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**Determinants of High-Performance Computing Systems Adoption and Continued Use amongst
University Staff and Students in Historically Disadvantaged Institutions**

BY

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Submitted in partial fulfillment of the requirements

For the degree of

Master of Commerce in Information Systems

In the
University of Fort Hare
Together in Excellence
FACULTY OF MANAGEMENT AND COMMERCE

At the

UNIVERSITY OF FORT HARE

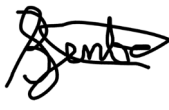
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2024

Declaration of Ownership, Authorship and Ethical clearance

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Abstract

The demand for High-performance computing (HPC) systems is increasing in research. This is because it can perform large and complex simulations at a faster speed. Cluster-based high-performance computing connects several host computers via high-performance Local Area Networks (LANs), utilizing parallel computing technology. HPC clusters can finish a task by allocating smaller tasks to various compute nodes. HPC is very convenient since they can complete tasks quicker than usual computers. The use of HPC is relatively low, this is because they are expensive to acquire and there isn't sufficient training on how to use them.

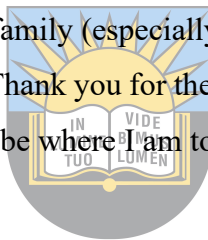
The purpose of this study is to investigate the determinants of high-performance computing systems adoption and continued use by staff and students in Historically Disadvantaged Institutions. The Unified Theory of Acceptance and Use of Technology (UTAUT) was used as the theoretical foundation of this study. The positivism paradigm was used as a metatheory guiding the study as the quantitative design was used to test the hypotheses formulated in the study. The research sample comprised of 306 users of High-Performance Computing systems selected through the convenience sampling. Employing a quantitative approach, the study used a cross-sectional survey research design to collect and analyse data to achieve the study's objectives.

The study findings revealed a significant relationship between computer self-efficacy and attitude towards high-performance computing systems. Similarly, there was a significant relationship between attitude toward high-performance computing systems and the intention to use high-performance computing systems. The intention to use high-performance computing systems and social influence were both found to positively affect the actual use of high-performance computing systems. However, there was an insignificant relationship between perceived ease of use, as well as perceived usefulness, and attitude towards high-performance computing system, suggesting that these two factors did not influence the adoption of the technology.

In summary, this research significantly enhances comprehension of the challenges associated with the adoption and continued use of High-Performance Computing Systems across five South African Historically Disadvantaged Institutions. It underscores the importance of addressing adoption and user education, to optimize the use of High-Performance Computing Systems in Higher Education. These actions are essential for fostering the effective utilisation of High-Performance Computing Systems and unlocking their potential benefits for economic growth and educational advancements in South Africa.

Acknowledgments

- Firstly, I would like to thank God for blessing me with this opportunity. I am thankful for the wisdom and strength that He has blessed me with. Without Him this would not have been possible.
- I would like to express my deepest gratitude to my supervisor, Prof Liezel Cilliers, for her invaluable patience and feedback. Thank you so much for supporting me and guiding me through this journey.
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- Prof Willie Chinyamurindi, thank you for making all of this possible, without you this would never have happened.
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- Lastly, I would like to thank my family (especially my mom, my sisters, my daughter, and my niece) as well as my friends. Thank you for the continued support, motivation, and love through this journey. I would not be where I am today without your support.



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Dedication

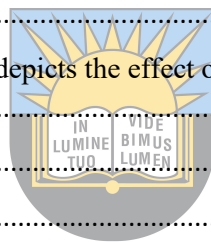
I dedicate this to my late father (Monwabisi Jikijela). I know how much this accomplishment would have made him happy.



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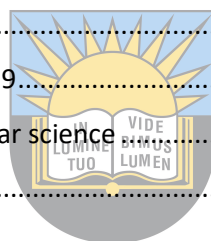
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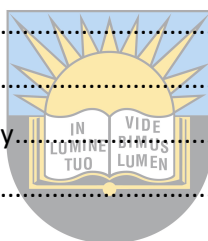
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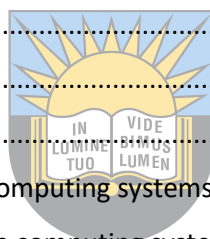
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Appendix B: Proofreader certificate


EDITING CERTIFICATE
TO WHOM IT MAY CONCERN

I, Kudzai Mhepo, acknowledge that I did the language editing of the

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Details of the language editing are evident in the version of the article in track changes and with comments for the author's attention. The quality of the final document, in terms of language, formatting and references remains the author's responsibility.



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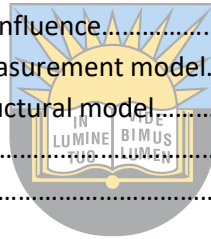
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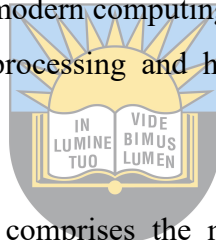


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Chapter 1: Introduction

1.1 Introduction

High-Performance Computing (HPC) is a focal point for nearly two decades, driven by increasing user demands for more powerful systems and advanced applications. Over this period, significant technological advancements have taken place, leading to substantial improvements at multiple levels. These developments have continuously pushed the boundaries of high-performance computing, enabling greater computational power and efficiency (Claude, 2020). High-Performance Computing (HPC) is designed to deliver fast and efficient computing solutions for solving complex scientific and real-world problems. The development of supercomputers has involved advancements in general-purpose and specialized system configurations. A key milestone in HPC history is the emergence of multicore architectures, which have made parallel programming a fundamental aspect of modern computing. This shift has enhanced computational efficiency, enabling large-scale data processing and high-precision problem-solving (Claude, 2020)



High-Performance Computing (HPC) comprises the most advanced and powerful computer systems globally, designed to process vast datasets and run sophisticated models to address complex scientific, engineering, and technological challenges. These systems are particularly crucial for tasks that involve modeling, simulation, and analysis of intricate, multivariable physical phenomena. HPC integrates multiple technologies, including computer architecture, programming, electronics, algorithms, and specialized software, into a unified platform to efficiently solve problems that were previously considered unsolvable (Ezell, 2022). High-Performance Computing (HPC) extends beyond serving the specialized needs of researchers in fields such as physics, chemistry, and biology. It plays a crucial role in addressing broader societal demands and supporting advancements in healthcare, climate modeling, artificial intelligence, and various other domains that impact daily life. As HPC continues to evolve, its applications are becoming increasingly essential for solving global challenges and driving technological progress across multiple industries (Navaux et al., 2023)

High-Performance Computing Systems are expensive to maintain and are deployed to improve educational institutions' performance, so underutilization is a source of concern and has an adverse effect on these educational institutions. Due to this, factors that lead to underutilization must be addressed (Liu, et al., 2020). Despite this benefit, the adoption of HPC has not always been successful. Some of the reasons for the poor adoption are the cost of implementing and maintaining the HPC infrastructure, training and education cost for staff and end users, the timely and ongoing process of upgrading and replacing equipment (Oracle, 2020). Hence the benefit of HPC in academia has not materialized as expected.

1.2 Problem statement

Information and communication technology (ICT) advancements have allowed higher education institutions to implement various technologies to improve learning efficiency (Binyamin et al., 2018). In recent years, universities have made significant expenditures in educational technology based on the notion that technology may help students in learning more successfully and efficiently, resulting in higher academic accomplishment (Clayton & Njoroge, 2017).

HPC can provide hundreds of times more powerful systems than ordinary systems, such as desktop computers and mobile phones. HPC platforms can solve difficulties instantly, that would take much longer on traditional computers (Raj et al., 2020). In many organizations, HPC infrastructure has been unavailable due to high costs as well as the specific skills required to maintain and build such infrastructure (Lynn et al., 2018). In addition, many of the concerns with the tools are familiar to the HPC community, particularly those relating to developer output: Tools are not platform-neutral, they do not scale well, and occasionally they're years behind the hardware (Raj et al., 2020).

The ever-widening mismatch between the complexities of hardware and the tools available to help developers has long been a source of concern in the HPC area, thus resulting in productivity blockage. More relevant to HPC use in higher education institutions is that infrastructure is difficult to use and expensive (Raj et al., 2020). However, without the availability of several HPC frameworks, deep learning would not be possible. HPC has not been adopted due to the availability and cost associated with the technology. HPC requires a significant upfront capital investment and

ongoing operational expenditure. As a result, major mature enterprises, government research institutions or agencies, and universities have limited access to HPC infrastructure (IDC, 2015). In South Africa, the CSIR has developed knowledge in specific sectors, and as a result, researchers can provide specialized assistance, but the uptake from universities for this service have not been as expected (Amax, 2019). This is like findings from the Zimbabwe Centre for High Performance Computing that also reported a low uptake of HPC services by academia and business (Mutunhu, Nyathi, & Dube, 2021). Despite investments in HPC infrastructure, many universities experience low utilization rates. This study explores the factors influencing HPC adoption and effective use among University Staff and Students in South Africa.

1.3 Research objectives

1.3.1 Primary objective

To investigate the determinants of high-performance computing systems adoption and continued use by staff and students in Historically Disadvantaged Institutions. The specific objectives are:

1. To assess the influence of Computer Self-Efficacy on attitude towards high-performance computing systems.
2. To assess the influence of Perceived usefulness on attitude toward high-performance computing systems.
3. To assess the influence of Perceived ease of use on attitude towards high-performance computing systems.
4. To assess the influence of Perceived ease of use on intention to use high-performance computing systems.
5. To assess the influence of Attitude toward high-performance computing systems on intention to use high-performance computing systems.
6. To assess the influence of Intention to use high-performance computing systems on the actual use of high-performance computing systems.
7. To assess the influence of Social Influence on the actual use of high-performance computing systems.
8. To evaluate the resulting model that depicts the effect of the determinants on the adoption of high-performance computing systems

1.4 Hypotheses

Hypotheses often serve as the starting point for the empirical phase of the scientific process. They propose statements that the scientific process seeks to evaluate, corroborate, verify, or falsify. The primary purpose of a hypothesis is to guide data collection, inform the analyses conducted, and shape the inferences drawn from the research (Thompson & Skau, 2023).

H1: Computer Self-Efficacy would positively influence attitude towards high-performance computing systems.

H01: Computer Self-Efficacy would negatively influence attitude towards high-performance computing systems.

H2: Perceived usefulness would positively influence high-performance computing systems.

H02: Perceived usefulness would negatively influence high-performance computing systems.

H3: Perceived ease of use would positively influence attitude towards high-performance computing systems.

H03: Perceived ease of use would negatively influence attitude towards high-performance computing systems.

H4: Perceived ease of use would positively influence intention to use high-performance computing systems.

H04: Perceived ease of use would negatively influence intention to use high-performance computing systems.

H5: Attitude toward high-performance computing systems would positively influence intention to use high-performance computing systems.

H05: Attitude toward high-performance computing systems would negatively influence intention to use high-performance computing systems.

H6: Intention to use high-performance computing systems positively affects the actual use of high-performance computing systems.



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H06: Intention to use high-performance computing systems negatively affects the actual use of high-performance computing systems.

H7: Social Influence would positively influence the actual use of high-performance computing systems.

H07: Social Influence would positively influence the actual use of high-performance computing systems.

1.5 Purpose of study

This study aims to assess the determinants of High-Performance Computing systems adoption and continued use of university staff and students. The choice to include staff and students in this study stems from the knowledge that these two groups are important participants in the academic and research environment of the university. Both viewpoints are necessary for a thorough evaluation of HPC usage and acceptance, even though their reasons and goals for implementing HPC systems are different.



1.6 Significance of the study

This study will investigate the adoption and continued use of HPC within universities in South Africa. The study is in response to a call from the Council for Scientific and Industrial Research (CSIR) to investigate the slow uptake of HPC and provide recommendations to improve the adoption and continued use of the technology (Moyake, 2016). Furthermore, the effect of the HPC could affect various areas of the South African economy, increasing human capital, industrial development, and global competitiveness (Sithole, 2019). Therefore, by increasing the adoption of HPC in South Africa, the knowledge pool of science and technology improves South Africa's economy.

1.7 Literature Review

In higher education, HPC is becoming more significant. The rapid use of supercomputing in education is a difficult task that opens up new possibilities (Fernández et al., 2021). Despite a scarcity of expertise and essential skills in this field, supercomputers is becoming a significant element in improving some areas of higher education even though supercomputers are not readily

available due to exorbitant expenses (Fernández et al., 2021). Technology developments occur on a near-daily basis, and their application in higher education has become an integral aspect of students' education (Fernández et al., 2021).

Even though technology directly impacts effective and meaningful learning, teachers' and students' usage of technology has remained minimal. The difficulties of incorporating technology into higher education, including technological infrastructure, faculty effort, technology satisfaction, and graduates' aptitude, may be to blame for the lack of impact (Ezell, 2022)

1.7.1 Empirical Literature

High-performance technology is becoming more important in higher education (Fernández et al., 2021). In many scientific, engineering, and commercial fields, HPC is the ability to rapidly solve complex computational problems through the combination of processing power and storage capacity (Samuel et al., 2021). Self-efficacy or perceived control, as well as attitudes towards behavior, can all be utilized to accurately predict intentions. Computer self-efficacy (CSE) and attitude are crucial indications of whether people want to use technology (Hanham et al., 2021).

1.7.1.1 Computer self-efficacy

The way an individual judges their capability of how to utilize a computer is called computer self-efficacy (CSE). This apparent ability influences chosen activities, the persistence of effort, and the effort spent. Computer self-efficacy is based on a sense of self-efficacy that has previously been created and represents the fundamental principles applied to the field of computer use and mastery. CSE is a crucial component for understanding societies' adoption of computer knowledge, such as HPC. CSE substantially impacts on the general public's acceptance and performance with technology education (Prifti, 2022).

Knowing students' perceptions of their ability to perform computer tasks is crucial for learning in a technologically advanced setting such as HPC. Because computers help learning and are common workplace tools, all students must become familiar with and comfortable with their use. CSE can predict a broad range of computing attitudes, opinions, actions, including outcomes.

People with a higher CSE score have less computer anxiety, use computers more frequently, and perform better on a variety of task (Hanham et al., 2021).

H1: Computer Self-Efficacy would positively influence attitude towards high-performance computing systems.

H01: Computer Self-Efficacy would negatively influence attitude towards high-performance computing systems.

1.7.1.2 Perceived usefulness

According to Fernández et al (2021), using a supercomputer in the classroom improves students' technological abilities. Perceived usefulness is a metric that assesses a potential user's subjective likelihood that using technology will benefit both his or her well-being and the adopting organization. Perceived utility, attitude toward technology use, and enabling variables all influence behavioral intention to utilize technology (Eksail & Afari, 2020).

Online information resources enable users to complete intensive academic tasks that involve complicated interactions with the many components of their resources. Students today are exposed to a high degree of digital technology; this enables them to be self-assured when searching for information online (Ugwuogu, 2023). As a result, if they have the capacity and knowledge of computer skills, they will be able to use internet resources successfully. As they transition from physical collections to digital libraries, students are searching for a simple, time-saving, and quick answer (Ugwuogu, 2023)

H2: Perceived usefulness would positively influence high-performance computing systems.

H02: Perceived usefulness would negatively influence high-performance computing systems.

1.7.1.3 Perceived ease of use

Technology is widely used and expected by all students and instructors at the university level. The current generation of students, labeled as digital natives because of their projected technology usage, is thought to be extremely proficient in using technology in their daily lives (Ugwuogu, 2023). Even individuals who are familiar with computer operations in their daily activities must master basic operations when using HPC resources, such as the usage of the software development

environment, simulation execution using HPC resources, pre- and post-processing, mesh construction, and data extraction (Ugwuogu, 2023).

Technology is a vital component of their education for these students, and they expect it from their instructors and institutions. Students use and enjoy technology in all aspects of their lives, including social media, which implies that they prefer and anticipate technology in higher education. Since technology is a natural extension of who they are, these digital natives have no trouble choosing it for their higher education (Ejarque et al., 2022).

Additionally, online information resources have gotten a lot of attention in the 21st century since they permit students to use a large amount of material that will help improve their academic performance. Students can use online resources such as online catalogs to find information, electronic journals, subscribed resources, and other electronic content through university libraries, which supports users' information-seeking ways (Ejarque et al., 2022).

H3: Perceived ease of use would positively influence attitude towards high-performance computing systems.

H03: Perceived ease of use would negatively influence attitude towards high-performance computing systems.

H4: Perceived ease of use would positively influence intention to use high-performance computing systems.

H04: Perceived ease of use would negatively influence intention to use high-performance computing systems.

1.7.1.4 Attitude

According to Almaiah et al (2022) an attitude is a mental and neurological state of preparedness that has developed through time and has a directive or dynamic influence on a person's conduct toward all things and situations with which it is linked. An individual's conduct is guided by three types of belief systems: normative belief, control belief, and behavioral belief. Combining these three belief systems yields a behavioral intention, which is regarded to be the decisive element in actual behavior. As a result, one's attitude can potentially impact one's actions (Almaiah et al., 2022)

Attitude describes a person's degree of interest in a certain technology, and it affects the technology's intended use as well as its actual implementation. The intention to use technology influences the amount of technology that is used over time. Because one's attitude toward an activity can predict one's intention, it's logical to believe that having a positive attitude will lead to positive actions. Based on research results, students' attitudes regarding digital technology impact their technology-based learning experiences (Almaiah et al., 2022).

Today's students already use digital technology for socializing and pleasure in their daily lives. They spend a lot of time on social networking, online gaming, and interactive media. Almaiah et al (2022) adds that even with this extensive use of digital technology by this generation such as Web 2.0, their use of digital technology is still limited in their academic studies.

H5: Attitude toward high-performance computing systems would positively influence intention to use high-performance computing systems.

H05: Attitude toward high-performance computing systems would negatively influence intention to use high-performance computing systems.



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1.7.1.5 Intention to use

HPC is a technology that is up to date, has been used almost exclusively for scientific computing in research institutions and universities (Kaur et al., 2024). With the increasing dependence on technology to improve education and instruction, finding the essential drivers influencing students' willingness to use technology in their education is still a critical challenge. A vital study question is to determine what characteristics influence the intentions of pupils to employ digital technology in their academic studies. Identifying such elements can assist educators and educational administrators better understanding how undergraduate students use digital technology to help them learn (Kaur et al., 2024).

Acceptance of technology refers to a person's eagerness to do something for the purposes for which it was designed. The degree to which an individual has consciously chosen to carry out or abstain

from a specific future action is known as their behavioral intention. A person's level of conscious decision-making over whether to carry out a specific future action is known as their behavioral intention (Kaur et al., 2024)

H6: Intention to use high-performance computing systems positively affects the actual use of high-performance computing systems.

H06: Intention to use high-performance computing systems negatively affects actual use of high-performance computing systems.

1.7.1.6 Social Influence

Social influence occurs when an individual feels that most important individuals agree with him or her and that he or she shouldn't try a different approach (Venkatesh et al., 2003). Furthermore, one of the four primary components of behavioral intention to use technology is social influence, which shapes behavioral intention through subjective norms and representations (Yuniarti & Safitri, 2022). According to research, social influence is a strong influence in change of behavior. To make improvements, people assess their own abilities and perspectives by comparing them to those of others. However, Yuniarti & Safitri (2022) argue that the role of social influence on technology adoption is very complicated. This is because literature around the Intention to use technology has been very inconsistent.

H7: Social Influence would positively influence actual use of high-performance computing systems.

H07: Social Influence would positively influence actual use of high-performance computing systems.

Below is the visual representation of the proposed empirical model that was discussed in the preceding sections.

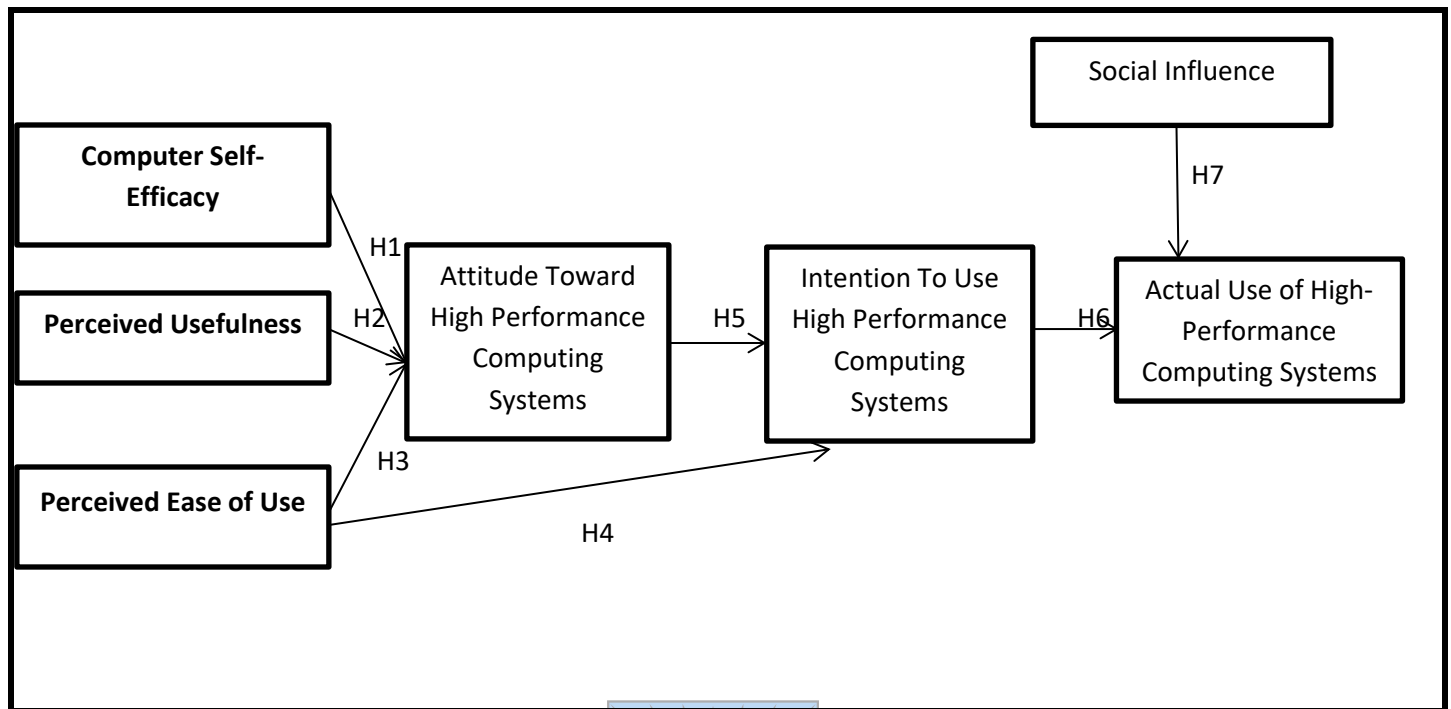


Figure 1: Empirical model (adopted from the UTAUT model) (Venkatesh et al., 2003)

1.7.2 Theoretical Literature

The Technology Acceptance Model (TAM) is among the most prominent and reliable structures for describing Information Technology (IT) and Information Systems (IS). Many theoretical models have been put out to assist explain the factors influencing new technology acceptance. (Qiao et al., 2021). Davis (1989) proposed the TAM as a tool for predicting whether a new technology will be adopted by people, groups, or organizations (Mortenson & Vidgen, 2016). The TAM model was one of the eight models used to create the UTAUT. The UTAUT was created to bring together previous TAM-related studies (Qiao et al., 2021).

1.7.2.1 Unified Theory of Acceptance and Use of Technology

Venkatesh et al. (2003) created a unifying theory that combines different perspectives on user and innovation acceptability called the UTAUT (Williams et al., 2015). The theory was developed by analyzing eight theories and models, including the Theory of Reasoned Action (TRA), Motivational Model, and Theory of Planned Behavior (TPB) (Williams et al., 2015). Performance expectancy, effort expectancy, social influence, and facilitating conditions are the four concepts that constitute the UTAUT and play a crucial part in determining user acceptability and usage behavior. Theoretically, attitudes toward technology, self-efficacy, and anxiety are not primary

drivers of Intention (Venkatesh et al., 2003). Social influence is the degree to which a person believes that other people think he or she should accept a new system. The degree to which someone believes that employing a particular strategy would enable them to achieve work performance is known as performance expectancy. How much someone feels the system is supported by an organizational and technical infrastructure is referred to as facilitating conditions (Venkatesh et al., 2003).

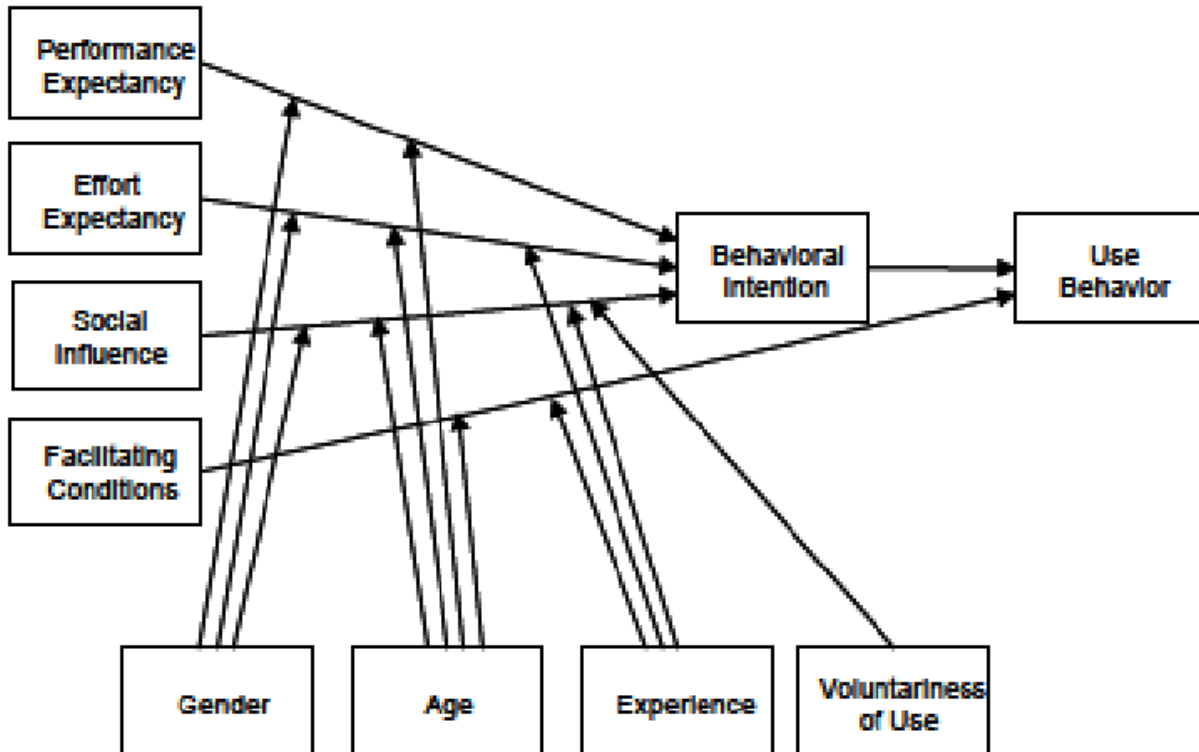


Figure 2: Unified Theory of Acceptance and Use of Technology (Venkatesh, 2012)

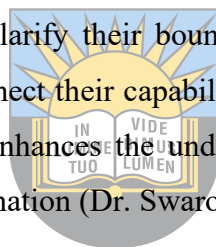
Venkatesh, et al., (2012) expanded UTAUT, Including three extra components (hedonic motivation, price value, and habit).

Alshref, Abas, and Bakar (2021) found that only hedonic motivation would be relevant in the educational context as students and staff may not pay for using e-learning provided by the university (price value) and habitual use of e-learning by the end users is not anticipated (habit). This only left hedonic motivation, which was disputed by Ain et al. (2016), which stated that habit or hedonic motivation has no behavioural objectives for eLearning system utilization.

1.8. Research methodology

Research methodology is a systematic approach to investigating and explaining a research problem. Research involves the pursuit of knowledge and the exploration of information. More specifically, it can be defined as a structured and methodical process of gathering, analysing, and interpreting relevant data on a particular topic. Methodology refers to the systematic and theoretical analysis of the methods applied within a particular field of study. It involves a critical evaluation of the principles, strategies, and ethical considerations that guide research practices. Typically, methodology includes key elements such as research design, theoretical frameworks, stages of investigation, and the selection of qualitative or quantitative approaches (Dr. Swarooprani. K, 2022)

Research methodology seeks to analyze and evaluate research methods, highlighting their limitations and strengths. It aims to clarify their boundaries and impact, examine underlying assumptions and implications, and connect their capabilities to the evolving edge of knowledge. Through this, research methodology enhances the understanding of how different approaches contribute to the advancement of information (Dr. Swarooprani. K, 2022).



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1.8.1 Research paradigm

Any research's foundation is established by its paradigm (Maksimović & Evtimov, 2023). This study used the positivism research philosophy. According to positivism, both natural and social phenomena are considered objective and measurable. This approach stresses the importance of researcher neutrality and the systematic testing of existing theories. Positivists typically begin their research by developing hypotheses—tentative assumptions drawn from established theories—which they then rigorously test through empirical observation and measurement (Maksimović & Evtimov, 2023). The positivism paradigms are suitable as they allow the researcher to be a neutral observer and study events that happen without them, with no influence or control over what is observed.

1.8.2 Research approach

Researchers widely recognize qualitative and quantitative methods as the two primary approaches for collecting effective data across various disciplines. In the social sciences—such as linguistics, psychology, and history—qualitative methods are often used to gain in-depth insights into complex phenomena through interviews, observations, and textual analysis, while quantitative methods focus on collecting numerical data that can be statistically analyzed. Together, these approaches provide a comprehensive toolkit for understanding and addressing research questions (Xiong, 2022).

In this study, a quantitative research approach was used, and a survey will be used in this study. In quantitative research, phenomena are explained by gathering numerical data and analyzing it using mathematical techniques, with a special emphasis on statistics (Xiong, 2022). Quantitative research involves describing current theories, developing and testing new hypotheses, and reevaluating current theories deductively in light of experimental findings (Barroga et al., 2023).

1.8.3 Research design

Research design is the framework of approaches and strategies that the researcher has selected to carry out the study. The word "research" refers to gathering information and supporting evidence based on the research problem, evaluating the results, and drawing conclusions while taking research procedures into account. By minimizing ambiguity as much as feasible, it guarantees the researcher that the evidence gathered from the study adequately addresses the research problem. In social science research, it is necessary to gather evidence that is pertinent to the research problem, particularly evidence that is needed to assess a problem, test a theory, or explain a phenomenon. Accurate and objective research insights should be produced by a successful research design (Wisenthige, 2023).

In this study, explanatory research design will be used. Explanatory research design is used primarily to investigate the underlying causes and mechanisms of a phenomenon. Unlike descriptive research, which focuses on outlining what is happening, explanatory research delves into understanding why it happens. This design is particularly useful when researchers aim to establish cause-and-effect relationships and test hypotheses (Riyaz Ansari et al., 2022)

1.8.4 Study population and sampling

An online survey was created and distributed to five universities within South Africa. These universities were the University of Fort Hare (16800 students), University of the Western Cape (22 000 students), Walter Sisulu University (27 500 students), Limpopo University (21000 students) and University of Venda (16300 students). The online questionnaire was sent to the staff and students, identified through convenience sampling, via email. The Raosoft calculator was used to determine the sample number of students and staff that participated in the study. Therefore, according to the findings from the Raosoft calculator, 377 students and staff were needed to obtain a generalizable result (confidence level 95% and margin of error 5%).

1.8.5 Data Collection

This research aims to look at the determinants of High-Performance Computing systems adoption and continued use of staff and students in universities in South Africa. To examine this, primary and secondary data was collected.

Data are facts or figures that allow for the drawing of conclusions. Primary data refers to original data that a researcher collects firsthand specifically for their study. This might involve surveys, interviews, or experiments tailored to answer research questions. In contrast, secondary data is information that has already been collected, processed, or published by others—such as in academic articles, government reports, or previous research studies—and is reused to support or complement current research efforts (Ajayi, 2023).

Table 1 depicts the instrument's level of reliability as determined by Alpha Cronbach Alpha. The Cronbach Alpha Coefficients in the below table are above the recommended threshold of 0.70, stipulated by Nunnally and Stein (1994). The study will use scales that have been adapted from previous research.

Table 1***Scales to be used***

Variable	Cronbach Alpha Coefficient	Source
Intention to Use High Performance Computing Systems Attitude toward High Performance Computing Systems Social Influence	0.82	(Gao et al., 2012).
	0.86	(Herath & Rao, 2009).
	0.76	(Venkatesh et al., 2003; Venkatesh & Zhang, 2010; Foon & Fah, 2011; Sripalawat et al., 2011).
Actual Use	0.82	(Rachman & Napitupulu, 2017).
Perceived Usefulness	0.91	(Davis, 1986)
Perceived Ease of Use	0.91	(Davis, 1986)
Computer Self-Efficacy	0.85	(Davis, Bagozzi & Warshaw, 1989)



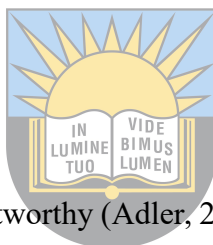
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1.8.6 Data analysis

Structural equation modeling (SEM) is a collection of statistical methods for estimating the magnitudes and directions of assumed causal effects in quantitative studies based on cross-

sectional, longitudinal, experimental, or other types of research designs. Its use can vary from more exploratory and data-driven research, where preliminary causal models are generated, to more confirmatory research, where one or more existing models based on a priori hypotheses are tested or compared. Although the data used in SEM are measured variables, they may be analyzed as approximating hypothetical constructs (Kline, 2023).

SEM is a versatile statistical technique that enables researchers to develop and analyze models consisting of equations that describe the relationships between latent constructs and their associated observed variables. This approach integrates multiple statistical methods, such as factor analysis and regression, allowing for the simultaneous estimation of complex relationships within a single framework. SEM is widely applied in various disciplines to examine theoretical models, assess causal connections, and explore both direct and indirect effects among variables (Schuberth et al., 2023).



1.8.7 Data trustworthiness

To be relevant, all research must be trustworthy (Adler, 2022). Although quips about statistics are often cynical, as numbers can be manipulated by those with an agenda, at least quantitative research has the facade of being intrinsically trustworthy. This is because the quantitative research process is more systematic and apparent, and finding relationships between numbers is assumed to be more rigorous than deriving meaning from words and actions (Adler, 2022). To ensure data trustworthiness, this study made use of validity and reliability. Validity and reliability are essential concepts that justify research quality. They are widely recognized as the two most relevant quality criteria for both quantitative and qualitative research (Nha, 2021). Reliability refers to the ability of a measurement process to produce consistent results under repeated conditions. It assesses the consistency, precision, repeatability, and trustworthiness of research, indicating the extent to which it is free from bias. In qualitative research, reliability ensures that an assessment tool is free from errors and produces stable, consistent results. Additionally, reliability is a crucial component of validity, as a measurement must be reliable to be considered valid (Karnia, 2024). Validity measures the extent to which research, or a measurement tool accurately assesses what it is intended to measure. When designing an experiment, establishing strong test-retest reliability and

internal consistency is essential, as these factors help ensure that the scores truly reflect what they are meant to measure, thereby confirming the validity of the research. Validity also refers to the degree to which an instrument effectively captures its intended concept and produces truthful results. To enhance validity, the instruments or tests used must fully encompass the experimental concept and adhere to the principles of the scientific method (Karnia, 2024).

1.9. Delimitations of the study

Only staff and students from five South African universities are included in this study. These universities include the University of Fort Hare, University of the Western Cape, Walter Sisulu University, Limpopo University and University of Venda. The study will only focus on the adoption and continued use of HPC within universities.

1.10 Ethical considerations

Ethics addresses moral issues related to the practice of research. It involves examining what is right and wrong and determining what researchers ought to do. The primary focus of research ethics is on the responsibilities of researchers toward their participants, audience, academic community, and society. To uphold ethical standards, researchers typically follow established guidelines to ensure adherence to principles of good research practice. In the context of research, ethics encompasses the norms and values that guide decisions related to data collection, analysis, and the dissemination of findings (Mirza et al., 2023). This research study followed the guidelines established by the University of Fort Hare's University Research Ethics Committee (UREC). The researcher kept the respondents' data private and confidential by anonymizing the questionnaire. The researcher ensured that informed consent was obtained from the respondents before the questionnaire was completed by placing a 'submit' button on the front page of the survey. Within this section the measures to ensure confidentiality and anonymity of the respondents were explained. No personal identifiable information was collected from the respondents in the questionnaire to ensure anonymity and the raw data set was only accessible to the researcher and supervisor, which will be stored on an encrypted device. Data will be deleted from this device after 5 years as per the UREC policy on data handling.



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Chapter 2: Theoretical Constructs

2.1 Introduction

High performance computing (HPC) systems are complicated machines that need to work together at the highest level of theoretical performance. Theoretical performance is used to measure the performance of computer processors. An HPC system's performance can be negatively impacted by a variety of issues, including faulty hardware, programs that reach unexpected or undesirable states, and improperly configured components. The ability to identify incorrect situations resulting from inappropriate behavior of one or more elements is a crucial feature of current and future supercomputers. This problem affects cloud and data center providers as well as scientific computing systems because their businesses rely heavily on the availability of their web services (Borghesi et al., 2022). HPC attempts to offer quick computing solutions to challenges in science and everyday life (Claude, 2020). Currently, HPC systems are well-known and accessible to users in research centers and universities. Researchers depend on these machines to do their most intensive computations (Tanash et al., 2019).

This chapter will discuss the background and history of HPC, define what HPC are, discuss the different HPC solutions and systems. The chapter will also discuss ICT in South Africa and how it is affecting different sectors. Further, it will discuss where HPC are used as well as the challenges of HPC. Lastly, it will discuss the use of HPC in South Africa as well as South African universities.

2.2 Background of HPC

In the last ten years, technology and software developments have made HPC more accessible than ever (Ko et al., 2022). Owing to the cheaper price in comparison to 3-conventional supercomputers and mainframes, computer clusters increased popularity in HPC environments at the beginning of the 1990s (Ko et al., 2022).

The demand from consumers for more powerful systems and applications has kept high performance computing in the public eye for roughly 20 years. There have been significant technological changes, as well as major improvements at various levels, expanding the capabilities of high-performance computers. Large scale calculations can be used to assess whether a theory

agrees with experimental results to challenge a large data set or to test a theory through high precision calculations, to understand how it works. Hence, HPC and cutting-edge research go hand in hand (Claude, 2020).

The most recent technology built on huge processing systems is known as a supercomputer. With the aid of supercomputers, tasks that call for a high level of calculation can be successfully completed. Applications or projects that are too large to operate on standard systems are run using supercomputing. Some processors are used, while some computers are deployed in cluster form. The first High Performance Computer was introduced in the 1940s, which marked the beginning of supercomputer technology. While simultaneous computer construction was developed for the first time in the 1960s, there have been significant developments in the field since then. In general, supercomputers are used in a wide range of fields, including those related to the life sciences, medicine, mechanics, economics, electronics, telecommunication, computer science, and engineering, among many others (Assiroj et al., 2019).

2.2.1 History of High-Performance Computing

HPC divides large applications into smaller ones that can be performed concurrently on various computing units to fulfill the high processing requirements of applications. These processing units may be found on a single computer (supercomputer), or on a network of computers that together make up an HPC cluster, cloud, grid, or HPC volunteer computing system (Hamza & Jiomekong, 2020).

2.3 Definition of High-Performance Computers

HPC systems are tools for acquiring, exchanging, and analyzing data (Tanash et al., 2019). HPC refers to computations that are so big that a single (desktop) computer is unable to meet the storage, main memory, and raw computational speed requirements (Ko et al., 2022). HPC systems are designed to quickly handle complicated computing problems that are either too big or would take too long to address using conventional computers. In various disciplines, including medical science (for drug development, breast cancer detection in photos, etc.), climate science (meteorology), physics (nuclear physics), mathematical science (applied mathematics), etc., they are used to address computational issues (Hamza & Jiomekong, 2020).

Existing solutions like HPC Supercomputer, HPC Cluster, HPC Cloud, or HPC Grid are not appropriate for resource-limited environments (mostly for underdeveloped nations) because their costs are typically too high (especially for academics), and the administrative difficulty of HPC Grid raises the barrier to entry cost (Hamza & Jiomekong, 2020). While an HPC cloud refers to a system that includes computers connected to a private or public network, an HPC cluster consists of computers connected to a local network. The HPC Grid is made up of computers that are linked together via wide-area networks, including the Internet. Due to their high prices, the suggested solutions cannot be used where resources are scarce. HPC clusters and HPC clouds require financial resources that most institutions in developing countries do not have. For HPC grids, one of the biggest challenges may be the administrative complexity involved in acquiring the required permissions to utilize the system. (Hamza & Jiomekong, 2020).

2.3.1 High performance computing solutions

2.3.1.1 HPC Supercomputers

From the early 1980s, supercomputers have been employed in a variety of industries. Programmers focused on vector tuning at the time because vector architecture was the norm for supercomputers. The mainstream of the supercomputer, however, shifted in the 1990s with the emergence of a parallel design. Under this trend, supercomputer development is still progressing (Geshi & Purposes, 2019). The Supercomputer is among the most well-known types of HPC solutions. A supercomputer is made up of a few hundred thousand, or even millions, computing units that are connected to a network to form a massive parallel processor. One system with 2, 414, 592 cores is the Summit - IBM Power System AC9221, situated at Oak Ridge National Laboratory. These processors collaborate to solve complex computing tasks (Hamza & Jiomekong, 2020) swiftly and effectively.

The idea of supercomputer is dynamic and can be best described as the most powerful computer which is constantly evolving as new developments in computing and technology take place. A supercomputer is a cutting-edge piece of technology built on massive computing systems that offers close to the highest sustained performance currently possible on difficult computational tasks based on powerful simulations (Fernández et al., 2019). Supercomputing is the process of running "large" projects or programs that are too big to execute on a small or ordinary computer

or that use at least half of a "large" machine's capabilities. To disperse the processing power of several computers, computer clusters are used, and many processors are used near one another (Fernández et al., 2019).

For scientists and engineers working in resource-limited environments, it is nearly impossible to purchase a supercomputer due to the high costs. Several HPC solutions that do not need a fully dedicated machine have been created because of this restriction. The HPC Cluster, Cloud, Grid, and Volunteer Computing are these solutions (Hamza & Jiomekong, 2020).

2.3.1.2 HPC cluster

Separate computers are connected by a high-performance local area network to create an HPC cluster, a computing machine designed to address difficult problems. An HPC cluster is made up of individual computers that have one or more processors or core, memory, storage, and network connections. Typically, a single administrative organization owns an HPC cluster. Users are given the impression that they are working with a one giant computer by the cluster management software, but the cluster may be made up of hundreds or thousands of separate machines. A single supercomputer with comparable performance is significantly more expensive than a cluster (Hamza & Jiomekong, 2020). The dedicated physical cluster at HP Laboratories Singapore (HPLS)2 is an illustration of a computer cluster. A single switch connects this cluster to a gigabit Ethernet network. There are twelve physical cores per server when it has two CPU sockets and a Processor with six cores (Hamza & Jiomekong, 2020).

2.3.1.3 HPC Cloud

In recent years, cloud computing has emerged as a third option. This phrase refers to the applications that are provided as services over the Internet as well as the system software and hardware in the data centers that provide these services. Technology behemoths like Amazon, Microsoft, and Google make their almost limitless computing capabilities available to users on demand by encasing them as "virtual machines," which are billed based on CPU and storage usage. In essence, users pay utility fees for the computational resources they utilize. It is far more expensive for end customers to use 1000 virtual computers for an hour than it is to use one virtual machine for 1000 hours. Because of this, a user can build their own virtual cluster "on the fly," expanding it to fit the growing complexity of the problem they are attempting to solve (Ko et al.,

2022). Internet-based development and computer technology are combined in cloud computing. With the use of cloud computing, users can reduce costs and energy usage. Cloud computing makes use of the Internet and virtual technology that can be immediately made available upon request, modified, and accessed from any location (Assiroj et al., 2019). Indeed, cloud computing provides a fantastic alternative for computing, software, and mass storage (Claude, 2020).

A high-performance computing cloud provides computing capacity on demand without the user's direct active management. With resources arranged in globally dispersed data centers, it offers dynamic and scalable computing power. The HPC Cloud reduces the upfront expenses of computing infrastructure by acquiring on-the-fly rather than as an asset. A cloud may be either public (serving a single enterprise) or private (open for public use) (Hamza & Jiomekong, 2020). Compared to other forms of HPC, cloud HPC has the advantage of allowing customers to use computing resources instantly without requiring distribution committee approval. Additionally, the service can be rendered without requiring direct communication between the user and the service provider. Users don't need extensive software/infrastructure management skills to use software, nor do they need to buy a license or install it. Nevertheless, in environments with limited resources, the fundamental disadvantage of HPC Cloud is that it depends on centrally controlled dedicated hardware, resulting in minimal cost that may be prohibitive for academia and small businesses (Hamza & Jiomekong, 2020).

2.3.1.4 HPC Grid

To solve critical problems requiring high-performance computing, a grid is made up of several computing resources connected by a network (like the Internet) that come from various administrative domains. The entire setup is referred to as an HPC Grid. The HPC Grid uses multiple computers, but they are scattered much more widely than in the HPC Cluster or Cloud. While some HPC Grids are situated around the globe, others are contained within a single company (Hamza & Jiomekong, 2020).

The computing resources for the HPC Grid are typically given by a variety of auxiliary organizations, including businesses, research groups, laboratories, and universities. HPC grid

tasks are usually managed by a specific organization. Many people frequently use large grid computing facilities to tackle challenging academic, scientific, and mathematical challenges. For universities and small firms, the administrative difficulty (obtaining the required authorizations) is a significant obstacle to using an HPC Grid (Hamza & Jiomekong, 2020).

The French Grid'50006 is one instance of Grid. There are 12,328 cores, 31 clusters, and 8 sites in this Grid. Every site has a cluster, and a quick network connects every site to every other site. To enable study on massively parallel and distributed systems, a reconfigurable, managed, and regulated experimental environment is intended (Hamza & Jiomekong, 2020).

2.3.1.5 HPC Volunteer Computing

In HPC Volunteer Computing (VC), citizens who own or use computers agree to donate their computing power to address HPC-related issues. VC is built around the cooperation of many volunteers who donate their computing capabilities to a project, as well as the provision and management of significant computing jobs. In contrast to HPC Cluster, HPC Cloud, and HPC Grid, HPC VC eliminates administrative and monetary hurdles. Volunteers contribute to the costs of purchasing, running, and maintaining the computing equipment (Hamza & Jiomekong, 2020).

Over the past ten years, HPC Volunteer Computing has yielded several outstanding scientific findings. SETI@home78, which is looking for intelligent life on other planets, and Folding@home9, a computing packages for statistical calculations of molecular dynamics trajectories for biological system models, are the two most popular VCs. A notable example of how significant scientific findings can be obtained with VC for challenges that are within the budget of other HPC schemes is the Folding@home initiative. For instance, it was employed in 2008 to research influenza hemagglutinin mutations (Hamza & Jiomekong, 2020).

The power of mobile devices, the need to encourage and support volunteer participation, and self-control of volunteer unreliability presents the main obstacles to a volunteer IT strategy. Despite the prior difficulties, Volunteer Computing may be an alternative HPC resource in environments with limited resources. In fact, the variety of commercial computer centers has made numerous equipment accessible in many underdeveloped nations. These devices are left idle for extended

periods of time. They can be utilized as a distributed computer infrastructure for no cost. It relies on devices that are typically owned by users and their community, requires no further hardware investment, and prioritizes basic tools that can be created on a freelance basis by a single developer (Hamza & Jiomekong, 2020).

2.3.1.6 Increasing the efficiency of HPC systems by using supervised machine learning to forecast work resources

One of the most crucial parts of an HPC system is the scheduler, which is software on a high-performance computing cluster that decides and controls which computations to do next and where (Tanash et al., 2019). In HPC systems, schedulers can create a bottleneck by managing many submitted jobs that consume lots of cluster resources (CPUs and memory). HPC system users come from a variety of academic backgrounds (Tanash et al., 2019).

2.3.2 How HPC work

For general-purpose computing, the central processing unit (CPU) and the graphics processing unit (GPU) are the two most common options (Sun et al., 2019). CPU and GPU systems are recognized to provide excellent performance for a variety of applications, such as matrix factorization, optical remote sensing image processing, parallelization of huge vector similarity calculations, etc. (Skrzypczak & Czarnul, 2023). CPUs are often combined with specialized coprocessors, such as graphics processing units (GPUs), to speed up specific processes by orders of magnitude (Ko et al., 2022). GPUs can be conceptualized as vector data stream converters and massively parallel matrix and vector multipliers. GPUs were originally created for producing visuals on a computer screen. The success of large-scale statistical computing depends on effectively integrating HPC into the statistical profession given the growing need to examine petabyte-scale data (Ko et al., 2022).

To make a simulation effective and quick, high-performance computing uses several approaches, including distributed memory parallelism, shared memory parallelism, vectorization, memory access optimizations, etc. (Houzeaux et al., 2018). Large memory usage is made possible and computation time is greatly reduced by using distributed memory parallel computing and shared memory parallelism (Verkaik et al., 2021).

Technological developments in the last ten years have increased accessibility to high-performance computing more than anything else. The current generation of supercomputers, based on multi-core processors and can be increased by accelerators, is designed to increase peak performance, and the era of exFLOPS is coming soon (Claude, 2020). The world entered the era of exFLOPS on May 30, 2022 with the introduction of Frontier, a supercomputer at Oak Ridge National Laboratory (ORNL) of the Department of Energy (DOE) that can perform one quintillion floating-point operations per second (FLOPS). It is difficult to design efficient code that scales well on a supercomputer. Since manycore processors are already widespread, the scalability problem is critical. Code optimization needs complex programming approaches, taking into consideration the specificities and limits of the target architecture (Claude, 2020).

2.2.2 High performance computing systems

The term "high-performance computing" refers to a broad range of both software and hardware systems that perform complex tasks that require large amounts of computing power, typically in "clusters" of computing nodes (Ghosh et al., 2023). Modern supercomputers are networked systems with progressively deep storage hierarchies that serve progressively more complicated and large-scale applications (Yang et al., 2023).

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2.2.2.1 multi-GPU node

In some circumstances, placing many GPUs on a single node allows for HPC (Ko et al., 2022). A specialized microprocessor known as a "graphics processing unit" (often abbreviated as "GPU") offloads and accelerates graphics rendering from the main processor. It served as a fixed-function graphics processor but was essentially a graphics chip. The GPU was created because of the chip's gradual increase in programmability and processing capacity (Claude, 2020). The capacity of GPUs to map a huge array of floating-point integers concurrently is one of its primary advantages. The user can program the mapping, which is referred to as a kernel. This capability is made possible by the SIMD architecture, which is formed by packing many basic computing cores onto a single processing chip. The programmability and high bandwidth of this GPU architecture, originally designed for high-quality video games to generate large numbers of pixels within strict time limits, quickly attracted the attention of the scientific computing community. Computations

such as matrix-vector multiplication and elementwise nonlinear vector transformation can be executed hundreds of times faster on a GPU than on a CPU (Ko et al., 2022).

Previously, just a single precision could be used for floating-point operations on GPUs, but now double and half precisions are supported. Support is also provided for more complex operations like tensor multiplication. High-end GPUs are now designed specifically for scientific computing, and they occasionally include error correction and other fault-tolerance features (Ko et al., 2022).

2.2.3 HPC Software Libraries

The following section will discuss software libraries for HPC. It will discuss deep learning as well as automatic differentiation.

2.2.3.1 Deep learning libraries

Distributed deep learning (DDL) is an area of artificial intelligence (AI) research in which the use of multiple accelerators can significantly reduce the training time of deep learning models. The last ten years have seen a large adoption of deep learning (DL) techniques in computer vision, natural language processing, audio and text processing, and other fields requiring pattern identification. The two main reasons DL algorithms perform better in these applications are the availability of massive volumes of data and the availability of powerful computational resources, including accelerators (Patil & Chickerur, 2023).

TensorFlow and PyTorch are the two most used deep learning software libraries. These libraries share two characteristics. The first is the computation graph, which automates the differentiation and loss function evaluation that backpropagation requires. The second part is a unified interface that works with both CPU and GPU for linear algebra and convolution techniques, and it is more relevant to statistical computation (Ko et al., 2022). Both the platforms offer multi-node and GPU computing. When two or more GPUs are sharing data and one of them requests data from the other, the GPUs automatically exchange the data without requiring user intervention. For densely connected HPC systems, it is advised to use MPI via the Horovod library for multi-node communication. PyTorch's interface torch distributed enables both multi-GPU and multi-node computing. This interface defines simpler communication primitives in the MPI paradigm (Ko et al., 2022).

2.2.3.2 Automatic differentiation

Automation differentiating (AD) describes a set of methods for precisely estimating the derivatives of a given function by a computer program. Most AD methods are based on the decomposition of the objective function into simple functions (primitives) whose derivatives are known, and on a computational graph—explicit or implicit—that represents the interdependencies between the primitives (Ko et al., 2022).

2.4 ICT in South Africa

ICT has applications across a variety of industries. Technology influences how the learning environment and process are improved (Alruwais et al., 2018). Utilizing technology in the classroom significantly increases efficiency, speeds up the preparation of lessons, allows the teacher to fully develop creative abilities, provides visibility, allows a large amount of educational material and increases the amount of work done in class (Abdurahimovna, 2020).

One of the main forces behind economic growth is thought to be ICT (Kossai & Piget, 2014). Worldwide, most people have access to ICT in some way. ICT refers to "the set of technologies that manage information and facilitate various forms of communication between a person and an electronic device" (Libri et al., 2018, p. 501).

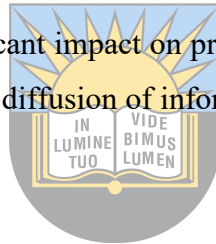
ICT has long served as a tool to aid in education. Sidney L. Presses invented an automated testing apparatus in the 1920s, which launched the use of technology in assessment. Also, schools began using automatic scoring software and standardized testing at the same time, which made large-scale testing convenient and affordable (Alruwais et al., 2018). The nation recognizes the contribution of IT to economic progress. The National ICT Strategy of South Africa was created with the primary goal of fostering ICT adoption and diffusion to achieve social and economic development (Noruwana et al., 2018).

As one of the lower middle-income developing countries, South Africa prioritizes eradicating poverty, advancing economic growth, and strengthening democracy. It does this by effectively incorporating cutting-edge technologies into society and making the most of its participation in

international trade. Several initiatives, including those utilizing ICTs to advance the nation and bring it into the digital era, have been led by South America. All citizens have equal access to government services regardless of their social status, gender, or color according to the e-inclusion strategy for the digital society and the government's universal access policy (Noruwana et al., 2018). Access to ICT, including gadgets and internet connectivity, is a problem in South Africa due to unequal access (Blignaut, 2021).

2.4.1 ICT and economic growth

One of the cutting-edge technologies used to handle information and communication is information and communication technology (ICT) (Makaula, 2021). The basis for increases in the standard of living is laid by productivity growth. Investments in ICT are a key component of increased productivity. In industrialized countries, this relationship has been thoroughly investigated at the business, industry, and national levels. Numerous studies have shown that ICT has a positive and economically significant impact on productivity (Niebel, 2018). ICTs can play a fundamental role in the gathering and diffusion of information which could in turn lead to long-term economic growth (Haftu, 2019).



One of the best investments in South Africa is still high-performance computing equipment, which helps the South African Weather Services produce more precise weather forecasts. Several leading organizations, like Petro SA, Johnson Matthey, De Beers Marine, and Sasol, have discovered the tremendous benefits of technology for their operations (*Boosting SA's Economy by Supporting Industry Research and Innovation*, n.d.).

2.4.1.1 HPC in business and economics

The domains of business research and economics are becoming more computational due to the advent of huge volumes of data and the extensive use of computing resources in corporate, scientific, and social contexts. The potential for real-time decision-making (for example, protecting IT security infrastructure and trading financial stocks), solving complex optimization problems that require a lot of computation (for example, in manufacturing and logistics), and analyzing vast amounts of data from sensors, mobile devices, and social media (for example, social media analytics, fraud detection, and business analytics) are some of the prospects and business

opportunities presented by these developments (Schryen et al., 2020). Secondly, university computing centers, public cloud service providers (such those found in Amazon Web Services, Microsoft Azure, and the Google Cloud Platform), and open-source communities are all beginning to offer HPC infrastructures, tools, libraries, and services as commodity commodities (e.g., Apache Hadoop framework). The recent purchase of Cray, a pioneer in supercomputer technology, by Hewlett Packard Enterprise highlights the high relevance of services made possible by HPC (Schryen et al., 2020).

The exponential growth in single processor core performance, which has been a key force behind cycles of economic and technical innovation over the previous few decades, is finally coming to a stop, and the era of sequential computing must make way for a new era in which parallelism is at the forefront. Regretfully, sequential applications will not benefit from the increases in processor performance brought about using parallel processing capabilities (Schryen et al., 2020).

2.4.2 ICT and agriculture

Since 1994, the agriculture sector has been well positioned to reduce poverty, increase rural food production, and drive long-term economic growth and development. The supply-side of food security is ensured through agricultural productivity, which also secures food availability (David & Grobler, 2019). Smallholder farmers have options to access agricultural information and agricultural advisors thanks to the usage of ICT. The availability of ICTs will contribute to the development of rural agriculture by supplying timely information that can aid smallholder farmers in making pertinent and wise decisions (Makaula, 2021).

According to studies, one factor in South Africa's high level of poverty is the inability to access food. Since excess domestic food production can be turned into money, encouraging food production at the household level may help to address the issues of food accessibility and poverty. To involve the household in food production, it is necessary to have the land for agricultural production, agricultural expertise, farm equipment, and ICT devices for information dissemination. Innovations in management and technology, including smart production methods, are major roadblocks to domestic production reaching its maximum potential (David & Grobler, 2019). Also, to observe an improvement in agricultural development, technological investment is

required, as well as farmers' participation in implementing new technology to boost yields (Makuala, 2021). Agricultural operations can be promoted and made easier with access to ICT, as ICT boosts production (David & Grobler, 2019).

2.4.2.1 Role of HPC in Farm/Land Assessment

To enhance crop productivity and reduce environmental impact, fluctuations in soil fertility and crop conditions must be managed. With the collection, analysis, and presentation of geographic data, Geographic Information Systems (GIS) offer the solution. Monitoring of various soil and crop characteristics can be done with the help of GIS, as it allows for the determination of the soil attributes and crop yield. High Performance Computing is used to address these issues (Ratna Prabha, 2023).

2.4.3 ICT and Small and Medium Enterprises (SME's)

Small and Medium Enterprises (SMEs) are seen as the main drivers of economic growth and employment creation in developing countries like South Africa. The National Small Business Act 102 of 1996 serves as the basis for the definition of a SME in South Africa. It considers the number of employees, yearly turnover, and gross assets (excluding fixed assets) in combination. SMEs account for more than 91% of all businesses in South Africa that generate economic activity. They consist of several companies, some of which are not registered as SMEs and do not have to pay value-added tax (VAT). (Department of Trade and Industry, Republic of South Africa (DTI) 2005). The economy is not expected to benefit from informal and non-VAT businesses, which are primarily operated for the owner's survival and are not likely to expand or add staff (Jere & Ngidi, 2020).

The development of the global economy depends on ICT, which is a key component of the infrastructure that connects the entire world. Companies that employ ICT as a business strategy increase production and greatly reduce costs. There are four ways that ICT adoption could aid in an organization's expansion: recognition of the organization, better information for small firms, the capacity to conduct business online and investigate new trade sectors are the first three (Jere & Ngidi, 2020). However, few research studies have investigated the elements that affect retail

SME's adoption of ICT; instead, most studies have concentrated on how individuals, governments, and large corporations use ICT (Jere & Ngidi, 2020).

2.4.4 ICT in teaching and learning

ICT is any electronic tool or machine used by a teacher to rapidly achieve teaching and learning goals and objectives. Examples include a video camera, projector, copier, scanner, and others that appeal to all the students' senses and emotions. These resources allow educators to engage with students in a way that builds comprehension and encourages learning. Given the changes in the last 20 years, South Africa's educational system has undergone several stages of development (Ojo & Adu, 2018). Although there has been controversy about the use of ICT in education, its pedagogical advantages in the classroom make it impossible to ignore. ICT has an impact on teaching and learning in schools because of its growing significance in the knowledge economy and educational ecosystem (Dlamini, 2018).

ICTs are now more than just a tool for information and communication; they are a force behind curricular innovation and the delivery of learning for both educators and learners (Ojo & Adu, 2018). ICTs acted as a gateway into previously inaccessible content, increasing the rate of teacher production. Additionally, they facilitate seamless communication between the two parties by enhancing students' access to knowledge and enabling teachers to employ sophisticated collaborative teaching and learning activities that are evident in the separation of place and time (Ojo & Adu, 2018).

According to data from the DoBE (Department of Basic Education 2019), 80% of government schools lack internet connection for teaching and learning, and 63.5% of schools lack a computer lab. The stark inequality in access to ICT resources and internet connectivity is highlighted by this. However, it appears that once these students enroll, the focus shifts to using technology such as a desktop computer, laptop, or tablet to search for information, print, or download an assignment written in Microsoft Word or create a PowerPoint presentation (Blignaut, 2021).

The most recent COVID-19 outbreak serves as a timely reminder of the fundamental impact that pandemics can have on educational institutions and the school system. Nelson Mandela University

encouraged lecturers to move to online instruction as one of its initial answers to COVID-19 since this environment requires distinct methods to teaching and learning (Blignaut, 2021).

2.4.5 ICT in health

The development of mobile health (mHealth) technology resulted from the requirement to enable healthcare professionals, staff, and patients to efficiently provide and receive services at any time and any place. mHealth includes the use of wearable technologies (and sometimes enabled wireless connections) to expedite the processing and delivery of up-to-date healthcare administration information. Using mobile technology like smartphones, tablets, and hand-held gadgets with sensors for health-related objectives is known as "mHealth" (Ogundaini et al., 2021). However, like other digital systems, the effective use of mHealth ICTs to support tasks in the professional activities of health professionals at the point of care is constrained by issues. Professionals in the health care industry make up a skilled labor force that includes nurses and doctors with specialized training that do clinical work tasks to deliver care services at the point of care. The term "point of care" describes areas within clinical settings where medical personnel carry out duties involving the management of patients' health and the delivery of services (Ogundaini et al., 2021). The ability to better manage diverse workloads is one of the benefits of high-performance computing in healthcare. HPC also helps in the development of medicines for conditions like diabetes and cancer by enabling faster, more precise patient diagnosis (Cirnu & Stanescu, 2022).

2.6 Where High-performance computers are used

Due to the rise in demand for computing power, high performance computing has evolved. This is a result of the rise in demand for quick computations. High performance computing is being employed in more and more industries. These days, engineering and research require long execution times to solve issues; as a result, effective hardware-based supercomputers are exceedingly expensive to construct and manage. Applications of high-performance computing are increasingly being employed in industries for the analysis of business problems and their solutions as well as in educational institutions and laboratories for scientific research (Libri et al., 2018).

In developed countries, HPC has supplied computer power to large-scale initiatives, frequently leading to significant scientific breakthroughs and inventions at the university or corporate level. However, due to financial limitations or other issues, many academics and small enterprises do

not always have access to the HPC. Businesses anticipated that the use of HPC would open opportunities for many enterprises in the intelligent information society to acquire and commercialize new technologies. To build and dominate the market, private businesses can engage in research and development (R&D) and technology commercialization. Public organizations can also secure technologies to enhance citizen quality of life and address social issues (Lee & Lee, 2021).

Since the fourth industrial revolution is heavily reliant on HPC, its application is growing in significance across several industries (Lee & Lee, 2021). Some areas of science and engineering, such as atmospheric science, chemical separations, astrophysics, geospatial science, and evolutionary biology, depend on and demand HPC resources through simulation, experimentation, and processing large amounts of data (Tanash et al., 2019). Lack of HPC resources is a challenge for scientists, engineers, and businesses in resource limited environments (Hamza & Jiomekong, 2020).



2.6.1 HPC during COVID 19

On a scale never seen, the abrupt onset of COVID-19 has had a catastrophic effect on communities worldwide (Blignaut, 2021). After the coronavirus sickness was discovered for the first time in December 2019, it swiftly spread to the majority of cities and nations worldwide (Wang et al., 2021). Respiratory droplets are the primary means of transmission for SARS-CoV-2 during face-to-face contact. The infection may result in very serious sepsis and shock, as well as moderate upper respiratory tract infection symptoms. In vulnerable individuals, particularly the elderly with comorbidities, it may result in severe and fatal consequences (Wang et al., 2021). Modern technologies like high-performance computing (HPC), artificial intelligence (AI), blockchain, Internet of Medical Things (IoMT), and Industry 4.0 have been crucial in the COVID-19 pandemic (Majeed, 2021). By identifying potentially contaminated individuals and locations and predicting emerging trends, these tools assisted in limiting the spread of the disease (Majeed, 2021).

2.6.1.1 High performance computing

The HPC community assembled the greatest global collection of HPC resources in March 2020 to assist the critical work being done by COVID-19 researchers, realizing that HPC could speed up

understanding and the rate of scientific discovery in the fight against the virus (Brase et al., 2022). Nevertheless, earlier research hasn't given a thorough analysis of HPC use in relation to COVID-19 and its importance for mitigating and controlling this pandemic (Majeed, 2021).

2.6.1.2 Artificial intelligence (AI)

A subfield of computer science known as artificial intelligence (AI) is able to simulate intelligent behavior via machine automation systems (Nawaz et al., 2022). AI models could recognize individuals who are more susceptible to the illness and early detect COVID-19 epidemiology. With the use of artificial intelligence, scientists may be able to find new uses for already-approved drugs, identify potential vaccination targets using SARS-CoV-2 mutation models, and identify compounds that might serve as adjuvants for vaccines (Wang et al., 2021). Before conducting the pathogenic test, AI approaches were used to extract the precise COVID-19 graphical elements that aid in clinical treatment/diagnosis, thus reducing the amount of time needed for pandemic control (Almotairi et al., 2023).



2.6.1.3 Blockchain

The European Parliamentary Research Service (EPRS) claims that blockchain technology is essential for combating COVID-19. Blockchain technology can be used to safeguard patient privacy and improve the security of health data (Alsaed et al., 2021). Recently, it was proposed to use blockchain to handle and securely record COVID-19 immunizations. However, it's possible that current systems won't entirely satisfy the needs of a worldwide vaccine management system (Medina et al., 2023). Utilizing reliable and unchangeable ledgers in a decentralized system to track virus transmission is one way blockchain technology may be used to combat COVID-19 (Alsaed et al., 2021).

2.6.1.4 Internet of Medical Things (IoMT)

Medical equipment and the Internet of Things (IoT) are combined on the Internet of Medical Things (IoMT). IoMTs—a system in which every medical device is linked to the Internet and under the supervision of medical professionals—will become the foundation of future healthcare systems (Razdan & Sharma, 2022). In some countries, IoMT technology has been used in conjunction with other strategies to tackle COVID-19. The use of IoMT improves protection for front-line staff, increases effectiveness by lowering the death toll from the disease, and lowers

fatality rates (Nasajpour et al., 2020). IoT-enabled/linked devices/applications are used to decrease the likelihood of COVID-19 spreading to others by early diagnosis and patient monitoring (Nasajpour et al., 2020).

2.6.1.5 Industry 4.0

The fourth industrial revolution, or industry 4.0, is a digital shift driven by information technology that enhances machine-human connection and boosts system self-optimization. The Covid-19 pandemic has accelerated this digitalization paradigm along with the use of Industry 4.0's emerging technologies (Moosavi et al., 2021). On the other hand, there is other data that indicates Industry 4.0 is not always adequate to address the COVID-19 pandemic. Industry 4.0 might possibly have some negative repercussions because of the social distance restrictions put in place during the COVID-19 crisis (Cugno et al., 2022)

2.6.2 How HPC assisted during COVID 19

The age of information gathering, processing, analytics, use, distribution, and elimination has been significantly altered by the unique coronavirus illness 2019 (COVID-19). Owing to the COVID-19 epidemic, numerous organizations are gathering a vast amount of data to determine the likelihood of exposure or locating affected people. Also, this pandemic has expanded the use of digital tools to track compliance with quarantine regulations and evaluate people's mobility. Also, a lot of businesses have provided governments with cutting-edge solutions to help them address the COVID-19 situation (Majeed, 2021).

Modern technology has played a major part in successfully combating this pandemic. By combining human and technological resources, several nations are better able to contain the pandemic. Each technology's cutting-edge characteristics have contributed to slowing the spread of disease. Some characteristics of this epidemic, including estimation of the probability of transmission, identification of potentially contaminated sites, contact tracing, mobility analysis, flow modeling, sharing information on infected people, data analysis, geofencing of high-risk areas, compliance monitoring, trend forecasting and predicting the likelihood of ending this outbreak has increased the use of DNA through the use fusion of data from heterogeneous sources and remote technologies (Majeed, 2021).

2.6.2 HPC use in engineering and nuclear science

High-performance computing is increasingly needed for scientific research and is in the front of engineering innovation (Hou & Liu, 2020). High performance computing is a crucial tool for conducting extensive and sophisticated simulations in research and engineering as well as for preserving scientific innovation and leadership (Zhu et al., 2022). High-performance Local Area Networks are frequently used to connect numerous hosts in cluster-based high-performance computing, which employs parallel computing technologies (LANs). A task can be finished by high performance computing (HPC) clusters by allocating subtasks to various computation nodes. There are various well-established high-performance computing platforms that can control numerous computing nodes, including Rocks Cluster, Redhat HPC, and Windows Server HPC. Several disciplines have produced a variety of scientific software that can be supported by HPC machines (Zhu et al., 2022).

Nuclear research and engineering often involve large, complex nuclear systems, hence HPC is necessary. Large volumes of data, several types of reactions, and multiple physics models must frequently be considered for nuclear system simulations (Zhu et al., 2022). In most of the scientific and industrial fields, HPC makes a significant contribution. HPC aids researchers in gaining important insights to spur innovation and discovery in nearly every branch of science, including large-scale data mining, quantum physics, and life sciences (Zhu et al., 2022).

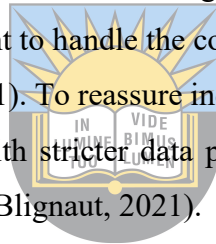
2.7 Challenges of HPC

Large-scale problems are being solved using cutting-edge methods, and programming has advanced significantly. However, there are still several conceptual and technological problems, some of which are made worse by the complexity of present and future HPC systems (Claude, 2020). HPC poses unique security and privacy concerns. Workloads for HPC systems are frequently distinct from their conventional counterparts. For example, scientific studies frequently use specialized hardware, software, and configurations that may not be regularly updated or well inspected or that provide completely new classes of vulnerabilities absent from more conventional contexts (Wofford et al., 2023). HPC can store a lot of private information (PII), intellectual property (IP), and sensitive research data that must be protected. Lastly, a range of various security

and regulatory restrictions are placed on HPC data and processing. These trade-offs need to be considered while developing solutions for data, computation, and process protection (Wofford et al., 2023).

2.7.1 Privacy and Security Issues

Due to the COVID-19 pandemic, numerous privacy and security concerns have been documented in international media due to the extensive data collecting and processing necessary to stop the virus's spread. As a result, protecting people's privacy is more important than ever (Blignaut, 2021). In the COVID-19 era, researchers might need to implement more robust institutional, constitutional, and technical safeguards to address privacy and digital application security risks because of serious privacy concerns. The issue will also get worse if researchers rely too much on digital solutions like IoE and IoT sensors, the Internet, SN, 5G networks, and HPC-based processing power. The continuing pandemic has brought to light the fact that the privacy and security systems in place are insufficient to handle the consequences for privacy and security that arise from the pandemic (Blignaut, 2021). To reassure individuals about their privacy obligations, they need to start over and comply with stricter data protection laws and regulations (such as HIPAA, IPA, GDPR, etc.) worldwide (Blignaut, 2021).



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2.7.2 High-Performance Computing Zone Threats

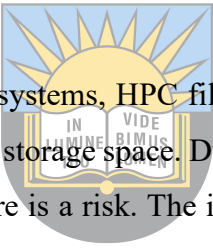
The HPC zone provides essential computational capabilities for an HPC system. Many users or tenants share the computer nodes. A major risk is the misuse of multi-user environments (side-channel attacks, leaks of user data/programs, etc.). Other sources of threats include accidental misconfigurations, software bugs caused by user-developed software, and system abuse by running applications that are not HPC mission compliant. These threats often lead to excessive resource consumption, poor performance, or complete HPC system failure. Side channel attacks, DoS and container evasion are potentially dangerous when using virtualization technologies such as containers in high performance computing (Wofford et al., 2023).

The majority of HPC applications operate in user space as a security mitigation technique, apart from system calls, which need to run in the kernel with elevated privilege. Accelerators, high-performance interconnects, specific protocols, and direct memory access between nodes are

extensively employed in the high-performance computing zone. Because of their speed, novelty, and complexity, some of these technologies may not have undergone comprehensive testing, made monitoring, and spotted suspicious behavior challenging. Direct memory access and node-to-node communication may avoid the kernel, losing the protections that the kernel provides (such as Security-Enhanced Linux [SELinux] [33]) (Wofford et al., 2023).

2.7.3 Data Storage Zone Threats

For the data storage zone, maintaining user data's confidentiality and integrity is crucial. Obtaining illegal privileged access poses a serious concern since data integrity can be compromised by intentional data deletion, corruption, pollution, or false data injection. Moreover, authorized individuals may handle sensitive data improperly, breaching confidentiality. File metadata, such as the author, size, and creation date of the file, can also reveal private information about the file (Wofford et al., 2023).



In comparison to typical enterprise file systems, HPC file systems in the data storage zone offer faster data access and significantly more storage space. Due to the enormous number of disks used in the data storage zone, hard disk failure is a risk. The implementation of incident response and contingency planning measures may be difficult, and forensic imaging, file backup, and recovery may become impossible. The performance of HPC file systems may be negatively impacted by the security controls that can be placed on corporate file systems and may require an unacceptable amount of time (Wofford et al., 2023).

Due to the abundance of data, providing data backup services is another problem in HPC. User data is frequently not automatically backed up, and users oversee keeping their own data copies current. Making data READ ONLY is one method of reducing the danger of accidental activities resulting in the permanent loss of data (such as accidentally deleting a file subdirectory). Some businesses use their own HPC systems to provide backup services, although these systems might be located close by or face similar environmental dangers (Wofford et al., 2023).

2.8 High performance computers in universities

Up until recently, HPC, which is normally only utilized in research, has been included more into undergraduate courses across disciplines. Although pricey, HPC resources are easily shared among institutions. In the context of undergraduate education, inter-institutional exchange of these materials is still quite rare (Ghosh et al., 2023). Despite the high setup and maintenance costs, HPC resources are perfect for inter-institution sharing because they do need the end user to be there. Shared HPC resources, especially those that are a component of a single system, can be used by several universities, which can help incorporate more HPC into undergraduate programs (Ghosh et al., 2023).

In recent decades, the use of computer systems to help learning processes has become more prevalent in educational practice. Because of their capacity to oversee substantial data and information, the rapid adoption of supercomputing technologies in education poses a significant challenge that has led researchers and educators to adopt a pedagogical perspective to best support the teaching of and use of these infrastructures (Fernández et al., 2019).

All of this results in new and important challenges for the higher education system, which call for thorough and comprehensive training, employing a variety of problem-solving techniques along the lines of inquiry-based learning, to encourage students' enthusiasm and curiosity. Such facilities can aid students, particularly senior undergraduate and graduate students, in developing their skills as both computer-competent users and non-competent users, helping to produce a new generation of professionals, businesses, and organizations in the field of science and technology (Fernández et al., 2019).

2.9 High performance computing in South Africa

The South Africa Center for High Performance Computing (CHPC) has merged its supercomputing and cloud infrastructures, joining the ranks of HPC facilities doing so. Until recently, the fastest computer on the continent was the 1.3 peta FLOPS Lengau supercomputer. Early in 2020, it added its OpenStack Production Cloud, enabling users to start utilizing resources for general purpose computing and storage that were orchestrated. But because of COVID-19, lockdown was implemented in South Africa on 26 March 2020, and its computing requirements

far surpassed the resources offered by Lengau and the OpenStack Production Cloud (April & Strandberg, 2021).

The South Africa CHPC, a major hub for large-scale computing in Africa, supports both academic and business research. Most recently, it took part in the search for the SARS-CoV-2 variant specific to South Africa. With supercomputing-level capacity, the Lengau cluster, installed in 2016, and its Lustre parallel file system have been utilized on several landmark projects, including enhanced weather modeling, energy storage materials, and the MeerKAT array (April & Strandberg, 2021). Additionally, it has provided funding for initiatives supported by the South Africa Development Co-Operative (SADC) and in other African nations like Ghana and Kenya. To offer processing power for the SKA's Science Data Processor (SDP), CHPC joined the Square Kilometer Array (SKA) project in 2017. South Africa is where the SKA's main construction is taking place (April & Strandberg, 2021).

2.10 HPC in universities in South Africa

Due to the ability to use these infrastructures to enhance learning, high performance computing is becoming more and more popular among a wider and more diverse population of higher education students, primarily senior undergraduates, and postgraduates (Fernández et al., 2019). In developed countries, HPC has supplied computer power to large-scale initiatives, frequently leading to significant scientific breakthroughs and inventions at the university or corporate level. However, due to financial limitations or other issues, many academics and small enterprises do not always have access to the HPC (Hamza & Jiomekong, 2020).

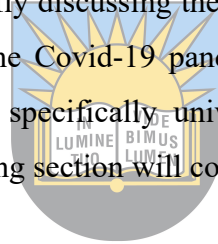
2.10.1 High performance computing at the University of Cape Town

For its research community, the University of Cape Town (UCT) provides a dependable, scalable, and computing service through its HPC facility. This is geared towards researchers that have major computing needs; however, it is also accessible to the full community, both for teaching and research (*EResearch Report 2021-2022*, 2022). The UCT HPC cluster is designed for postgraduate research under the supervision of a professor that will lead to the publication of a peer-reviewed manuscript in an acknowledged journal or an MSc or PhD. However, access is provided to the cluster for undergraduates as well (*EResearch Report 2021-2022*, 2022).

The University of Cape Town (UCT) is used in HPC research due to its status as Africa's leading research institution, its established HPC infrastructure, and strategic partnerships with national initiatives like South Africa's Centre for High-Performance Computing (CHPC). UCT's diverse academic community enables the study of varied HPC use cases across disciplines, while insights from its adoption process can guide other institutions in developing effective HPC strategies.

2.11 Conclusion

The chapter discussed the development and implementation of HPC in various fields and contexts. HPCs have infiltrated many different areas and while it may be complex to use and expensive to implement, the advantages of the technology cannot be denied. The chapter defined High-Performance Computing Systems, briefly discussing their history and why they are beneficial in economies and industries, including the Covid-19 pandemic. The chapter also discussed how HPCs are used in South Africa and specifically universities, providing an example of the University of Cape Town. The following section will cover the empirical literature review.



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Chapter 3: Unified Theory of Acceptance and the Use of Technology (UTAUT)

3.1 Introduction

The Unified Theory of Acceptance and the Use of Technology (UTAUT) is made up of four concepts which are effort expectancy, performance expectancy, social factors and facilitating conditions and four moderating variables (age, gender, education, and voluntariness of use). The constructs directly influence the assessment of behavioral intention in combination with various moderating variables. The UTAUT has been extensively used to assess how well technologies are received (Raffaghelli et al., 2022). Since its creation, the UTAUT has been extensively tested and utilized to estimate system usage and make judgments about the adoption and use of technology (Chao, 2019). Most academics concur that using modern technologies in education can enhance student experience and knowledge (Alhramelah & Alshahrani, 2020).

This chapter will discuss the UTAUT and how it was created. It will also further discuss a model that was created that discusses various concepts which affect the adoption of technology.

3.2 Model unified theory of acceptance and use of technology

The UTAUT is based on the principles of psychology and sociology, the aim of UTAUT is to explain the user's "why" and "how" of using information systems (Puspitasari et al., 2019). The study of Venkatesh et al. (2003) was the first to use the UTAUT on the use of information technology (Ferzizi & Louail, 2020). Numerous applied research studies have focused on the UTAUT. The UTAUT provides a framework that addresses not only the actual application of these technologies and systems but also the acceptance of IT and IS (Chao, 2019). Within the combined UTAUT, there are determining elements that have a direct impact on intention or use. These determining factors are performance expectancy (PE), social influence (SI), effort expectancy (EE) and facilitating conditions (FC) (Ayaz & Yanartaş, 2020). The UTAUT considers several current technology acceptance models. The UTAUT is more complicated but highly explainable and has been actively used in technology acceptance research, including research on adoption of Internet of Things (IoT) devices over the last few years (Ayaz & Yanartaş, 2020).

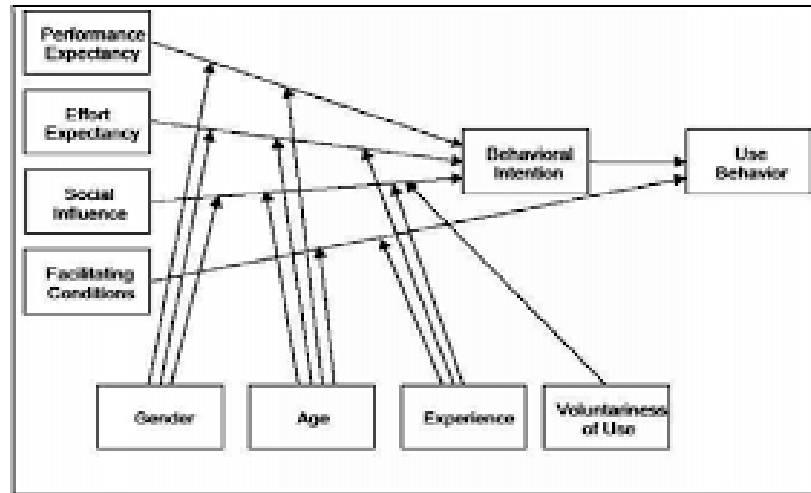


Figure 3: UTAUT (Venkatesh et al., 2003)

3.2.1 Performance expectancy

The degree to which a person believes that using the system would help him or her perform better on the job is known as performance expectation (Chao, 2019). This is the primary independent factor influencing a person's behavioral intention to utilize technology (Alhramelah & Alshahrani, 2020). Performance expectancy has been shown to have an impact in both voluntary and compulsory settings as well as in less experienced circumstances. However, from a theoretical standpoint, performance expectancy might vary based on a person's age and gender (Ayaz & Yanartaş, 2020). An essential component influencing the behavioral intention to use technology is performance expectancy (Shiferaw & Mehari, 2019).

3.2.2 Effort expectancy

The UTAUT includes effort expectancy, which is a key predictor of technology adoption (Chao, 2019). The effort expectation is defined by the system's degree of ease of use. Effort expectancy describes the system's level of usability convenience. The effort expectancy component affects behavioral intention in contexts where use is both voluntary and required. However, it has been noted that with long-term and continuous use, the effort expectancy factor becomes insignificant, which supports earlier findings (Ayaz & Yanartaş, 2020). The effort expectancy assesses the learnability, adaptability, usability, and interface design of a system (Ayaz & Yanartaş, 2020).

3.2.3 Social Influence

The extent to which a person considers it crucial that others think they should adopt a new system is known as social influence (Momani, 2020). In numerous studies using the UTAUT, it has been demonstrated that the social influence element has a major impact on intention to use (Ayaz & Yanartaş, 2020). Social influence is defined by Venkatesh (2003) as it is the knowledge of significance that others attribute to the user for the use of the system. This construct shows how the opinions and perception of others in the immediate social group influences the use of online systems within higher education institutions (Alhramelah & Alshahrani, 2020). According to (Alhramelah & Alshahrani, 2020), as social media sites are changing and information technology becomes more advanced, the focus of the construct has shifted from the physical to the virtual.

3.2.4 Facilitating conditions

The degree to which a person thinks that an organization and technological foundation exist to facilitate the use of the system is referred to as the concept of facilitating conditions (Momani, 2020). Other relevant research on technology adoption found that facilitating condition was a key determinant of behavioral intent to use technology (Shiferaw & Mehari, 2019). Facilitating conditions have an immediate positive impact on intent to use, but the effect disappears after the first use, so the model suggests that facilitating conditions have an immediate significant impact on use behavior (Momani, 2020).

Organizational and IT infrastructures (such as systems, internet speeds, cloud connectivity, computers, etc.) represent facilitating conditions. This construct has proven to be effective in the literature on technology adoption (Wamba & Queiroz, 2019). The facilitating conditions range from procedural to human support and technical support to organizational support (Alhramelah & Alshahrani, 2020).

3.3 How UTAUT was developed

UTAUT was developed using eight theories, those eight models are: Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behavior (TPB), a model which combines TAM and TPB (C-TAM-TPB), Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT), and Social Cognitive Theory (SCT) (BERNOVA et al., 2020).

3.3.1 Theory of Reasoned Action (TRA)

Theory of Reasoned Action (TRA) is a generalized theory that can be used to explain almost any human behavior. The theory was first proposed in 1991 by Martin Fishbein and Icek Ajzen (Hewavitharana et al., 2021). Theory of Reasoned Action (TRA) describes conduct that modifies itself in response to the outcomes of its goals, which are in turn impacted by societal standards and personal perspectives on action (Bernova et al., 2020). The theory was created by using research in social psychology. One of the most fundamental theories of human behavior is said to be TRA (Mohamed et al., 2021). In accordance with TRA, a person's conduct is determined by their behavioral intention (BI) to carry out the behavior. BI is a measure of how much effect a person's intention to engage in that behavior has, and it is determined by two variables: attitude toward behavior and subjective norm concerning behavior (Mohamed et al., 2021). TRA provided a theoretical framework for comprehending human behavior, which was a major contribution to IS acceptance theories (Momani, 2020).



3.3.2 Technology Acceptance Model (TAM)

Davis (1989) used these TRA and TPB as the foundation for the Technology Acceptance Model (TAM). TAM uses two perceptions to predict intention to utilize a particular technology: perceived usefulness and perceived ease of use (Sagnier et al., 2020). Perceived usefulness is the degree to which an individual believes that using a particular technology would enhance his or her capacity to complete tasks. Perceived ease of use is the measure of how easy a system is seen by a user to operate. According to numerous studies, perceived usefulness is the best indicator of usage intention (Sagnier et al., 2020). TAM has been widely utilized by researchers to characterize various information system types. For example, teachers utilized TAM and modified TAM models to explain user behavior in E-learning systems; online shopping, e-commerce, and online banking systems; e-services; and acceptance of Radio Frequency Identification (RFID) (Hewavitharana et al., 2021).

The fact that there has been a considerable amount of effort on TAM shows how well accepted technology is in general. However, there is still a gap in existing knowledge regarding representative academic literature that underlie research on TAM in educational context (Granić & Marangunić, 2019). Some academics disagree and argue that the TAM has many disadvantages,

such as (1) not providing enough context for people's perceptions of innovative systems; (2) ignoring its indicators and focusing on the external variables of perceived usefulness (PU) and ease of use (PEOU); and (3) ignoring the connection between usage intention and usage attitude (Chao, 2019).

3.3.3 Motivational Model (MM)

The motivational theory has been used in numerous research to explain how people react in various situations. Most motivational theory studies agree that humans are motivated by both inner and external factors. The MM constructs are built upon these two determinants. In information system research, motivational theory has been applied to comprehend how new technologies are adopted and employed. It is well recognized that the main elements influencing an individual's inclination to embrace new technologies are extrinsic and intrinsic motivation (Mohamed et al., 2021). The core constructs for MM are intrinsic Motivation, users would want to perform an activity. Extrinsic Motivation Users would want to perform an activity “because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions” (Mohamed et al., 2021: p. 201). This model suggests that people's willingness to use computers at work is largely driven by how useful they are in improving their work performance and how much fun they have using them. This model also found that the ability of the system to be enjoyed could increase the adoption rate unless it reduces the usefulness of the system (Hewavitharana et al., 2021).

3.3.4 Theory of Planned Behavior (TPB)

The theory of planned behavior (TPB) has been successfully applied to explain and predict behavior in a wide range of behavioral domains, including consumer behavior, recycling, safer sex, drug use, technology adoption, and privacy protection, to name a few (Ajzen, 2020). The TPB states that three different types of considerations govern human behavior: beliefs about the likely consequences of the behavior (behavioral beliefs), beliefs about the normative expectations of others (normative beliefs), and beliefs about the existence of factors that may help or hinder the performance of the behavior (control beliefs). In their respective aggregates, behavioral beliefs result in a positive or negative attitude toward the behavior, normative beliefs provide a sense of

societal pressure or a subjective standard, and control beliefs produce a sense of behavioral control or self-efficacy. The influences of attitude toward the behavior and subjective norm on intention are moderated by perception of behavioral control. Positive attitudes, subjective norms, and feelings of control are generally higher when an individual has a stronger motivation to engage in the desired action. In conclusion, individuals who possess a considerable degree of genuine control over their actions are expected to follow through on their objectives when the opportunity arises. Therefore, it is considered that behavior has an immediate cause, which is intention (Bosnjak et al., 2020).

3.3.5 Combined of TAM and TPB Model (C-TAM-TPB)

This model incorporates the "perceived usefulness" concept from TAM together with the TPB constructs. To evaluate the variables in both models and identify the factors that have a bigger influence, several studies have merged TPB and TAM (Mohamed et al., 2021). To identify the intentions behind the usage of technology and its behavior, the TAM is regarded as a model that is acknowledged and accepted by many studies. Despite the TAM model's exclusion of social and control elements, these two components have a direct impact on behavioral changes. Taylor and Todd therefore combined the TAM with the TPB parts to produce the C-TAM-TPB model (Hewavitharana et al., 2021). This model's primary characteristic is the variation between intention and conduct, which enables it to be used to both tech-savvy individuals and non-tech-savvy individuals. Additionally, compared to individual TAM or TPB models, this model enables a better interpretation for the acceptance of technology because it incorporates subjective norms and perceived behavioral control variables (Hewavitharana et al., 2021).

3.3.6 Model of PC Utilization (MPCU)

The Model of PC utilization (MPCU), first proposed by Thompson et al., (1991), differs from theory of reasoned action in that it distinguishes cognitive and affective components within attitude. In MPCU's view, behavior is shaped by people's beliefs – what they envision as desirable outcomes, a set of social standards – judgments about what is needed, their behaviors, what they typically do, and a set of anticipated outcomes of their behavior. This model measures an employee's level of PC (personal computer) use in situations where use of the device is optional within the company and value is assigned based only on the user (Sebastián et al., 2022).

This approach is consistent with the common view that PC use is impacted by a variety of factors, including affect, norm, and habits. The social conventions around PC use in the workplace have an impact on the user's affect, or feelings regarding using a computer. Conventional practices surrounding its utilization stem from outcomes, prior PC experiences, and the circumstances that are already in place at work (Sebastián et al., 2022).

3.3.7 Innovation Diffusion Theory (IDT)

Innovation Diffusion Theory (IDT) has been used to investigate numerous innovation components across several academic disciplines since the 1960s. Why various innovations require varied rates of adoption may be explained by the aspect of qualities as perceived by an individual. In the context of IS research, Rogers' original model was modified and improved to fit technology adoption studies (Mohamed et al., 2021).

IDT is one of the most well-known theories that has attempted to determine what elements affect a person's decision to accept a new technology or product. It proposes a connection between the features of innovations and their acceptance. The adoption rate is based on the following constructs: compatibility, relative advantage and complexity, compatibility, trialability, and observability. It tells how, why and at what rate new concepts and technologies will be adopted across different cultures (Hewavitharana et al., 2021).

Table 2

Constructs of DIT (Hewavitharana et al., 2021)

Constructs	Definition
Compatibility	How much of an innovation is perceived as being difficult to understand

	and implement
Relative advantage	The extent to which people believe a new idea is better than an old one
Complexity	The extent to which an idea is thought to be comparatively challenging to comprehend and apply
Trialability	The extent to which an invention can be tested in a restricted setting
Observability	How much the innovations can be observed by other people



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3.3.8 Social Cognitive Theory (SCT)

The Social Cognitive Theory (SCT) discusses how an individual's surroundings and personal circumstances affect their conduct (Hewavitharana et al., 2021). It is made up of three main parts: behavior, personal factors, and environmental factors, which are interconnected. The expectations, beliefs, self-perceptions, objectives, and intentions that everyone possesses give their behavior structure and direction when examining the relationship between behavior and personal elements. In contrast, the relationship between environment and personal factors illustrates how personal factors (e.g., human expectations, preferences, emotions) are influenced by social factors. Human reactions are triggered by social cues (e.g., age, body shape, race, gender, physical attractiveness, etc.) (Hewavitharana et al., 2021).

One of the most significant theories in the study of human behavior is SCT. To investigate IS research on computer usage, SCT is being further developed. The model was first created for the study of computer usage, but because it incorporates a shared core principle, it may also be used to examine how people embrace and use information technology (Mohamed et al., 2021). The social cognitive theory also suggests that behavior and environment are related to one another. In the interactions of daily life, behavior changes the environment, and the environment changes the behavior. An individual is unlikely to adopt innovations, for instance, if the external environment is dominated by old methods and top management is resistant to technology. Therefore, that person's behavior is influenced by their external work environment (Hewavitharana et al., 2021).

3.4 Empirical model

Researchers have proposed several theories of planned behavior (TPB)-based models to explain and forecast public acceptance of technology use. Performance expectations, effort expectations, social influence, facilitating conditions, and forecasting behavioral intention to use a technology and satisfaction with usage in business environments are all part of the unified theory of acceptance and use of technology (UTAUT) (Mohamed et al., 2021). Students' attitudes toward technology have long been seen as an indicator of technological literacy. However, there is still little evidence on how students interact with the components of technological literacy. Furthermore, student attitudes are shaped by a wide range of direct and indirect factors. Technological literacy plays an important role in the innovative economy (Rupnik & Avsec, 2019). In essence, understanding

technology adoption has always been a top priority in the IS industry. There are many factors that influence how people adopt technology. These can be both good and bad, and they can come from both internal and external of people (Inan et al., 2022).

3.4.1 Computer self-efficacy

One of the most significant psychological concepts examined in organizational literature is self-efficacy, or the belief in one's capacity to carry out a specific behavior (Gupta & Bostrom, 2019). Self-efficacy refers to how well people believe they can execute a particular task. It has less to do with a person's skills than it does with how they apply those skills. Self-efficacy is the conviction that an individual has the abilities and skills necessary to succeed in an activity involving technology (Chao, 2019).

These beliefs determine the behaviors we choose to engage in, the amount of effort we put forth, and the expectations we have for a particular outcome when carrying out a task. A high degree of self-efficacy enhances performance and speeds up cognitive processing (Meinhardt-Injac & Skowronek, 2022). It has been argued to be the most significant predictor of behavioral shift in people (Gupta & Bostrom, 2019). An individual with low perceived computer self-efficacy, has less interest in learning how to use computers (Meinhardt-Injac & Skowronek, 2022). High computer self-efficacy predicts computer usage frequency and improves computer abilities (i.e., computer performance). There may be a reciprocal aspect to this relationship: High computer performance and frequency of use may boost computer self-efficacy (Meinhardt-Injac & Skowronek, 2022).

The ability to utilize a system effectively and to learn and master the skills necessary for efficient computer use are both significantly influenced by one's level of computer self-efficacy (Meinhardt-Injac & Skowronek, 2022). Numerous research studies have revealed that one of the key factors influencing how well educational systems are received is self-efficacy (Almaiah et al., 2019).

While research on computer self-efficiency has improved our understanding of its effectiveness, there are two main issues with the literature: 1) inconsistency in usage and 2) problems with measurement. A few research studies have employed computer self-efficacy as an independent and dependent variable. Reviews in this field, however, have drawn attention to the term computer self-efficacy's inconsistent use to refer to a variety of ideas (Gupta & Bostrom, 2019).

H1: Computer Self-Efficacy would positively influence attitude towards high-performance computing systems.

H01: Computer Self-Efficacy would negatively influence attitude towards high-performance computing systems.

3.4.2 Perceived usefulness

Perceived usefulness (PU) of an information system is defined as “the extent to which individuals believe that using the new technology will improve their task performance” (Kasilingam, 2020: p. 10). According to preliminary research, perceived utility is a crucial element in the technological area that encourages the employment of a certain technology (Kasilingam, 2020). Usefulness refers to the ability of a technology to reduce the duration of and effort needed to learn or use it because, in essence, people think the technology is simple to use and doesn’t make it hard for users to perform their tasks (Neves et al., 2022). PU has multiple aspects, including simplifying tasks, boosting output, improving efficiency, improving job performance, and assisting in obtaining raises, bonuses, and other rewards (Wicaksono & Maharani, 2020). Therefore, users are more inclined to use technology when it is more beneficial to them (Tahar et al., 2020).

H2: Perceived usefulness would positively influence high-performance computing systems.

H02: Perceived usefulness would negatively influence high-performance computing systems.

3.4.3 Perceived ease of use

Perceived ease of use (PEU) is described as "the extent to which an individual believes that using a particular technology will require little or no mental effort." Additionally, ease of use is a sign of technology acceptance (Kasilingam, 2020). Users have higher interest in using a technology if they feel it is easy to use (Tahar et al., 2020). PEU has several different characteristics, like being simple to use, responding quickly, having an excellent and simple to grasp display or interface, and being accessible everywhere and at any time (Wicaksono & Maharani, 2020).

Several researchers have found that people who utilize technology often have preconceived notions about how simple or complex it will be to use. Thus, researchers must study the perceived ease of use from users to understand the of use, according to studies, hence this factor needs to be carefully taken into account (Kasilingam, 2020). Along with perceived usefulness, perceived ease

of use is a fundamental concept that is essential to the process of a technology being adopted (Chen & Aklikokou, 2020).

H3: Perceived ease of use would positively influence attitude towards high-performance computing systems.

H03: Perceived ease of use would negatively influence attitude towards high-performance computing systems.

H4: Perceived ease of use would positively influence intention to use high-performance computing systems.

H04: Perceived ease of use would negatively influence intention to use high-performance computing systems.

3.4.4 Attitude

An individual's attitude refers to their capacity to assess a symbol, object, or aspect of the world in a positive or negative manner. Even though socialization is the process by which attitudes are acquired, cultural and social factors cause attitudes to differ between individuals and groups. A person's attitude can be defined as their "personal beliefs and views" or a "learned, global evaluation of an object (person, place, or problem)" (Mafhoum, 2023: p. 5). Since attitudes are based on beliefs, an attitude can also be based on an overall assessment of different beliefs (Luik & Taimalu, 2021).

Attitude toward Technology Use (ATU) is a measure of willingness to utilize technology. Studies have frequently examined how attitudes regarding technology use affect people's intentions to utilize technology (Luik & Taimalu, 2021). Studies on attitudes toward technology education have primarily focused on the affective attitudinal component (Svenningsson et al., 2022).

Many academics have identified the elements that influence people's perceptions of using technological improvements. A person's beliefs about their capacity to do so and their judgments of what other people think they should do (i.e., subjective norms) (i.e., perceived behavioral control) affect their attitudes toward partaking in a particular activity (Mafhoum, 2023).

It is crucial for technology education research to examine students' attitudes, including what drives attitudes and the nature of the affective, cognitive, and behavioral components of attitudes

(Svenningsson et al., 2022). An attitude is an assessment of a mental nature object that can be expressed in terms like good versus poor, pleasant versus unpleasant, or likeable against dislikeable. Traditionally, attitudes have been thought of as consisting of three main parts: affective, cognitive, and behavioral components (Svenningsson et al., 2022).

For example, a person's attitude towards technology is based on their beliefs about the topic, and those beliefs can influence their behavior. The cognitive component is concerned with the role cognition plays in a person's attitude toward a particular psychological object, including beliefs and/or thoughts about a particular technology. A person's favorable or negative feelings about a specific technology, such as the above dimension of pleasant versus unpleasant, are the focus of the affective component (Svenningsson et al., 2022).

The theory of planned behavior (TPB) is among the most well-known theories concerning the connection between overall attitude and behavior. This theory states that attitude is made up of both cognitive and affective components. Behavioral intention, the primary driving force behind conduct, is influenced in part by the affective and cognitive aspects of attitudes. Therefore, it is believed that these two aspects of attitude directly lead to behavioral intention (Svenningsson et al., 2022).

H5: Attitude toward high-performance computing systems would positively influence intention to use high-performance computing systems.

H05: Attitude toward high-performance computing systems would negatively influence intention to use high-performance computing systems.

3.4.5 Intention to use

User "intention" is described as a person's level of commitment to achieving the target behavior as well as their willingness to pursue a specific behavior (Alhramelah & Alshahrani, 2020). A person's intention to continue using new media and technology is referred to as their behavioral intention to utilize. According to literature, one's attitude toward using a computer affects their behavioral intention to use (ITU). If the user has a positive attitude towards using computers, they will create an intention to use computers consistently (Teo, 2019). For instance, users that have strong ITU are more likely to use university resources for teaching and learning than those with lower intentions. When users see technology as useful, it would directly impact their ITU

technology (Teo, 2019). When a person or organization doesn't think the system can assist them with their task, they have no intention of using it (Wicaksono & Maharani, 2020). An individual's initial intention to use a specific technology forms the basis of the adoption perspective. The user's usage behavior is what determines whether or not they intend to accept and use a technology (Nassar et al., 2019).

H6: Intention to use high-performance computing systems positively affects the actual use of high-performance computing systems.

H06: Intention to use high-performance computing systems negatively affects actual use of high-performance computing systems.

3.4.6 Social Influence

Social influence refers to the extent to which consumers feel that others think they should be using a particular technology. This third construct in UTAUT's model can significantly affect user adoption. (Almaiah et al., 2019). Decision-making is influenced by those in close proximity to an individual (Chen & Aklikokou, 2020). Social influence can be exerted by family, friends and peers (Wamba & Queiroz, 2019). Technology adoption research has long placed a high priority on the issue of how social effects from individuals or the referent group impact the adoption of innovation. Potential users estimate the usefulness of an innovation based on their prior experience with similar products and information from reliable sources, including those considered important. A significant originator of the decision to adopt new technologies is the social impact of the referent population (Yoo et al., 2021).

H7: Social Influence would positively influence actual use of high-performance computing systems.

H07: Social Influence would positively influence actual use of high-performance computing systems.

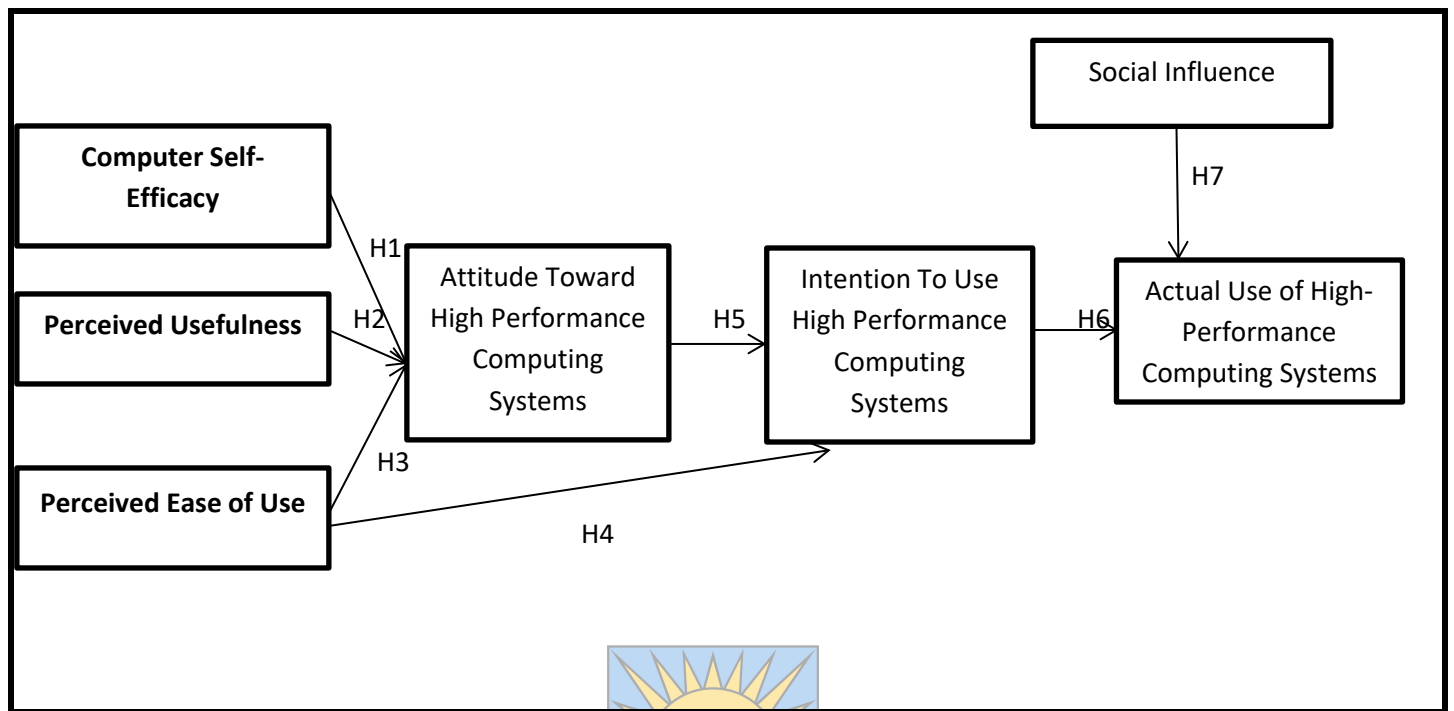


Figure 4: The empirical model (own source)

3.5 Conclusion

This chapter presented the theoretical literature that is the grounding of this study. The UTAUT was discussed in detail as well as how it was developed. The chapter then presented the UTAUT within the context of the study to explain making use of empirical literature how the hypotheses of the study were developed. Finally, the chapter concluded with the empirical model that will be used to test the hypotheses to determine what factors influence the adoption and continued use of adoption and usage of HPCs in higher education.

Chapter 4: Research design and methodology

4.1 Introduction

An empirical study is a type of research approach in which a phenomenon is investigated through the application of approved scientific methodologies. One of the most important parts of research is the research methodology since an empirical study needs to explore both the known and unknown components of the topic being studied (Kumatongo & Muzata, 2021). The design, processes for gathering and analyzing data, and subject selection are among the elements of a study that are included under research methodology (Kumatongo & Muzata, 2021).

The term methodology refers to the methodologies, types, and paradigms of study, whereas methods refer to the instruments utilized in data collection, inference, and interpretation. Methodology is the philosophy of how research should be conducted, comprising the presumptions, guidelines, and protocols controlling the application of techniques (Farghaly, 2019). The specific investigative instruments or processes utilized to collect and process data are called methods. It is evident that technique has an impact on the methods selected (Farghaly, 2019).

4.2 Research paradigm

Scientists utilize a set of common presumptions and guidelines called research paradigms to formulate and address issues. To respond to the three fundamental problems of ontology, epistemology, and synthesis, scientists use paradigms (Kumatongo & Muzata, 2021). Modern social work research is organized and structured by a number of paradigms or worldviews (e.g., post positivism, constructivism, participatory action frameworks, or pragmatism) They all have the following characteristics and are fundamentally philosophical in nature: axiology, ontology, epistemology and methodology (Kaushik & Walsh, 2019).

4.2.1 Positivism

Positivism is a research paradigm that seeks to explain and predict what happens in the social world by searching for regularities and causal relationships between its constituent elements (Bonache & Festing, 2020). According to positivists, reality is a single, cohesive world that can be discovered via scientific enquiry. Experiments and other scientific approaches only produce

conclusive results that cannot be subject to numerous interpretations. Similar to ontological, positivists believe that reality is predetermined objectively and that it can be measured using characteristics that are independent of the researcher and his or her tools. Knowledge is thought to be measurable and objective (Kumatongo & Muzata, 2021). According to this paradigm, it is typical to assume that things can be understood through models and relationships between variables, and that it is the responsibility of researchers to offer (deductive-nomological) explanations through broadly applicable causal mechanisms that can be empirically measured (Bonache & Festing, 2020). Positivism is therefore closely linked to objectivism which argues that reality exists external to the researcher and must be investigated through a rigorous process of scientific inquiry (Kumatongo & Muzata, 2021).

Positivism will be used in this study as the research philosophy. The positivism paradigm is appropriate for this study as the objective was to prove hypotheses to generate explanatory linkages or casual relationships that ultimately lead to predictions of the main research question.

4.2.2 post-positivism

Post-positivism is a pluralistic approach to political and social issues, rather than the traditional positivist approach of analyzing issues in terms of what the majority say is acceptable. This paradigm includes historical, comparative, philosophical and phenomenal analysis as well as quantitative analysis along with historical, historical, and sociological analysis (Shah, Ansari & Panhwar, 2017). Post-positivism is an approach to thinking that challenges the traditional notion of absolute positive knowledge about human behavior and actions. Researchers can now use a new paradigm in which they are able to identify and assess the causes that influence outcomes, such as those found in experiments (Kumatongo & Muzata, 2021). Post-positivists promote the triangulation of qualitative and quantitative methods to explore the diversity of facts researchable through various kinds of investigations but respecting and valuing all findings as the essential components for the development of knowledge (Kumatongo & Muzata, 2021).

4.2.3 Interpretivism

Interpretivism is an approach to philosophy which aims to make sense of the meanings and intentions of individuals in each context. It does so without imposing a priori analytic categories, such as those imposed by sociologists and anthropologists for analysis of human behavior or

language (Bonache & Festing, 2020). Interpretivists are researchers who believe that there is no single correct way or method to knowledge and that no objective knowledge is independent of thinking or human reasoning. Interpretivists believe in reality based on people's subjective experiences of the external world, rather than objective knowledge (Kumatongo & Muzata, 2021). The supporter of interpretive paradigm believes in the deep understanding of a concept and explores the understanding of the world in which they live. They develop subjective meanings of their experiences or towards certain objects or things. This paradigm is also called Constructivism, Social Constructivism or Qualitative Research paradigm (Rahi, 2017).

4.2.4 Pragmatism

Pragmatism is a philosophy which embraces both quantitative and qualitative designs; hence it underpins the mixed method philosophical paradigm. Pragmatics are pluralists in that they are not inclined to one system of philosophy like positivists and interpretivists. The use of mixed designs by pragmatics enables researchers to have a thorough understanding of the phenomena under study. (Kumatongo & Muzata, 2021). The aim of Pragmatism is to find the weaknesses in the study and to strengthen them by using a mixed method approach. Instead of method being important, researchers should use all approaches to understand the problem statement. The researchers are free to use both quantitative and qualitative approaches (Rahi, 2017). Pragmatism is the dominant paradigm in mixed research methodologies because it is applicable in contexts with complex social processes (Kumatongo & Muzata, 2021).

4.3 Research approach

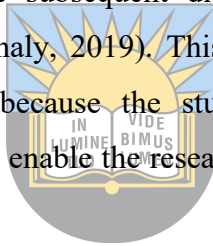
Some professionals utilize two distinct study methodologies in the field of science: the quantitative approach, and the qualitative approach (Atmowardoyo, 2018). There are three general types of research methodologies: mixed methods, quantitative methods, and qualitative methods (Boru, 2018).

4.3.1 Quantitative

A quantitative researcher uses methods from the natural sciences that are designed to ensure objectivity, generalizability, and reliability. Quantitative research is an objective form of conducting research where knowledge should be proved by scientific methods and not by feelings,

opinions, values and personal interpretations (Kumatongo & Muzata, 2021). The scientific methodology, the quantitative method, has its roots in the positivist worldview. This approach ignores an individual's emotions and sentiments as well as the context of the surroundings and instead concentrates on gathering new data from a broad population in line with the problem. Similar to this, we've spoken about how the quantitative approach measures something objectively through actions and opinions, allowing researchers to describe data rather than interpret it (Rahi, 2017).

There are several designs that may be created using the quantitative research approach, including experimental, quasi-experimental, and non-experimental designs. There are types and techniques for each of these designs. One group of people receives an intervention in an experimental design, while another group does not. It would be ideal if the two groups were comparable so that the intervention could be blamed for the subsequent difference. The most popular design in quantitative research is this one (Farghaly, 2019). This study will use a quantitative research approach. This approach was used because the study formulated hypotheses to explain observations. Quantitative research will enable the researcher to identify relationships within the data collected.



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4.3.2 Qualitative

Qualitative studies seek to explore individuals' understanding of a social phenomenon. Mohajan (2018) defines qualitative research as a form of social action focusing on how people interpret and make sense of their experiences to understand the social reality of individuals. The majority of qualitative studies are investigative processes in which researchers use comparison, contrast, replication, cataloging, and classification to progressively make understanding of a social phenomenon (Kumatongo & Muzata, 2021). A qualitative method is employed to collect in-depth data regarding a specific topic. This approach assumes that one person speaks for the group's emotions, which are just as important to understand but are ignored by the quantitative method. This tactic is commonly employed by the interpretive community (Rahi, 2017). Qualitative research uses the inductive method to look for patterns and links in the visible data before creating and testing hypotheses to generate theory. Accordingly, theory advances in qualitative research through the course of the study (Farghaly, 2019).

4.3.3 Mixed methods

The “third methodological orientation,” sometimes known as mixed methods research, builds on the advantages of both quantitative and qualitative research designs (Kumatongo & Muzata, 2021). In mixed research, data are collected and examined in a single study or program of inquiry utilizing both qualitative and quantitative approaches. After integrating the findings, conclusions are made (Kumatongo & Muzata, 2021). The main goal of mixed methods research, which integrates qualitative and quantitative research components, is to reinforce and expand a study's findings and, as a result, add to the body of published literature.

4.4 Research design

The research method is a systematic procedure that a researcher uses to solve the defined research questions (Atmowardoyo, 2018). The “procedures for collecting, evaluating, interpreting, and reporting data in research investigations” are known as research designs. It is a broad method for connecting conceptual research problems to the pertinent (and feasible) actual study. To put it another way, the study design establishes the procedures for gathering, analyzing, and applying the data to address the research issue. Exploratory, descriptive, and explanatory research designs are the three types that can be used (Boru, 2018, p. 57).

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4.4.1 Exploratory research

The purpose of exploratory research is to generate preliminary ideas and insights and to provide guidance for any further research that may be needed. An exploratory study is essential when a researcher wants to identify problems, provide a more exact description of the problem, and set any objectives or data. Exploratory research is when a study is conducted to investigate a topic about which little is known or to determine whether a certain research study may be conducted (Swaraj, 2019).

Exploratory research is done when there is insufficient information available about a phenomenon or an issue that has not been fully identified. It simply dives into the topic at different levels of complexity rather than attempting to address the research difficulties definitively. That means that its main objective is to solve novel problems for which little or no previous research has been done. Even in the worst situation, exploratory research sets the initial sample plan, research design, and

data collection method and lays the groundwork for subsequent, more definitive research (Boru, 2018).

4.4.2 Descriptive research

Research methodologists generally agree on the definition of descriptive research. Finding the best accurate description of the phenomena that already exist is the goal of descriptive research. The term "existing phenomena" distinguishes experiment research—which similarly observes phenomena following a certain duration of treatment—from descriptive research. Descriptive research finds phenomena that are already well-known. A researcher must use research instruments such as tests, questionnaires, interviews, and even observation to compile the data that is currently available. The main goal of descriptive research is to accurately describe the events under study (Atmowardoyo, 2018). Descriptive research includes some subcategories of research methods such as surveys, correlation studies, qualitative studies, or content analysis (Atmowardoyo, 2018).

4.4.3 Explanatory research

Explanatory research, on the other hand, seeks to support and clarify the descriptive data. Consequently, as opposed to "what" questions like those in descriptive research, "why" and "how" questions are the focus of explanatory studies. It builds on exploratory and descriptive research to identify the real reasons for a phenomenon. Explanatory research looks for reasons and drivers and provides information that can be utilized to support or refute a theory or hypothesis. It is done in order to identify and document any correlations between different aspects of the event under study (Boru, 2018).

4.5 Data Collection

Data collection refers to the process of gathering and analyzing information on variables of interest in a defined and methodical way to evaluate findings, test hypotheses, and respond to specific research questions. The data collection stage of research is common to all academic fields, including the humanities, social sciences, business, and physical sciences. Regardless of the research topic or favored data definition approach (qualitative versus quantitative), accurate data collecting is essential to maintaining the integrity of the study (Muhammad & Kabir, 2018). Being a highly specialized activity, research involves more than just compiling information and writing

an outline. It comprises the deliberate collection of data, which is subsequently subjected to in-depth analysis to provide answers to research questions and evaluate the results. The primary element of any research approach, regardless of the topic under investigation, is data collection (Parveen & Showkat, 2017). The data in this study will be examined using Cronbach's Alpha, as indicated in the table below.:



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Table 3

Scales to be used

Variable	Cronbach Alpha Coefficient	Source
Intention to Use High Performance Computing Systems	0.82	(Gao et al., 2012).
Attitude toward High Performance Computing Systems	0.86	(Herath & Rao, 2009).
Social Influence	0.76	(Venkatesh et al., 2003; Venkatesh & Zhang, 2010; Foon & Fah, 2011; Sripalawat et al., 2011).
Actual Use	0.82	(Rachman & Napitupulu, 2017).
Perceived Usefulness	0.91	(Davis, 1986)
Perceived Ease of Use	0.91	(Davis, 1986)
Computer Self-Efficacy	0.85	(Davis, Bagozzi & Warshaw,



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4.5.1 Primary data collection

Data that has been obtained from first-hand experience is known as primary data. Primary data is not yet released and is more trustworthy, real, and objective. Primary data has a higher level of validity than secondary data because it has not been changed or tampered with by humans. The importance of original data When conducting statistical surveys, it is imperative to obtain information from original sources and work with primary data (Muhammad & Kabir, 2018).

Information that the researcher has personally gathered is referred to as primary data. The information is purposefully gathered by the researcher because there are no previous recordings of the data that are accessible to the public. To collect primary data, a range of methods can be employed, such as focus groups, interviews, surveys, and more. These kinds of data are thought to be quite reliable (Parveen & Showkat, 2017).

4.5.2 Secondary data collection

Information obtained from a source that has previously been made available in any format is referred to as secondary data. Secondary data is the foundation of any research that makes use of literature reviews. It is gathered by someone else with a different intent, but the investigator uses it for something else (Muhammad & Kabir, 2018).

Information that has been collected and processed by someone and is accessible to the public is known as secondary data. It is the data that the investigator has acquired from various sources and from past investigations. When primary data is used for one study project and then again for another, it becomes secondary data. Examples of secondary data include departmental records, government reports, census data, and so forth (Parveen & Showkat, 2017). Both primary and secondary data were collected in this study. Primary data was collected by using an online survey. Primary data was used in this study because it is very reliable and authentic as it has never been published before. Secondary data is used because it is readily available, and the researcher will collect the data much easier.

4.5.3 Ethnography

The systematic study of communities and cultures is known as ethnography. It records, observes, and analyzes members of a society in their natural “environment” or “fields.” The information is acquired using techniques meant to record their typical behaviors and the social connotations associated with them. For the goal of gathering data, the researcher may observe the events rather than actively participate in them. While recording the material, care is taken to avoid imposing its meaning on the respondents. One of the main techniques for gathering qualitative data in the social sciences is ethnography. They give detailed descriptions of the traditions, customs, behaviors, and shared characteristics of various societies and cultures (Parveen & Showkat, 2017).

There are numerous formats for ethnographic research. Confessional, life history, feminist, realist, critical, and other types of ethnographic research are a few examples. Out of all the possible forms, realistic and critical ethnography are the two most common and popular types of ethnographic study (Sharma & Clark, 2018).



4.5.4 Netnography

Netnography has become a commonly used research technique in the social sciences. It has been applied to a wide range of issues, including culture, identity, interpersonal relationships, and civic empowerment. A qualitative research methodology known as “netnography” can be broadly defined as one that applies classic ethnographic methods to the study of the “net,” which refers to the online communities, customs, and cultures created by computer-mediated interactions (Addeo, Paoli & Esposito, 2019).

Netnography is much less time-consuming from a data collection perspective, even though it demands a new set of skills due to the peculiarities of computer-mediated communication and the dramatically increased accessibility of field sites, which necessitates decisions about field sites and the types of data to gather and analyze (Addeo et al., 2019). In theory, netnography is one of the most important research tools. It enables researchers to access community members' knowledge online, which contributes to the provision of in-depth customer insights (Kozinets, 2019).

4.5 Data analysis

The analysis of qualitative data might have various objectives. The original goal might have been

to describe a phenomenon too thoroughly or too succinctly. A specific individual or group's personal experiences could be the phenomenon (e.g., the way people continue to live despite a fatal diagnosis). This could focus on the case (individual or group), its distinct qualities, and the relationships between them. The study may also focus on drawing comparisons between various scenarios (individuals or groups) and emphasizing the parallels or differences between them (Speidel, 2018). Structural equation modeling was utilized to analyze the survey's findings.

An increasingly used statistical technique in social science research is structural equation modeling. Currently, it is the analysis method of choice, particularly for doctoral dissertations and academic studies (Civelek, 2018). Structural equation modeling (SEM) is a powerful multivariate method that is increasingly being used in scientific studies to examine and evaluate multivariate causal relationships. SEMs are distinct from other modeling techniques in that they examine both the direct and indirect effects on proposed causal linkages. SEM is the result of combining two statistical techniques: route analysis and confirmatory factor analysis. With its roots in psychometrics, confirmatory factor analysis aims to evaluate latent psychological traits such as attitude and satisfaction (Fan et al., 2016).

Structural equation modeling was used as a data analysis tool for testing the proposed model in this study. SEM also allows the researcher to test validity of a theoretical model.

4.6 Data reliability and validity

The validity and reliability of the scales used are essential elements for the research to yield meaningful results. Researchers develop a conceptual model with specific variables for the problems they find in their research or for the topics they want to study. Then, using a questionnaire to collect and evaluate data, they test the conceptual model they have created (Sürücü, 2020).

Validity and reliability in qualitative research encourage openness and lessen the chance of researcher bias. Reviewing the methods used for data collecting is part of a comprehensive reliability and validity assessment for all secondary data (Mohajan, 2017). Although validity and reliability are two distinct criteria, they both play a role in assessing a research's quality. In quantitative research, dependability typically relates to two situations: (i) a measure's consistency when repeated multiple times, and (ii) a measure's stability at all times (Chan & Idris, 2017).

Validity basically means “measure what is intended to be measured” (Taherdoost, 2020).

To ensure that data is trustworthy and consistent, validity and reliability will be used in this study. This will also increase transparency in this research and ensure accuracy.

4.7 Delimitations of the study

This study is limited to students and academics at five Universities in South Africa. The study focused on the adoption and continued use of HPC within universities.

4.8 Ethical considerations

Due to the potential for mistreating the subject of the study to produce high quality and more thorough conclusions, the behavior of researchers is under constant observation. Whatever the nature of the study, researchers must make sure that the rights and welfare of research respondents are recognized and upheld. Researchers have an ethical duty to uphold the values of honesty, integrity, responsibility, transparency, and professional standards application. Ethical behavior is required of researchers to guarantee and safeguard respondents' well-being, minimize any possible harm, physical or psychological discomfort, social harm, and danger. The likelihood of negligence lawsuits is decreased by ethical behavior (Kang & Hwang, 2021).

The University Research Ethics Committee (UREC) of the University of Fort Hare has established certain rules, policies, and processes that this research study will abide by. The researcher is aware of the need to maintain the confidentiality of the respondent data. The respondents' approval was sought if any information needs to be disclosed. The researcher ensured that informed consent is obtained from the respondents before the questionnaire is completed by placing a 'submit' button on the front page of the survey. Within this section, the measures to ensure the confidentiality and anonymity of the respondents were explained. No personal identifiable information was collected from the respondents in the questionnaire to ensure anonymity, and only the researcher and supervisor will have access to the raw data set, which will be stored on an encrypted device. Data will be deleted from this device after 5 years.

4.8.1 Voluntary, Informed Consent

All research subjects voluntarily and lawfully gave consent to take part in the study after being

informed of the benefits and disadvantages. They had the freedom to exit the study whenever they choose (Clark-kazak, 2022).

4.8.2 Confidentiality and Privacy

Researchers have an obligation to protect respondents' privacy and not provide any identifying characteristics that could compromise anonymity, especially when sample numbers are small (Clark-kazak, 2022).

4.9 Conclusion

This chapter presented a comprehensive outline of the research methodology used in the study. The chapter was organized to encompass an elucidation of the research paradigm, a depiction of the research methodology utilized in the study, an evaluation of the population and sampling techniques, a delineation of the data analysis process, an inquiry into the dependability of data collection methods, a discussion on the constraints of the study, and an investigation into ethical considerations. The subsequent chapter will showcase the presentation of data analysis.



Chapter 5: Presentation of results

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5.1 Introduction

The aim of this study was to investigate the determinants of High-performance computing systems adoption and continued use amongst previously disadvantaged universities in South Africa. This was investigated amongst the staff and students in these universities. To investigate the adoption and continues use of HPC, a questionnaire was created and distributed within the previously disadvantaged universities. The data gathered was analyzed and the results are presented in this chapter. The analysis was aligned with the hypotheses stated in chapter three as the decisions must be made on whether the hypotheses are confirmed or not.

5.2 Demographics

The demographics in the study were divided according to gender, institution, computer knowledge, HPC knowledge and level of education. The demographics will be discussed further.

5.2.1. Gender

In this study, the respondents consisted of 56% female and 44% of male participants. There were more female respondents than male respondents. According to Statistics South Africa (Stats SA) (2021), the population stats reveal that there are more female than male citizens. Approximately 51,1% (about 30,75 million) of the population is female and approximately 48,9% (about 29,39 million) is male.

5.2.2 Institution

The study investigated the determinants of High-Performance computing systems adoption and continued use amongst University Staff and Students in Historically Disadvantaged Institutions. The respondents in this study were from the following universities: University of Fort Hare (31%), University of Venda (15%), University of Limpopo (18%), University of the Western Cape (17%), Walter Sisulu University (8%) and University of Zulu Land (11%). The following is the population of students and staff at the Historically disadvantaged institutions: University of Fort Hare - students 16 982, staff- 920; University of Venda- students 16 783, staff 924; Walter Sisulu University- students 33 572, staff 1480; University of the Western Cape – student 23 784, staff 4982 and University of Limpopo – 21 490, staff 1210.



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5.2.3 Computer knowledge

The rate of computer knowledge was divided into four categories, which are beginner, novice, knowledgeable and expert. Most of the respondents were knowledgeable (89%), 11 % had expert knowledge. None of the respondents had beginner (0%) or novice knowledge (0%). Table 5 shows the rate of computer knowledge.

5.2.4 HPC knowledge

HPC knowledge, like computer knowledge, was divided into four categories which are beginner, novice, knowledgeable and expert. When it came to HPC knowledge, the majority of those surveyed were knowledgeable (61%). Twenty-four percent (24 %) of the respondents had expert knowledge. The respondents which had novice knowledge were 15%. There were no respondents which had beginner knowledge (0%). Below table 5.1 provides the information with regards to the HPC knowledge of the respondents.

5.2.5 Level of education

There were no respondents with only a grade 12 Senior certificate. The current stage of respondents with Diploma/Advanced Diploma were also zero. Most respondents had Masters/PhD/Post doc qualification. The respondents with a bachelor's degree were 14% and with an Honors Degree were 18 %.

Most students in public Higher Education Institutions (HEIs) have undergraduate degrees (597 384) and were enrolled in 2019; these were followed by undergraduate certificates and diplomas (274 159) and postgraduate degrees below master's level (86 192). There were fewer students (14,719) engaged in occasional study. Between 2018 and 2019, enrollment decreased for undergraduate certificates and diplomas, postgraduate degrees below master's level, and occasional students; however, enrollment increased for other categories of qualifications (undergraduate degrees, advanced diplomas, postgraduate certificates in education, Master's and doctoral degrees) (DHET (SA), 2021).



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Table 4

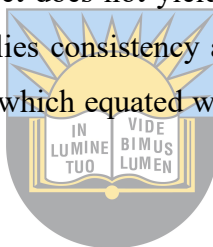
Demographics

GENDER	MALE	FEMALE				
N	136 (44%)	170 (56%)				
INSTITUTION	University of Fort Hare	University of Venda	University of Limpopo	University of Western Cape	Walter Sisulu University	University of Zulu Land
N	96 (31%)	45 (15%)	53 (18%)	52 (17%)	25 (8%)	35 (11%)
RATE COMPUTER KNOWLEDGE	Beginner	Novice	Knowledgeable	Expert		
N	0 (0%)	0 (0%)	271 (89%)	35 (11%)		
RATE HPC KNOWLEDGE	Beginner	Novice	Knowledgeable	Expert		
N						

N	0	45 (15%)	187 (61%)	74 (24%)	
CURRENT STAGE	Grade 12 Senior Certificate	Diploma/Advanced Diploma	Bachelor's Degree	Honours Degree	Masters/PhD/Postdoc
N	0 (0%)	0 (0%)	44 (14%)	54 (18%)	208 (68%)

5.3 Item analysis

The definition of reliability is the consistency of a method used to measure something. Reliability of the measurement is demonstrated by the ability to consistently acquire the same result under identical circumstances using the same approach. For instance, the thermometer consistently displays the same temperature when water temperature is measured under identical conditions several times, demonstrating the validity of the readings. In contrast, it shows that a questionnaire's capacity to precisely evaluate a sickness is insufficient if it is used by different medical professionals to diagnose a condition yet does not yield the same diagnosis (Ahmed & Ishtiaq, 2021). Reliability in measurement implies consistency and precision, lack of reliability implies inconsistency and imprecision, both of which equated with measurement error (Amirrudin et al., 2020).



Cronbach Alpha is a commonly used measure of dependability (Amirrudin et al., 2020). One can determine the reliability estimate of an instrument and define Cronbach's Alpha, the commonly used objective reliability assessment. In the context of multi-item measuring instruments, Cronbach's alpha is also used as a measure of internal consistency and has more uses today than it did when it was initially introduced (Amirrudin et al., 2020). Despite a lot of misconceptions, misinterpretations, incorrect applications, and even arguments that it cannot accurately assess reliability, Cronbach Alpha has become popular recently (Amirrudin et al., 2020).

5.3.1 Actual use of high-performance computing systems

Cronbach Alpha values above .70 are considered reliable (Cohen, 1988). A Cronbach Alpha of .58 was obtained for the *actual use of high-performance computing systems scale*, after the initial round of analysis, which is below the minimum threshold of .70 regarded as acceptable (Cohen, 1988; Nunnally & Bernstein, 1994). Items AHPC1 and AHPC2 were flagged as problematic and therefore, removed. That significantly increased the Cronbach Alpha to .90. The corrected item-

total correlation values shown in the Item-Total Statistics table are above the .30 level minimum required threshold. This indicates that the loadings are adequate. According to Cohen (1988), guidelines correlations that are between .10 and .29 are small, between .30 and .49 are medium while those between .50 and 1.0 are large. Low values of less than .30 indicate that the item is measuring something different from the scale (Pallant, 2016). The inter-item correlation matrix as indicated in Table 5, is .82 which indicates that relationship exists between the two items of the *actual use of high-performance computing systems scale*.

Table 5

Item analysis for actual use of high-performance computing systems

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.900	.900	2

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Inter-Item Correlation Matrix		
	AHPC3	AHPC4
AHPC3	1.000	.818
AHPC4	.818	1.000

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
AHPC3	3.26	1.897	.818	.669	.
AHPC4	3.27	1.817	.818	.669	.

5.4.2 Intention to use high performance computing systems

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
INTHPCS1	4.26	2.332	.329	.112	.494
INTHPCS2	4.08	2.086	.400	.160	.384
INTHPCS3	3.97	1.960	.355	.131	.460

A Cronbach Alpha of .55 was obtained for the *intention to use high performance computing systems scale*. According to Pallant (2016), acceptable values for the Cronbach's Alpha should be above .70, hence the reliability coefficient of the *intention to use high performance computing systems scale* was below the minimum threshold and therefore unacceptable. None of the items would significantly increase the Cronbach Alpha if deleted and all the items were retained as depicted in Table 6. The corrected item-total correlation values shown in the Item-Total Statistics table are all above the minimum threshold of 0.30. The inter-item correlation matrix as indicated in table 6, ranges from .24 to .33 which indicates that small to large relationships exist between the items in the *intention to use high performance systems scale*.

Table 6

Item analysis for the intention to use high performance systems

Reliability Statistics

	Cronbach's Alpha Based on Standardized Items	N of Items
Cronbach's Alpha	.550	3

Inter-Item Correlation Matrix

	INTHPCS1	INTHPCS2	INTHPCS3
INTHPCS1	1.000	.299	.240
INTHPCS2	.299	1.000	.330
INTHPCS3	.240	.330	1.000

5.4.3 Attitude towards high performance computing systems

A Cronbach Alpha of .50 was obtained for the *attitude towards high performance computing systems scale*. According to Pallant (2016), acceptable values for the Cronbach's Alpha should be above .70, hence the reliability coefficient of the *attitude towards high performance computing systems scale* was below the minimum threshold and therefore unacceptable. None of the items would significantly increase the Cronbach Alpha if deleted and all the items were retained as depicted in Table 7. The corrected item-total correlation values shown in the Item-Total Statistics table are between .179 and .362. The inter-item correlation matrix as indicated in table 7, ranges from .034 to .468 which indicates that small to moderate relationships exist between the items in the *attitude towards high performance systems scale*. 3 of the items in the scale had corrected item-total correlations below 0.30. A decision was made to exclude itemATC1 which was below 0.20. The other items were retained to have 4 items since the scale is short.

Table 7

Item analysis for attitude towards high performance computing systems



Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.501	.518	5

Inter-Item Correlation Matrix					
	ATCS1	ATCS2	ATCS3	ATCS4	ATCS5
ATCS1	1.000	.301	.297	-.032	-.034
ATCS2	.301	1.000	.463	.073	.075
ATCS3	.297	.463	1.000	.089	.069
ATCS4	-.032	.073	.089	1.000	.468
ATCS5	-.034	.075	.069	.468	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ATCS1	11.26	5.204	.179	.128	.507
ATCS2	11.00	5.049	.362	.247	.401
ATCS3	11.18	4.844	.355	.246	.396
ATCS4	12.24	4.650	.253	.223	.463
ATCS5	12.55	4.847	.256	.222	.458

5.4.4 Computer self-efficacy

Cronbach Alpha values above .70 are considered reliable (Cohen, 1988). The reliability analysis for the *computer self-efficacy scale* is .65 which is slightly below the 0.70 level (Nunnally & Bernstein, 1994). Based on the Cronbach alpha values in the last column of the Item-total statistics as indicated in Table 8, if we consider removing item CSE1, this will increase the Cronbach alpha from $\alpha = .65$ to .74. The degree to which each item correlates with the whole scale is shown by the corrected item-total correlation values displayed in the item-total statistics table (Pallant, 2016). The corrected item-total correlation indicated that all the items were above 0.30 except for item CSE1 which was subsequently excluded from the study thereby increasing the scale reliability alpha to $\alpha = 0.737$ (Pallant, 2016). According to Cohen (1988) guidelines correlations that are between .10 and .29 are small, between .30 and .49 are medium while those between .50 and 1.0 are large. The inter-item correlation matrix as indicated in Table 8, ranges from -.009 to .55 which indicates that a small to large relationship exists between the items in the *computer self-efficacy scale*.

Table 8

Item analysis for computer self-efficacy

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.646	.634	4

Inter-Item Correlation Matrix				
	CSE1	CSE2	CSE3	CSE4
CSE1	1.000	-.009	.079	.297
CSE2	-.009	1.000	.500	.394
CSE3	.079	.500	1.000	.552
CSE4	.297	.394	.552	1.000

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
CSE1	9.95	4.597	.155	.110	.737
CSE2	10.11	3.724	.418	.279	.584
CSE3	10.00	3.099	.551	.401	.480
CSE4	10.19	3.012	.615	.392	.430

5.4.5 Perceived usefulness

The *perceived usefulness scale* has an internal consistency coefficient of .74 which is greater than the minimum threshold of .70 (Cohen, 1988; Nunnally & Bernstein, 1994). None of the items would result in a significant increase in Cronbach alpha, therefore all items were retained. The corrected item-total correlation indicated that all the items correlated above .30 with the total score (Pallant, 2016). The inter-item correlation matrix as indicated in Table 9, ranges from .23 to .61 which indicates that a small to large relationship exists between the items in the *perceived usefulness scale*.

Table 9*Item analysis for perceived usefulness*

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.743	.750	4

Inter-Item Correlation Matrix				
	PU1	PU2	PU3	PU4
PU1	1.000	.527	.607	.272
PU2	.527	1.000	.462	.469
PU3	.607	.462	1.000	.233
PU4	.272	.469	.233	1.000

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PU1	10.58	5.152	.596	.446	.653
PU2	10.49	4.797	.641	.415	.623
PU3	10.32	5.442	.542	.396	.684
PU4	10.09	5.399	.396	.221	.771

5.4.6 Perceived ease of use

Cronbach Alpha values above .70 are considered reliable (Cohen, 1988; Nunnally & Bernstein, 1994). A Cronbach Alpha of .76 was obtained for the *perceived ease of use scale* which is considered acceptable. None of the items was flagged as problematic, therefore, all items were

retained. The corrected item-total correlation ranged from .40 to .64. Values under the inter-Item correlation matrix ranges from .30 to .60. The output is presented in Table 10.

Table 10

Item analysis for perceived ease of use

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.755	.759	4

Inter-Item Correlation Matrix				
	PEU1	PEU2	PEU3	PEU4
PEU1	1.000	.565	.483	.300
PEU2	.565	1.000	.598	.323
PEU3	.483	.598	1.000	.373
PEU4	.300	.323	.373	1.000

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PEU1	12.25	5.786	.565	.359	.690
PEU2	12.10	5.809	.642	.460	.651
PEU3	12.22	5.600	.623	.416	.657
PEU4	12.35	6.368	.398	.164	.783

5.4.7 Social influence

The *social influence scale* had an internal consistency of $\alpha = .89$ that is above the minimum acceptable level of .70 considered adequate (Cohen, 1988; Nunnally & Bernstein, 1994). Since eliminating any of the items will not significantly raise Cronbach alpha, all the items were retained.

The degree to which each item corresponds with the overall score is shown in the Corrected Item-Total Correlation column. Concern should be expressed about items with corrected item-total correlation values less than .30, as they may be assessing something unrelated to the scale. An inspection of the corrected item-total correlation shows that all items had loadings above .70 with the total score which is adequate (Pallant, 2016). Values under the Inter-Item Correlation Matrix are all above .60. the output is displayed in Table 11.

Table 11

Item analysis for social influence

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.892	.892	4

Inter-Item Correlation Matrix				
	SI1	SI2	SI3	SI4
SI1	1.000	.667	.664	.677
SI2	.667	1.000	.678	.686
SI3	.664	.678	1.000	.675
SI4	.677	.686	.675	1.000

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SI1	9.12	13.833	.754	.569	.863
SI2	9.10	13.918	.766	.587	.859

SI3	9.29	13.397	.759	.576	.862
SI4	9.03	14.259	.769	.592	.858

5.5 Dimensionality analysis

The findings of the exploratory factor analysis (EFA) of the measurement scales utilized in the current investigation are presented in this section. The degree of uni-dimensionality of the scales is examined in this section. The uni-dimensionality assumption is crucial when constructing parcels for the overall measurement and structural model.

5.5.1 Actual use of high-performance computing systems

Exploratory factor analysis shows that the *actual use of high-performance computing systems scale* is factor analyzable as indicated by the KMO index and Bartlett's test of sphericity values of .50 and 334.214 ($df = 1$; $p = 0.00$) respectively (see Table 12). Brown et al. (2010) recommends acceptance of KMO values greater than .50. The Bartlett's Test of Sphericity should be significant ($p < .05$) for factory analysis to be suitable (Brown et al., 2010). The *actual use of high-performance computing systems scale* was found to be uni-dimensional. Only one factor with an eigenvalue greater than 1 was obtained and this factor accounted for 90.888% of the variance. The factor loadings were all above .90 suggesting that the factor solution provided a valid explanation of the observed inter-item correlation.

Table 12

Dimensionality analysis for actual use of high-performance computing systems

KMO and Bartlett's Test				
Kaiser-Meyer-Olkin Measure of Adequacy.		Sampling		.500
Bartlett's Test of Sphericity	Approx. Chi-Square			334.214
	df			1
	Sig.			.000

Total Variance Explained						
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.818	90.888	90.888	1.634	81.718	81.718
2	.182	9.112	100.000			

Factor Matrix ^a	
	Factor 1
AHPC3	.904
AHPC4	.904

5.5.2 Intention to use high performance computing systems

Exploratory factor analysis shows that the *intention to use high-performance computing systems scale* is factor analyzable as indicated by the KMO index and Bartlett's test of sphericity values of .616 and 70.668 ($df = 3$; $p = 0.00$) respectively (see Table 13). Brown et al. (2010) recommends acceptance of KMO values greater than .50. The Bartlett's Test of Sphericity should be significant ($p < .05$) for factory analysis to be suitable (Brown et al., 2010). The *actual use of high-performance computing systems scale* was found to be uni-dimensional. Only one factor with an eigenvalue greater than 1 was obtained, and this factor accounted for 52.698% of the variance. The factor loadings were all above .40 suggesting that the factor solution provided a valid explanation of the observed inter-item correlation.

Table 13

Dimensionality analysis for intentions to use high performance computing systems

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.616
Bartlett's Test of Sphericity	Approx. Chi-Square	70.668
	df	3
	Sig.	.000

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.581	52.698	52.698	.892	29.739	29.739
2	.762	25.416	78.114			
3	.657	21.886	100.000			

Extraction Method: Principal Axis Factoring.

Factor Matrix^a

	Factor
	1
INTHPCS1	.467
INTHPCS2	.638
INTHPCS3	.516

Extraction Method:
Principal Axis Factoring.

a. 1 factors extracted. 14

iterations required.

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5.5.3 Attitude towards high performance computing systems

Exploratory factor analysis was conducted on the *attitude towards high performance computing systems scale*. The KMO index and Bartlett's test of sphericity were computed and yielded the values of .688 and 493.789 ($df = 3$; $p = 0.00$), respectively. Brown et al. (2010), these values are highly acceptable and show that the correlation matrix of the *attitude towards high performance computing systems scale* was factor analyzable. The *attitude towards high performance computing systems scale* was found to be uni-dimensional. Only one factor with an eigenvalue greater than 1 was obtained, and this factor accounted for 78.671% of the variance. The output is presented in Table 14.

Table 5.14

Dimensionality of attitude towards high performance computing systems

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.688
Bartlett's Test of Sphericity	Approx. Chi-Square	493.789
	df	3
	Sig.	.000

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.360	78.671	78.671	2.089	69.647	69.647
2	.460	15.341	94.012			
3	.180	5.988	100.000			

Extraction Method: Principal Axis Factoring.



Factor Matrix^a

Uni	Factor 1	are
ATHPCS1	.934	
ATHPCS2	.875	
ATHPCS3	.671	

Extraction Method:
Principal Axis Factoring.

a. 1 factors extracted.
12 iterations required.

5.5.4 Computer self-efficacy

The *computer self-efficacy scale* obtained a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy value of .65, and Bartlett's Test of Sphericity test statistic value was 571.329 ($df = 10$; $p = 0.00$). Brown et al. (2010) recommends acceptance of KMO values greater than .50. The Bartlett's Test of Sphericity should be significant ($p < .05$) for factory analysis to be suitable (Brown et al., 2010). The values indicate that factor analysis can be conducted. As depicted in Table 15, the *computer self-efficacy scale* failed the uni-dimensionality test. exploratory factor

analysis (EFA) showed the existence of two factors accounting for 43.968 % and 19.265 % of the variance respectively. The factor loadings were all above 0.50. except for CSE1, and CSE2. The results are depicted in Table 15.

Table 15

Dimensionality analysis for computer self-efficacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.646
Bartlett's Test of Sphericity	Approx. Chi-Square	571.329
	df	10
	Sig.	.000

Total Variance Explained							
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings ^a
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	2.534	50.688	50.688	2.198	43.968	43.968	1.777
2	1.291	25.825	76.513	.963	19.265	63.232	1.844
3	.567	11.339	87.852				
4	.410	8.191	96.043				
5	.198	3.957	100.000				

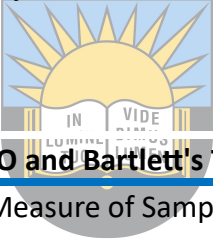
Pattern Matrix ^a		
	Factor	
	1	2
CSE1	-.039	-.939
CSE2	.049	-.844
CSE3	.825	.021
CSE4	.678	-.108
CSE5	.621	.047

5.5.5 Perceived usefulness

Exploratory factor analysis showed that the *perceived usefulness scale* is factor analyzable as indicated by KMO index and Bartlett's test of sphericity values of .70 and 325.929 (df = 6; p = 0.00) respectively. According to Brown et al. (2010) these values indicate the factor analyzability of the correlation matrix of the *perceived usefulness scale*. The *perceived usefulness scale* was found to be uni-dimensional. Only one factor with an eigenvalue greater than 1 was obtained, and this factor accounted for 57.68% of the variance. The factor loadings were all above .44 suggesting that the factor solution provided a valid explanation of the observed inter-item correlation. The results are shown in Table 16.

Table 16

Dimensionality analysis for perceived usefulness



KMO and Bartlett's Test			
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.			.700
Bartlett's Test of Sphericity	Approx. Chi-Square		325.929
	df		6
	Sig.		.000

Total Variance Explained						
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.307	57.678	57.678	1.798	44.957	44.957
2	.865	21.622	79.301			
3	.448	11.204	90.505			
4	.380	9.495	100.000			

Factor Matrix^a

	Factor 1
PU1	.760
PU2	.744
PU3	.683
PU4	.448

5.5.6 Perceived ease to use

Exploratory factor analysis shows that the *perceived ease to use scale* is factor analyzable as indicated by the KMO index and Bartlett's test of sphericity values of .75 and 318.381 (df = 6; p = 0.00) respectively. As depicted in Table 17, only one factor with an eigenvalue greater than 1 was obtained and this factor accounted for 58.62% of the variance for this scale. The factor loadings were all substantially above .40, suggesting that the rotated factor solution provided a reasonably credible explanation of the observed inter-item correlation. The results are displayed in Table 17.



Table 17

Dimensionality analysis for perceived ease to use
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KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.747
Bartlett's Test of Sphericity	Approx. Chi-Square	318.381
	df	6
	Sig.	.000

Total Variance Explained						
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.345	58.618	58.618	1.858	46.438	46.438
2	.763	19.064	77.682			

3	.513	12.828	90.510			
4	.380	9.490	100.000			

Factor Matrix ^a	
	Factor 1
PEU1	.677
PEU2	.798
PEU3	.749
PEU4	.447

5.5.7 Social influence

Exploratory factor analysis shows that the *social influence scale* is factor analyzable as indicated by the KMO index and Bartlett's test of sphericity values of .846 and 682.480 (df = 6; p = 0.00) respectively. As depicted in Table 18, only one factor with an eigenvalue greater than 1 was obtained and this factor accounted for 75.575% of the variance for this scale. The factor loadings were all substantially above .80, suggesting that the rotated factor solution provided a reasonably credible explanation of the observed inter-item correlation. The results are displayed in Table 18.

Table 18

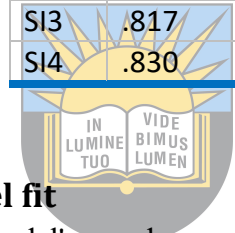
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Dimensionality analysis for social influence

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.846
Bartlett's Test of Sphericity	Approx. Chi-Square	682.480
	df	6
	Sig.	.000

Total Variance Explained						
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.023	75.575	75.575	2.697	67.429	67.429
2	.339	8.484	84.058			
3	.326	8.141	92.199			
4	.312	7.801	100.000			
Extraction Method: Principal Axis Factoring.						

Factor Matrix ^a	
	Factor 1
SI1	.812
SI2	.826
SI3	.817
SI4	.830



5.6 Overall measurement model fit

To evaluate the total measurement model's goodness of fit, several fit statistics are used. To evaluate the closeness of fit, the Root Mean Square Error of Approximation (RMSEA) is used. Values less than 0.05 are considered a good fit, the values between 0.05 and 0.08 represent a reasonable fit, values between .08 and 1.0 indicate a mediocre fit, and values greater than .10 are indicative of a poor fit (Diamantopoulos & Siguaw, 2000). Therefore, based on the results which indicate a value of 0.0921, for the RMSEA, the overall measurement model has a mediocre fit. The Root Mean Squared Residual (RMR) and the standardized RMR values are 0.0830 and 0.0781 respectively. The RMR and standardized RMR values indicate a poor fit.

The Comparative Fit Index is a measure of relative fit (De Bruin, 2018). The indices assess how well the current model fits against a "null model," which makes no mention of any relationships between the components. The goal of any researcher is to have the model outperform the null model by a significant margin. A researcher always hopes to see that the model performs much better than the null model. The CFI ranges from zero to unity, where a value of 1.00 indicates a

perfect fit. Researchers tend to regard CFI values $> .95$ as indicative of a good fit and values $> .90$ as an acceptable fit. CFI is regarded as a measure of relative fit (Diamantopoulos & Siguaw, 2000).

The GFI has a value of 0.90 which is indicative of a good fit. The statistics, as indicated in Table 19, the NFI, NNFI, CFI, IFI and RFI values are 0.935, 0.921, 0.951, 0.952 and 0.894 respectively. These indices indicate a relatively good fit. The measurement model path diagram is depicted in Figure 5.

Table 19

Goodness of fit indices for the measurement model

Fit Index	Value
Degrees of Freedom	56
Satorra-Bentler Scaled Chi-Square	200.543 (P = 0.0)
Root Mean Square Error of Approximation (RMSEA)	0.0921
90 Percent Confidence Interval for RMSEA	(0.0786; 0.106)
P-Value for Test of Close Fit (RMSEA < 0.05)	0.000
Normed Fit Index (NFI)	0.935
Non-Normed Fit Index (NNFI)	0.921
Parsimony Normed Fit Index (PNFI)	0.575
Comparative Fit Index (CFI)	0.951
Incremental Fit Index (IFI)	0.952
Relative Fit Index (RFI)	0.894
Critical N (CN)	127.598
Root Mean Square Residual (RMR)	0.0830
Standardized RMR	0.0781
Goodness of Fit Index (GFI)	0.90
Adjusted Goodness of Fit Index (AGFI)	0.812

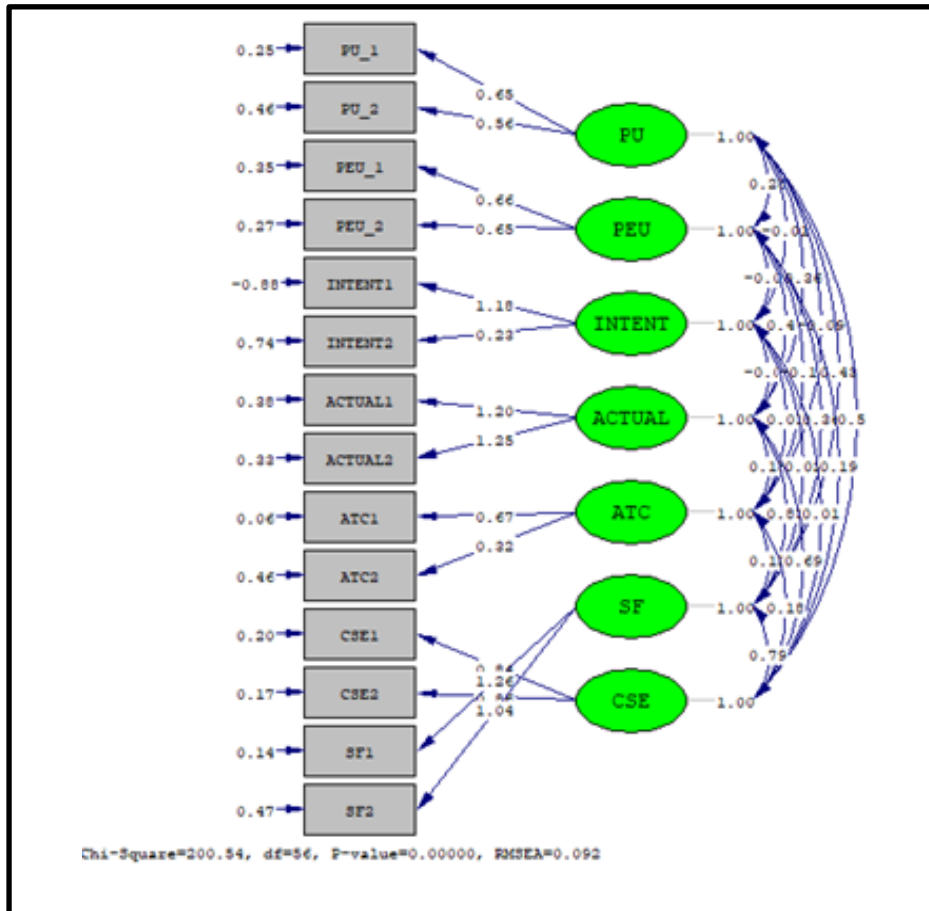


Figure 5: The Measurement Model path diagram

5.7 Goodness of fit for the structural model

The link between latent, or unobserved, and measurable, or seen, variables is tested using the structural model (Austin & MacCallum, 2000). To determine the fit of the structural model the LISREL programme, version 8.80 was used. The indices are presented in Table 20 and the path diagram of the structural model is represented in Figure 6. The results indicate a value of 0.105, for the RMSEA thereby indicating a mediocre fit for the structural model. The Root Mean Squared Residual (RMR) and the standardized RMR values are 0.0761 and 0.0770 respectively. The RMR and standardized RMR values indicate a poor fit.

The GFI has a value of 0.90 which is indicative of a good fit. The statistics, as indicated in Table 20, the NFI, NNFI, CFI, IFI and RFI values are 0.89, 0.86, 0.91, 0.92 and 0.82 respectively. These indices indicate a relatively good fit. The structural model path diagram is depicted in Figure 6.

Table 20

Goodness of fit indices for the structural model

Fit Index	Value
Degrees of Freedom	40
Satorra-Bentler Scaled Chi-Square	173.356 (P = 0.0)
Root Mean Square Error of Approximation (RMSEA)	0.105
90 Percent Confidence Interval for RMSEA	(0.0890; 0.121)
P-Value for Test of Close Fit (RMSEA < 0.05)	0.000
Normed Fit Index (NFI)	0.892
Non-Normed Fit Index (NNFI)	0.857
Parsimony Normed Fit Index (PNFI)	0.541
Comparative Fit Index (CFI)	0.913
Incremental Fit Index (IFI)	0.915
Relative Fit Index (RFI)	0.822
Critical N (CN)	112.691
Root Mean Square Residual (RMR)	0.0761
Standardized RMR	0.0770
Goodness of Fit Index (GFI)	0.901
Adjusted Goodness of Fit Index (AGFI)	0.808

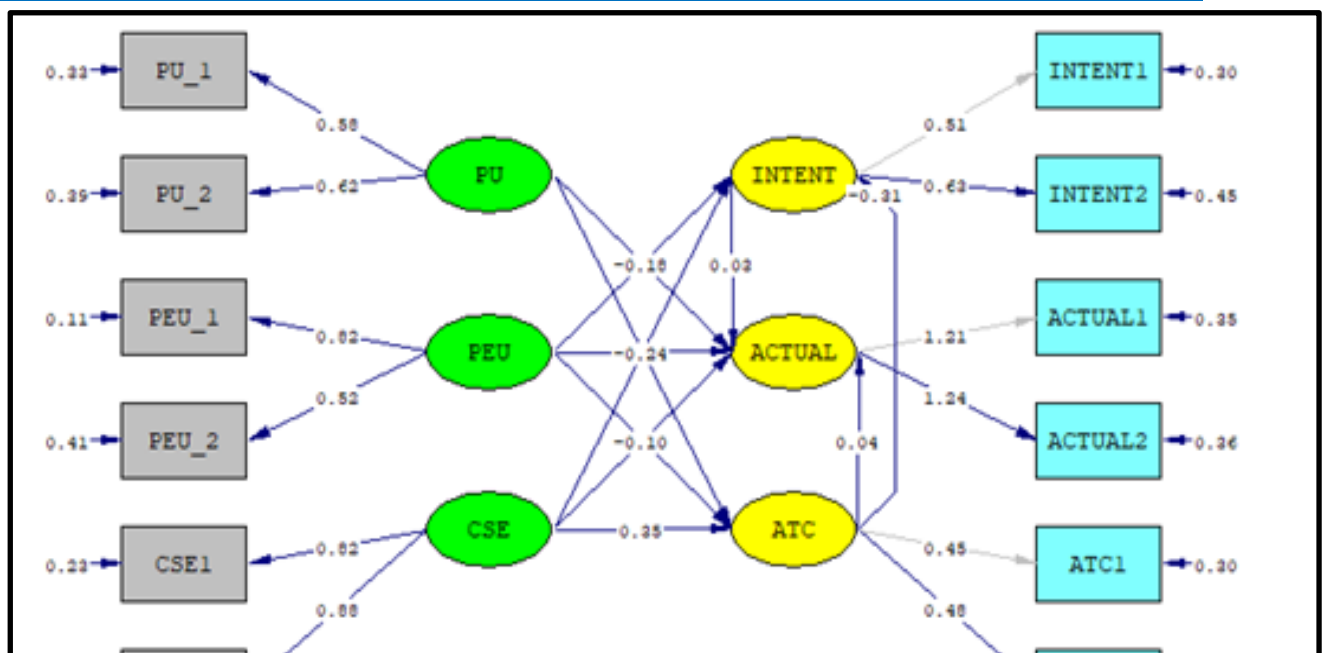


Table 21*Beta matrices*

	ATHPC	INTHPC	AUHPC
ATHPC	-----	-0.309 (0.133) -2.327	-----
INTHPC	-----	-----	0.027 (0.058) 0.474
AUHPC	0.043 (0.067) 0.638	-----	-----

**Table 22***Gamma matrices*

GAMMA	PU	PEU	CSE
INTHPC	-----	-0.122 (0.075) -1.612	0.098 (0.079) 1.237
AUHPC	-0.177 (0.083) -2.133	0.387 (0.060) 6.491	0.686 (0.084) 8.189
ATHPC	-0.238 (0.118) -2.014	-0.105 (0.086) -1.220	0.350 (0.120) 2.919

5.8 Relationships between latent variables

Hypothesis 1: *Computer self-efficacy would positively influence attitude towards high-performance computing systems.*

The t-value of the link between *computer self-efficacy* and *attitude towards high-performance computing systems* is more than 1.645 ($t = 2.919, p < .05$) (see Table 22). A significant positive relationship is, therefore evident between *computer self-efficacy* and *attitude towards high-performance computing systems*. Therefore, the proposed relationship between the two variables was supported.

Hypothesis 2: *Perceived usefulness* would positively influence *attitude towards high-performance computing systems*.

The t-value of the link between the two variables is more than 1.645 ($t = -2.014, p < .05$) (see Table 22). There is a significant negative relationship between *perceived usefulness* and *attitude towards high-performance computing systems*. Therefore, the proposed relationship between the two variables was not supported.



Hypothesis 3: *Perceived ease of use* would positively influence *attitude towards high-performance computing systems*.

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The relationship between *perceived ease of use* and *attitude towards high-performance computing systems* was not supported as the t-value of the link between the two variables is less than 1.645 (see Table 22). There is no significant relationship between *perceived ease of use* and *attitude towards high-performance computing systems*. This finding suggests that the proposed relationship between the two variables was not supported.

Hypothesis 4: *Perceived ease of use* would positively influence *intention to use high-performance computing systems*.

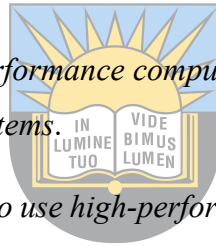
The t-value of the link between *perceived ease of use* and *intention to use high-performance computing systems* is less than 1.645 (see Table 22). A non-significant ($p < .05$) relationship is therefore evident between *perceived ease of use* and *intention to use high-performance computing systems*.

systems. This finding suggests that the proposed relationship between the two variables was not supported.

Hypothesis 5: *Attitude toward high-performance computing systems would positively influence intention to use high-performance computing systems.*

The t-value of the link between *attitude toward high-performance computing systems* and *intention to use high-performance computing systems* is more than 1.645 (see Table 21). A significant ($p < .05$) relationship is evident between *attitude toward high-performance computing systems* and *intention to use high-performance computing systems*. Therefore, the proposed relationship between these two variables was supported.

Hypothesis 6: *Intention to use high-performance computing systems positively affects the actual use of high-performance computing systems.*



The relationship between *the intention to use high-performance computing systems* and *actual use of high-performance computing systems* was not supported as the t-value of the link between the two variables is less than 1.645 (see Table 21). A significant ($p < .05$) positive relationship is, therefore, evident between *the intention to use high-performance computing systems* and *actual use of high-performance computing systems*. Therefore, the proposed relationship between these two variables was supported.

Hypothesis 7: *Social Influence would positively influence actual use of high-performance computing systems.* The t-value of the link between *social Influence* and *actual use of high-performance computing systems* is more than 1.645 ($t = 23.322$, $p < .05$) A significant positive relationship is, therefore evident between *social Influence* and *actual use of high-performance computing systems*. Therefore, the proposed relationship between the two variables was supported.

5.9 Conclusion

This chapter's objective was to offer an analysis of the information gathered. The data was collected through a questionnaire which was distributed to six previously disadvantaged universities, the University of Fort Hare had the highest number of respondents. The results from the questionnaire suggested that computer self-efficacy, perceived usefulness, attitude, and intention to use had a positive influence toward high performance computing systems. On the other hand, perceived ease of use did not positively influence attitude and influence toward high performance computing systems.

Chapter 6: Discussions, Implications, Limitations and Future Research

6.1 Introduction

The study's collected data, which came from the study respondents, was presented in the previous chapter. The study's conclusion and a summary of the key findings are presented in this chapter. The consequences of the study, its limits, and finally its recommendations for future research will all be covered in this chapter. The aim of this study was to investigate the determinants of High-performance computing systems adoption and continued use amongst previously disadvantaged universities in South Africa. The objectives of the study were to:

- To determine the influence of Computer Self-Efficacy on attitude towards high-performance computing systems.
- To determine the influence of Perceived usefulness on high-performance computing systems.
- To determine the influence of Perceived ease of use on attitude towards high-performance computing systems.
- To determine the influence of Perceived ease of use on intention to use high-performance computing systems.
- To determine the influence of Attitude toward high-performance computing systems on intention to use high-performance computing systems.

- To determine the influence of Intention to use high-performance computing systems on the actual use of high-performance computing systems.
- To determine the influence of Social Influence on the actual use of high-performance computing systems.
- To determine the goodness of fit of the model

6.2 Main findings

To understand technology adoption has always been a priority in the Information Systems industry. There are various factors which influence how people adopt technology. The main aim of this study was to investigate the determinants of high-performance computing systems adoption and continued use amongst previously disadvantaged universities in South Africa. Below the main findings of the study will be discussed, according to the results of the study.

The study has demonstrated a correlation between the utilization of high-performance computer equipment and self-efficacy. Self-efficacy is the belief that an individual has the abilities as well as skills to succeed in using technology (Chao, 2019). Compared to someone with low self-efficacy, a person with high self-efficacy is more inclined to use technology. Individuals with high self-efficacy use a computer more and have abilities to use a computer (Meinhardt-Injac & Skowronek, 2022). Computer self-efficacy does positively influence attitudes towards high-performance computing systems.

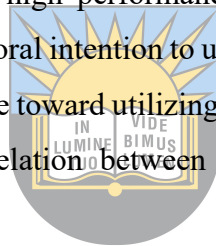
Perceived usefulness is the degree to which people think that utilizing a new technology will enhance their ability to execute a task (Kasilingam, 2020). According to the study, perceived usefulness does not positively influence the attitude towards high-performance computing systems.

According to the study, a Cronbach Alpha of .76 was obtained for the perceived ease of use which is considered acceptable. The degree to which a person perceives that utilizing a technology will require little to no effort is known as perceived ease of use (Kasilingam, 2020). Users are more likely to use a technology if they believe it is simple to use (Tahar et al., 2020). The results from

the study, however, suggest that perceived ease of use negatively influences the attitude towards high-performance computing systems.

Attitude is a person's ability to evaluate a symbol, object or feature of the world in a negative or positive way (Mafhoum, 2023). Attitude toward a technology (ATU) is the intention individuals have to use a technology (Luik & Taimalu, 2021). A Cronbach Alpha of .50 was - obtained for the attitude towards high-performing computing systems scale, which means it was below the minimum threshold and is therefore unacceptable. However, the results revealed that attitude toward high performance computing systems would positively influence intention to use high-performance computing systems.

The reliability coefficient of the intention to use high-performance computing systems was below the minimum threshold and this makes it unacceptable. This was because a Cronbach Alpha of .55 was obtained for the intention to use high performance systems. An attitude toward using a computer affects an individual's behavioral intention to use. A person will intend to use computers frequently if they have a positive attitude toward utilizing them ((Teo & Zhou, 2014). The findings indicate that there is a positive correlation between the intention and actual use of high-performance computing equipment.



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Social influence, or how much people believe others should think they should be utilizing a certain technology, is one of the UTAUT constructs (Almaiah et al., 2019). This is influenced by people of close proximity (Chen & Aklikokou, 2020). The social influence scale was .89 which is above the minimum level and is acceptable.

In terms of the goodness of fit of the model tested in the study, both the measurement and structural models failed to reach the acceptable fit categories as the RMSEA values for the measurement and structural model were 0.0921 and 0.105 respectively. In terms of the other fit indices the measurement model had a GFI value of 0.90 which is indicative of a good fit. The statistics, as indicated in Table 19, the NFI, NNFI, CFI, IFI and RFI values are 0.935, 0.921, 0.951, 0.952 and 0.894 respectively. These indices indicate a relatively good fit. The measurement model path diagram is depicted in Figure 5. For the structural model - the Root Mean Squared Residual (RMR) and the standardized RMR values are 0.0761 and 0.0770 respectively. The RMR and standardized

RMR values indicate a poor fit. The GFI has a value of 0.90 which is indicative of a good fit. The statistics, as indicated in Table 20, the NFI, NNFI, CFI, IFI and RFI values are 0.89, 0.86, 0.91, 0.92 and 0.82 respectively. These indices indicate a relatively good fit. The structural model path diagram is depicted in Figure 6. Generally, both the measurement and structural model failed to reach the acceptable goodness of fit indices.

6.3 Discussion and implications

Hypothesis 1: Computer self-efficacy would positively influence attitude towards high-performance computing systems

The t-value of the link between computer self-efficacy and attitude towards high-performance computing systems is more than 1.645 ($t = 2.919, p < .05$). A significant positive relationship is, therefore evident between computer self-efficacy and attitude towards high-performance computing systems. Support was found for the suggested association between the two variables.

The relationship between self-efficacy and the attitude towards high-performance computing systems is positive since self-efficacy is an essential intrinsic motivation (Han & Geng, 2023). Self-efficacy beliefs influence people's feelings, thoughts, motivation, and behavior. Additionally, research has demonstrated a connection between students' self-efficacy in using various technology devices and academic success (Moca & Badulescu, 2023). Strong self-efficacy learners exhibit behaviors that are likely to improve academic performance and learning. This entails putting in extra effort and tenacity when completing tasks, staying strong in the face of difficulties, and selecting challenging learning assignments over simpler ones when given the option. On the other hand, students who have relatively low self-efficacy are more likely to act in ways that hinder their ability to learn new things and enhance their academic performance. Self-efficacy has been demonstrated to be linked to academic success in addition to motivational outcomes (Hanham et al., 2021).

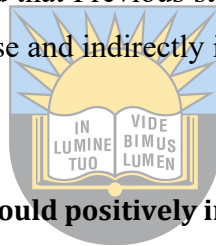
Hypothesis 2: Perceived usefulness would positively influence attitude towards high-performance computing systems.

The t-value of the link between the two variables is more than 1.645 ($t = -2.014, p < .05$). There is a significant negative relationship between perceived usefulness and attitude towards high-

performance computing systems. Therefore, the proposed relationship between the two variables was supported.

Hanham et al. (2021) agrees with the above result as the state that perceived usefulness represents customers' expectations that a certain piece of technology, whether software, hardware, or a system, will increase their productivity. Several studies using the concept of the TAM model have been conducted, that show perceived usefulness have a positive effect on attitude toward use (Islami et al., 2021).

Additionally, empirical research revealed a strong correlation between students' emotional experiences and how they viewed and used technology. Particularly, pleasurable feelings like enjoyment are connected to students' perceptions of the use of technologies, while unfavorable feelings like fear are connected to students' frustrating encounters with technologies (Han & Geng, 2023). Chahal and Rani (2022) also add that Previous studies on e-learning demonstrate a strong effect of perceived usefulness toward use and indirectly influence the behavioral intention.



Hypothesis 3: Perceived ease of use would positively influence attitude towards high-performance computing systems.

The relationship between perceived ease of use and attitude towards high-performance computing systems was not supported as the t-value of the link between the two variables is less than 1.645 (see Table 22). Attitude toward high-performance computing systems and perceived ease of use do not significantly correlate. According to this result, there was no evidence to substantiate the suggested association between the two variables.

The above result contrasts with a few studies. Islami et al. (2021) suggests that perceived ease of use positively influences attitude toward use. Perceived ease of use of e-commerce has a positive and significant effect on the attitude toward using e-commerce. A number of factors substantially influence perceived ease of use, such as users' views about e-learning and their satisfaction with using technology in the classroom (Nuryakin et al., 2023).

According to Kelly and Palaniappan (2023), because many people think that technology is difficult to use, people do have a negative attitude of computers, the Internet, and other technical equipment. While this study argues that it is the result of a user's unfavorable attitude toward technology and

its uses, it may also be occasionally linked to individual users' concerns about technology, which is a relative element of life.

Hypothesis 4: Perceived ease of use would positively influence intention to use high-performance computing systems.

The t-value of the link between perceived ease of use and intention to use high-performance computing systems is less than 1.645 (see Table 22). A non-significant ($p < .05$) relationship is therefore evident between perceived ease of use and intention to use high-performance computing systems. This finding suggests that the proposed relationship between the two variables was not supported.

Not everyone can quickly adopt or learn computer technology well, especially older people. This is because they are less likely to be interested in learning new technologies and have less mental capacity (Nujmatul Laily & Fenty Shintya Riadani, 2022).

Hypothesis 5: Attitude toward high-performance computing systems would positively influence intention to use high-performance computing systems.

The t-value of the link between attitude toward high-performance computing systems and intention to use high-performance computing systems is more than 1.645 (see Table 22). A significant ($p < .05$) relationship is evident between attitude toward high-performance computing systems and intention to use high-performance computing systems. Therefore, the proposed relationship between these two variables was supported.

A person's attitude toward a technology can be used to gauge their level of acceptance of it because attitude will indicate whether they have positive or negative feelings about it. A technology's success is significantly influenced by the user's attitude toward it. It will further raise the desire or behavior to use attitude toward usage, which has an impact on boosting the intention to use technology, along with perceived utility and ease of use (Islami et al., 2021). It makes the claim that if a technology is both beneficial and simple to use, a positive attitude toward it may develop in the user. It has been proposed that attitude directly influences behavioral intentions. The persistence of intention to use technology was significantly influenced positively by attitude

(Chahal & Rani, 2022). Users' ongoing intentions are mostly driven by attitude, along with satisfaction and perceived usefulness. To comprehend the variables impacting users' intention toward a specific system, attitude has added explanatory power. Researchers discovered that attitude had a beneficial impact on customers' intention to use Internet banking in the context of ongoing use (Daragmeh et al., 2021).

Thus, how information technology is used is greatly influenced by attitude. Numerous studies have demonstrated that m-learning attitudes play a significant role in the development of behaviors that involve these systems as desirable tools (Moca & Badulescu, 2023).

Hypothesis 6: Intention to use high-performance computing systems positively affects the actual use of high-performance computing systems.

The relationship between the intention to use high-performance computing systems and actual use of high-performance computing systems was not supported as the t-value of the link between the two variables is less than 1.645 (see Table 21). A significant ($p < .05$) positive relationship is, therefore, evident between the intention to use high-performance computing systems and actual use of high-performance computing systems. Therefore, the proposed relationship between these two variables was supported.

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Previous studies have shown that user behavior has a major positive impact on how e-learning is actually used (Chahal & Rani, 2022). Nonetheless, due to limited studies focusing on habit as a factor driving academic behavior, we concur that understanding behavioral intention by applying the traditional adoption models like Technology Acceptance Model (TAM) is incomplete without considering habit (Kumar et al., 2020).

Hypothesis 7: Social Influence would positively influence actual use of high-performance computing systems. The t-value of the link between social Influence and actual use of high-performance computing systems is more than 1.645 ($t = 23.322$, $p < .05$) A significant positive relationship is, therefore evident between social Influence and actual use of high-performance computing systems. Therefore, the proposed relationship between the two variables was supported.

These findings are consistent with Azman Ong et al. (2023) study. Social influence is what determines consumers intention to use a certain technology. For example, when most of their peers encouraged them to use mobile learning technology, college students are more inclined to do so. According to the results of another study, teenagers will use wearable technologies because of the influence of their friends if they see their friends using them.

Humans are susceptible to social influence. We display a range of behaviours, such as conformity, compliance, and submission to authority, that show this (Lucas et al., 2019). It is well established that social influence has an impact on behavioral intent to utilize new or adapted technology. For instance, prior research has demonstrated that social influence affects the behavioral intention to use eHealth services, web-based banking, Instagram messaging, mobile evaluations, social networking, e-government, e-learning, and accounting systems (Guetz & Bidmon, 2022).

Nassar et al. (2019) mentioned that Through the influence of peers and senior management, who encourage administrative employees to use ICT by outlining its advantages and importance before and while being used, social influence may have an impact on the ICT administration personnel. If other users believe that ICT is important enough to influence their decision to use and embrace ICT, then social influence is affecting the users' plan to use ICT. Colleagues may have an impact on these kinds of decisions, which could have both positive and negative effects on ICT. Users may be influenced by adoption social influence if they observe others utilizing ICTs and reaping its benefits (Nassar et al., 2019).

In conclusion, as part of the process to continue using high performance systems or to gradually implement the systems, school leaders should implement initiatives that increase students' and teachers' awareness of and proficiency in using high performance computing systems. For instance, almost all HPC platforms and/or applications require an understanding of parallelism, an inherently difficult concept to grasp. Currently, a substantial portion of HPC education seems ad hoc, and requires a more structured approach. High performance systems also require appropriate infrastructures to support student learning, and guidance to faculty on how to incorporate HPC into their curricula. Lastly, new approaches are needed to advance the education of high-performance computing systems.

6.4 Contributions

The findings of the study on high-performance computing (HPC) adoption among previously disadvantaged universities in South Africa present several practical implications. Firstly, the positive correlation between self-efficacy and HPC use highlights the importance of fostering self-confidence in technology use among students and faculty. Universities should invest in training programs that enhance computer skills and self-efficacy, which could lead to increased adoption and effective utilization of HPC systems.

Despite perceived usefulness typically being a significant factor in technology adoption, the study found it did not positively influence attitudes towards HPC. This suggests that other factors might be more critical in this context. Universities might need to shift their focus from merely demonstrating the usefulness of HPC to addressing other motivational factors such as immediate benefits, specific applications relevant to users' needs, or incorporating HPC use into the curriculum in more engaging ways.

The negative influence of perceived ease of use on attitudes towards HPC is counterintuitive and warrants further investigation. It might indicate that users perceive HPC systems as complex and challenging, which could deter use. Therefore, simplifying the user interface and providing robust technical support could mitigate these negative perceptions. Furthermore, addressing this disconnect through user-centered design and continuous feedback mechanisms may enhance user experience and satisfaction.

The study also found that while attitudes towards HPC positively influenced the intention to use, the reliability coefficients for these constructs were below acceptable thresholds. This calls for refining the measurement scales used in the study to ensure they accurately capture the constructs. Improving the reliability of these scales will provide more robust data for future research and better inform interventions aimed at increasing HPC adoption.

Social influence was found to be a strong factor, suggesting that leveraging peer networks and faculty endorsements could be effective strategies for promoting HPC use. Universities could implement peer mentoring programs and involve influential faculty members in advocacy roles to boost adoption rates.

Future studies should aim to refine these models to better capture the dynamics of HPC adoption in this specific context. By addressing these practical implications, universities can enhance the adoption and continued use of HPC systems, ultimately improving educational outcomes and research capabilities.

6.5 Limitations

This study aimed at investigating the continued use and adoption of high-performance computers in historically disadvantaged institutions, therefore it did not include the rest of the universities in South Africa. For future research, the study can be extended to the rest of the universities. During data collection, an online questionnaire was created. This excluded the students which are physically on campus.

Another limitation is that there are not a lot of previous studies with regards to High performance computing systems. There is not enough research done, especially when it comes to the use of high-performance computing systems in South African universities.



6.6 Future Research

Future research can be done in all the universities of South Africa, to get a broader picture of the use of high-performance computing systems in South African universities. When this research is done, it will be best to do an online survey as well as surveys distributed on campuses. Future research can also include which universities have high-performance computing systems and which don't.

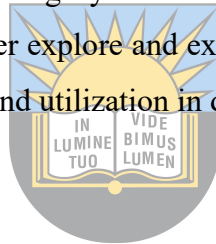
6.7 Conclusion

The present study has contributed to the researcher's knowledge and comprehension of the various factors which influence the adoption and continued use of high-performance computing systems amongst previously disadvantaged universities in South Africa. By examining users from various institutions in South Africa, the study has yielded significant findings that elucidate the factors that influences the adoption of High-Performance Computing Systems. This study has, through the application of measurement and structural models, along with advanced statistical analysis

techniques, produced valuable insights into the complex relationships between the variables of interest.

The findings from the measurement model indicated a reasonably good fit, providing confidence in the measurement instruments used to assess adoption of High-Performance Computing Systems. The structural model analysis demonstrated a notable level of congruence between the proposed model and the observed data, supporting the validity of the relationships proposed in the study's hypotheses.

In conclusion, this study contributes to the existing body of knowledge by examining the role of the adoption and continued use of high-performance computing systems amongst previously disadvantaged universities in South Africa. The findings underscore the importance of addressing computer efficacy, perceived usefulness, attitude, and social influence to enhance the adoption and utilization of High-Performance Computing Systems in Historically Disadvantaged Institutions. Future research endeavors should further explore and expand upon these findings to advance our understanding of technology adoption and utilization in diverse settings.



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Appendices

Appendix A: Ethical clearance



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ETHICS CLEARANCE
REC-270710-028-RA Level
01

Project Number: CIL021SZEM01

Project title: **Determinants of High-Performance Computing Systems Adoption and Continued Use amongst University Academics and Students in Historically Disadvantaged Institutions.**

Qualification: Master of Commerce: Information Systems

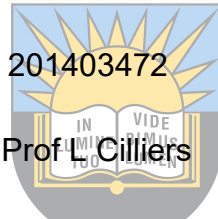
Student name: Sandisiwe Zembe

Registration number 201403472

Supervisor: Prof L Cilliers

Department: Information Systems

Co-supervisor: Prof B Mahembe



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On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby grant ethics approval for CIL021SZEM01. This approval is valid for 12 months from the date of approval. Renewal of approval must be applied for BEFORE termination of this approval period. Renewal is subject to receipt of a satisfactory progress report. The approval covers the undertakings contained in the above-mentioned project and research instrument(s). The research may commence as from the 03/01/23, using the reference number indicated above.

Note that should any other instruments be required, or amendments become necessary, these require separate authorisation.

Please note that UREC must be informed immediately of

- Any material changes in the conditions or undertakings mentioned in the document.

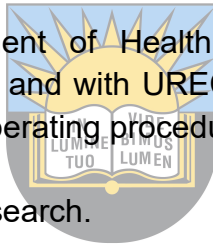
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research.

The student must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

UREC retains the right to

- Withdraw or amend this approval if.
 - Any unethical principle or practices are revealed or suspected.
 - Relevant information has been withheld or misrepresented.
 - Regulatory changes of whatsoever nature so require.
 - The conditions contained in the Certificate have not been adhered to.
- Request access to any information or data at any time during the course or after completion of the project.

Your compliance with Department of Health 2015 guidelines and any other applicable regulatory instruments and with UREC ethics requirements as contained in UREC policies and standard operating procedures, is implied.



UREC wishes you well in your research.

Yours sincerely

University of Fort Hare
Together in Excellence

2023.01.19
11:20:24 +02'00'

Dr N Taole-Mjimba

Chairperson: University Research Ethics Committee

06 January 2023



University of Fort Hare
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Appendix B: Proofreader certificate



EDITING CERTIFICATE

TO WHOM IT MAY CONCERN

I, Kudzai Mhepo, acknowledge that I did the language editing of the

Master of Commerce in Information Systems In the Faculty Of Management And Commerce

by

Sandisiwe Zembe student number 201403472

Titled:

Determinants of High-Performance Computing Systems Adoption and Continued Use amongst University Staff and Students in Historically Disadvantaged Institutions.

Details of the language editing are evident in the version of the article in track changes and with comments for the author's attention. The quality of the final document, in terms of language, formatting and references remains the author's responsibility.

A handwritten signature in black ink, appearing to read 'Kudzai Mhepo'.

Kudzai Mhepo

+27 76 638 9713 kudzaimhepo20@gmail.com / mhpkud001@myuct.ac.za

Lecture (University of Zimbabwe: Commercial Law Unit)

LLB cum laude (University of Fort Hare)

LLM in International Trade Law (University of Cape Town)

PhD Candidate in Public International Law (University of Cape Town)

01/12/2023.

Appendix C: Turnitin report

Zembe dissertation 29 April

ORIGINALITY REPORT

22%	19%	10%	12%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	hdl.handle.net Internet Source	4%
2	etd.uwc.ac.za Internet Source	3%
3	www.mdpi.com Internet Source	1%
4	thesai.org Internet Source	1%
5	pdffox.com Internet Source	1%
6	epubl.ktu.edu Internet Source	<1%
7	www.researchgate.net Internet Source	<1%
8	myscholar.umk.edu.my Internet Source	<1%
9	vital.seals.ac.za:8080 Internet Source	<1%

Appendix D: Questionnaire with consent form



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INDIVIDUAL INFORMATION SHEET AND INFORMED CONSENT FORM¹

(AGES 18 YEARS AND ABOVE)



Please note:

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Title of Study: Determinants of High-Performance Computing Systems Adoption and Continued Use amongst University Academics and Students in Historically Disadvantaged Institutions

Dear participant,

My name is Sandisiwe Zembe and I am studying at the University of Fort Hare.

I am conducting a study to determine the determinants of High-Performance Computing Systems Adoption and Continued Use amongst University Academics and Students in Historically Disadvantaged Institutions.

¹ Approved by UREC (13 November 2019)

Purpose of Study

This study will investigate the utilization and accessibility of cyber-infrastructure within universities in South Africa. The study is in response to a call from the Council for Scientific and Industrial Research (CSIR) to investigate and improve the field of human-computer interaction

We would like you to allow us to send you a questionnaire to complete that will take 10 minutes to fill in.

Study Procedure

The questionnaire will be send to you electronically via e-mail.

Some questions may be of a personal and/or sensitive nature. The questionnaire will be asking some questions that you may not have thought about before. We know that you cannot be absolutely certain about the answers to these questions, but we ask that you try to think about these questions. When it comes to answering questions there are no right and wrong answers.



Please understand that **your participation is voluntary** and you are not being forced to take part in this study. The choice of whether to participate or not, is yours. However, we would really appreciate it if you do share your thoughts with us. If you choose not to take part, you will not be affected in any way whatsoever. If you agree to participate, you may stop me at any time and tell me that you don't want to go on with the questionnaire. If you do this there will also be no penalties and you will NOT be prejudiced in ANY way.

The information will remain confidential. This means that your name and address will not be linked in any way to the answers you give. We study and report on the answers given by all the people we interview and not on an individual basis. The research data will be anonymous – with all personal respondent information removed and will be archived at the University.

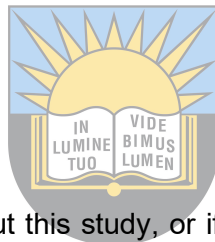
Risk-Benefit Ratio

At the present time, we do not see any risks in your participation. The risks associated with participation in this study are no greater than those encountered in daily life.

There are no immediate benefits to you from participating in this study. However, this study will be helpful in finding out how high performance computing can be used in higher education to improve teaching and learning.

Who to contact if you have been harmed or have any concerns

This research has been approved by the Inter-Faculties Research Ethics Committee (IFREC) as per delegated authority of the University Research Ethics Committee (UREC). If you have any complaints about ethical aspects of the research or feel that you have been harmed in any way by participating in this study, please call the IFREC Administrator, [Aphiwe Jadezweni, 040 602 2561 and ajadezweni@ufh.ac.za]



Reporting and Complaints

If you have questions at any time about this study, or if you have concerns/questions you may contact the researcher/project leader whose contact information is provided on the first page. If you have questions regarding your rights as a research participant, or if problems arise which you do not feel you can discuss with the researcher/project leader, please contact the IFREC Chairperson, Dr A Nyika on [040 602 2516 and ANYika@ufh.ac.za] or the UREC Chairperson, Dr N Taole-Mjimba on [043 704 7507 and nTaole-Mjimba@ufh.ac.za] .

If you have concerns or questions about this study please feel free to contact the project coordinators: **Researcher/Project Leader:**

Name: Sandisiwe Zembe

Department: Information Systems

Address: 50 Church street, East London, 5201

Phone: 072 430 5311

Email: 201403472@ufh.ac.za

Name: Prof Liezel Cilliers

Department: Information Systems

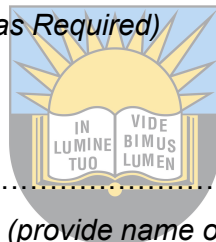
Address: 50 Church street, East London, 5201

Phone: 0835184009

Email: lcilliers@ufh.ac.za

INFORMED CONSENT FORM

(Edit as Required)



I *(name of participant)*

have been informed about the study by *(provide name of researcher/ project leader/ fieldworker)*

.....
University of Fort Hare
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I understand the purpose, procedures, and risk-benefit ratio of the study.

I have been given opportunity to ask questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any procedurals that I would usually be entitled to.

I have been informed about any available compensation or medical treatment if injury occurs to me as result of study-related procedures

I understand that I will be given a copy of this informed consent.

I understand that if I have any questions or complaints about my rights as a study participant, or if I may have concerns about any aspect of the study or the researcher/s then I may contact the Chairperson of the Inter-Faculty Research Ethics Committee, Dr. Aceme Nyika or Chairperson of University Research Ethics Committee, Dr N Taole-Mjimba (details available from the Researcher or by contacting the University of Fort Hare or Website www.ufh.ac.za)

Participant signature:

Consenting for Audio Recording– when necessary

YES / OR

Participant signature:



Witness signature:

(to be altered according to the study)

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Translator signature:

(to be altered according to the study)

Data curation – I understand that the information that I provide will be stored electronically and will be used for research purposes now or at a later stage (to be altered according to the study)

Participant signature:

Date:

No	Please put a cross in the appropriate block indicating whether you strongly disagree, disagree, neither agree nor disagree, agree, or strongly agree with each of the following statements:	Strongly disagree	disagree	Neutral	Agree	Strongly agree
Risky Cyber-Security Behaviours						
1.	I share passwords with friends and colleagues	1	2	3	4	5
2.	Using online storage systems (Dropbox, G-Drive etc) to exchange and keep personal or sensitive information	1	2	3	4	5
3.	Using free institution Wi-Fi or public Wi-Fi to browse emails and other documents online	1	2	3	4	5
4.	Relying on a trusted friend or colleague to advise you on aspects of online security tips	1	2	3	4	5
5.	Downloading free anti-virus software from an unknown source	1	2	3	4	5
6.	Using the same password for multiple websites.	1	2	3	4	5
7.	Clicking on links contained in unsolicited emails from an unknown source	1	2	3	4	5
8.	Downloading data and material from websites on my computer without checking its authenticity	1	2	3	4	5
9.	Checking that software for your smartphone/tablet/laptop/PC is up to date.	1	2	3	4	5
10.	Downloading digital media (music, films, games) from unlicensed sources	1	2	3	4	5

11.	Storing personal and institutional information on my personal electronic device (e.g., smartphone/tablet/laptop)	1	2	3	4	5
12.	Clicking on links contained in an email from a trusted friend or work colleague.	1	2	3	4	5
Attitudes towards Cybersecurity						
13.	I would not know how to report a cyberattack if one happened on my Institutional System	1	2	3	4	5
14.	I think that reporting cybercrime is a waste of time.	1	2	3	4	5
15.	I feel that the Police are far too busy to deal with cybercrime	1	2	3	4	5
16.	I think that cybercriminals only target a company/institution when there is a substantial financial gain.	1	2	3	4	5
17.	I am aware of the institution's IT use policy and attempt to follow it.	1	2	3	4	5
Planned use of High-Performance Computing Systems (HPC's)						
18.	I am willing to adopt high performance computing systems	1	2	3	4	5
19.	People who are close to me think that I should use High-Performance Computing Systems.	1	2	3	4	5
20.	It is certain that I will use High-Performance Computing Systems	1	2	3	4	5