational Sciences: Theory and Practice*, *19*(2):3-21.

Kim, M.O., Coiera, E. & Magrabi, F. 2017. Special Focus on Much study has been done on errors arising from applications that have been implemented in the Health Field: a systematic review. *Journal of the American Medical Informatics Association*, 24(2):246–250. https://doi.org/10.1093/jamia/ocw154.

Kinnunen, U.M., Heponiemi, T., Rajalahti, E., Ahonen, O., Korhonen, T. & Hyppönen, H. 2019. Factors Related to Health Informatics Competencies for Nurses - Results of a National Electronic Health Record Survey. *CIN: Computers, Informatics, Nursing*, 37(8):420–429.

Kinnunen, U.M., Kuusisto, A., Koponen, S., Ahonen, O., Kaihlanen, A.M., Hassinen, T. & Vehko, T. 2023. Nurses' informatics competency assessment of health information system usage: a cross-sectional survey. *CIN: Computers, Informatics, Nursing*, *41*(11):869-876

Kipturgo, M.K., Kivuti-Bitok, L.W., Karani, A.K. & Muiva, M.M. 2014. Attitudes of nursing staff towards computerisation: a case of two hospitals in Nairobi, Kenya. *BMC Medical Informatics and Decision Making*, *14*:1-8.

Kleib, M., Chauvette, A., Furlong, K., Nagle, L., Slater, L. & McCloskey, R. 2021. Approaches for defining and assessing nursing informatics competencies: a scoping review. *JBI Evidence Synthesis*, 19(4):794-841. https://journals.lww.com/jbisrir/Fulltext/2021/04000/Approaches_for_defining_and_assessing_nursing.6.aspx. [2 December 2022].

Klink, M.V.D. & Boon, J. 2002. The investigation of competencies within professional domains. *Human Resource Development International*, 5(4):411-424.

Knight, P. 2002. *Small-Scale Research: Pragmatic Inquiry in Social Science and the Caring Professions.* London: SAGE Publications Ltd.

Kokol, P., Saranto, K. & Blažun Vošner, H. 2018. eHealth and health informatics competences: A systemic analysis of literature production based on bibliometrics. *Kybernetes*, 47(5):1018-1030.

Kolin, K. 2011. Philosophy of information and fundamental problems of modern informatics. *tripleC: Communication, Capitalism & Critique. Open Access Journal for a Global Sustainable Information Society*, 9(2):454-459

Konttila, J., Siira, H., Kyngäs, H., Lahtinen, M., Elo, S., Kääriäinen, M., Kaakinen, P., Oikarinen, A., Yamakawa, M., Momoe, F., Yoko, U., Akari, H. & Kristina, H. 2019. Healthcare professionals' competence in digitalisation : A systematic review *Journal of Clinical Nursing*, *28*(5-6):745–761.

Korpela, M., Mursu, A. & Soriyan, H.A. 2002. Information Systems Development as an Activity. *Computer Supported Cooperative Work (CSCW)*, 11:111–128.

Korpela, M., Soriyan, H.A., Olufokunbi, K.C., Onayade, A.A., Davies-Adetugbo, A. & Adesanmi, D. 1998. Community Participation in Health Informatics in Africa: An Experiment in Tripartite Partnership in Ile-Ife, Nigeria. *Computer Supported Cooperative Work*, 7:339–358.

Kotze, F.J. 2012. *A historical perspective: private nursing institutions in South Africa (1946–2006)* Doctoral thesis., North-West University. https://repository.nwu.ac.za/bitstream/handle/10394/8436/Kotze_FJ.pdf?sequence=1 [2 December 2022].

Koumamba, A.P., Bisvigou, U.J., Ngoungou, E.B. & Diallo, G. 2021. Health information systems in developing countries: case of African countries. *BMC Medical Informatics and Decision Making*, *21*:1-10.

Krive, J., Isola, M., Chang, L., Patel, T., Anderson, M. & Sreedhar, R. 2023. Grounded in reality: artificial intelligence in medical education. *JAMIA open*, *6*(2):ooad037. https://doi.org/10.1093/jamiaopen/ooad037

Kudinov, D.A., Borisov, I. V., Elykomov, V.A. & Nomokonova, E.A. 2021. Overview of Promising Information Technologies in the Healthcare System from the Position of a System Approach. In A. V Bogoviz, (ed.). *Complex Systems: Innovation and Sustainability in the Digital Age: Volume 2.* (Studies in Systems, Decision and Control (SSDC). Cham: Springer International Publishing, 225–235.

Kuek, A. & Hakkennes, S. 2020. Healthcare staff digital literacy levels and their attitudes towards information systems. *Health Informatics Journal*, *26*(1):592-612.

Kulikowski, C.A., Shortliffe, E.H., Currie, L.M., Elkin, P.L., Hunter, L.E., Johnson, T.R., Kalet, I.J., Lenert, L.A., Musen, M.A., Ozbolt, J.G., Smith, J.W., Tarczy-Hornoch, P.Z. & Williamson, J.J. 2012. AMIA Board white paper: Definition of biomedical informatics and specification of core competencies for graduate education in the discipline. *Journal of the American Medical Informatics Association*, 19(6):931–938.

Kumar, S. 2018. Understanding Different Issues of Unit of Analysis in a Business Research. *Journal of General Management Research*, *5*(2):70-82.

Lameire, N., Joffe, P. & Wiedemann, M. 1999. Healthcare systems - An international review: An overview. Nephrology Dialysis Transplantation, Suppl.(December, 01):14(6):3-9. https://doi.org/10.1093/ndt/14.suppl_6.3

Latif, L., 2025. Regulating Digital Health and Health Apps in South Africa: Lessons Learnt. *Available at SSRN 5122390*.

Layton, R. 1997.*An Introduction to theory in anthropology. Cambridge, United Kingdom:* Cambridge University Press.

le Roux, L., Bimerew, M. & Chipps, J.A. 2024. A survey of nurse informatics competencies of professional nurses in clinical practice public hospitals in South Africa. *International Journal of Africa Nursing Sciences*, 21:100783.

Leavy, P. 2017. *Research Design, Quantitative, Qualitative, Mixed Methods, Arts-Based and*

LeBlanc, R. 1996. Healthcare information: opportunities and challenges. *Leadership in health services = Leadership dans les services de santé*, 5(4):3.

Leech, N.L. & Onwuegbuzie, A.J. 2009. A typology of mixed methods research designs. *Quality and Quantity*, 43(2):265-275.

Leidig, P. 2020. *IS 2020: Developing an ACM/AIS information systems model curriculum for undergraduate programs.* https://web.archive.org/web/20220802074230id_/https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1144&context=icis2020 [2 December 2022].

Lekalakala-Mokgele, E., Lowane, M.P. & Mogale, N.M. 2023, Knowledge, perceptions and attitudes of eHealth and health technology among nursing students from Gauteng Province, South Africa. *Healthcare,*11(12):1672.

Lesotho Ministry of Communications Science and Technology. 2005. ICT POLICY FOR LESOTHO Table of Contents (March).

Levine, B. ed., 1996. *Works about John Dewey, 1886-1995*. SIU Press

Levy, Y. & Ellis, T.J. 2006. A systems approach to conduct an effective literature review in support of information systems research. *Informing Science*, 9.

Lewis-Beck, M., Bryman, A.E. & Liao, T.F. (eds.). 2003. *The Sage Encyclopedia of Social Science Research Methods.* Thousand Oaks, California: Sage Publications.

Liberia Ministry of Health. 2016. Liberian Health Information System & ICT Strategic Plan.

Lincoln, Y.S. & Guba, E.G. 1985. Criteria for Assessing Naturalistic Enquiries as Reports. https://files.eric.ed.gov/fulltext/ED297007.pdf [2 December 2022].

Lippeveld, T., Sauerborn, R. & Bodart, C. (eds.). 2014. *Design and implementation of health information systems*. Geneva: World Health Organization 2000 Publications.

Liu, C.H., Lee, T.T. & Mills, M.E. 2015. The experience of informatics nurses in Taiwan. *Journal of Professional Nursing*, 31(2):158-164.

Locatelli, P., Restifo, N., Gastaldi, L. & Corso, M. 2012. Health Care Information Systems: Architectural Models and Governance. In Kalloniatis, C. (ed.). *Innovative Information Systems Modelling Techniques,* 71-*96.*

Lokmic-Tomkins, Z., Raghunathan, K., Almond, H., Booth, R.G., McBride, S.G., Tietze, M., Honey, M., Procter, P., Peddle, M. & McKenna, L. 2024. Perspectives on the implementation of health informatics curricula frameworks. *Contemporary Nurse*, 60(2):178-191

Longenecker, H.E., Campbell, S.M., Landry, J.P., Pardue, J.H. & Daigle, R.J. 2011. A health informatics curriculum compatible with IS 2010 and IMIA recommendations for an undergraduate degree. In *Information Systems Education journal* (ISEDJ) 10:15-32. https://files.eric.ed.gov/fulltext/EJ1136759.pdf. [29 January 2025].

Lysak, D., Palamarek, K., Trieu, J. & Kleib, M. 2022. Nursing Student Awareness and Utilization of Educational and Professional Resources Towards Informatics Competency Development. *Canadian Journal of Nursing Informatics*, 17(1).

Machleid, F., Kaczmarczyk, R., Johann, D., Balčiūnas, J., Atienza-Carbonell, B., von Maltzahn, F. & Mosch, L. 2020. Digital Health in Medical Education: Findings from a Mixed-Methods Survey among European Medical Students. *Journal of Medical Internet Research*.

Mackenzie, N. & Knipe, S. 2006. Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research*, *16*(2):193-205.

Mafumiko, F.S.M. 2006. *Micro-scale experimentation as a catalyst for improving the chemistry curriculum in Tanzania*. Doctoral Thesis, University of Twente, Enschede, den Haag. https://ris.utwente.nl/ws/portalfiles/portal/6119658/thesis_Mafumiko.pdf [2 December 2022].

Mahmoud, M.H.& Bayoumy, H.M., 2014. Barriers and facilitators for execution of nursing process from nurses' perspective. *International journal of advanced research*, *2*(2): 300-315.

Mahoney, D.F. 2011. The aging nurse workforce and technology Aging nurse workforce. *Gerontechnology*, *10*(1):13-25.

Maina, A.M. & Singh, U.G. 2020. Why National eHealth Strategies Matter - An Exploratory Study of eHealth Strategies of African Countries. *International Conference on Electrical and Electronics Engineering, ICE3 2020*, 14-15 February 2020. Gorakhpur, Uttar Pradesh, India, 670–675. https://www.researchgate.net/publication/342405102_Why_National_eHealth_Strategies_Matter_-_An_Exploratory_Study_of_eHealth_Strategies_of_African_Countries [29 January 2025]

Management Interventions for Health Care Consumers: A Systematic Review. PLoS Med 10(1):e1001362.

Mandel, J.C., Kreda, D.A., Mandl, K.D., Kohane, I.S. & Ramoni, R.B. 2016. SMART on FHIR: A standards-based, interoperable apps platform for electronic health records. *Journal of the American Medical Informatics Association*, 23(5):899–908.

Mannevaara, P., Saranto, K., Kinnunen, U.M. & Hübner, U. 2024. Recommended target audience, course content and learning arrangements for teaching health informatics competencies: A scoping review. *Health Informatics Journal*, *30*(3):14604582241260643.

Mantas, J. & Hasman, A. 2017. IMIA Educational Recommendations and Nursing Informatics. *Studies in Health Technology and Informatics*, 232:20–30.

Mantas, J. 1996. Nursing Informatics Educational Issues: The NIGHTINGALE Project. *Medical Informatics Europe'96*, IOS Press.

Mantas, J. 2016. Biomedical and Health Informatics Education–the IMIA Years. *Yearbook of medical informatics*, 25(S 01):S92-S102.

Mantas, J., Ammenwerth, E., Demiris, G., Hasman, A., Haux, R., Hersh, W., Hovenga, E., Lun, K.C., Marin, H., Martin-Sanchez, F. & Wright, G. 2010. Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. *Methods of Information in Medicine*, 49(02):105–120.

Manyazewal, T., Woldeamanuel, Y., Blumberg, H.M., Fekadu, A. & Marconi, V.C. 2021. The potential of digital health technologies in African context, Ethiopia. *medRxiv.* https://doi.org/10.1101/2021.03.27.21254466.

Maphumulo, W.T. & Bhengu, B.R. 2020. Perceptions of professional nurses regarding the National Core Standards tool in tertiary hospitals in KwaZulu-Natal. *Curationis*, 43(1):1-9.

Marna, B., Adele, B. & Marlien, H. 2014. The benefits and challenges of e-Health Application: A content Analysis of the South African context. *The International Conference on Computer Science, Computer Engineering, and Social Media*

Marcelo, A., Adejumo, A. and Luna, D., 2011. Health informatics for development: a threepronged strategy of partnerships, standards, and mobile Health. *Yearbook of medical informatics*, *20*(01): 96-101

Mars, M. 2010. Health capacity development through telemedicine in Africa. *Yearbook of Medical Informatics, 10(01)*:87–93. https://doi.org/10.1055/s-0038-1638696.

Mars, M. 2012. Building the capacity to build capacity in e-health in sub-Saharan Africa: the KwaZulu-Natal experience. *Telemedicine and e-Health*, 18(1):32-37.

Mars, M. 2014. Tele-education in South Africa. *Frontiers in Public Health*, 2:173.

Marshall, J.E., Raynor, M.D. & Nolte, A. (eds.). 2016. Myles *Textbook for Midwives 3E African Edition.* Mumbai: Elsevier Health Sciences.

Martikainen, S., Kaipio, J. & Lääveri, T. 2020. End-user participation in health information systems (HIS) development: Physicians' and nurses' experiences. *International Journal of Medical Informatics*, 137:104117.

Masic, I. 2013. The history and new trends of medical informatics. *Donald School Journal of Ultrasound in Obstetrics and Gynecology*, 7(3):301–302

Masic, I. 2014.. Five periods in development of medical informatics. *Acta Informatica Medica*, 22(1):44–48.

Matney, S.A., Avant, K., Clark, L. & Staggers, N. 2020. Development of a Theory of Wisdom-in-Action for Clinical Nursing. *Advances in Nursing Science*, 43(1).

Matney, S.A., Langford, L.H. & Staggers, N. 2021. Are nursing informatics competencies good enough? *JBI Evidence Synthesis*, 19(4):747–748.

McCartney, G., Popham, F., McMaster, R. & Cumbers, A. 2019. Defining health and health inequalities. *Public health*, 172:22-30.

McGregor, S.L. 2004. The nature of transdisciplinary research and practice. *Kappa Omicron Nu.* (Human Sciences Working Paper Series), 1–12.

Mckenney, S. & Reeves, T.C. 2014. Chapter 9 : Educational Design Research. *Handbook of Research on Educational Communications Technology*, 131–140.

McKenney, S. & Reeves, T.C. 2020. Educational design research: Portraying, conducting, and enhancing productive scholarship. *Medical Education*, 1–11.

McLane, T.M., Hoyt, R., Hodge, C., Weinfurter, E., Reardon, E.E. & Monsen, K.A. 2021. What industry wants: an empirical analysis of health informatics job postings. *Applied Clinical Informatics*, 12(02):285-292.

Menachemi, N. & Collum, T.H. 2011. Benefits and drawbacks of electronic health record systems. *Risk management and healthcare policy,* 47-55.

Merriam-Webster Inc. 2022. *Merriam Webster Dictionary*. https://www.merriam-webster.com/dictionary/. [2 December 2022].

Merry, L., Castiglione, S.A., Rouleau, G., Létourneau, D., Larue, C., Deschênes, M.F., Gonsalves, D.M. & Ahmed, L. 2023. Continuing professional development (CPD) system development, implementation, evaluation and sustainability for healthcare professionals in low-and lower-middle-income countries: a rapid scoping review. *BMC Medical Education*, 23(1):498.

Mertens, D.M. & Wilson, A.T. 2018. *Program evaluation theory and practice.* New York, United States of America: Guilford Publications.

Michie, S., Yardley, L., West, R., Patrick, K. & Greaves, F. 2017. Developing and evaluating digital interventions to promote behavior change in health and health care:

Recommendations resulting from an international workshop. *Journal of Medical Internet Research*, 19(6).

Mihalas, G.I. 2014. Evolution of Trends in European Medical Informatics. *Acta Informatica Medica,* 22(1):37-43.

Miles, M. & Huberman, M. 1994. Q*ualitative Data Analysis*: *An expanded sourcebook*, SAGE Publications Inc.

Ministry of Health Ghana. 2009. National eHealth Strategy. : 1–80.

Ministry of Health Zambia. 2017. eHealth Governance Structure.

Mitchell, C., Cordell, D. & Fam, D. 2015. Beginning at the end: The outcome spaces framework to guide purposive transdisciplinary research. *Futures*, 65: 86-96

Mohajan, H.K. 2017. Two criteria for good measurements in research: Validity and reliability. *Annals of Spiru Haret University. Economic Series*, 17(4):59-82.

Montesanti, S., Robinson-Vollman, A. & Green, L.A. 2018. Designing a framework for primary health care research in Canada: A scoping literature review. *BMC Family Practice*, 19(1):1-8.

Moore, M.E. & Shaw-Kokot, J. 2012. Health informatics professional core competencies. *Canada's Health Informatics Association*, 19(4):99-103.

Morgan, D.L. 2007. Paradigms Lost and Pragmatism Regained: Methodological Implications of Combining Qualitative and Quantitative Methods. *Journal of Mixed Methods Research*, 1(1):48–76.

Morgan, D.L. 2017. Pragmatism as a Paradigm for Mixed Methods Research. *Integrating Qualitative and Quantitative Methods: A Pragmatic Approach*. Thousand Oaks, California: Sage Publications.

Morin, K.H. 2014. Nursing education : The past , present and future. *Journal of Health Specialties*, 2(4).

Morris, M.E., Brusco, N.K., Jones, J., Taylor, N.F., East, C.E., Semciw, A.I., Edvardsson, K., Thwaites, C., Bourke, S.L., Raza Khan, U. & Fowler-Davis, S. 2023, March. The widening gap between the digital capability of the care workforce and technology-enabled healthcare delivery: a nursing and allied health analysis. *Healthcare*, 11(7):994.

Moseholm, E. & Fetters, M.D. 2017. Conceptual models to guide integration during analysis in convergent mixed methods studies. *Methodological Innovations*, *10*(2):2059799117703118.

Mostert-Phipps, N., Pottas, D. & Korpela, M. 2013. Guidelines to encourage the adoption and meaningful use of health information technologies in the South African healthcare landscape. *Studies in Health Technology and Informatics*, 192(1):147-151.

Mothupi, M.C., Knight, L. & Tabana, H. 2020. Improving the validity, relevance and feasibility of the continuum of care framework for maternal health in South Africa: A thematic analysis of experts' perspectives. *Health Research Policy and Systems*, 18(1):1-14.

Mouton, J. 2011. Doctoral production in South Africa: Statistics, challenges and responses. *Perspectives in Education*, *29*(3):13-29.

Muhaise, H., Ejiri, A.H., Muwanga-Zake, J.W.F. & Kareyo, M. 2020. The Research Philosophy Dilemma for Postgraduate Student Researchers. *International Journal of Research and Scientific Innovation (IJRSI)*, 7(4):201–204.

Mulder, M. (2017). Competence Theory and Research: A Synthesis. In: Mulder, M. (ed.). Competence-based Vocational and Professional Education. Technical and Vocational Education and Training: Issues, Concerns and Prospects, Cham:Springer, 23:1071-1106. https://doi.org/10.1007/978-3-319-41713-4_50.

Muldoon, L.K., Hogg, W.E. & Levitt, M. 2006. Primary care (PC) and primary health care (PHC): What is the difference? *Canadian Journal of Public Health*, 97(5):409-411.

Müller, J., Reardon, C., Coetzee, F., Bester, J., Dube, K., Hanekom, S., du Plessis, E. & Couper, I. 2022. Transformative learning through participation: experiences at a rural clinical training site in South Africa. *BMC Medical Education*, *22*(1):183.

Munene, D., Alunyu, A. & Nabukenya, J. 2020. Towards a Digital Health Curriculum for Health Workforce for the African Region : A Scoping Review State of DH Workforce and Conceptualization of Training Competencies in the African Region. *Journal of Health Informatics in Africa*, 7(256):38–54. https://doi.org/10.21203/rs.2.13130/v1.

Munkvold, B.E. & Bygstad, B. 2016. The Land of Confusion–Clearing up some common misunderstandings of interpretive research. Paper presented at NOKOBIT 2016, Bergen, 28-30 Nov. NOKOBIT, Bibsys Open Journal, 24(1). http://urn.nb.no/URN:NBN:no-58515. [27 December 2025].

Munn, Z., Peters, M., Stern, C., Tufanaru, C., McArthur, A. & Aromataris, E. 2018. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, 18(143). https://doi.org/10.1186/s12874-018-0611-x.

Murphy, J., Honey, M., Newbold, S., Weber, P. & Wu, Y.H., 2018. Forecasting informatics competencies for nurses in the future of connected health. In *Nursing Informatics 2018*:58-59. IOS Press.

Murray, P.J., Betts, H., Roberts, J., Richardson, G., Ward, R. & Wright, G. 2005. Report on the Education Steps project: the Otley meeting (full report). *Swindon: The British Computer Society Health Informatics Forum*, 1–33.

Murray, P.J., Betts, H.J., Wright, G. & Tshayingca-Mashiya, N.V. 2009. Health informatics education and capacity building in Eastern Cape Province, South Africa. *Yearbook of Medical Informatics,* 18(01):158–163.

Mutula, S.M. 2015. Factors Influencing Perceptions and Attitudes of Nurses Towards the Use of ICT in Patient Care in KwaZulu Natal Province, South Africa. *The African Journal of Information Systems*, 8(1):1.

Myers, M.D. & Newman, M. 2007. The qualitative interview in IS research: Examining the craft. *Information and Organization*, 17(1):2-26.

Nabyonga-Orem, J. 2017. Monitoring Sustainable Development Goal 3: How ready are the health information systems in low-income and middle-income countries? *BMJ Global Health*, 2(4): e000433.

Nagle, L.M., Kleib, M. & Furlong, K.E. 2020. Digital Health in Canadian Schools of Nursing Part A: Nurse Educators' Perspectives. *Quality Advancement in Nursing Education-Avancées en formation infirmière*, *6*(1):4.

Namibia Ministry of Health and Social Services. 2020. National Health Policy Framework. , (July 2010).

Nara, M.M. 2020. *Implementation of a Training Program in the Use of the Electronic Medical Record to Improve Performance on Quality Measures and Reduce Burnout Among Healthcare Providers.* Doctoral thesis, University of Nevada, Las Vegas. https://digitalscholarship.unlv.edu/cgi/viewcontent.cgi?article=4937&context=thesesdissertations [2 December 2022].

National Department of Health. 2005. Nursing Act , 2005. *Corporate Governance*, (33):1–45.

Nazeha, N., Pavagadhi, D., Kyaw, B.M., Car, J., Jimenez, G. & Car, L.T. 2020. A Digitally Competent Health Workforce: Scoping Review of Educational Frameworks. *Journal of Medical Internet Research*, 22(11).

Ndebele, N.C. & Enaifoghe, A. 2024. The Adoption of Innovative Strategies for Enhanced Service Delivery in the South Africa Public Sector. *Social Sciences and Education Research Review*, *10*(2):114-121.

Ndebele, N.C., Mlambo, V.H., Molepo, N.J. & Sibiya, L.M. 2021. The South African health sector and the World Health Organization South Africa's health sector and its preparedness for the National Health Insurance (NHI): challenges and opportunities. *European Journal of Economics, Law and Social Sciences*. https://openscholar.ump.ac.za/handle/20.500.12714/509. [27 December 2025].

Neumann, M. 2015. Grounded simulation. *Journal of Artificial Societies and Social Simulation*, 18(1):9.

Neville, C. 2007. Effective Learning Service: Introduction to Research and Research Methods. *Bradford University School of Management*, 1-44.

Nicolescu, B., 1999, April. The transdisciplinary evolution of learning. In *Symposium at the annual meeting of the American Educational Research Association,* 19-23 April 1999. Montreal, Canada, 1-11. https://api.semanticscholar.org/CorpusID:15354177.

Nieveen, N. 1999. Prototyping to reach product quality. In van den Akker, J., Branch, R.M., Gustafson, K., Nieveen, N., Plomp, T. (eds.). *Design Approaches and Tools in Education and Training.* Dordrecht:Springer, 125-135. https://doi.org/10.1007/978-94-011-4255-7_10.

Nigeria Federal Ministry of Health. 2015. National Health ICT Strategic Framework 2015-2020.

Niglas, K., 2010. The multidimensional model of research methodology. SAGE handbook of mixed methods in social & behavioral research, pp.215-236.

Niknafs, A. & Berry, D. 2017. The impact of domain knowledge on the effectiveness of requirements engineering activities. *Empirical Software Engineering*, 22(1):80-133.

Nimkar, S. 2016. Promoting individual health using information technology. Trends in the US health system. *Health Education Journal*, *75*(6):744-752.

Nkosi, Z. Z., Asah, F. & Pillay, P. 2011. Post-basic nursing students' access to and attitudes toward the use of information technology in practice: A descriptive analysis. *Journal of Nursing Management*, 19(7):876-882.

Nordstrom, K.L., Horner, C.E., Méndez, V.E., Izzo, V., Carpenter, N., Faulkner, J.W. & Caswell, M. 2022. An Undergraduate Agroecology Research Fellows Program Engages Co-learning Through Participatory Action Research. *Frontiers in Sustainable Food Systems*, *5*:760995.

Nwokeji, J.C., Stachel, R., Holmes, T. & Orji, R.O. 2019. Competencies Required for Developing Computer and Information Systems Curriculum. In [AUTHORS] *Proceedings of the 2019 IEEE Frontiers in Education Conference (FIE)*, 2019-October 2019, Covington, KY, USA: IEEE, 1-9. https://doi.org/10.1109/FIE43999.2019.9028613.

Nyangena, J., Some, K., Kuria, M., Nangulu, A., Kasasa, S., da Costa Vroom, F.B., Wright, G. and Were, M.C., 2022. Developing Harmonized Benchmarks for the Master of Science in Health Informatics for the East African Region. In *MEDINFO 2021: One World, One Health–Global Partnership for Digital Innovation* (pp. 907-911). IOS Press.

O'Reilly, C.J. 2016. Creative Engineers: Is Abductive Reasoning Encouraged enough in Degree Project Work? *Procedia CIRP*, 50:547–552.

Oluwakemi, O.Y., 2020. Health Information Systems and Healthcare Service Delivery in Public Health Facilities in Southwest. Nigeria (Doctoral dissertation, Ritsumeikan Asia Pacific University).

Odekunle, F.F., Odekunle, R.O. & Shankar, S. 2017. Why sub-Saharan Africa lags in electronic health record adoption and possible strategies to increase its adoption in this region. *International Journal of Health Sciences*, 11(4):59.

Olaniyi, P.O., Oluwatobi, F.T., Olaniyan, M.E., Olajide, O.A., Sunday, B.A., Aborode, A.T., Inya, C.O. & Chinonso, U.U.A. 2022. Healthcare systems strengthening in Africa: The call for action to achieve SDG 3. The *International Journal of Health Planning and Management, 37*(1):14-20.

Onwuegbuzie, A.J. & Collins, K.M.T. 2007. A typology of mixed methods sampling designs in social science research. *The Qualitative Report*, 12(2):474-498.

Onwuegbuzie, A.J. & Johnson, R.B. 2006. The validity issue in mixed research. *Research in the Schools*, *13*(1):48-63.

Oussous, A., Benjelloun, F.Z., Lahcen, A.A. & Belfkih, S. 2018. Big Data technologies: A survey. *Journal of King Saud University-Computer and Information Sciences*, 30(4):431-448.

Ovwasa, D.E. 2021. Current Status of Nursing Informatics education in South African Universities. *ATBU Journal of Science, Technology and Education,* 9(2):340–351.

Oxford Dictionary. 2022. Oxford Lexico Dictionary. *Oxford,Lexico*. https://www.lexico.com/definition/healthcare. [2 December 2024].

Ozbolt, J.G. & Saba, V.K. 2008. A brief history of nursing informatics in the United States of America. *Nursing Outlook*, 56(5).

Pandey, N., de Coninck, H. and Sagar, A.D., 2022. Beyond technology transfer: Innovation cooperation to advance sustainable development in developing countries. *Wiley Interdisciplinary Reviews: Energy and Environment*, *11*(2) : e422.

Panerai, R.B. 2014. Health information systems. *Global perspectives in health: Health information systems*: 1-6

Pang, E., Wong, M., Leung, C.H. & Coombes, J. 2019. Competencies for fresh graduates' success at work: Perspectives of employers. *Industry and Higher Education*, *33*(1):55-65.

Park, Y. & Yoon, H.J. 2020. Understanding personal health record and facilitating its market. *Healthcare Informatics Research*, 26(3):248-250.

Patton, M.Q. 2002. *Qualitative Research & Evaluation Methods.* Thousand Oaks, California: Sage Publications.

Pears, M., Yiasemidou, M., Ismail, M.A., Veneziano, D. & Biyani, C.S. 2020. Role of immersive technologies in healthcare education during the COVID-19 epidemic. *Scottish Medical Journal*, 65(4):112-119.

Peirce, C.S. 1878. How to make our ideas clear. *Popular Science Monthly*, 1:286–302.

Peltonen, L.M., Nibber, R., Block, L., Ronquillo, C., Lozada Perezmitre, E., Lewis, A., Alhuwail, D., Ali, S., Georgsson, M., Jeon, E. & Tayaben, J.L. 2021. Nursing informatics research trends: findings from an international survey. *Nurses and Midwives in the Digital Age.* IOS Press, 284:344-349. https://doi.org/10.3233/SHTI210741.

Perez, C.M. 2017. Bridging Healthcare and Health IT. *Journal of Health Science*, 5:236-238.

Piscotty Jr, R.J., Kalisch, B. & Gracey-Thomas, A. 2015. Impact of Healthcare Information Technology on Nursing Practice, *Journal of Nursing Scholarship*, 47(4):287–293.

Plano Clark, V.L. 2017. Mixed methods research. *The Journal of Positive Psychology*,

Plomp, T. 2007. Educational Design Research: An Introduction. In Plomp, T. & Nieveen, N. (eds.). *Educational Design Research.* Enschede, the Netherlands: Netherlands Institute for Curriculum Development (SLO), 10-51.

Pohl, C. & Hadorn, G.H. 2008. Core terms in transdisciplinary research. *Handbook of Transdisciplinary Research*: 427–432.

Pope, A.M., Snyder, M.A. & Mood, L.H. (eds.). 1995. *Nursing Health, & Environment.* Washington: National Academies Press.

Portilho, L. 2018. Access to and Use of ICT Among Brazilian Healthcare Facilities. (2017):2016–2021.

Priestley, M., Philippou, S., Alvunger, D. & Soini, T. 2021. Curriculum making: A conceptual framing. In Priestley, M., Alvunger, D., Philippou, S. & Soini, T. (eds.). *Curriculum making in Europe: Policy and practice within and across diverse contexts.* Bingley: Emerald Publishing Limited, 1-28.

Purabdollah, M., Zamanzadeh, V., Ghahramanian, A., Valizadeh, L., Mousavi, S. & Ghasempour, M. 2023. Competencies expected of undergraduate nursing students: A scoping review. *Nursing Open*, 10(12):7487-7508

Ramachandra, R. & Math, S.B. 2014. Nursing students' attitudes towards computers in health care: a comparative analysis. *Journal of Health Informatics*, 6(2).

Ramnund, S., Baloyi, O.B., Nkwanyana, N.M. & Jarvis, M.A. 2023. Midwives' acceptance of mHealth applications in the dissemination of maternal health education in primary healthcare clinics. *Information Development*, 39(2):294-303

Ravele, T.A. 2018.*Perceptions of learner nurses and nurse educators regarding Information and Communication Technology in teaching and learning at the Limpopo College of Nursing South Africa. Masters* thesis, University of Limpopo, South Africa. http://ulspace.ul.ac.za/bitstream/handle/10386/3685/ravele_ta_2018.pdf?sequence=1&isAllowed=y [29 January 2025]

Reid, L., Button, D. & Brommeyer, M. 2023. Challenging the myth of the digital native: A narrative review. *Nursing Reports*,*13*(2):573-600.

Reid, L., Maeder, A., Button, D., Breaden, K. & Brommeyer, M. 2021. Defining Nursing Informatics: A Narrative Review. *Nurses and Midwives in the Digital Age*, 284:108-112.

Republic of Uganda Ministry of Health, M. 2016. Uganda National eHealth Policy November 2016.

Ricks, E.J. 2018. An autobiographical account of nursing transformation: 1970-2018. *Inaugural lecture delivered at Nelson Mandela University,* 10 September 2018, 1-27. https://lectures.mandela.ac.za/lectures/media/Store/documents/Inaugural%20lectures/Full-text-of-lecture-Essie-Ricks.pdf [27 January 2025].

Rienhoff, O., Van Der Werff, T.J. & Reichertz, P.L. 1980. Medical informatics. Developments in West Germany and South Africa. *South African Medical Journal*, 58(1):30-34.

Roehrs, A., Da Costa, C.A., da Rosa Righi, R. & De Oliveira, K.S.F. 2017. Personal health records: a systematic literature review. *Journal of medical Internet research*, *19*(1):e5876.

Roos, V. & Hoffman, J. (eds.). 2022. *Age-inclusive ICT innovation for service delivery in South Africa: A developing country perspective*. Springer Nature.

Roos, V.& Hoffman, J. 2022. *Age-inclusive ICT innovation for service delivery in South Africa: A developing country perspective*. Springer Nature.

Roulston, K. and Choi, M., 2018. Qualitative interviews. *The SAGE handbook of qualitative data collection*: .233-249

Rubin, H. J. & Rubin, I. S. 2005. *Qualitative Interviewing: The Art of Hearing Data*. 2nd ed. Thousand Oaks, California. Sage Publications. https://doi.org/10.4135/9781452226651.

Ruckdeschel, A.R. 2018. *Electronic health record instruction in first-semester nursing students: A comparative study*. Doctoral thesis, University of Nevada, Las Vegas. https://digitalscholarship.unlv.edu/cgi/viewcontent.cgi?article=4384&context=thesesdissertations [2 December 2022].

Ruhode, E., Tiihonen, T. & van Zyl, I. 2013. An Information Systems Approach to Addressing Health Care Provision Challenges in Socially Marginalized Communities : Case of Grabouw Settlement in the Western Cape, South Africa. *Journal of Health Informatics in Africa*, 1(1):1.

Ruxwana, N.L., Herselman, M.E. & Conradie, D.P. 2010. ICT applications as e-health solutions in rural healthcare in the Eastern Cape Province of South Africa. *Health Information Management Journal*, *39*(1):17-29.

Saba, V K. 2001. Nursing informatics: yesterday, today and tomorrow. *International Nursing Review*, 48(3):177–187.

Sabin, M., Alrumaih, H. & Impagliazzo, J., 2018, April. A competency-based approach toward curricular guidelines for information technology education. In *Proceedings of 2018 IEEE Global Engineering Education Conference (EDUCON),* 17-20 April 2018. Santa Cruz de Tenerife, Spain: IEEE.

Saldaña, J. 2009. *The coding manual for qualitative researchers*,2nd ed. London: SAGE Publications Ltd. https://emotrab.ufba.br/wp-content/uploads/2020/09/Saldana-2013-TheCodingManualforQualitativeResearchers.pdf (29 January 2025)

Saldana, J. 2016. *The Coding Manual for Qualitative Researchers*, 3rd ed. Thousand Oaks, California: SAGE Publications Inc.

Salm, M., Ali, M., Minihane, M. & Conrad, P. 2021. Defining global health: findings from a systematic review and thematic analysis of the literature. *BMJ Global Health*, *6*(6):e005292.

Samarah, M., Ocansey, A.K., Samarah, E.M.S. & Babalola, O. 2024. Bringing Diversity in Software Engineering Education from the Middle East and Africa. In Blincoe, K., Ford, D., Serebrenik, A. & Masood, Z. (eds.). *Equity, Diversity, and Inclusion in Software Engineering: Best Practices and Insights*. Berkeley, CA: Apress, 365-384.

SAQA. 2022. Registration and Accreditation Processes. 2022. https://www.saqa.org.za/services/registration-of-qualifications/ [2 December 2022].

Saranto, K. & Kinnunen, U.M. 2022. Milestones and Outcomes in Health and Human Services Informatics Education Programmes. In Mantas, J., Hasman, A. & Haux, R. (eds.). *Achievements, Milestones and Challenges in Biomedical and Health Informatics*. IOS Press, 77-92,

Saranto, K., Korpela, M. & Kivinen, T. 2001. Evaluation of the outcomes of a multi-professional education programme in health informatics. *MEDINFO 2001* . IOS Press.

Sarkis, J.M. & Conners, V.L. 1986. Nursing research: historical background and teaching information strategies. *Bulletin of the Medical Library Association*, *74*(2):121.

Saunders, M.N.K., 2009. *Research Methods for Business Students*. Person Education Limited.

Saunders, M.N.K., Lewis, P. & Thornhill, A. 2007. *Research Methods for Business Students*. United Kingdom: Financial Times/Prentice Hall.

Saunders, M N.K., Lewis, P, Thornhill, A & Bristow, A. 2015. Understanding research philosophy and approaches to theory development. In Saunders, M.N.K., Lewis, P & Thornhill, A. (eds.). *Research Methods for Business Students.* Harlow: Pearson Education, 122–16.

Scheckel, M. 2016. Nursing education: Past, present, future. In Roux. G. & Halstead, J.A.(eds.). *Issues and Trends in Nursing 2nd ed.* MA: Jones & Bartlett: 31-62.

Schramme, T. 2023. Health as complete well-being: The WHO definition and beyond. *Public Health Ethics*, *16*(3):210-218.

Schroeder, M.J. 2022. Multidisciplinarity, interdisciplinarity, and transdisciplinarity: The tower of Babel in the age of two cultures. *Philosophies*, *7*(2):26.

Schueller, S.M. 2021. Grand challenges in human factors and digital health. *Frontiers in Digital Health*, *3*:635112. https://doi.org/10.3389/fdgth.2021.635112.

Schwirian PM. 1986. The NI pyramid--a model for research in nursing informatics. *Computers in Nursing Management*. 4(3):134-6.

Scott, P.J. & Briggs, J.S. 2009. A pragmatist argument for mixed methodology in medical informatics. *Journal of Mixed Methods Research*, 3(3):223-241.

Scribante, J., Schmollgruber, S. & Nel, E. 2004. Perspectives on critical care nursing: South Africa. *Connect: The World of Critical Care Nursing*, *3*(4):111.

Senne, A. and Strand, B., 2009. PETE students' knowledge of appropriate instructional strategies and perceived practice of their high school physical education Teachers. *Missouri Journal of Health, Physical Education, Recreation & Dance*, *19*: 25-40.

Seo, K., Min, Y.H., Choi, S.H. & Lee, H. 2019. Evaluation of the Korean version of the self-assessment of nursing informatics competencies scale. *BMC Nursing*, 18:1-9.

Serge, B., Ebongue, M., Ngwete Ndumbe, K.E., Saha Tahoum, U.A., Tania, B.L. & Humphrey, K. 2024. Africa's Experience in Enhancing the Quality of Data and Information Portals: The Case of the Integrated African Health Observatory, http://dx.doi.org/10.2139/ssrn.4704816.

Shackelford, R., McGettrick, A., Sloan, R., Topi, H., Davies, G., Kamali, R., Cross, J., Impagliazzo, J., LeBlanc, R. & Lunt, B. 2006. Computing curricula 2005: The overview report. *ACM SIGCSE Bulletin*, 38(1):456-457. https://doi.org/10.1145/1124706.1121482

Shaft, T.M. & Vessey, I. 1998. The relevance of application domain knowledge: Characterizing the computer program comprehension process. *Journal of Management Information Systems*, 15(1):51–78.

Shaw Morawski, T., Liang, M.Q., Chang, P., Hsu, C.L.C., Chen, Y., Xiao, Q., Ji, M., Sun, J., Qian, Y., Luo, W. & Xue, P. 2022. The TIGER Initiative: Global, Interprofessional Health Informatics Workforce Development. In Hübner, U.H., Wilson, G.M., Shaw Morawski, T. & Ball, M.J. (eds.). *Nursing Informatics: A Health Informatics, Interprofessional and Global Perspective.* Cham: Springer International Publishing.

Shaw, T., Blake, R., Hübner, U., Anderson, C., Wangia-Anderson, V.& Elias, B., 2017. The evolution of TIGER competencies and informatics resources. *Executive Supplemental Report*, https://www.himss.org/sites/hde/files/media/file/2020/03/10/the-evolution-of-tiger-competencies-and-informatics-resources-final-10.2017.pdf [25 January 2025].

Sheikh, A., Cornford, T., Barber, N., Avery, A., Takian, A., Lichtner, V., Petrakaki, D., Crowe, S., Marsden, K., Robertson, A. & Morrison, Z., 2011. Implementation and adoption of nationwide electronic health records in secondary care in England: final qualitative results from prospective national evaluation in "early adopter" hospitals. *BMJ 343*.

Shiferaw, K.B., Tilahun, B.C. & Endehabtu, B.F. 2020. Healthcare providers' digital competency: a cross-sectional survey in a low-income country setting. *BMC Health Services Research*, 20(1):1–7.

Shopo, K.D., Kruger, L. & Bester, P. 2020. Nurses' attitudes towards a computerised health information system in a private South African hospital. *Africa Journal of Nursing and Midwifery*, 22(1):1-15.

Shortliffe, E.H. & Blois, M.S. 2014. The Science and the Pragmatics In E.H. Shortliffe, J.J. Cimino (eds.), Biomedical Informatics London: Springer-Verlag, 3-37. http://dx.doi.org/10.1007/978-1-4471-4474-8_1.

Shortliffe, E.H. & Cimino, J.J. 2014. *Biomedical informatics: computer applications in health care and biomedicine*. London: Springer-Verlag.

Silverman, H.D., Steen, E.B., Carpenito, J.N., Ondrula, C.J., Williamson, J.J. & Fridsma, D.B. 2019. Domains, tasks, and knowledge for clinical informatics subspecialty practice: Results of a practice analysis. *Journal of the American Medical Informatics Association*, 26(7):586–593.

Singh, F. & Masango, T. 2020. Information technology in nursing education: perspectives of student nurses. *The Open Nursing Journal*, *14*(1).

Skiba, D.J. 2017. Nursing Informatics Education: From Automation to Connected Care. *Studies in health technology and informatics*, 232(55):9-19.

Soiferman, L.K., 2010. Compare and Contrast Inductive and Deductive Research Approaches. *Online Submission. ERIC ED542066* https://eric.ed.gov/?id=ED542066. 1-23. [27Januray 2025].

South African Council on Higher Education. 2013. *The Higher Education Qualifications Sub-Framework*. https://www.che.ac.za/sites/default/files/inline-files/PUB_Higher%20Education%20Qualifications%20Sub-Framework%20%28HEQSF%29%202013.pdf [2 February 2022].

South African National Department of Health. 2012. Regulations relating to categories of Hospitals. *National Department of Health South Africa*. https://knowledgehub.health.gov.za/system/files/elibdownloads/2023-04/Hospital%252520Regulations%2525202012.pdf [2 February 2022].

South African National Department of Health. 2019. *National Digital Health Strategy for South Africa. 2019-2024.* www.health.gov.za. [2 February 2022].

South African Nursing Council (SANC) 2022 Annual Statistics [Online]. Pretoria: South African Nursing Council. https://www.sanc.co.za/sanc-statistics/ [2 February 2022].

South African Nursing Council SANC. 2022a. *Education and Training of Nursing and Midwifery Students.* https://www.sanc.co.za/education-and-training/ [2 February 2022].

South African Nursing Council SANC. 2022b. *History and Overview SANC*. https://www.sanc.co.za/history/ [2 February 2022].

South African Nursing Council SANC. *Nursing Act 33 of 2005*. https://www.sanc.co.za/wp-content/uploads/2020/06/Nursing-Act-2005.pdf [2 February 2022].

South African Nursing Council SANC.2019. South African Nursing Council Annual Report | 2019/2020. https://www.sanc.co.za/wp-content/uploads/2021/07/Annual-Report-2019-2020.pdf [2 February 2022].

South African Nursing Council. 2013. The Relationship between the Scope of Practice, Practice Standards and Competencies. *Nursing Act, 2005*: 1–4.

South Sudan Ministry of Health. 2015. HEALTH SECTOR DEVELOPMENT PLAN 2011 - 2015 Government of South Sudan Ministry of Health Transforming the Health System for Improved Services and Better Coverage. , (March 2011).

Sreeramareddy, C.T. & Sathyanarayana, T. 2019. Decentralised versus centralised governance of health services. *Cochrane Database of Systematic Reviews*. http://dx.doi.org/10.1002/14651858.CD010830.pub2.

Staggers, N. & Miller, S. 2001. Using a web-based prototype and human-computer interaction concepts to develop a vision for a next generation patient care management system. In *Proceedings of the AMIA Symposium* American Medical Informatics Association, 3-7 November 2001. Washington, DC, USA, p652

Staggers, N. & Parks, P.L. 1993a. Description and initial applications of the Staggers & Parks Nurse-Computer Interaction Framework. *Computers in Nursing*, *11*(6):282-290.

Staggers, N. & Parks, P.L., 1993b. Collaboration between unlikely disciplines in the creation of a conceptual framework for nurse-computer interactions. In *Proceedings of the Annual Symposium on Computer Application in Medical Care* , 661-665. American Medical Informatics Association.

Staggers, N. & Thompson, C.B. 2002. The Evolution of Definitions for Nursing Informatics. *Journal of the American Medical Informatics Association*, 9(3):255–261.

Staggers, N., Gassert, C.A. & Curran, C. 1999. Informatics Competencies for Nurses at Four Levels of Practice. *Journal of Nursing Education*, *40*(7), pp.303-316.

Staggers, N., Gassert, C.A. & Curran, C. 2002. A Delphi study to determine informatics competencies for nurses at four levels of practice. *Nursing Research*, 51(6):383–390.

Stroetmann, K.A., 2018, May. Integrating Digital Health Services: An Open Platform Approach for Resource-Constrained Countries. In *International Conference on Multidisciplinary Research*. 2018, 6-7 October 2018. Makassar, Indonesia.

Sudarsana, I.K., Nakayanti, A., Sapta, A., Haimah, Satria, E. Saddhono, G.S.A., Daengs, E., Putut, T., Helda, T., Mursalin, M. 2019. Technology Application in Education and Learning Process. *Journal of Physics: Conference Series* 1363(1): 1–7.

Sunnasy, A. 2020. *Exploring nurse educators lived experiences with technology-mediated education within private nursing colleges in Gauteng*. Masters thesis, Stellenbosch: Stellenbosch University. https://scholar.sun.ac.za/server/api/core/bitstreams/69d3c24e-fb4e-499d-ac8b-597b0e1ab3e9/content [2 December 2024].

Svennevig, J. 2001. Abduction as a methodological approach to the study of spoken interaction. *Norskrift*, 103:1–22.

Swaziland Ministry Of Health. 2020. Kingdom of Swaziland eHealth Strategy. , (March 2016).

Taguma, M., Feron, E. & Lim, M.H. 2018. Future of Education and Skills 2030: Curriculum Analysis. *8th Informal Working Group (IWG) Meeting,* 29-31 October 2018, OECD Conference Centre, Paris, France, 1–25.

Takada, S., Cuadros-Vargas, E., Impagliazzo, J., Gordon, S., Marshall, L., Topi, H., van der Veer, G. & Waguespack, L. 2020. Toward the visual understanding of computing curricula. *Education and Information Technologies,* 25:4231-4270.

Tang, R., Hu, Z., Henry, N. & Martin, E. 2023. Towards an optimal competency framework for InterProfessional Informationists (IPI): A multiphased and mixed methods investigation into competency areas, elements, and framework structures. *Education for Information*, *40*(1):65-87. https://doi.org/10.3233/efi-230044.

Tanzania, Ministry of Health, Community Development, Gender and Children, 2019. *The National Digital Health Strategy 2019-2024.*

Tashakkori, A. & Teddlie, C.(eds.). 1998. *Mixed methodology : combining qualitative and quantitative approaches*. Thousand Oaks California: *Sage Publications*.

Tashakkori, A. & Teddlie, C.(eds.). 2003. *Handbook of Mixed Methods in Social & Behavioral Research*. Thousand Oaks California: *Sage Publications*.

Tavakol, M. & Dennick, R. 2011. Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*: 53.

Technology Informatics Guiding Education Reform (TIGER). 2007. *TIGER Initiative: Informatics competencies for every practicing nurse: Recommendations from the TIGER Collaborative,* 1–34.

https://www.tigersummit.com/uploads/3.Tiger.Report_Competencies_final.pdf (29 January 2025).

Testa, M., Livingston, J.A. & VanZile-Tamsen, C. 2011. Advancing the study of violence against women using mixed methods: Integrating qualitative methods into a quantitative research program. *Violence against women*, *17*(2):236-250.

Thate, J. & Brookshire, R.G. 2022. Health informatics education: Standards, challenges, and tools. In Hübner, U.H., Wilson, G.M., Shaw Morawski, T. & Ball, M.J. (eds.). *Nursing informatics: A health informatics, interprofessional and global perspective,* 627-646). Cham: Springer International Publishing.

The Department of Health, 2014/2015-2018/2019. Western Cape Government Department of Health (Road to Health 2030). https://d7.westerncape.gov.za/assets/departments/health/healthcare2030.pdf [2 March 2022].

The Joint ACM/AIS IS 2020 Task Force. 2020. Competency Model for Undergraduate Degree Programs in Information Systems. https://www.acm.org/binaries/content/assets/education/curricula-recommendations/is2020.pdf [2 March 2022].

The Presidency, Republic of South Africa.2014. Twenty year review South Africa, 1994-2014. Pretoria: Government Printing Works; 2014. https://www.dpme.gov.za/news/documents/20%20year%20review.pdf [12 December 2024].

Thimbleby, H. 2013. Technology and the future of healthcare. *Journal of Public Health Research*, *2*(3):jphr-2013.

Thye, J., Shaw, T., Elias, B., Egbert, N., Saranto, K., Babitsch, B., Procter, P., Ball, M.J. & Hübner, U. 2019. Towards the tiger international framework for recommendations of core competencies in health informatics 2.0: Extending the scope and the roles. *Studies in Health Technology and Informatics*, 264:1218-1222.

Tiainen, M., Ahonen, O., Hinkkanen, L., Rajalahti, E. & Värri, A. 2021. The definitions of health care and social welfare informatics competencies. *Finnish Journal of eHealth and eWelfare*, 13(2):147-159.

Tiihonen, T., Vesisenaho, M. & Sutinen, E. 2008. Concept on Context: IS Meeting Context in Developing Countries. *Technology for Innovation and Education in Developing Countries.*

Tilahun, B., Zeleke, A., Fritz, F. & Zegeye, D. 2014. New Bachelors Degree Program in Health Informatics in Ethiopia: Curriculum Content and Development Approaches. *Studies in Health Technology and Informatics*, 205:798-802.

Tilahun, B., Zeleke, A., Fritz, F., Mola, M. & Andualem, M. 2014. Towards problem-based health informatics education and research : ten years of experience and future directions in Ethiopia. In *9th Health Informatics in Africa Conference (HELINA 2014)*, 7-11 March 2015. Accra, Ghana, *114.*

Tisdell, E.J., Merriam, S.B. and Stuckey-Peyrot, H.L., 2025. *Qualitative research: A guide to design and implementation*. John Wiley & Sons

Torres-Alzate, H.M., Wilson, L.L., Harper, D.C., Ivankova, N.V., Heaton, K. & Shirey, M.R. 2020. Essential global health competencies for baccalaureate nursing students in the United States: A mixed methods Delphi study. *Journal of Advanced Nursing*, *76*(2):725-740

Trafford, V. & Leshem, S. 2009. Doctorateness as a threshold concept. *Innovations in education and teaching international*, *46*(3):305-316.

Tsai, C.H., Eghdam, A., Davoody, N., Wright, G., Flowerday, S. & Koch, S. 2020. Effects of electronic health record implementation and barriers to adoption and use: A scoping review and qualitative analysis of the content. *Life*, 10(12):1-27.

Tsegaye, T. & Flowerday, S. 2021. A System Architecture For Ensuring Interoperability in a South African National Electronic Health Record System. *South African Computer Journal*, 33(1):79–110.

Turley, J.P. 1996. Toward a model for nursing informatics. *The journal of nursing scholarship*, 28(4):309–313.

Ückert, F., Ammenwerth, E., Dujat, C., Grant, A., Haux, R., Hein, A., Hochlehnert, A., Knaup-Gregori, P., Kulikowski, C., Mantas, J. and Maojo, V., 2014. Past and next 10 years of medical informatics. *Journal of medical systems*, *38*:1-7.

United Nations ,Statistical Annex, Country Classifications,2021. https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/WESP2022_ANNEX.pdf [12 March 2024].

United Nations (UN). 2016. The 2030 Agenda for sustainable development. Arsenic Research and Global Sustainability - Proceedings of the 6th International Congress on Arsenic in the Environment, AS 2016: 12–14.

United Nations (UN). 2019. The sustainable development goals report 2021. United Nations publication issued by the Department of Economic and Social Affairs: 64.

Valenta, A.L., Berner, E.S., Boren, S.A., Deckard, G.J., Eldredge, C., Fridsma, D.B., Gadd, C., Gong, Y., Johnson, T., Jones, J. & Manos, E.L., 2018. AMIA Board White Paper: AMIA 2017 core competencies for applied health informatics education at the master's degree level. *Journal of the American Medical Informatics Association*, *25*(12):1657-1668

van den Akker, J., 2007. Curriculum design research. *An introduction to educational design research*, (37), 37-50.

van den Akker, J. 2010. Building bridges: How research may improve curriculum policies and classroom practices. In Stoney, S.M. (ed.). *Beyond Lisbon 2010: Perspectives from research and development for educational policy in Europe.* Berkshire: CIDREE. 175-195.

van den Akker, J. 2013. Curricular development research as specimen of educational design research. In Plomp, T. & Nieveen, N. (eds.). *Educational Design Research.* Enschede, the Netherlands: Netherlands Institute for Curriculum Development (SLO), 53-70.

van den Akker, J., Gravemeijer, K., McKenney, S. & Nieveeen, N. 2006. Introducing educational design research. In van den Akker, J., Gravemeijer, K., McKenney, S. & Nieveeen, N. (eds.). *Educational Design Research.* United Kingdom: Taylor & Francis, 3-7

van Straten, S., Stannard, C., Bulabula, J., Boodhia, K., Paul, K., Leong, J. & Klipin, M.J. 2017. A third of patients treated at a tertiary-level surgical service could be treated at a secondary-level facility. *South African Medical Journal*,*107*(9):788-790.

Vandali, V., 2017. Computer in Nursing. *International Journal of Advances in Nursing Management*, *5*(1):89-92.

Vehko, T., Hyppönen, H., Puttonen, S., Kujala, S., Ketola, E., Tuukkanen, J., Aalto, A.M. & Heponiemi, T. 2019. Experienced time pressure and stress: Electronic health records usability and information technology competence play a role. *BMC Medical Informatics and Decision Making*, 19(1):1–9.

Vera, S., Nikki, S., Helen, S. & David, S. 2017. Addressing social determinants of health in South Africa : the journey continues. *South African Health Review*, 2017(1):77–87.

Vladova, G., Haase, J. & Friesike, S. 2024. Why, with whom, and how to conduct interdisciplinary research? A review from a researcher's perspective. Science and Public Policy. https://doi.org/10.1093/scipol/scae070.

Von Soest, C. 2023. Why do we speak to experts? Reviving the strength of the expert interview method. *Perspectives on Politics*, 21(1):277-287.

Voorheis, P., Bhuiya, A.R., Kuluski, K., Pham, Q. & Petch, J. 2023. Making sense of theories, models, and frameworks in digital health behavior change design: qualitative descriptive study. *Journal of Medical Internet Research*, *25*:e45095.

Wallace LS. 2013. A view of health care around the world. The Annals of Family Medicine. 11(1):84. https://doi.org/10.1370/afm.1484.

Walsham, G. 2006. Doing interpretive research. *European Journal of Information Systems*,*15*(3):320-330.

Wang, M., Xie, Y., Guo, X. & Fu, H. 2024. Interdisciplinarity in the Built Environment: Measurement and Interdisciplinary Topic Identification. *Buildings*, 14(12):3718.

Weaver, K. 2018. Pragmatic Paradigm. In Frey, B.B. (ed.). *The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation*. https://doi.org/10.4135/9781506326139.n534

Weber, R. 2004. The Rhetoric of Positivism Versus Interpretivism: A Personal View. *MIS Quarterly*, 28(1):iii–xii. https://doi.org/10.2307/25148621.

Weber, P., Peltonen, L.M. & Junger, A. 2022. The Essence and Role of Nurses in the Future of Biomedical and Health Informatics. In Mantas, J., Hasman, A. & Haux, R. (eds.). *Achievements, Milestones and Challenges in Biomedical and Health Informatics.* IOS Press, 164-176.

Were, M.C., Gong, W., Balirwa, P., Balugaba, B.E., Yeung, A., Pierce, L., Ingles, D., Kim, Y. & Shepherd, B.E. 2020. Coverage of IMIA-recommended Competencies by Masters in Health Informatics Degree Programs in East Africa. *International Journal of Medical Informatics*, 143:104265.

Were, M.C., Siika, A., Ayuo, P.O., Atwoli, L. & Esamai, F. 2015. Building Comprehensive and Sustainable Health Informatics Institutions in Developing Countries: Moi University Experience. *Studies in Health Technology and Informatics*, 216: 520–524.

Western Cape Government Health. 2014. Healthcare 2030 The Road to Wellness. https://www.activateleadership.co.za/wp-content/uploads/2020/10/healthcare2030_0.pdf [12 December 2022].

Whitehead, D., 2004. Health promotion and health education: advancing the concepts. J*ournal of Advanced Nursing*, *47*(3):311-320.

Whittaker, S., Shaw, C., Spieker, N. & Linegar, A. 2011. Quality Standards for Healthcare Establishments in South Africa. *South African Health Review*, 59–67.

WHO (World Health Organization). 2001. WHO report 2000 [3]. *Lancet*, 358(9287):1097–1098.

WHO (World Health Organization). 2007. Strengthening Health Systems to Improve Health Outcomes. https://iris.who.int/bitstream/handle/10665/43918/9789241596077_eng.pdf [12 November 2024].

WHO (World Health Organization). 2010. The World Health Report 2010. https://www.who.int/publications/i/item/9789241564021 [07 November 2024].

WHO (World Health Organization). 2020. Draft global strategy on digital health 2020–2024. https://cdn.who.int/media/docs/default-source/documents/gs4dh_1ae1ed25-9aef-42ce-832c-8bc292460976.docx?sfvrsn=cd577e23_18 [26 November 2024].

WHO (World Health Organization). World health statistics 2014. https://iris.who.int/bitstream/handle/10665/112738/9789240692671_eng.pdf. [26 November 2024].

WHO (World Health Organization-Africa Region). 2006. Knowledge Management In The Who African Region: Strategic Direction. https://www.afro.who.int/sites/default/files/sessions/resolutions/AFR-RC56-R8-06-Knowledge%20Mangmt%20-%20Final.pdf [02 November 2022].

WHO (World Health Organization-Africa Region). 2010. Ehealth Solutions In The African Region: Current Context And Perspectives. https://iris.who.int/bitstream/handle/10665/19931/AFR-RC60-R3-eng.pdf?sequence=8&isAllowed=y [02 November 2022].

WHO (World Health Organization-Africa Region). 2013. Utilizing Ehealth Solutions To Improve National Health Systems In The African Region https://www.afro.who.int/sites/default/files/sessions/documents/nv-afr-rc63-9-Utilizing-eHealth-solutions-to-improve-national-health-systems.pdf [02 November 2022].

WHO (World Health Organization-Africa Region). 2021. Framework For Implementing The Global Strategy On Digital Health In The Who African Region. https://www.afro.who.int/sites/default/files/2021-11/AFR-RC71-10%20Framework%20for%20implementing%20the%20Global%20strategy%20on%20digital%20health%20in%20the%20WHO%20African%20Region.pdf [02 November 2022].

WHO (World Health Organization-Africa Region). 2024. Health information and knowledge management. https://www.afro.who.int/health-topics/health-information-and-knowledge-management [02 November 2022].

WHO. 2008. Framework and standards for country health information systems. *World Health*. https://iris.who.int/bitstream/handle/10665/43872/9789241595940_eng.pdf [07 November 2024].

WHO. 2022. world Health Organisation. https://www.who.int/about/governance/constitution . [02 November 2022].

WHO. Constitution of the World Health Organization (1946). https://apps. who.int/gb/bd/PDF/bd47/EN/constitution-en.pdf [07 November 2024].

World Health Organisation. 2003. Health Systems : principled integrated care. *World Health Organisation*: 103–132.

World Health Organization, 2009. Toolkit on monitoring health systems strengthening. *WHO. 2008b. WHO*, pp.17-3.

World Health Organization, 2017. *Health education: theoretical concepts, effective strategies and core competencies. 2012* https://applications.emro.who.int/dsaf/emrpub_2012_en_1362.pdf [07 November 2024].

World Health Organization. 1998. List of Basic Terms. Health Promotion Glossary., frogymoyohttp://www.who.int/hpr/NPHj/ddoocs/hp_glossary_en.pdf.

World Vision.2023. Why is education important and how does it affect ones future? . https://www.worldvision.ca/stories/education/why-is-education-important. [07 November 2024].

World Vison Canada. 2023. https://www.worldvision.ca/stories/education/why-is-education-important#What-is-education [02 December 2024].

Wright, G., O'Mahony, D. and Cilliers, L., 2017. Electronic health information systems for public health care in South Africa: A review of current operational systems. *Journal of Health Informatics in Africa*, *4*(1).

Wright, G., Verbeke, F., Nyssen, M. & Betts, H. 2015. Health Informatics: Developing a Masters Programme in Rwanda based on the IMIA Educational Recommendations and the IMIA Knowledge Base. *Studies in Health Technology and Informatics*, 216(2010):525–528.

Wright, G., Yogeswaran, P., Govere, F., Sisulu, W., Africa, S., Africa, S., Practice, M., Africa, S., Wright, G & Commons, C. 2012. Knowledge and attitudes of nurses in community health centres about electronic medical records. : 1–6.

Wu, W. 2022, July. Investigating internship experiences of data science students for curriculum enhancement. In *Proceedings of the 27th ACM Conference on Innovation and Technology in Computer Science Education. 1*:505-511.

Yana, T. & Turkowski, V. 2024. Florence Nightingale (1820-1910): The Founder of Modern Nursing. *Cureus*, *16*(8).

Yao, X., Zhou, Y., Wang, Y. & Li, Z. 2023. Cross-disciplinary training of nursing informatics and nursing engineering at the postgraduate level: A feasibility analysis based on the qualitative method. *Nurse Education Today*, *121*: 105708.

Yazdani, S., Hajiahmadi, M. & Shakerian, S. 2020. Rethinking interdisciplinarity: Proposing a multilayered model. Medical Journal of the Islamic Republic of Iran, 34: 118

Yılmaz, A.A. & Ozdemir, L. 2017. Development and implementation of the clinical decision support system for patients with cancer and nurses' experiences regarding the system. *International journal of nursing knowledge*, *28*(1):4-12

Young, M. 2016. ScholarWorks at WMU Private vs. Public Healthcare in South Africa.

Yu, C.H. 2006. Abduction, Deduction, and Induction: Their implications to quantitative methods. *Work*, 480(January):812–9743.

Zegwaard, K.E., Pretti, T.J., Rowe, A.D. & Ferns, S.J. 2023. Defining work-integrated learning. In Zegwaard, K.E. & Pretti, T.J. (eds.). *The Routledge International Handbook of Work-Integrated Learning.* Routledge, 29-48.

Zeleke, A., Tilahun, B., Zegeye, D., Andualem, M. & Molla, M. 2014. 9th Health Informatics in Africa Conference (HELINA 2014) A successfully handed over Master of Public Health in Health Informatics Program at University of Gondar , Ethiopia. , 251(Helina).

Zierhofer, W. & Burger, P. 2007. Disentangling Transdisciplinarity: An Analysis of Knowledge Integration in Problem-Oriented Research. *Science Studies*, 20(1):51–72.

Ziqubu, S. & Orton, P.M., 2023. Perspectives of Nurse Educators Towards Technology-based Education in Selected KwaZulu-Natal Nursing Colleges. *Africa Journal of Nursing and Midwifery*, *25*(1):12.

APPENDIX A: Ethical Clearance

Cape Peninsula
University of Technology

P.O. Box 652 • Cape Town 8000 South Africa •Tel: +27 21 469 1012 • Fax +27 21 469 1002
80 Roeland Street, Vredehoek, Cape Town 8001

Office of the Research Ethics Committee	**Faculty of Informatics and Design**

The Faculty Research Ethics Committee hereby grants ethics clearance to Ms Sophie Bhebe, student number 214292789 for research activities related to the Doctor of ICT at the Faculty of Informatics and Design, Cape Peninsula University of Technology.

Title of research topic:	Health Informatics: A trans-disciplinary perspective on nursing and information technology practitioners training

Comments

Permission to conduct the research is to be obtained from CPUT and the institutions mentioned in the proposal.

Research activities are restricted to those detailed in the research proposal.

Signed: Faculty Research Ethics Committee	8/04/2019 **Date**

RESEARCH ETHICS COMMITTEE
INFORMATICS AND DESIGN
ETHICS APPROVAL GRANTED
8 APR 2019
Cape Peninsula
University of Technology

APPENDIX B: Permission Letter

Cape Peninsula University of Technology

Office of the Deputy Vice-Chancellor: Teaching and Learning
Cape Town Campus
P O Box 652
Cape Town
8000
Tel: 021-4603356
Fax: 021-4603983
Email: staaka@cput.ac.za

26 August 2015

To whom it may concern

I, Prof Anthony Peter Staak, in my capacity as Deputy Vice Chancellor Teaching and Learning at ***Cape Peninsula University of Technology,*** give consent in principle to allow ***Sophie V Bhebe***, a student at the Cape Peninsula University of Technology, to collect data in this company as part of his/her DTech (IT) research. The student has explained to me the nature of his/her research and the nature of the data to be collected.

This consent in no way commits any individual staff member to participate in the research, and it is expected that the student will get explicit consent from any participants. I reserve the right to withdraw this permission at some future time.

Whether the company's name may or may not be used in theses, conference papers, journal articles or research posters will be dependent on a decision of the Higher Degrees Committee.

Yours sincerely

APStaak

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APPENDIX C: Pre-test for Attitudes Towards Computers in Healthcare Assessment Scale (P.A.T.C.H) Assessment Tool

P.A.T.C.H. Assessment Scale v.3

Pretest for Attitudes Toward Computers in Healthcare

Directions:

Each indicator is to be rated using a five-point Likert scale.

Mark with an "**X** "the response that best reflects your attitude for each statement.

1. The computer is a powerful enabling tool.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

2. In healthcare, computers could save a lot of paperwork.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

3. Machines and I don't mix.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

4. I feel I am a skilled typist.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

5. I feel alarmed when I think of using a computer.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

6. I have excellent finger dexterity.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

7. I regularly use a computer at home.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

8. I would love to be a proficient user of computers.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

9. Bedside computers will irritate patients.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

10. I will never feel relaxed about using a computer.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

11. Computers can help me to be creative.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

12. I would enjoy learning course work using a computer program.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

13. Computers are frustrating to use

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

14. Listening to people using computer jargon intimidates me.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

15. Computers will someday put health professionals out of a job

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

16. I am in control when I use a computer.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

17. I relate well to technology and machines.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

18. I feel confident that I can master using a computer.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

19. I can let my creativity flow when writing using a computer.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

20. Computers in healthcare will create more work for nurses.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

21. Computers can be great problem-solving tools.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

22. Computers are too complicated for me to learn well

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

23 Computers are impersonal and dehumanizing.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

24 The future promise of computers in healthcare excites me

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

25 I feel restless and confused when I think of using a computer.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

26 I don't intend to own a home computer.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

27 I feel a computer course in nursing is totally unnecessary.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

28 People who like computers are introverted and antisocial.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

29 I know more about computers than most faculty or administrators do

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

30 Working with computers is boring and tedious.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

31 I can easily master the content of a computer lesson.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

32 I feel ambivalent about computers and technology.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

33 Computers are everywhere, it is natural for them to used in healthcare.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

34 I like to use the Internet to research health and nursing information.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

35 It takes longer to chart on the computer than on paper

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

36 I enjoy using technology to communicate with colleagues (email, etc.)

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

37 Computers help me to keep up to date with nursing issues, knowledge, research.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

38 Computers are just another object that takes me away from my patients

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

39 I resent the thought of having to use computers in my nursing practice.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

40 Using technology in practice interferes with my ability to be caring to my patients.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

41 Patients should not look for health and illness information on the Internet.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

42 Social media tools enrich health care professional communication and collaboration.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

43 I use health care apps on my cellphone or SMART phone.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

44 Nursing related online groups, forums, and email discussion lists are a waste of time

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

45 Electronic charting restricts how nurses record patient care.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

46 Personalized Electronic Health Records streamline access to information and interdisciplinary communication about patients.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

47 Online support groups are a waste of time and have no value for patients.

1. Agree Strongly	2. Agree	3. Not	4. Disagree	5. Strongly Disagree

Certain

48 Computers are great tools for patient education.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

49 Hand written charting is much more complete than electronic documentation.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

50 Nurses should be involved in the planning of national Electronic Health Records.

1. Agree Strongly	2. Agree	3. Not Certain	4. Disagree	5. Strongly Disagree

2

Nursing Informatics Competencies Self-Assessment and Plan of Action

Each nurse and student has a unique level of computer literacy in the various computer applications available.

1. Take a few minutes now to assess your level of computer literacy and mark it with an "**X** "on the response that best reflects your assessment.
2. Then, write out a plan of action to help develop your desired level of computer literacy in the following applications. You do not need to include all of these – focus on the ones that interest YOU.

1 Word Processing

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

2 **Graphic Programs**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

3 **Databases**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

4 **Spreadsheets**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

5 **Power Point Presentations**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

6 **Educational Software**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

7 **Desktop Publishing**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

8 **World Wide Web**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

9 **E-mail**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

10 **Discussion Mailing Lists**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

11 **Social Media Applications**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

12 **Chat Rooms, Forums**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

13 **Decision Support Systems**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

14 **Nursing Information Systems**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

15 **Hospital Information Systems**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

16 **Community Information Systems**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

17 **Electronic Health Records**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

18 **Electronic Medication System**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

19 **eHealth Systems**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

20 **Telehealth Systems**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

21 **Web site Design**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

22 **Multimedia Design**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

23 **Flash Animation**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

24 **Research Software**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

25 **Electronic Portfolios**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

26 **Webcasting**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

27 **Videoconferencing**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

28 **Virtual Reality, Simulation**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

29 **Internet Radio/Video/TV**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

30 **E-learning Software**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

31 **Cell and Smart Phones**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

32 **Tablets (e.g. iPad)**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

33 **Other Mobile Devices**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

34 **Digital Camera and Photo Manipulation**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

35 **Educational Games**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

36 **Artificial Intelligence**

A. No experience, Novice	B. Some experience Advanced Beginner	C. Comfortable user, Competent	D. Skilled User, Proficient

Plan of Action:

3.

NURSING INFORMATICS COMPETENCIES GOALS

In the space below, write out five goals for yourself, related to learning Nursing Informatics theory and application. Try to make these fairly short-term, i.e. within the next five years.

GOAL 1.

GOAL 2.

GOAL 3.

GOAL 4.

GOAL 5.

4. **Section D - Biography**

Lastly, we would like to ask a few questions about yourself. This will only be used for statistical purposes

1 Sex

A. Male	B. Female	C. Other

2 Age

A. <19	B. 20-29	C. 30-39	D. 40-49	E. 50-59

3. Years You have been studying Nursing Practice

A. 0-1	B. 2-4	C. 5-10	D. 11-15	E. 16-20	F. >20

4. Years You have been practicing Nursing

A. 0-1	B. 2-4	C. 5-10	D. 11-15	E. 16-20	F. >20

5. Specialization in Nursing

A. Public Health	B. Occupational Health	C. Oncology	D. Other (Please specify in the space below)

____
____
____
____

6. Highest Level of Education

A. Matriculant	B. Higher Certificate	C. Diploma	D. Bachelors	E. Post grad

7. Please indicate if you are willing to participate in a follow-up interview

Yes	No

If you have indicated "Yes", please may you add your email address in the space provided below:

____

8. If you have any questions you feel were not applicable in the South African Nursing Context, please indicate, giving reasons in the space provided below:

____
____
____
____
____
____
____

9. If you have any questions you feel should have been added as they are applicable in the South African Nursing Context, please indicate, giving reasons in the space provided below:

____
____
____
____
____
____
____

10. If you have any further comments on Nursing Informatics, please indicate in the space provided below:

____
____
____
____

APPENDIX D: Kaminsky’s PATCH Assessment Score Interpretation

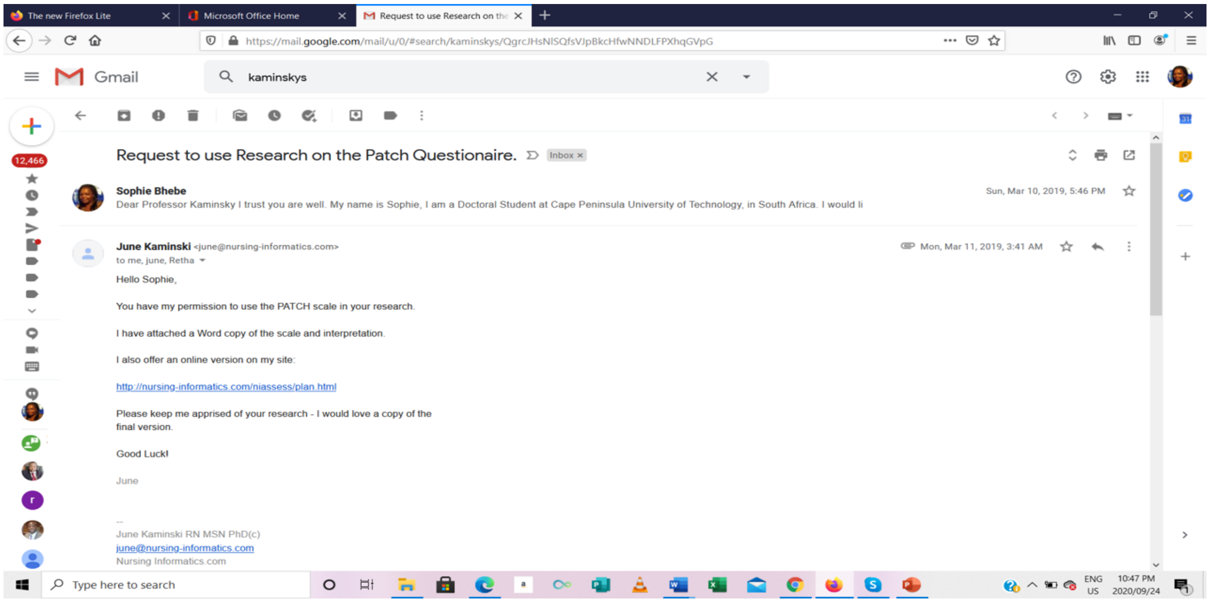
P.A.T.C.H. Assessment Scale v 3
Score Interpretations

Find the Range that contains the Score You Achieved on the P.A.T.C.H. Scale

https://nursing-informatics.com/niassess/plan.html

0 to 17 points	**Positive indication of Cyberphobia. Beginner stage in experience with computer basics or applications. Ambivalence or anxiety may occur, related to the use of computers in healthcare. May appreciate help learning basic computer skills.**
18 to 34 points	**Indicates some uneasiness about using computers. Very basic knowledge of computer basics and applications. Unsure of usefulness of computers in healthcare.**
35 to 52 points	**Moderate comfort in using computers. Has basic knowledge of computers and applications. Limited awareness of applications of computer technology in healthcare.**
53 to 69 points	**Feels comfortable using user-friendly computer applications. Aware of the usefulness of computers in a variety of settings. Has a realistic view of current computer capabilities in healthcare.**
70 ti 86 points	**Confident of ability to use a variety of computer programs. Sees computers as beneficial in the development of society. Enthusiastic view of the potential of computer use in healthcare.**
87 to 100 points	**Very confident that they can learn to use a computer to boost creativity and perform routine functions. Recognizes the unique value of using information technology in society. Idealistic, positive view related to computer applications in healthcare.**

APPENDIX E: Consent to Use Questionnaire


Request to use Research on the Patch Questionaire.

Sophie Bhebe Sun, Mar 10, 2019, 5:46 PM

Dear Professor Kaminsky I trust you are well. My name is Sophie, I am a Doctoral Student at Cape Peninsula University of Technology, in South Africa. I would li

June Kaminski <june@nursing-informatics.com> Mon, Mar 11, 2019, 3:41 AM

to me, june, Retha

Hello Sophie,

You have my permission to use the PATCH scale in your research.

I have attached a Word copy of the scale and interpretation.

I also offer an online version on my site:

http://nursing-informatics.com/niassess/plan.html

Please keep me apprised of your research - I would love a copy of the final version.

Good Luck!

June

--

June Kaminski RN MSN PhD(c)
june@nursing-informatics.com
Nursing Informatics.com

APPENDIX F: Research Questions, Objectives and Interview Guide Questions

<table>
<tr><th colspan="4">Research Question (RQ1): What are the competencies of appropriate education programs that integrate applied competencies with the work activities of Nursing and ICT Practitioners in Africa?</th></tr>
<tr><th>Research sub-questions</th><th>Research objectives</th><th>Interview questions for data collection</th><th>RQ key concept</th></tr>
<tr><td rowspan="3">SRQ 1: What is the current status of informatics in nursing and ICT courses?</td><td rowspan="3">To determine the current status of the respective programmes globally and in a specific context</td><td>What do you know about Nursing Informatics or Health Informatics?</td><td>Awareness of Nursing Informatics or Health Informatics</td></tr>
<tr><td>How have informatics competencies been integrated in your nursing program?</td><td>Current state of Informatics in Nursing Programs</td></tr>
<tr><td>How has health domain knowledge been integrated into informatics program?</td><td>Current state of health domain knowledge in Informatics Programs</td></tr>
<tr><td>SRQ2: How are the informatics competencies applied in practice in healthcare?</td><td>To establish the attitude and competencies for digital technology use in practice</td><td>Where do nurses utilise informatics competencies in their work practise?</td><td>Use of Informatics in Nursing Practice</td></tr>
</table>

Research Question (RQ2): Why is the intersection between health sciences and informatics complicating the design of relevant courses for required competencies in the two respective disciplines?			
SRQ 3: How do nursing informatics courses develop competencies to equip nurses' involvement in digital health technologies development and support?	To determine how nursing informatics courses develop domain competencies to involve nurses in digital health technologies development and support	What are the challenges of developing informatics courses for nurses?	Complications of intersection between health sciences and informatics
		How can nursing informatics courses enable nurses to develop digital health technologies?	Training needs
SRQ4: How do health informatics courses develop/prepare ICT practitioners to involve nurses in the development and support of digital technologies to enable nursing practices?	To determine how informatics courses develop ICT practitioners to involve nurses in the development and support of digital technologies to enable nursing practices?	What are the challenges of developing health domain knowledge courses for ICT practitioners?	Complications of intersection between health sciences and informatics
		How can health informatics courses enable ICT practitioners to involve nurses in the development of digital health technologies?	Training needs

APPENDIX G: Sample Questionnaire Health Informatics Expert

Health Informatics

We would like to get your opinion as an IT expert on what topics should be taught to IT students to become competent in the design, develop and implement health systems/services/applications.

Study details.

Cape Peninsula University of Technology

Dear Participant

We would like to thank you very much for agreeing to participate as an expert in this research study with the following title:

TITLE: Health Informatics: A trans-disciplinary perspective on nursing and information technology practitioners training.

AIM:

1. To explore the ICT training needs of Nursing Practitioners and the Health training needs of Informatics practitioners.
2. To understand the relevant Health Informatics training programs that are suitable for Nursing and ICT practitioners in South Africa.
3. To explore capacity development built on the capabilities of health informatics stakeholders through knowledge generation from practice.

The information provided by you in this questionnaire will be used for research purposes. Anonymity will be protected in the following manner (unless noted below) names, and use of pseudonyms.

Thank you very much for agreeing to participate in this survey.
Should you have any further queries please do not hesitate to ask the researcher or her Supervisor whose details are included below.

Yours faithfully,

Sophie V Bhebe
Cape Peninsula University of Technology
sophiebhebe@gmail.com

Supervisors :

Professor Retha De La Harpe — delaharper@cput.ac.za

Prof Doreen Kauru — doreen.mugendi@gmail.com

Informed consent

If you volunteer to participate in this study the following will be done:

1. The purpose of the research will be explained so that you are informed about what to expect - this appears at the top of this form;
2. You are welcome to contact the researcher directly if there is anything that you would like to ask for more clarity
3. You are welcome to contact the researcher directly if you would prefer to have the questions in your own home language
4. Your responses will be treated with full confidentiality and that, if published, it will not be identifiable as yours
5. You may omit answering questions if you do not want to answer except in cases marked as compulsory because we need your input for that specific question
6. The questions do not pose any realistic risk of distress or discomfort, either physically or psychologically, to you;
7. We will provide you with feedback at the end of the research if requested

You are invited to contact the researchers should you have any questions about the research before or during the study. You will be free to withdraw your participation at any time without having to give a reason.

Researchers:

Contact person: Sophie Bhebe
Contact number: +27 82726 1170 Email: sophiebhebe@gmail.com
Supervisors: Prof Retha de la Harpe
Prof Doreen Kaura

Informed consent *

	Yes	No
I understand the purpose of the r...	☐	☐
I understand what the research re...	☐	☐
I volunteer to take part in the rese...	☐	☐
I know that I can withdraw at any ...	☐	☐

Your name *

Short answer text

Your (Health) IT expertise *

Long answer text

Your organisation *

Short answer text

What is your role in the organisation? *

Short answer text

What is your highest qualification? *

Short answer text

Competency definition

Competency – "An observable ability of a health professional, integrating multiple components such as knowledge, skills, values, and attitudes. Since competencies are observable, they can be measured and assessed to ensure their acquisition. Competencies can be assembled like building blocks to facilitate progressive development." (Valenta, et al. 2018:1660)

As an example: Universal Health Informatics Competency Domains for Post-graduate Studies (Jidkov, et al. 2019:12)

1. Information governance & security
   - Clinical relevant governance procedures, e.g. use of personal mobile devices to communicate patient information
   - Practical cybersecurity knowledge
2. System use & clinician safety
   - Using EHR in routine clinical practice
   - Critical appraisal new technologies in terms of "good"/"bad" system design
   - Appraisal of hardware, e.g. handheld devices
3. Digital communication
   - Transfer and retrieval of digital patient data
   - Increase frequency of remote working
   - Understanding the risks for under or over communication
4. Information & knowledge management
   - Understand the properties of different media
   - Decision-support – digital information
   - Secondary use of data; nuances of digital recording; use of digital recorded data; data analysis
5. Patient empowerment
   - Teaching patients and endorsing informatics resources to enforce patient uptake of informatics resources to manage their own health
   - Clinicians to be aware of how patients utilise informatics resources
   - Consider patient choice and involvement with increasing digitisation
6. Emerging technologies
   - Deal with fast technology advances to remain contemporaneous
   - Be aware of future directions of healthcare technology to ensure forward thinking and integration of these into routine practice

Problem statement:

Nurses, the largest group of end users of Healthcare Information Systems(HIS) are unable to impact HIS development in the way they would choose. Having informatics who understand the needs of clinical practitioners based on the workflows in a health environment will result in improving HIS (Mantas & Hassman, 2017; Martikain et al, 2020).

Your expert input:

If you were asked to design a Health Informatics Course in an undergraduate programme to teach IT students to develop, implement and evaluate Health Information Systems, Health Information Technologies or Health Applications for the African context what topics would you suggest? Please list the five to ten most important topics.

1. Please list your suggested topics and add a short description for each.

Long answer text

2. Please indicate the proposed level of study for each of your suggested topics.

It is possible for a topic to appear in more than one level.

	Fundamentals (Fir...	Diploma - vocation...	Degree (3 years)	Degree (4th year)
Topic 1	☐	☐	☐	☐
Topic 2	☐	☐	☐	☐
Topics 3	☐	☐	☐	☐
Topic 4	☐	☐	☐	☐
Topic 5	☐	☐	☐	☐
Topic 6	☐	☐	☐	☐
Topic 7	☐	☐	☐	☐
Topic 8	☐	☐	☐	☐
Topic 9	☐	☐	☐	☐
Topic 10	☐	☐	☐	☐

3. Please indicate for each of the suggested topics what students would be expected to do.

Long answer text

4. Please indicated for each of the suggested topics the competencies that students should have.

Long answer text

5. How can IT practitioners already working in the field require the necessary healthcare domain competencies?

Long answer text

6. Anything you would like to add that may be useful to consider for the African context?

Long answer text

Thank you

Thank you for your time and patience in answering the questions. your contribution is highly appreciated.

APPENDIX H: Turnitin Report

Health Informatics: A Trans-disciplinary Perspective of Nursing and Information Technology Practitioners Training

ORIGINALITY REPORT

11%	9%	7%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

2%

★ etd.cput.ac.za

Internet Source

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		

APPENDIX I: List of recent INDEHELA Publications co-authored by CPUT Researchers

ARTICLES

Bhebe, S., de la Harpe, R., Kaura, D., Kabaso, B. 2024. Expert Perspectives on Competencies in Health Informatics for Informatics Students. Journal of Health Informatics in Africa,11(1):22-32.

Cox, S., Steenkamp, A. & de la Harpe, R. 2019. Taalkommunikasiedosente se persepsies en verwagtinge van e-leerondersteuning om dienslewering te verbeter. LitNet Akademies Jaargang 16(1).

De la Harpe, R. 2014. The level of participation during the development of a mobile application for home-based healthcare data in a developing context: An actor-network theory perspective. South African Computer Journal. 54:20-33.

De la Harpe, R., Lotriet, H., Pottas, D. & Korpela, M. 2012. Socio-technical approach to community health: designing and developing a mobile care data application for home-based healthcare, in South Africa. The Journal of Community Informatics. 9(2).

De la Harpe, R. 2020. Volunteer-based online information services to invisible users in underserved contexts. Communitas 25: 1-21.

Debrah, R.D., de la Harpe, R. & M'Rithaa, M.K. 2017. Design probes and toolkits for healthcare: Identifying information needs in African communities through service design, The Design Journal, 20:sup1, S2120-S2134.

Du Preez, V. & de la Harpe, R. 2019. Engaging Ageing Individuals in the Design of Technologies and Services to Support Health and Wellbeing: A Constructivist Grounded Theory Study. Journal of Internet Medical Research, 2(1).

Du Preez, Vikki, and de la Harpe, R. 2019. "The Art of Listening: Engaging Ageing Individuals in the Design of Online Services." The International Journal of Design in Society 13 (1): 35-51. doi:10.18848/2325-1328/CGP/v13i01/35-51.

Mohsam, F. de la Harpe, R. 2024. An analysis of nurses' lived experience with digital health technologies in practice Journal of Health Informatics in Africa,11(1):51:63.

M'Rithaa DKM, Fawcus S, Korpela M, de la Harpe R. 2015. The expected 2015 and actual communication of health care workers during the management of intrapartum: An interpretive multiple case study. African Journal of Primary Health Care & Family Medicine 2015:7(1). http://www.phcfm.org/index.php/phcfm/article/view/91.

Nyatuka, D. & de la Harpe, R. 2020. Design considerations for patient-centered eHealth interventions in an underserved context: A case of health and wellbeing services in Nairobi City County, Kenya. The Electronic Journal of Information Systems in Developing Countries. DOI: 10.1002/isd2.12164.

Nyatuka, D. & de la Harpe, R. 2021. Service design as a catalyst for cloud-based Patient-centered eHealth: A case of maternal health information services in Nairobi slums, Kenya. International Journal of Information System Modeling and Design.

Ogundaini, O, de la Harpe, R. Mclean, N. 2021. Unintended consequences of technology-enabled work activities experienced by healthcare professionals in tertiary hospitals of sub-Saharan Africa. African Journal of Science, Technology, Innovation and Development.

Sibuyi IN, de la Harpe R, Nyasulu P. 2022. A Stakeholder-Centered mHealth Implementation Inquiry Within the Digital Health Innovation Ecosystem in South Africa: MomConnect as a Demonstration Case. JMIR Mhealth Uhealth 2022;10(6):e18188.
URL: https://mhealth.jmir.org/2022/6/e18188. doi: 10.2196/18188.

CONFERENCES

Bantom, S., de la Harpe, R. & Ruxwana, N. 2016. Accessibility to patients' own health information: a case in rural Eastern Cape, South Africa. The 2016 Annual Conference of the South Afr8ican Institute of Computer Scientists and Information Technologists. 26-28 September 2016, University of Johannesburg.

Bhebe, S., Korpela, M. and de la Harpe, R. 2015. Health Informatics Education: A literature review of current capacity building initiatives in Africa. Conference: IRIS 38: 38th Information Systems Research Seminar in Scandinavia At: Oulu, Finland. network to inform and educate caregivers in home-based healthcare in South Africa. The Sixth ICPCA Conference on Pervasive Computing and the Networked World. 26-28 Oct, 2011. Port Elizabeth, South Africa.

De la Harpe, R. & Van Zyl, I. 2014. Mobile application design for health intermediaries: considerations for information access and use. *Proceedings of the 7th International conference of Health Informatics: HealthInf2014. 3-6 March 2014. Angers, France..*

De la Harpe, R. 2005. A Research Agenda for research projects in the Private Healthcare Sector of South Africa. Proceedings of the 8th International Working Conference of the International Federation for Information Processing. IFIP WG 9.4, 26-28 May 2005, Abuja, Nigeria.

De la Harpe, R. 2011. Mobile Home-based Healthcare. 7th Health Informatics in Africa Conference – HELINA 2011 - Health Information Systems: Scaling up solutions to transform healthcare delivery in Africa. Nov 28 – 30, 2011. Yaoundé, Cameroon.

De la Harpe, R. 2012. : Lessons learnt from the participatory design of a mobile care data application in a resource-restricted context. Industry Case at the Participatory Design Conference 2012 conference theme: Embracing New Territories of Participation. 12-16 Aug 2012, Roskilde, Denmark.

De la Harpe, R. 2012. A Semiotic View on Paper and Mobile Care Data Quality. Proceedings of the 24th European Medical Informatics Conference - MIE2012: Quality of Life through Quality of Information. Pisa, Italy. August 26th -29th, 2012.

De la Harpe, R. 2013 : The level of participation during the development of a mobile care data application for home-based healthcare: An actor-network theory perspective. Proceedings of the 12th International Conference on Social Implications of Computers in Developing Countries: Into the Future: Themes, insights and agendas for ICT4D research and practice. Ocho Rios Jamaica, 19-22 May, 2013.

De la Harpe, R. 2014. Interactions of participants during mobile development of a healthcare application. 8th Multi Conference on Computer Science and Information Systems 2014: Interfaces and Human Computer Interaction IHCI2014. 15-17 July 2014. Lisbon, Portugal.

De la Harpe, R. Barnes, J. & Korpela, M. 2010. Information needs in home-based healthcare in South Africa. Proceedings of the 13th World Congress on Medical and Health Informatics. Cape Town, 12-15 September 2010.

De la Harpe, R., Korpela, M. & Van Zyl, I. 2015. Co-Design for Development: Lessons Learnt from an Information Systems Project for Underserved Communities. In Oinas-Kukkonen H, Iivari N, Kuutti K, Öörni A, Rajanen M (eds). Nordic Contributions in IS Research: 6th Scandinavian Conference on Information Systems, SCIS 2015, pp. 61-74, 9-12 August, At Oulu, Finland.

De la Harpe, R., Korpela, M., Kamanga, E. 2005. The potential of community informatics in small medical practice in South Africa. Proceedings of the 2nd annual conference of the Community Informatics Research Network in Cape Town, South Africa. August 23-26 2005.

De la Harpe, R., Pottas, D., Lotriet, H. & Korpela, M. 2010. Towards a Socio-Technical Approach in ICT-Supported Socio-Economic Development. Proceedings of the IST-Africa Conference. Durban, 19-21 May 2010.

De la Harpe, R., Cilliers, R. & Shetley, C. 2019. Online counselling services for Youth@risk. International Conference on Information Resources Management (Conf-IRM), Auckland, New Zealand, 27-29 May 2019.

Debrah, R., Bhebe, S. & de la Harpe, R. 2014. Design approach towards health education and promotion. 4th International Conference on Design, Development & Research. 10 September 2014, Cape Town, South Africa.

Debrah, R., Bhebe, S. & de la Harpe, R. 2015. Information Communication Technology and Community Development: the case of Grabouw, Cape Town-South Africa. 9th Health Informatics in Africa Conference: “Informatics for Universal Health Coverage in Africa: From Point of Care Systems to National Strategies”. 7– 11 March 2015, Accra Ghana.

Debrah, R., Bhebe, S. De la Harpe, R., Ruhode, E. Mugendi, D.M.K. & Vainikainen. 2015. Technology assimilation in community healthcare in the Western Cape, South Africa. 9th Health Informatics in Africa Conference: “Informatics for Universal Health Coverage in Africa: From Point of Care Systems to National Strategies”. 7– 11 March 2015, Accra Ghana.

Debrah, R.D., De la Harpe, R., Bhebe, S, & Mugendi, D.M.K.. 2014. Multimedia learning and nursing informatics education in South Africa. 4th International Conference on Design, Development & Research. 10 September 2014, Cape Town, South Africa.

Korpela, M, Mursu, A., Soryiyan, H.A., De la Harpe, R. & Macome, E. 2006. Information systems practice for development in Africa : Results from INDEHELA. Proceedings of the International Federation for Information Processing (IFIP) WG8.2 International Working Conference, July 12-15, 2006, Limerick, Ireland. Social Inclusion: Societal and Organizational Implications for Information Systems. Eds. Trauth, E.M., Howcroft, D., Butler, T., Fitzgerald, B. & DeGross, J.I.

Korpela, M., De la Harpe, R. & Luukkonen, I. 2008. Depicting the landscape around Information Flows: Methodological Propositions. Proceedings of the special interest group on ICT and Global Development: SIG GlobDev’s First Annual Workshop. Paris, France, December 13, 2008.

Korpela, M., Hanmer, L., de la Harpe, R., Macome, E., Mursu, A., Soriyan, A. 2004. How can African Healthcare facilities get appropriate software? *Sociotechnical research in the INDEHELA-Context project.* Medinfo 2004, Portland.

Li Hunt, G. & de la Harpe, R. Exploring mobile technology as a medium to facilitate access to care giver experiences. Design, Development and Research Conference. 26-27 September 2011. Cape Town, South Africa.

McCracken, I., de la Harpe, R. & Di Ruvo, M. 2019. Developing Dementia Personas for User Centered Architectural Design Considerations in Non-specialized Contexts. Dementia Lab 2019. Making Design Work: Engaging with Dementia in Context 4th Conference, D-Lab 2019, Eindhoven, The Netherlands, October 21–22, 2019, Proceedings. Editors: Brankaert, Rens, IJsselsteijn, Wijnand (Eds.). DOI:10.1007/978-3-030-33540-3_5.

Mugendi-M'Rithaa, D. de la Harpe, R. & Fawcus, S. 2016. Development spots in communication during the management of intrapartum: An interpretive multiple case study in a developing context. Health Informatics Conference: Digital health innovation for consumers, clinicians, connectivity and community. 25-27 July 2016. Melbourne, Australia.

Mugendi-M'Rithaa, D., Forchu, M. & de la Harpe, R. 2016. The design of a hands-free speech recognition application during the intrapartum stage: A descriptive case study. Melbourne 25-27 July 2016. HIC 2016: Health Informatics Conference: Digital health innovation for consumers, clinicians, connectivity and community. 25-27 July 2016. Melbourne, Australia.

Nyatuka, D.R. & de l Harpe, R. 2019. Evaluating mHealth Interventions in an Underserved Context Using Service Design Strategy: *A Case of Kenya.* 2019 3rd International Conference on Medical and Health Informatics ICMHI 2019 Conference in Xiamen, China on May 17-19.

Ogundaini, O.O. & de la Harpe, R. 2019. Integration of mHealth technologies to support service interaction moments in tertiary healthcare of Western Cape, South Africa. International Conference on Information Resources Management (Conf-IRM), Auckland, New Zealand, 27-29 May 2019.

Ouma, S, Herselman, M, De la Harper, R and VanGruen, D. 2010. Assessing the healthcare landscape within developing nations: impact on design reality gaps. Proceedings of the

IASTED Conference HEALTH INFORMATICS (Africa HI 2010), Gaborone, Botswana, 6-8 September 2010, pp 210-216.

Tswane, S., Banze, C.M., Banze, V., M'Rithaa, D.M., Korpela, M., Muquingue, H. and de la Harpe, R. 2015. Co-analysing maternal healthcare work: Lessons learnt from INDEHELA-ISD4D. Conference: IRIS 38: 38th Information Systems Research Seminar in Scandinavia At: Oulu, Finland.

Van Zyl, I. & de la Harpe, R. 2011. AT-HOME 2.0 – A collaborative training model for home-based healthcare. Red-conference: rethinking education in the knowledge society – International conference, March 7-10 2011, Switzerland.

Van Zyl, I., Winchiers, H. & de la Harpe, R. 2017. Ethics for the 'Common Good': Actionable guidelines for community-based research. In the C&T '17: Proceedings of the 8th International Conference on Communities and Technologies. Troyes, France. 26-30 June 2017. Pp. 298-300.

BOOK CHAPTERS

Nyatuka, D. & de la Harpe, R. 2023. Co-designing person-centered e-health information services: the case of maternal health care in Kenya (forthcoming). Service Design for Emerging Technologies Product Development: Bridging the Interdisciplinary Knowledge Gap. Eds. UZA Hamid & M Suoheimo.. Springer Series in Design and Innovation (SSDI, volume 29): pp73-86.

de la Harpe, R. & Ogundaini, O. 2023. A Proposed Transformation Service Design Research Framework for Underserved Settings (forthcoming). Service Design for Emerging Technologies Product Development: Bridging the Interdisciplinary Knowledge Gap. Eds. UZA Hamid & M Suoheimo.. Springer Series in Design and Innovation (SSDI, volume 29):pp299-326.

APPENDIX J: Editing Certificate

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To Whom It May Concern

This document certifies I have copy-edited the following thesis by Sophie Bhebe:

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Please note this certificate does not cover any content, conceptual organisation, or textual changes made after the editing process.

Best regards

Dr Patricia Harpur

24 February 2025