THE IMPACT OF ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND BIG DATA ANALYTICS ON IT OPERATIONS IN HIGHER EDUCATION

by

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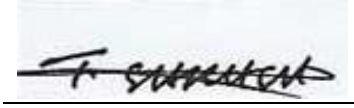

Signature

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Date

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ABBREVIATION/ACRONYM	FULL NAME
APIs	Application Program Interfaces
AV	Audio Visual
AIOps	Artificial Intelligence in IT Operations
BYOD	Bring Your Own Device
CEO	Chief Executive Officer
CIO	Chief Information Officer
CI	Configuration Item
CPU	Central Processing Unit
DevOps	Development Operations
ERP	Enterprise Resource Planning
I&O	Input & Output
iOS	iPhone Operating System
IOT	Internet of Things
ICT	Information & Communication Technology
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITS	Information Technology Services
IVR	Integrated Voice Recordings
JSE	Johannesburg Stock Exchange
MIS	Management Information Systems
NASA	National Aeronautics and Space Administration
OMR	Optical Mark Reading
POPI	Protection of Personal Information
RAM	Random Access Memory
RCA	Root Cause Analysis
ROI	Return on Investment
RPA	Robotic Processing Automation
SAN	Storage Area Network
SLA	Service Level Agreement
TCO	Total Cost of Ownership
TOE	Technology-Organization-Environment
UP	University of Pretoria

ABSTRACT

Title: The impact of Artificial Intelligence, Machine Learning and Big Data Analytics on IT operations in higher education.

Background: Over the years, organizations have relied on IT to manage their operations and achieve their objectives. On the other hand, IT has developed at a fast pace, culminating in virtual, cloud, data analytics and artificial intelligence technologies. Accompanying the IT developments have been major IT incidents that have resulted in some organizations closing down, others suffering financial losses, reputational damages and the loss of customers. This has placed IT operations at the centre of organizational sustainability. The root cause of the problem is the inability of IT operations to manage and resolve IT related problems and related incidents on time in an environment that is increasing in complexity and demands.

Purpose: The study focuses on Artificial Intelligence in IT Operations (AIOps). Artificial intelligence for IT operations (AIOps) are software systems that combine big data, artificial intelligence and machine learning functionalities to enhance and partially replace a broad range of IT operations processes and tasks, including availability and performance monitoring, event correlation and analysis, IT service management, and automation. The study is also about identifying enablers and barriers to the implementation of AIOps in the higher education sector. The study aims to provide propositions and guidelines for management and practitioners for the implementation of AIOps.

Research Methodology: The study adopted the case study strategy underpinned by an interpretive philosophy. It followed a qualitative approach and collected primary data through semi-structured interviews at two institutions of higher learning.

Key Findings: Based on the collected and analysed data, it has been found that both institutions are not ready to implement AIOps. They have more barriers than enablers. A significant observation is that the barriers are centred on salient technical issues, which are critical, such as IT architecture infrastructure, diagnostic predictive tools, automated tracking and monitoring, data analysts and others. The enablers centred on the non-technical issues such as IT skills, IT policy, IT strategy, governance and others.

Value of the study: The study broadly contributes to the emerging field of knowledge in AIOps. Furthermore, it highlights barriers to implementing AIOps in institutions of higher learning. The study provides insights on how IT operations are managed at institutions of higher learning, and how these institutions can start preparations for the implementation of AIOps.

Keywords: AIOps, Artificial Intelligence, IT operations, Big Data Analytics, Machine Learning

1. INTRODUCTION

1.1 BACKGROUND

This chapter deals with a review of the concept of IT operations as well as its role and significance. It looks at how developments in information technology have affected IT operations and the evolution that has taken place. The impact of artificial intelligence, machine learning and big data analytics on IT operations is considered. The research question and rationale, including assumptions are also considered.

IT operations may have different meanings for different people. For this research, IT operations are the activities of identifying, integrating and managing different products and processes to provide a stable, responsive and robust IT environment (Schussed, 2010:37). In some documents, IT operations is referred to as systems management. As information technology enables the functioning of organizations, IT operations play a crucial and supportive role. A healthy IT organization provides key competitive advantages for organizations in a fast-paced market (Tarun, 2017). IT operations deal with the management of software and hardware, IT support, network administration, device management and their related functions in an organization.

According to a whitepaper released by Loom Systems (2017), digital leaders indicated that 43% lost their competitive position because of IT performance issues, $72,000 was lost per minute on service outages, 48% of organizations spent more than 60 minutes repairing performance issues per incident. Similar issues are experienced by the higher education sector. Some lecturers have experienced downtime that negatively impacted on teaching and learning activities. As reported by Smile and Regalado (2017:68) some faculties and lecturers in the higher education environment have expressed reluctance in adopting online learning management systems due to the impact of IT performance. No university wants to cancel an examination due to the IT downtime.

Paddy, Kayak & Signor (2018), explain that traditional IT operations are domain centric in their management and monitoring of IT, which presents an element of inadequacy in the management of IT operations. They focus on the different domains such as server management, network management, application support and datacentre management. With these different domains, the IT operations team is unable to correlate data from the different domains to provide insights that the IT operation’s teams require to manage the environment proactively. Thus, while IT operations are central to the performance of the organization, their architectures present a challenge.

Developments around artificial intelligence and big data analytics offer an opportunity for IT operations to improve how IT operations are managed. Artificial intelligence offers the opportunity to overcome IT operations challenges relating to monitoring, alerts, redundancies, downtimes, slow response and others (Janakiram, 2017). Artificial intelligence for IT operations (AIOps) is a combination of big data and machine learning which optimizes the related processes and tasks. According to Gartner (2016), by 2019, 25% of enterprises will be using AIOps to support two or more major IT operations functions.

Andenmatten (2019:334) concludes that 40% of all large companies will combine data and machine learning functions to replace the service desk partially as well automation processes and functions. The link between big data and artificial intelligence has facilitated the development of AIOps. Big data and machine learning are central to AIOps to understand real-time insights into problems, incidents and issues that affect the IT operations environment. Such insights are predictive and are accompanied by automated recommendations to fix problems. The diagram below is an illustration of AIOps.

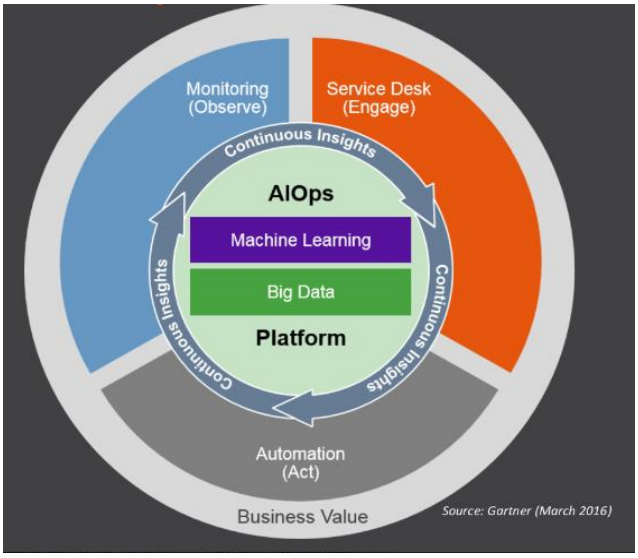


Figure 1. Gartner's visualization of the AIOps platform. Source: Gartner (2016).

The essence of the diagram is that AIOps consists of two main components, which are big data and machine learning. Thus a move away from the silo approach of the traditional IT operations is required to aggregate the data (e.g. from monitoring systems, incident logs, alerts, operating systems) inside a big data platform. Once the data is aggregated, AIOps performs an analysis and machine learning process of the combined data. The results are insights to the IT operations environment across the board, which suggests improvements and fixes using automation. This information becomes part of the service desk, the automation of IT operations and the monitoring service, which when combined add significant business value to the IT operations contribution.

1.2 RESEARCH OBJECTIVES

The study investigated the enablers and barriers to the implementation of AIOps in the higher education sector. In investigating the enablers and barriers to the implementation of AIOps, the study assessed current literature and theory to establish the research advancements in IT operations. The study aimed to provide propositions and guidelines for management and practitioners for the implementation of AIOps.

1.3 PROBLEM STATEMENT

IT operations are like the engine of an organization. The IT platform needs to be operated efficiently and effectively to enable the organization to perform optimally. IT architectures are complex environments with many points of failures. Identifying these points of failures and resolving them on time presents a challenge to various organizations. Traditional IT operations, based on domain centric monitoring are unable to cope with the volumes of data produced that provide the required insight into the IT environment (Paddy, Kayak & Signor, 2018). IT operations that are not optimally managed will negatively affect the performance of the organization. “It is no secret that IT service outages and disruptions can cost companies anywhere from thousands up to millions of dollars per incident – plus significant damage to company reputation and customer satisfaction”, Oats (2017:1).

The problem is the inability of IT operations to manage and resolve IT related problems/incidents on time in an environment that is increasing in complexity and demands. The growing complexity and the amount of data that is produced by organizations such as a university creates new demands for the IT operations. IT departments need to make sense of this information and link it to broader organizational objectives.

Mohanty and Vyas (2018:174) point out that, “Today’s IT landscape is too complex for any single person or even a team to manage on their own; instead, the skills required consist of multiple specializations (full-stack engineers)”. In such circumstances, the IT operations team requires all the assistance it can get to manage the IT environment optimally to avoid downtime that can have negative consequences for the organization.

The impact and consequences of IT problems/incidents not resolved can be severe as outlined above where for example $72,000 was lost per minute on service outages, 48% of organizations spent more than 60 minutes repairing performance issues per incident. It can lead to loss of life, businesses collapsing, reputational damage to institutions, and so on. It can also affect the adoption of useful technologies as shown by the reluctance of some faculties and lecturers (Loom Systems (2017), Smile and Regalado (2017:68). The IT operations environment, especially the production environment is concerned with making sure

that IT services are available, that problems are predicted in time before they occur, when they occur they are resolved in time and a root cause analysis is performed. On the other hand, organizations are adopting new technologies, new applications which put pressure on the IT operations. This results in IT operations being in a constant catch-up situation, which is not ideal. At some stage the IT operations environment may become chaotic and unmanageable (Mohanty and Vyas, 2018:176).

In terms of the problem outlined above, the Executive management that considers and approves the budget for IT infrastructure and subsequent changes and upgrades would be interested in the research problem being considered. Looking at the flexibility of the IT infrastructure, Chanapos and Krairit (2006:633) pose the question, “The question is, with a large investment, how can IT infrastructure be managed to best achieve today’s business goals as well as future demand”? IT operations practitioners, hardware vendors, software vendors, application developers and application support practitioners, the end-users, artificial intelligence and machine learning researchers and practitioners, big data analytics researchers and practitioners would also have an interest in the research problem being addressed.

The extant literature has limited studies focusing on AIOps and to the researcher’s knowledge, there are no studies investigating the barriers and enablers of AIOps in the higher education context. This point is supported by Dang, Lin and Huang (2019:5) in “ AIOps innovations call for a close partnership between academia and industry…While the proliferation of open-source software enables easy access to source code for the research community, it is far from enough for AIOps innovations”. The study contributes to the current research about IT operations, artificial intelligence and machine learning. It provides a review of the implementation of AIOps in the IT operations environment. It also makes recommendations for consideration in implementing AIOps in a higher learning environment since IT operations are the lifeblood of an organization (Tarun, 2017).

1.4. RESEARCH QUESTIONS

This study investigated IT operations and the level of artificial intelligence and machine learning implementation in the higher education sector. The primary question is “*What are the barriers and enablers to the implementation of AIOps?* The secondary research question is: *“How can an understanding of the barriers and enablers assist in the implementation of AIOps?*

1.5 ASSUMPTIONS

In this study, an assumption is made that as IT systems become sophisticated, they become more complex. The study assumed that current IT operations are not adequate in responding to recent technological developments. The study assumed that AIOps may improve the management of IT operations.

1.6 LIMITATIONS

The concept of AIOps is a new development and a big shift from the traditional IT operations approach. It is a multifaceted approach combining artificial intelligence, machine learning and big data analytics within the IT operations domain. The study is limited to the tertiary education environment.

1.7 RATIONALE FOR THE STUDY

The study looked at the enablers and barriers to the implementation of AIOps. The understanding of enablers and barriers will guide researchers, management and practitioners on the important considerations and what needs to be done to shift to AIOps. It will augment and extend the existing literature on AIOps. The recommendations of the research may be applied to any organization aiming to implement AIOps.

1.8 SUMMARY

This chapter introduces the context of the research. It outlines the concept of IT operations, its significance, challenges and the consequences when not properly managed. The chapter introduces artificial intelligence, machine learning and big data analytics as they apply to IT operations. Lastly, the chapter looks at how the objectives of the research relate to the research question of identifying enablers and barriers to the adoption and implementation of AIOps.

2. LITERATURE REVIEW

2.1 INTRODUCTION

Under the literature review section, the concept of artificial intelligence in IT operations (AIOps) including its role and significance are considered. A review of artificial intelligence in other business functions, such as customer service, human resources and others is conducted, followed by trends in IT operations, with a reflection of the evolution of IT operations. The interplay amongst the concepts of artificial intelligence, big data and data analytics is outlined. Lastly, the chapter looks at the contribution of artificial intelligence, big data and data analytics could make to IT operations in an organization.

2.2 WHAT IS ARTIFICIAL INTELLIGENCE IN IT OPERATIONS (AIOps)

With the influence of artificial intelligence on IT operations, a new term has been framed, called AIOps. AIOps stands for Artificial Intelligence for IT operations and essentially it is about the application of algorithms in IT operations. It is about the use of artificial intelligence and machine learning to automate tasks and processes that are undertaken to plan and manage IT operations. Mohanty and Vyas (2018:174) refer to AIOps as, “a set of diagnostic and predictive tools, automation and humans-in-the-loop capabilities that will enable operation teams to embrace change”. AIOps is thus not a solution or software tool, it is a combination of capabilities that guide IT operations teams in handling the challenges of complexity and high-performance demands that characterize IT operations, utilizing the new and powerful technologies that provide the potential to transform IT operations. AIOps provides the ability to conduct real-time analysis of the entire IT operations environment, detecting and addressing issues and incidents at the same time.

2.3 WHAT IS THE ROLE AND SIGNIFICANCE OF AIOps?

With the technology that is evolving rapidly, organizations are struggling to catch up with the big volumes of data, increasing customer demands and too many processes that are sometimes inefficient. The same applies to the IT operations environment. This is where the crucial role and significance of AIOps become apparent. The significance of AIOps in the IT operations environment is outlined in the points below.

2.3.1 Log analysis

Log analysis is about the analysis of the data generated by the logs. Most of the computer components such as hardware, software, operating systems, servers, databases and applications generate logs. The IT operations teams rely on these logs in order to get an understanding of the performance and health status of the different IT components. This process is significantly human, with the teams analysing these logs and determining the root cause of the problem or potential problem as well as determining the intervention approach.

AIOps introduces machine-learning algorithms, which can proactively find problems and potential problems before they happen (Thankachan, 2017:716).

2.3.2 Capacity planning

In most IT operations environments, capacity planning is performed manually, based on existing specifications and analysing performance-related shortcomings. As one can imagine, such an approach will present a challenge, especially for large, complex environments, with multiple tier applications. The IT operations team matches the application to the number of CPU cores required, the amount of RAM storage and the network bandwidth. AIOps through machine learning algorithms is capable of learning from existing deployments and current performance to recommend the right configuration for each workload (Kibria, Nguyen, Villardi, Ishizu, 2018:32330).

2.3.3 Infrastructure scaling

Infrastructure scaling is the process of tuning elements to scale out when more capacity is required. IT operations teams normally do this manually when they see a need for more resources required. With AIOps, the IT operations team can configure the infrastructure in a manner that learns from the previous load conditions and usage patterns (Chanopas, Krairit and Khang, 2006). As a result, the system develops intelligence that allows it to scale in future, when a need arises.

2.3.4 Cost management

The estimation of costs is a crucial element for an optimal IT infrastructure. With AIOps machine learning can accurately forecast the costs by analysing current workloads and patterns across various IT components (Paddy, Nayak and Signore, 2018:11). This will assist in compiling accurate IT budgets. The combination of artificial intelligence and data analytics in the IT operations environment provides an opportunity for the generation of data that provides real insights into the IT environment. The key attributes are that data is actionable and relevant.

2.4. ARTIFICIAL INTELLIGENCE IN OTHER BUSINESS FUNCTIONS

Artificial intelligence refers to the combination of technologies where a machine that can sense, learn and act is produced. Such machine assists humans in doing what humans have been doing better and faster. According to Cochrane (2018), artificial intelligence is described as part of the fourth industrial revolution. The first industrial revolution saw the launch of the steam engine and the textile industry. The second industrial revolution was characterized by the advent of electricity, gas, oil, telephone, cars and the aeroplane. The third phase of the revolution was the era of electronics, computers and nuclear energy. Thus, the fourth industrial

revolution is termed as the machine revolution, with artificial intelligence at the forefront. It needs to be pointed out that developments, upgrades, optimization of the previous revolution items are still taking place today. The following are some of the business functions that utilize artificial intelligence.

2.4.1 Customer service

Artificial intelligence is widely used in the customer service business function. Contact centers consist of a variety of AI capabilities, from customer service agents that are available 24/7 to interactive voice responses (IVR) systems. A white paper on artificial intelligence released by the University of Pretoria (2018) mentions that machine learning can assist the financial services companies in tracking customer behavior and offer tailor-made financial advice. These companies use artificial intelligence to analyse credit scores, spending patterns to assess the risk and offers solutions tailor-made for that particular customer profile.

2.4.2 Human resources

Recruiting suitable employees is characterized by many computer applications that match talent supply with demand. This saves time and money during the recruitment process, as humans do not need to go through thousands of documents to determine suitable candidates or assessing behavioral profiles. Another example of artificial intelligence in human resources is that of NASA as reported by Davenport and Ronanki (2018:4). After experiencing budget pressures, NASA used robotic processing automation (RPA) technologies with a result of 86% processes being completed without human intervention.

2.4.3 IT Help desk

The help desk has adopted some of the AI technologies to provide better services to customers. Davenport and Ronanki (2018:6) report, "An Italian insurer, for example, developed a "cognitive help desk" within its IT organization. The system engages with employees using deep learning technology (part of the cognitive insights category) to search frequently asked questions and answers, previously resolved cases, and documentation to come up with solutions to employees' problems". This is an indication of how artificial intelligence can be applied successfully within the service desk environment.

2.4.4 Sales

The impact of artificial intelligence in sales is illustrated by the technology offered by a South African company Clevva (Simons, 2016). It uses artificial intelligence, with virtual advisors on AI platforms to advise sales and technical consultants. The technology is based on the objective of enabling an organization to capture and scale its sales, support and systems, empowering the sales team. The virtual advisors act like online advisors who ask the relevant

questions based on the company's policies and procedures regarding sales, they then provide advice and recommend action based on the answers provided.

2.4.5 Security

There are several security functions where artificial intelligence is being utilized. One of them is the authentication of the user's identity. For example, Purgason and Hibler (2012:398) proposed the utilization of artificial intelligence and biometrics to identify users based on their behavior, actions, and tendencies as a security measure. Machine learning and artificial intelligence are capable of identifying unusual activities on the network, whether they relate to performance issues or security issues and develop learning patterns where they generate predictions or recommendations for specific actions.

2.4.6 Business intelligence

Large organizations are struggling to coordinate large amounts of data and deduce patterns and meaning useful to the organization. It would require large amounts of time and energy for employees to collage these volumes of data and generate meaningful reports. With artificial intelligence, tasks like data sourcing, analysis, interpretation and report generation are automated, where charts, tables and reports can be generated within a short time (Davenport and Ronanki, 2018:7).

2.4.7 Logistics / Delivery

The Amazon drone case study (Welch, 2015) is an innovative indication of artificial intelligence applied in the logistics/delivery business function. In 2013, the Amazon CEO surprised many people when he announced that Amazon will be using a drone to deliver packages to customers. Amazon was commended for this innovative approach to drone technology. This approach has certainly provoked a lot of thinking from different people and provided an opportunity to expand transportation and delivery service in a way never imagined before. The drone technology brings a labour-saving and capital-using technology as drones replace labour and trucks. However, there are some challenges Amazon needs to deal with, such as how the drone delivers in a block of flats, how do you know the owner of the package will be at home during delivery, how to validate that the customer receiving the package is the right person?

In conclusion, the role of artificial intelligence is pervasive across business functions. Lessons that may be drawn from the role of artificial intelligence in other business functions relate to AI as a subject that should not be ignored by organizations, especially during the fourth industrial revolution. Artificial intelligence has the potential to assist organizations, however, it is not simple, and it is complex and requires the development of a comprehensive strategy in order

to realize its benefits. As Davenport and Ronanki (2018:8) argue, “In time, cognitive technologies will transform how companies do business. Today, however, it’s wiser to take incremental steps with the currently available technology while planning for transformational change in the not-too-distant future”. There is potential to waste time and money if an organization adopts the wrong technology regarding artificial intelligence. A good understanding of technology may increase the chances of success. The IT operations team needs training and education in AIOps, there will be a need to consider involving data scientists to augment the team with the necessary big data skills. Success will be based on the team’s willingness to learn, some team members will embrace the opportunity to learn new things while others will want to stay with the old tools they are familiar with and used to.

2.5. TRENDS IN IT OPERATIONS AND THE EVOLUTION OF IT OPERATIONS

2.5.1 IT operations trends

IT operations is a management and administrative function executed by the IT department in an organization, which involves the IT infrastructure components, applications, services, storage, networking and connectivity. Essentially, this management and administrative function is driven by various processes, which ensure the availability, efficiency and performance of an organization's IT services. IT operations play a critical role in the provision of IT services to an organization. Without a properly managed IT operations environment, IT will not be able to enable the operations of an organization. There will be endless downtimes and wastage of resources, which will eventually frustrate the end-users. From the perspective of Schussed (2010:37), IT operations entail the identification and integration of various products and processes to deliver and manage a stable IT environment that is responsive to organizational and employee needs. The key areas covered by IT operations in a conventional organization include:

2.5.2 Cloud computing

Cloud computing is about using a network of servers hosted by a service provider to achieve computing power, networking and storage as opposed to operating your on premise datacentre. It has developed over time and is now accepted service where organizations may choose to pay for services consumed instead of purchasing network, storage and computing equipment. With the wide acceptance and usage of cloud computing, the scale and complexity of services have increased, leading to challenges for the IT operations team, challenges that can be addressed by AIOps (Dang, Lin, Huang, 2019:4). The digital transformation requirements have put pressure on organizations to adopt cloud computing to respond to rapid development and production capabilities. However, these demands present challenges. According to Mohanty and Vyas (2018:175) these demands, driven by continuous innovation,

adoption of machine agents, Internet of Things (IOT), Application Program Interfaces (APIs) create complexities for the IT operations team. This forces the IT operations environment to evolve and innovate to meet these developments and manage hybrid environments. This trend is expected to grow, according to Gartner (2016).

2.5.3 Network architecture

The network infrastructure deals with all the networking functions such as wide area network, local area network, telephone system, remote access for authorized users to the organization's network, access to outside servers, resolving any issues and monitoring issues related to network resources. Since networks were first used, capacity and user experience has always been a balancing act. As services were deployed by the organization, these were consumed by the users in an increasing fashion, which drove up the requirements for more and more speed and faster access. This became a linear solution, which unfortunately does not scale. Wang, Su, Xia, Muppala and Hamdi (2015:283) explain the critical role of the datacentre and the network architecture as, "To support the growing cloud computing needs, the number of servers in today's data centres are increasing exponentially, thus resulting in enormous challenges to network design for interconnecting these servers".

2.5.4 Server management

Server management deals with the management of the servers, and storage and their interface to the network. This function includes setting up of servers, e-mail and authorization, the management of approved devices like laptop, desktop and mobile computing devices. Server management incorporates remote server management, which is a combination of products and services that allow the IT operations team to monitor and control servers from offsite. Bajgoric (2010:317) asserts that in 21st century era, "The main requisite is an integrated server platform that is always on, uninterruptible and characterised by high availability". The availability of servers is thus of extreme importance for organization that utilize information technology.

2.5.5 Application support

The primary function of application support services is to support all current and future deployed distributed applications. This cluster is responsible for delivery of the application support services of all implemented applications. Application support covers day-to-day small application enhancements, problem resolution, bug fixing, and infrastructure support such as test environment management.

An example of a business process driven by application support is the ordering of book, where one has to check availability, verifies credit card details and process shipping details. Zou,

Guo, Foo and Hung (2009:315) contend that, “Modifying business applications is a time-consuming and error-prone task. To correctly perform this task, developers require an in-depth understanding of multi-tiered applications and the definitions of the business processes that they implement”. Thus, application support is characterized by specialized skills required to ensure that a high level of service is maintained. They are repeatable best-practice methods that need to be followed to contribute to service excellence. Some tools are preferred to support the delivery of service excellence. Considering the cross-functional role of this area, some methods and processes are employed to improve the effectiveness of the environment and thereby contribute to overall service excellence. Applications are characterized by varying levels of complexity, they stay for a long time and are required to use computer and network resources efficiently. They are expected to be reliable and be able to recover quickly in case of a disaster. They form a key focus area for the IT operations environment.

2.5.6 Service Desk

The service desk is the first point of contact for users with IT-related problems. The service desk provides an organized and coordinated first line and second line technical support service to users regardless of geographical location. The service desk is the focal point of support and provides the platform for communication, feedback and management information. The service desk needs to have clearly defined and communicated objective depending on what the organization seeks to accomplish. In the IT operations environment, the service desks aim to:

- Provide a single and central point of contact between users and the IT department.
- Provide an interface for users to other service management functions, such as change management, problem management, configuration management, release management, and so on.
- Deliver the high-quality support required for achieving business goals.
- Identify and lowering the total cost of ownership (TCO) of IT services.
- Support changes across business, technology, and process boundaries.
- Improve customer satisfaction.
- Retain all customers.
- Identify additional business opportunities.

The role of a service desk is crucial in the digital age. According to Elliot and Andrews (2017), service desks need to be transformed into a proactive function through artificial intelligence. From the diagram below, it can be seen that service desk plays an important role in being a central point for the IT operations and processes.

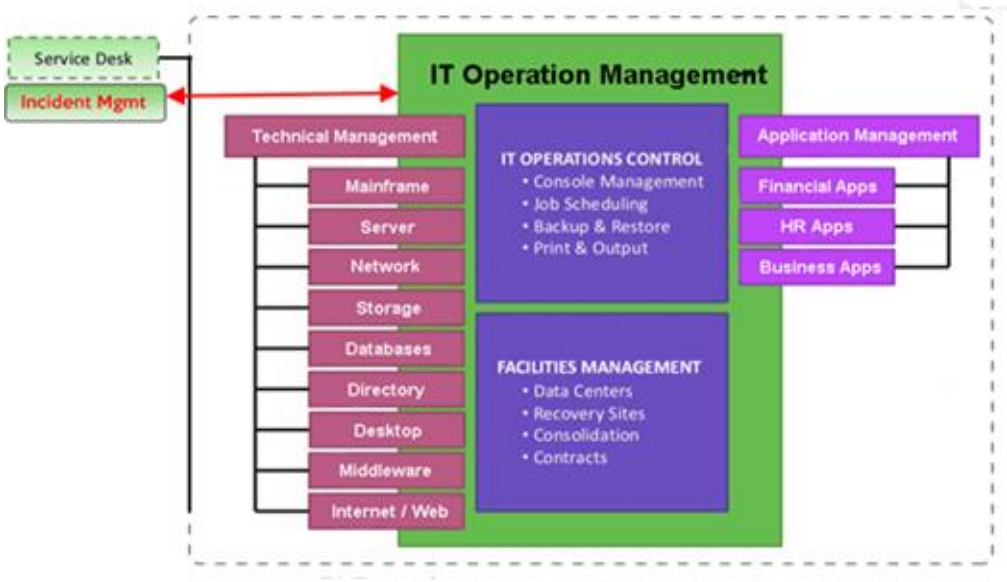


Figure 2. ITIL Service Operations Functions. Source: Brahmachary, (2018)

2.5.7 IT operations evolution

From an evolutionary perspective, IT operations have developed over some time. Organizations used best effort to guarantee services that were available for consumers. However, the lack of visibility into how these services were operating increased operational costs and risk often resulting in poor customer satisfaction. Organizations that managed to stay in business quickly focused their attention on increasing visibility through acquiring various products that could monitor their infrastructure and applications. This approach gave birth to management frameworks such as ITIL (Schussed, 2010:37).

Organizations could now be quickly informed when services were experiencing problems rather than waiting for customers to inform them of an outage. However, the business applications portfolio has continued in the silo approach (Chaffey, 2009:155). The author attributes this development to a variety of reasons such as different technology architectures for different functional areas, separate databases in different areas and different processes in different functional areas. Chaffey (2009:155) points out that silos in applications result in inefficiencies that often cost more to purchase, support and maintain. The recommendation for IT operations is an integrated environment as depicted below.

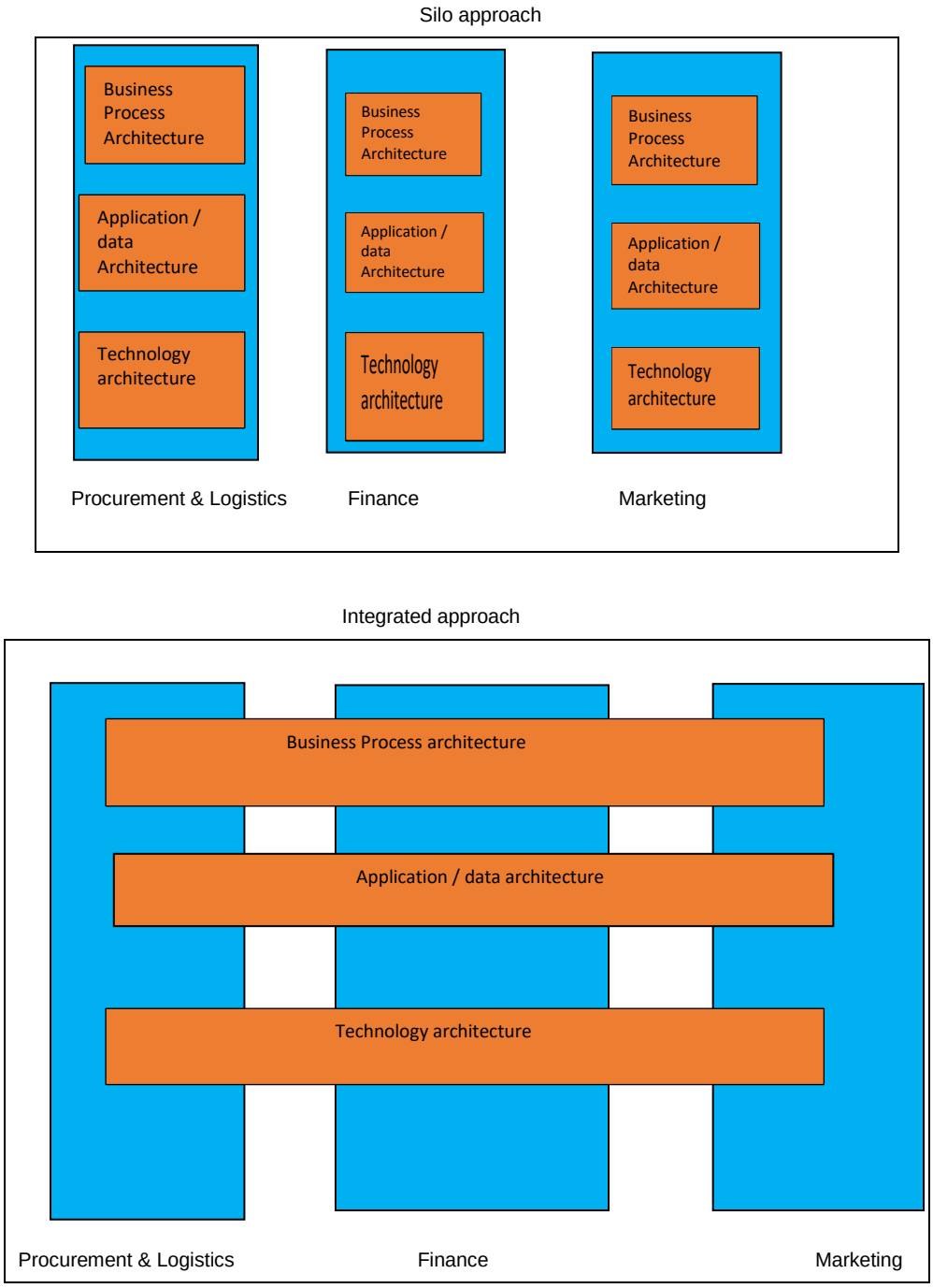


Figure 3. Silo approach vs Integrated approach for IT operations, Source: Adapted from Chaffey (2009)

2.6. CHALLENGES AND RISKS FOR IT OPERATIONS

Businesses such as telecommunications, transportation, and logistics rely on IT to drive the organization, where products, services are marketed, sold and supported with IT, (Active Batch, 2017). While IT operations are central to the success or failure of organizations, challenges are being faced by IT operations. As mentioned earlier, the challenges faced by IT operations are attributed to developments and innovations in information technology. IT is not becoming simpler, it is being more complicated and sophisticated. Concepts such as virtualization, containers, elastic clouds, micro services attest to this complexity and

sophistication. Focussing on the challenges faced by IT operations personnel, Mohanty and Vyas (2018:173) write, “IT operations personnel spend a significant amount of time and energy trying to keep everything up and running and are always under mounting pressure to predict when things will go wrong and be prepared with fixes and lengthy root cause analysis documents”. The development of cloud computing, big data analytics, mobility and social media have resulted in the following challenges being faced by IT operations.

2.6.1 Scalability

It is interpreted that the volumes of traffic that are managed by IT operations are increasing at a rapid rate, without any prospect of decreasing. Many organizations have responded by increasing bandwidth, networking and processing power in a desperate attempt to keep up with the demand for growth. On the server environment, virtualization has been a response to the challenge of scalability, so that resources can be made available on demand. The concept of cloud computing also addresses the challenge of scalability. Cloud computing can accommodate demands and scale up when required and scale down when requirements are no longer required (Kirsch, 2017). This allows cloud computing to accommodate all different sizes of organizations with different processing and transaction requirements.

2.6.2 New demands

As the technological landscape is developing at a high pace, so are the new demands placed on the IT operations environment. These demands come in the form of volumes for systems, volumes for applications, user and data. More applications in different formats and levels of complexity are required by different types of users, different types of data are also required. According to Schussed (2010:45), “Today's IT executives work in a fast-paced world of ever-changing technology and ever-increasing demands from customers. They may be faced with dozens of decisions daily and an even larger number of tasks to juggle and prioritize". Commenting on the role of the Internet in the telecommunications industry, Qi, Wu, Li and Shu (2007:272) point out that the market has shifted from a stable one to a user-driven one, where the success of the telecom operator will depend on the ability to create services and applications that are embraced by the users.

2.6.3 Multiple and diverse platforms, tools and devices

About the proliferation of technologies, which the IT operations team must contend with, it is not just Windows or Linux, but smartphones and tablets, iOS, Android, and a variety of devices (appliances, each with its tools and management models). Besides, with the emergence of BYOD, there is no let-up in sight. As new technologies are released, the organization need to perform assessments based on their clients and decide on implementation plans (Chaffey 2009: 217).

2.6.4 Continuous operations and frequent changes

Release cycles in the IT environment are very short, in some case a few weeks. Organizations cannot wait months to enhance capabilities because, by the time they make the change, their competitors will already have completed something new and gone to market. Agile methodologies have introduced another dimension in the IT operations environment. Organizations have adopted DevOps as a way to respond or risk being left behind. Changes need to be implemented fast, without bypassing the required processes, which put the IT operations team under pressure. Referring to the digital transformation demands and the pressure on the IT operations team, Mohanty and Vyas (2018:175) argue, “It is clear that digital transformation requires increased cloud adoption and readiness to respond to rapid development and production deployment capabilities. This strains the traditional service management best practices, the team’s capabilities, and the skills and tools to the breaking point”.

2.6.5 High profile incidents

Some high profile incidents are emanating from the failure of IT operations, which highlight the importance of addressing IT challenges proactively as outlined by Ahmed (2017). He points out that in August 2016, an IT operations failure that resulted in an outage caused the delay of 2300 flights of Delta Airlines in Atlanta, delaying hundreds of thousands of passengers and prompting backlogs that lasted for three days. It was established that the root cause was an old piece of equipment that caused a fire in the datacentre, which knocked out the primary and backup systems. On the 18th June 2018, the Johannesburg Stock Exchange experienced a two-hour delay to its trading due to a technical glitch emanating from the IT operations (IT Web, 2018). The consequences were a 1% loss in trading and embarrassing reputational damage for the institution. The Home Affairs department was offline for three weeks in April 2019, which negatively affected the citizens and caused reputational damage for the department (Ngema, 2019).

2.7 IT OPERATIONS IN HIGHER EDUCATION

The South African higher education setting has been transformed over a period since the introduction of democracy. Smaller universities have been incorporated into bigger ones with some being renamed. There are now public and private universities in South Africa. The focus of this study is on public universities. Public universities are divided into three types: traditional universities, which offer theoretically-oriented university degrees; universities of technology ("technikons"), which offer vocational oriented diplomas and degrees; and comprehensive universities, which offer a combination of both types of qualification. Information technology is central in the provision of teaching and learning as well as management of these universities. ICT in university education in South Africa is not the focus

in itself, it enables the value creation process by enabling the business and administration of the university. The table below indicates the areas where ICT would be utilized in typical public university and where the IT operations team would be involved, which are areas that would be candidates for AIOps.

IT operations in higher education are not significantly different from other organization's operations. The difference is the focus areas, which form the main processes of an institution of higher education such as student admissions, student data, learning systems, staff administration, payroll and financial accounting, inventory systems and library systems. IT operations in a higher education environment will face challenges concerning the systems outlined in the table below.

Table 1: IT operations areas in higher education

Service	Description	Purpose	Client Focus
Data Centre	Provision of a managed, secure, available and energy-efficient environment for the 'hosting' of the core network, server and SAN equipment; and to provide services for monitoring, backup handling.	Provision of 'hosting' environments (primary Data Centre, and secondary Network / Server rooms) and associated services to underpin the provision of stable systems to staff and students	Enterprise-wide
Servers & SAN Storage	Provision of a managed, secure, available and energy efficient server and SAN storage platforms for enterprise systems	Server and SAN storage provisioning, including services for hardware and operating systems installation/maintenance, backups, disaster recovery, virus protection, etc. Provision of 3rd-level incident support and request management.	Enterprise-wide

Service	Description	Purpose	Client Focus
Network (Wired / Wireless, Data and Voice / Telephony)	Provision of managed, secure, available and energy-efficient network platforms (wired and wireless) for data and voice (telephony)	Network and network access provisioning, including services for network equipment, cabling, fibre, network point, telephone, etc, installation, maintenance and monitoring. Provision of 3rd-level incident support and request management.	Enterprise wide
Workstations	Ensuring appropriate IT standards for workstations and image casting, to do problem solving for workstation systems, to investigate new applications for workstations, and to contribute to IT-innovation.	Provision of fully functional and (as far as possible) standardized workstations (desktop, laptop, etc) for improved effectiveness, efficiency, operability, software license management and maintenance.	Enterprise wide
Service desk	Acceptance of requests for changes, incident logging, new user registration, for all infrastructure used by IT	To have a single point of entry from where operational backup is provided to all IT supplied infrastructure and software	All staff and students
Central computing facilities for teaching and learning purposes	Provide student computing services on campus and at Residences for: usage by students for assignments and research, classrooms for practical classes, writing of electronic tests in a controlled	Provides access to Internet, printing facilities, computer systems to perform academic work on.	All registered students and lecturers

Service	Description	Purpose	Client Focus
	environment, service stations for registration of students.		
Application Support	Installation, customization, maintenance, upgrade, backup, documentation, monitoring etc of databases, system software and applications which provide a usable system to staff and students	Provision available and stable systems to staff and students	Enterprise wide

A study conducted on ICT investment in Rwandan higher education (Ssempebwa, Canene and Mugabe, 2007:20) concluded that while quality and quantity were important factors, managers needed to prioritize the avoidance or elimination of downtime. The study recommended that downtime needs to be acknowledged, with its cost to both the industry and end users, the causes of downtime need to be identified and plans to address it developed. Additionally, the study highlighted that when investment decisions are made regarding IT for institutions of higher learning, there should be plans of how this investment will be maintained and operated so that it is not caught in negative downtime, which will negate the investment objectives. Highlighting the significance of IT operations in the higher education sector, the University of Stellenbosch (2013) highlighted the following initiatives covering learning and teaching as being central to the utilization of IT in the South Africa.

- Teaching and learning (the systems vary from Blackboard to Moodle).
- Web 2.0, social networks and emerging technologies for learning and teaching, e-Portfolios such at some of the universities, e-Portfolios offer students an opportunity to build up proof of their learning development in an electronic format.
- The recording of lectures has been implemented at some universities, Wi-Fi has full-strength coverage in most classrooms and is available campus wide.
- A strong focus on the digital literacy of students and lecturers in the learning and teaching strategy of all the universities.
- E-learning regarded as an integral part of learning and teaching.

The point made is that IT is central to the effective provision of learning and teaching in higher education. It is against this background that IT operations are required to perform optimally for universities to achieve their objectives. Without stable and robust IT operations, universities will struggle to operate efficiently and effectively in the digital transformation era. From an

AIOps perspective, Dang, Lin and Huang (2019:1) call for a coordinated collaboration between institutions of higher learning and the software engineering industry. The point out that, “AIOps innovations call for a close partnership between academia and industry. The real pain of software and service engineers needs to be well understood. The running behaviours of real-world services need to be researched. While the proliferation of open-source software enables easy access to source code for the research community, it is far from enough for AIOps innovations”. This is an opportunity for the higher learning environment to play a meaningful role in the development of AIOps.

2.8 OPPORTUNITIES FOR IT OPERATIONS

2.8.1 Complex IT architectures

To respond to the digital transformation era, organizations require dynamic IT architectures and an ability to be agile in the development and deployment of applications. Many organizations have adopted complex cloud systems. Cloud systems run on different platforms with little visibility for the IT operations team. This creates a challenge to track, diagnose and resolve incidents or problems timeously. Delays in resolving problems are costly to the organization. As mentioned earlier, to mitigate this situation, some organizations have increased their IT operations teams. It is argued by scholars such as Tarun (2017:1) that increasing the IT operations team is not a sustainable intervention. It is postponing the inevitable, where the IT operations team is unable to handle the complex environment. AIOps is a suitable intervention to deal with the increasing complexity. AIOps save the organization time and money since the IT operations team will have more time to spend focusing on scaling systems than dealing with multiple alerts (Tarun, 2017:3). It is through AIOps that IT systems can predict potential incidents and resolve them without human intervention, and report back.

2.8.2 Digital transformation

The concept of digital transformation is widely used across the IT research environment. According to Hess, Matt, Benlian and Wiesbock (2016:123), “Digital transformation is concerned with the changes digital technologies can bring about in a company’s business model, which result in changed products or organizational structures or in the automation of processes”. So digital transformation is a product of developments in information technology, which sometimes if referred to as the digital age. The driving objectives are to improve customer service, improve relationships with suppliers and internal stakeholders. The IT operations environment is also affected by digital transformation. They need to match the pace of digital transformation by avoiding outages and ensure that applications will be up and available. AIOps provides an opportunity for IT operations to be part of the organization during the digital transformation phase.

2.8.3 Silo IT operations

It has been mentioned that traditional IT operations are characterized by siloes in the management and monitoring of the different elements. This silo approach has rendered IT operations not being efficient in managing the IT environment. Paddy, Kayak & Signor (2018:5) argue that, “Domain-centric tools provide a deep view into a specific domain, but they cannot provide a correlated, end-to-end view across domains". Due to the silo approach, it takes longer to execute mean time to resolve issues, which frustrates the organization and the users. AIOps offers an opportunity for IT operations to rectify the situation.

2.8.4 Managed data growth

The amount of data generated by the IT operations environment has always been huge due to the nature of the environment, coming from the servers, networks, operating systems, telephony, help desk and many more. The introduction of the digital transformation complicates the ability of the IT operations team to manage, understand and have an analytical view of this data. As is the situation with the silo approach, adding more staff will not address the change of increased data. Instead, staff will be overwhelmed and make errors in interpreting the data, leading to ineffective resolution of incidents. With AIOps, there is the ability to correlate millions of data, analysis the data to determine patterns and present the data in meaningful formats (Paddy, Kayak & Signor, 2018:5).

2.9 WHAT IS AI / BIG DATA / DATA ANALYTICS?

2.9.1 Artificial intelligence

Artificial intelligence refers to the combination of technologies where a machine that can sense, learn and act is produced. Such machines assist humans in doing what humans have been doing, however, the machines perform better and faster. Artificial intelligence is described as part of the fourth industrial revolution. It needs to be pointed out that developments, upgrades, optimization of the previous revolution items are still taking place today. AI works closely with machine learning. Machine learning is when computers use algorithms to learn routine actions that are normally performed by human beings. Machines in this era are outstanding at pattern recognition and learning, and have made a big leap forward to see them eclipse their human programmers (Cochrane, 2018). Machine learning can be viewed as a subset of artificial intelligence where machines or systems can learn patterns and make decisions without the intervention of human beings. The relationship between machine learning and artificial intelligence is important. According to Kibria, Nguyen, Villardi, Ishizu (2018:32332) machine learning is a concept based on artificial intelligence where machines learn by themselves after being exposed to large volumes of data. Artificial intelligence covers

the software aspect of the machines being able to carry out tasks intelligently. Artificial intelligence is widely implemented in a variety of industries and fields.

2.9.2 Big data

Different scholars, with different degrees of emphasis, define big data in different terms. Alharthi, Krotov and Bowman (2017:286) define big data as massive volume digital data that is difficult to manage by conventional data analysis tools. They refer to Gartner, who emphasizes that such data is characterized by volume, variety and velocity. Big data is thus the ability of current applications and technologies to manage and analyse data to get insights from that. It is about the volumes and the ability of technologies to analyse and process such volumes. Sun, Cegielski, and Jia & Hall (2018:193) assert that “big data, which is characterized by the so-called “4Vs” of volume, variety, velocity, and veracity, has progressed from being merely a fashionable trend to becoming critical for both business and IT”. Thus big data presents opportunities for organizations to innovate and benefit by managing their data optimally.

The concept of big data is widely accepted and many organizations are considering a move towards leveraging big data. While the concept of big data is widely accepted, research shows that many organizations are facing challenges to cope with big data (Bilbao-Osorio, Dutta and Lanvin, 2014). Kalema and Mokgadi (2017:260) note that the growth of data in organizations is overpowering the current traditional tools to analyse data. As indicated in the previous sections, big data is central to AIOps. AIOPs relies on big data and machine learning to deliver proactive and predictive insights of the IT operations environment. Big data technologies form the foundation that correlates cross domain environments, across applications and devices to provide the correct operations insights (Paddy, Kayak and Signor 2018:1).This shows that big data has matured and is acknowledged as critical in the provision of IT operations. According to Mohanty and Vyas (2018:182), “The general adoption of APIs and open data platforms enables the sharing of critical information that used to be siloed in tools and databases”.

2.9.3 Big data analytics

Big data analytics has evolved from the information overload up to the advent of big data. It relates to the processes, methodologies and tools used to process, analyse and present large volumes of data sets to discover hidden patterns, correlations, market trends and customer preferences. Arguing for organizations to have a plan to implement big data analytics, Kalema and Mokgadi (2017:261), write, “Big Data analytics becomes mandatory. Hence, big data analytics has become a top priority for many organizations as they expect to derive intuitions from the analysed data to improve productivity, enhance the customer experience, reduce churn, cut costs, as well as seizing new business opportunities". In the higher education

sector, the relationship between artificial intelligence, big data and machine learning is demonstrated in a variety of areas such as online tutoring. The higher education sector is experiencing huge data growth, advances in technology that have the potential to enhance teaching and learning Adego and Connolly (2017:156). However, higher education institutions need to develop roadmaps to benefit and improve teaching and learning, taking into account developments from big data analytics, artificial intelligence and machine learning.

From a commercial perspective, the role of big data and data analytics is articulated by Manyika (2017) in, “Data and analytics have been changing the basis of competition in the years since our first report on big data in 2011. Leading companies are using their capabilities not only to improve their core operations but also to launch entirely new business models”. This is a confirmation of the central role of big data analytics in the 21st century, where organizations can benefit from their operations as well as customer engagement and improve organizational effectiveness. On the network operations management perspective, Kibria et al (2018:32329) also highlight the fundamental role played by data analytics, highlighting the point that network monitoring and optimization are still predominantly performed on old/recorded data, which limits optimum management.

While the role and significance of big data is important and acknowledged, it acceptance and utilization is not where it should be, according to Alharti, Krotov and Bowman (2017:287). In a study they conducted among 330 American public companies, they found that many of these companies were not ready to implement big data for the benefit of the organization. The barriers they identified include the new skill required from employees, the changes that are required on the IT infrastructure as well as the changes that management needs to undergo. Cloud computing offers an opportunity in addressing the IT infrastructure challenges. However, it needs to be implemented properly, as in most cases these initiatives fail due to technical and economic factors, according to Alharti and others (2017:287). However, the authors conclude that taking advantage and embracing the opportunities offered by big data is a step in the right direction. Therefore, organizations need to plan for the adoption of big data, create a culture that is conducive and recruit and training the required resources.

2.10 WHAT COULD AI / BIG DATA / DATA ANALYTICS COULD DO FOR THE IT OPERATIONS FUNCTION IN AN ORGANIZATION?

There are several opportunities presented by a combination of artificial intelligence, big data and data analytics in the form AIOps could do for the IT operations function in an organization. It has the potential to make the IT operations function the centre of business in an organization. AIOps practices may save companies time and money. “IT Ops teams can spend time building

scalable systems, rather than chasing down noisy alerts and doing redundant tasks." Tarun (2017:1). To illustrate the potential impact of AI / big data/data analytics for the IT operations function in an organization, the study will use the Loom Systems (2019) study of an organization's implementation of AIOps over three years. The organization had 15000 employees, located across the world, 600 tier 1, 2, and 3 service desk employees; and an average monthly incident volume of 18,000 with 4,000 nodes (real or virtual servers under management).

Below is a table with figures on the return on investment (ROI) after implementing AIOps over three years, which is an indication of what AI/ big data and data analytics could do for an organization. On the first column, IT Productivity Improvements, before AIOps, the organization was using disparate systems to collect logs and there was no automation concerning resolving incidents. With AIOps, all log sources were centralized and the root cause analysis function was automated, resulting in 45% reduction of time required to resolve incidents. By the end of year three, the organization benefited more than $5 million in IT productivity improvements.

About the prevention of outages, the implementation of AIOps facilitated a correlation of tickets and consolidation of incidents before they could escalate. This resulted in the reduction of downtime, saving the organization more than $4 million over three years. Automation deals with the creation of a knowledge base for high-value incidents as well as the reduction of human intervention in resolving these incidents. With the implementation of the AIOps, the overall capacity of the IT operations team increased by 18% yielding a $1.3 million saving over three years.

Table 2: AIOps return on investment

Benefit	Year 1	Year 2	Year 3	Total
IT Productivity Improvements: Incident Response - Faster Root Cause Analysis	$827,280	$1,755,000	$2,511,000	$5,093,280
Prevention of Outages and Effort in severity 1 Incident Management	$777,600	$1,512,000	$1,814,400	$4,104,000
Automation: Increased efficiency due to automating Root Cause Analysis	$225,000	$747,000	$837,000	$1,809,000
Increased Output from Employees	$375,000	$450,000	$562,500	$1,387,500

Cost Savings: Reduced License and Outsource Costs	$360,000	$360,000	$350,000	$1,070,000
			Total Benefit	**$13,463,780**

Benefit	**Year 1**	**Year 2**	**Year 3**	**Total**
Loom License Costs: Including implementation, on-going costs, and license.	$842,000	$650,000	$650,000	$2,142,000
			Total Savings	**$11,321,780**
			Total ROI	**529%**

Source: Loom Systems, 2019.

As this study is concerned with the enablers and barriers to the implementation of AIOps in the higher education setting, below are some of them as noted from the literature. As technology develops, it presents a combination of challenges and opportunities for organizations, which must be considered equally to benefit from such developments. The same applies to AIOps.

Table 3: AIOps barriers and enablers

Barriers			
	Category	**Description**	**References**
1	Organizational	Uncertainty in organizations on whether AIOps is a hype or a true innovation, since it is a major shift from traditional IT operations	Padhye, S., Nayak, B., & Signore, E. (2018:1) https://www.ca.com/content/dam/ca/us/files/white-paper/the-definitive-guide-to-aiops.pdf
2	Organizational	Because of the transformative nature of AIOps to IT operations, which requires realignment of people, processes and technology, it may	Tarun, T, (2017). Kalema, B. M., & Mkgadi, M. (2017:263)

Barriers			
	Category	**Description**	**References**
		discourages organization to seriously commit on AIOps	
3	Technological	The IT architecture required for AIOps in terms of hardware and software may require large investments	Alharthi, K., Krotov, V., & Bowman, M. (2017:288) Hess, T., Matt, C., Benlian, A., & Wiesbock, F. (2016:136)
4	Skills	Not having the correct skilled personnel may inhibit the successful implementation of AIOps	Pankaj Prasad, Charley Rich. Gartner. Market Guide for AIOps Platforms. 12 November 2018 Kalema, B. M., & Mkgadi, M. (2017:263)
5	Big data	Lack of understanding of big data, low confidence in managing big data is a potential barrier to AIOps	Kibria, M. G., Nguyen, K., Villardi, G. P., & Ishizu, O. Z. (2018 : 32326) Thankachan, K. (2017:716)

Enablers			
	Category	**Description**	**References**
1	Technological	Cloud computing and Network and Data Center Operations with AI	Mohanty and Vyas (2018 : 175), Dang, Y., Lin , Q., & Huang, P. (2019 : 4)
2	Organizational	Coordinated collaboration between institutions of higher learning and the software engineering industry	Dang, Lin and Huang (2019:1) Qi, J., Wu, F., Li, L., & Shu, H. (2007: 285)
3	Organizational	97.2% of executives are investing in building or launching Big	https://www.ca.com/content/dam/ca/us/files/white-paper/the-definitive-guide-to-aiops.pdf Gartner, 2016

Enablers			
	Category	**Description**	**References**
		Data and AI initiatives and in 2019 more organizations would have one or two functions using AIOps	
4	Big Data	The ability to correlate millions of data, analysis of the data, determination of patterns and presentation of data in meaningful formats	Paddy, Kayak & Signor (2018 : 5), Kibria, M. G., Nguyen, K., Villardi, G. P., & Ishizu, O. Z. (2018: 32329)
5	Skills	Training in AIOps related field are being provided, by companies and some tertiary institutions, such as the Big Data Science degree at the University of Pretoria	https://www.up.ac.za/school-of-information-technology/article/2324622/mit-in-big-data-science-stream-c Davenport, T. H., & Ronanki, R. (2018:7)

2.11. CONCLUSION

The literature review indicates that IT operations play a crucial role in an organization. There are situations where the failure of IT operations has resulted in very serious situations for some organizations, with long-lasting consequences. It is proposed that this is avoidable and should not be accepted as part of the IT operations possibilities. There are reasons for such incidents, including the silo approach IT operations adopt in managing the IT environment, which results in some crucial processes being missed. The literature points to a need for IT operations to review and evolve the way they manage the IT environment.

IT operations are impacted by the artificial intelligence revolution with predictions that by 2019, 25% of enterprises will be using AIOps to support two or more major IT operations functions. The literature outlines the significant role of AIOps in functions such as capacity planning, infrastructure scaling and cost management. This is by no means an exhaustive list of areas where AIOps's significance is evident. Studies on AIOps focus on trends in IT operations, the evolution that has taken place as well as challenges and risks that face IT operations. The main points covered are that IT operations are significant for the efficient and effective functioning of IT services, that IT operations are still focused on silo operations, which render them inadequate to meet the requirements and demands of the digital transformation era. The digital transformation era is characterized by new technologies that are developed and deployed at a fast pace, such as cloud services and mobile applications. IT operations are required to be prepared to deal with high levels of complexities and big data without compromising the availability and functionality of the IT services. AIOps offers IT operations and opportunity to contribute to the strategic objectives of organizations and facilitate to the move towards digital transformation. This study seeks to understand how AIOps may contribute in the context of higher education institutions.

3. RESEARCH METHODOLOGY

3.1 BACKGROUND

“Research is the main tool that is used to find answers and resolve problems in society. Research is a logical and systematic search for new and useful information on a particular topic. It is an investigation that finds solutions to scientific and social problems through objective and systematic analysis. It is a search for knowledge, a discovery of hidden truths” (Rajasekar, Philominathan and Chinnathambi, 2013:2). The research onion model (Saunders, Lewis and Thornhill, 2019:130) is useful in understanding the research process that is used in this chapter. The model covers the stages that a researcher must consider when developing a research strategy as shown below.

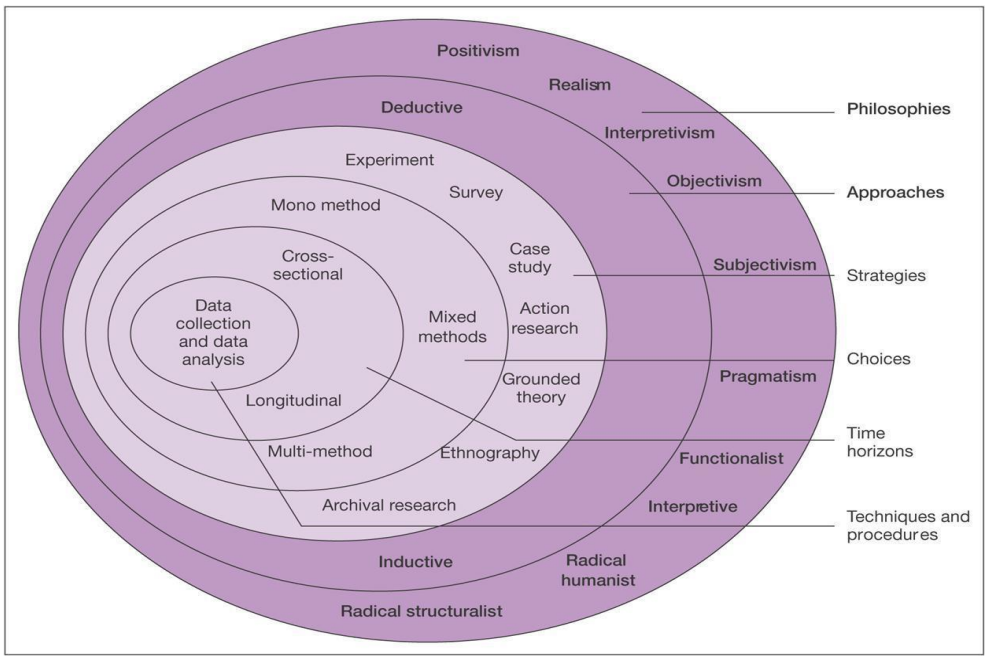


Figure 4: The research onion. Source: Saunders, Lewis and Thornhill (2019)

The essence of the research onion is the provision of a tool that guides the formulation of a proper methodology to be used in a research project. The outer layer, which represents the first step, is the research philosophy and it needs to be addressed upfront. The adoption of the research philosophy leads to the acceptance of the relevant approach for the research project, which is represented by the second layer. The approach can be either deductive or inductive. These two approaches are not exclusive, in some instances, they can be used together. The third layer is the adoption of the appropriate research strategy. The researcher may choose from the different strategies based on the nature of the problem being addressed by the research. The fourth layer identifies the time horizon, where a determination in terms of time is required. In some research projects, data needs to be collected at a certain time, in some instances over a long period. Lastly, the fifth layer deals with the different methods of

data collection, where the techniques and procedures of collecting the required data are finalized. A further look at the research onion layers as they apply to this study is outlined below.

3.2 RESEARCH PHILOSOPHY

Chilisa and Kawulich (2015:1) describe a “paradigm as a way of describing a world view that is informed by philosophical assumptions about the nature of social reality". They assert that this is what informs researchers, whether consciously or subconsciously. The process of generating knowledge is informed by some form of assumptions. Positivism is a research paradigm that assumes that in reality, things are the same, organized and objective. The positivist approach makes the basic assumption that the world is ordered, regular and not random. It can be investigated objectively and reality is separate from the individual who conducts the research (Farquhar, 2012). The research philosophy chosen for this study is therefore not positivist. The researcher does not see himself as an outsider looking into the research problem. He has a relationship and some understanding of the research topic. The objective of the research was not to provide an explanation, but rather gain an understanding of the research topic, from the qualitative data collected that was collected.

Based on the above-mentioned outline, the research study adopted the interpretive philosophical paradigm. The researcher sees himself as part of the research, having an understanding of the IT operations environment as well as some knowledge of the topic being researched. The research being carried is therefore subjective, where results can be influenced by the opinion of the researcher, based on the qualitative data to be collected. Regarding the critical research in information systems, Goldkuhl (2012:2) argues that interpretivism is more used in research in information systems although critical research is also making inroads, which leads to the paradigm of pragmatism.

Pragmatism in research is based on the principle of the term pragmatic, which includes dealing with things sensibly and realistically in a way that is based on practical rather than theoretical considerations. In research, pragmatism takes the view that the best research methods should be those that help answer the research question effectively, whether that necessitates the combination of quantitative and qualitative methods. Goldkuhl (2012:2) asserts that, “Pragmatism is concerned with action and change and the interplay between knowledge and action. This makes it appropriate as a basis for research approaches intervening into the world and not merely observing the world”. This research study is concerned with the phenomena of AIOps intervening into the IT operations world as opposed to just observing and explaining its impact. In conclusion, among the four paradigms of research (positivism, interpretivism, critical theory, pragmatism), the interpretivism approach was adopted because it assists in

addressing the research question, it is flexible and rejects the notion that only one truth exists. Interpretivism also allows and manages the subjective aspects of the researchers, taking into account the fact that researchers have worldviews, have been exposed to some concepts and backgrounds.

3.3 RESEARCH APPROACH

As mentioned earlier, the adoption of the philosophy provides the basis for the research approach. The research approach as indicated in the research onion is either deductive or inductive. It is also noted that the deductive and inductive approaches are not necessarily mutually exclusive (Battacherjee, 2012). In a deductive approach the goal is to test an existing theory through formulating hypotheses and applying statistical techniques. The deductive approach aims to explain causal relationships among phenomena and is mostly associated with quantitative research. The inductive approach aims to explore new concepts or phenomena and is generally linked to qualitative studies. The inductive approach typically aims to generate theory from observed data or may also use an extant theory to inform the research study or formulate research questions to be explored. This study aimed to explore and illuminate the barriers and enablers to the implementation of AIOps in the higher education setting which has limited research studies. In the case of this study, the inductive approach was deemed appropriate.

3.4 RESEARCH STRATEGY

There is a variety of research strategies available to researchers as indicated by the research onion, from experiments, surveys, historical analysis, case studies, computer based analysis and others. These strategies have different ways of collecting and analysing data. They have their own advantages and disadvantages. In this study, the case study research strategy was adopted. Yin (2003:14() asserts, “single- and multiple-case studies are in reality but two variants of case study designs”. The case study design for this research study was premised on that understanding, where two academic institutions will be used to ascertain enablers and barriers to the implementation of AIOps. Case studies make it possible to fully understand the ICT integration process of an educational institution by examining all the participants through either interviews or observations, by determining the related needs in detail, and by providing supportive data through document analysis (Unluer, 2012:4). This view is supported by Myers and Avison (2002:81) when they highlight the following benefits with regards to case study research as a viable research strategy in the IT space:

- The researcher studies IT in its natural setting, learning about its state and generate theories from practice.
- The researcher can consider "why" and "how" questions relating to the complexity of the processes taking place.

- Case study research is appropriate for research in areas where few previous studies have been conducted.

Case studies can either be single or multiple. In this study, the chosen approach was that of a multiple case study. The motivation for a multiple case study approach was that it allowed an opportunity to contrast the results within each situation and across the situation as pointed out by Gustafsson (2017). This allowed a broader exploration of research questions as well as the theoretical exploration. On the negative perspective Gustafsson (2017) points out that, multiple case studies can be expensive and time consuming. In conclusion, the research adopted a multiple case study on IT operations selected from two public universities to ascertain enablers and barriers to the implementation of AIOps.

3.5 QUALITATIVE RESEARCH

Since the purpose of the study is to determine an understanding, positions, relationships, experiences, and IT processes in academic institutions, the qualitative research approach would be appropriate as opposed to the quantitative approach, which focuses on figures and statistics. “Data from qualitative studies describes the qualities or characteristics of something. You cannot easily reduce these descriptions to numbers—as you can with the findings from quantitative research; though you can achieve this through an encoding process.”(Madrigal, 2012:3). From an IT perspective, Myers and Avison (2002:13) point out that information systems should be viewed concerning the organization and the people they serve, reinforcing the appropriateness of qualitative research for IT.

3.6 CASE STUDY SITE SELECTION

The research was based on two organizations in the higher education sector. The organizations were selected because of the size and complexity of their IT environment and accessibility to the researcher. Yin (2003:19) justifies using the case study for research. He points out that case studies have been used in many situations to understand and contribute knowledge on individual, group, organizational, social, political and related phenomena. He argues that a case study, like other research strategies, is a way of investigating a topic by following a set of procedures that are specified upfront. Case studies are said to be useful in understanding how and why phenomena of issues. They are useful in providing a particular context to the subject of the research. The focus of the study is on the academic learning environment as well as the IT operations team as a group. Information Technology (IT) underpins all of the academic institution’s principal activities. In many areas, it contributes directly to the efficiency of the organization‘s operations and in others, it is vital for the existence of the activity. IT has direct and indirect roles in supporting and enabling the institution’s vision and strategic objectives. For nearly all students and staff, the use of IT has

become an integral component of their university life. The study aimed to understand the views of university IT teams on AIOPs, the factors that may enable the implementation of AIOps along with risks and barriers that may be experienced.

3.7 POPULATION AND SAMPLING

The population for this study are professionals who are working in the IT operations environment at higher education institutions. The choice of this population was based on the understanding that they are best placed to be able to answer the research questions pertaining to the barriers and enablers applicable to the implementation of AIOps. This approach is referred to as purposeful sampling in research literature. In defining the concept of purposeful sampling Palinkas (2013:534) highlight the importance of identifying and selecting individuals that are knowledgeable about the topic of research and also available and willing to participate. This is in contrast to the concept of random sampling which focuses on achieving a wide spectrum and avoidance of bias. This section deals with how a sample within the higher education sector was selected to provide the appropriate data relevant to the research. The unit of analysis was individual employees from the IT departments of two universities that are responsible for the provision of IT operations. That is why the research is not positivist, it is not objective and not random. The engagement involved employees from different levels of responsibility and authority. It focused on the processes and tools utilized to provide IT operations to identify enablers and barriers to the implementation of AIOps within the organization. It was not about the group dynamics of the IT operations teams. This is confirmed by Yin (2003) who points out that identifying a unit of analysis assists in understanding how the case study relates to a broader range of knowledge. The proposed size of the sample was 18 participants chosen from two universities.

3.8 DATA SOURCES - INTERVIEWS

Interviews are used extensively in interpretive and qualitative research as a method of data collection. Interviews may be structured, semi-structured or unstructured, (Petty and others 2012:380). The study adopted the accepted approach about interviews in qualitative research, which includes a combination of structured and unstructured interviews. A structured interview is similar to a questionnaire type approach. A semi-structured interview involves some preparation on areas of interest with some prompts to guide the conversation. In this study, a set of open ended and closed questions formed the basis of the interview, with follow up questions to clarify any areas that require further clarity. The interviews were recorded accordingly and notes taken as well.

3.9 DATA COLLECTION

Since this is a qualitative study, as outlined above, the process of data collection for the study consisted of interviews and interviews were conducted in person. Interviews were done formally (structured), semi-structured, or informally. Questions were focused, clear, and encouraged open-ended responses. The nature of the research and its data required further engagement and deliberations and clarity, which cannot be done through other research instruments. The interviews were the main data collection instruments. This approach is reinforced by (Walsham, 1995) where he states that interviews are regarded as the best method of collecting primary data for interpretive studies. Interviews were conducted at the premises of the tertiary institutions, within the offices of the interviewed officials. Before the interviews were conducted, the participants signed consent forms, which indicated that they are participating on a voluntary basis in the study and are assured of privacy and confidentiality. The tertiary institutions were approached to grant permission for the study to be conducted. All the interviews were recorded.

3.10 DATA ANALYSIS

The Thematic analysis approach as recommended by Nowell, Norris, White and Moules (2017:2) was used as the data analysis tool for the research from the transcribed interviews. The authors point out that the tool is a relevant qualitative research method, it is a method for identifying, analysing, organizing, describing, and reporting themes found within a data set. The tool's phases are indicated in the table below, which was followed accordingly. The rational of following this approach is the need for consistency and validity in data analysis. According to Yin (2003:110), "Data analysis consists of examining, categorizing, tabulating, testing or otherwise recombining both quantitative and qualitative evidence to address the initial propositions of a study. The issue emphasized by the author is that analysis affects the data and the data affects the analysis. Following data collection, rather than performing statistical analysis, researchers look for trends in the data. When it comes to trends, researchers look for statements that are identical across different research participants (Madrigal, 2012).

Table 4: Thematic analysis phases

	Phases	Description of Analysis Process
1	Familiarising yourself with the data	i)Transcribing the data, ii) Re-reading the data and noting down initial ideas
2	Generating initial codes	i)Coding interesting features of the data in a systematic fashion across entire data set ii)Collating data relevant to each code

	Phases	Description of Analysis Process
3	Searching for themes	i)Collating codes into potential themes ii)Gathering all data relevant to each potential theme
4	Reviewing themes	i)Checking if themes work in relation to the coded extracts ii)Checking if themes work in relation to the entire data set iii)Reviewing data to search for additional themes iv)Generating thematic “map” for the analysis
5	Defining and naming themes	i)On-going analysis to refine the specifics of each theme ii)Generating clear definitions and names for each theme
6	Producing the report	i)Selection of vivid, compelling extract examples ii)Final analysis of selected extracts iii)Relating the analysis back to the research question, objectives and previous literature reviewed

3.11 VALIDITY

Validity is an important concept in the research field. In positivist and quantitative research, validity is well established and understood. However, in interpretive and qualitative research, there are different approaches considered. The objective is to achieve valid results that can be trusted. Noble (2015:34) argues that "Unlike quantitative researchers, who apply statistical methods for establishing validity of research findings, qualitative researchers aim to design and incorporate methodological strategies to ensure the ‘trustworthiness’ of the findings”. From the literature, there are various approaches used by researchers to deal with the challenge of validity as outlined below.

3.11.1 Internal validity

Internal validity is concerned with assessing whether the research was done in the right way. According to Yin (2013:37) internal validity deal with two concerns. Firstly, it addresses the concern of causal relationships, which applies to only to explanatory case studies. Secondly, it addresses the issue of inferences that are possible from the researcher’s perspective. It looks at whether these inferences are relevant, appropriate, and not detrimental to the research. The author suggests the use of pattern matching as a measure to enhance internal validity, which will be considered in this study. Empirically observed patterns will be compared with predicted one and compared with established ones. Data was collected from reliable sources and was measured for trustworthiness to enhance internal validity.

3.11.2 External validity

External validity deals with the challenge of consistency of the research findings, especially in case studies. It looks at whether the findings from a case study are consistently applicable to other environment, whether the same results would be found at another research site (Yin 2003:37). In this study, the fact that the population being researched is clearly defined and that the participants are knowledgeable and experienced in the field being studied enhanced the external validity. Another point is the fact two educational institutions being subject of the research enhanced the external validity as there will be the opportunity to cross reference between the participants of the different institutions. Any patterns that are similar and not similar provided an opportunity for further deliberations.

3.11.3 Construct validity

Construct validity is concerned about how the research concept is properly conceptualised and whether the data collected is addressing the problem identified (Gibbert, Ruigrok and Wicki, 2008: 1466). Thus, construct validity deals with the extent to which the research leads to accurate observations. In this research, the researcher endeavoured to establish a clear chain of evidence from the research questions to the conclusions to enhance the construct validity of the research. Yin (2003:35) mentions that some of the tactics used in case studies to enhance construct validity include the use of multiple sources of evidence and having the key participants reviewing the draft case study report. In this study, the draft results were engaged with the senior participants for validation.

3.12 RELIABILITY

Reliability is an important element of research. According to Noble and Smith, (2015:34) reliability is a challenge for case studies. The challenge is based on the requirement that if a case study is conducted by a researcher, the expectation is that a follow up case study by another research should yield the same results. Thus reliability is based on minimizing errors and the researcher's biases in the study. Contrasting reliability in quantitative research as opposed to qualitative research Leung (2015:326) points out that in quantitative research reliability is about the replicability of processes and results. This is not simple to achieve in qualitative research, which is characterised by different paradigms, hence the author suggests that the essence of reliability in qualitative research is consistency. The processes followed in collecting data, the choice of the participants in the research and a meticulously recorded and contextualised process assisted in improving the study's reliability.

3.13 LIMITATIONS

The limitations envisaged for this study relate to the fact that it involves two tertiary education institutions in one province. There is also the issue of these institutions being part of the large ones and thus missing the opportunity that may perhaps be unique to the smaller ones. Such studies have been criticized for reflecting one side of the environment and being unable to apply the research findings to other environments due to the unique circumstances (Yin 2003:14). However, on the other hand, such studies have been used for significant explanations and understanding of contextual factors.

3.14 ETHICS

Ethics are an integral part of the research. Ethics in research are part of the process of guiding research and mitigate potential conflicts. Ethical guidance assists in areas of responsibility to participants, researchers and sponsoring agencies as well as the general public. Thus, ethics are the cornerstone of successful research studies. Without the guidance provided by the ethical guidelines, research and its findings would be questionable. It is therefore apparent that ethics are part of successful research. Universities require ethical clearance to be granted for research projects. This research study followed the prescribed requirements for ethical clearance and approval as stipulated by the Department of Informatics and EBIT faculty. As pointed out by Jayant (2018:1), “Research that involves human subjects or participants raises unique and complex ethical, legal, social, and political issues. Research ethics specifically deals with the analysis of ethical issues that are raised when people are involved as participants in research”. It is an expectation from researchers that they become aware of the ethical issues that relate to their research, in order to avoid complications after the research is finished. It is against this background that this research study accordingly followed the principles of agreed and signed consent, keeping data confidential, without mentioning the personal details of the participants, while ensuring that they participate on a voluntary basis.

3.15 CONCLUSION

Based on the focus of the research, which is to investigate the enablers and barriers to the implementation of AIOps institutions of higher learning, an interpretive research approach was adopted. Due to the circumstances of researching two academic institutions, a multiple case study strategy was followed. Interviews were conducted with the relevant stakeholders where data was analysed and reported. Issues of validity, reliability, population sampling and ethics as they apply to the study were addressed.

4. AIOPS CONCEPTUAL FRAMEWORK

4.1 DEFINITION OF CONCEPTUAL FRAMEWORK

A conceptual framework within this research can be viewed as a recipe or blueprint. It is an outline of how the researcher will conduct the research and also positioning the research topic within the broad research field. It is a reflection of the researchers' understanding of the topic and how it fits in the broader phenomenon. Jabareen (2009:51) defines the term conceptual framework as, "a network, or "a plane," of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena. The highlights of this definition are the relationships between the concepts that give rise to the concept, the assumptions, beliefs and expectations that are attached to these concepts and how these concepts inform the research that is being undertaken.

The above-mentioned view of the term conceptual framework is supported by Imenda (2014:189) in, "a conceptual framework may be defined as a result of bringing together several related concepts". The researcher investigated the topic through the introduction of the broader concept of IT operations in the current context, the role, significance and impact of IT operations in organizations across the board. The influence of artificial intelligence, machine learning and data analytics in IT operations was considered as part of the literature review.

4.2 RESEARCH DONE ON AIOps

There is not much research that has been completed on the concept of AIOps in relation to enablers and barriers in the higher education sector. There is an indication from the literature that AIOps is a new concept and most of the research is focused on the definition and understanding of the potential of AIOps. Most of the references are recent in terms of years. Prior research on AIOps mainly covers the areas such as definition of AIOps, the innovative aspects of AIOps, the components of AIOps, the potential use areas of AIOps and the strategy or roadmap to implement AIOps The following table indicates the prior research conducted on AIOps.

Table 5: Prior research on AIOps

Author (s)	Title	Description
Andenmatten, 2019	AIOps – Artificial Intelligence for IT Operations	An overview of AIOps, it origins, applications, elements, advantages and disadvantages as well as a roadmap when considering adopting AIOps

Author (s)	Title	Description
Dang and Huang, 2019	AIOps: Real-World Challenges and Research Innovations	A summary of real world challenges in building AIOps solutions
Kalema and Mokgadi, 2017	Developing countries organizations' readiness for Big Data analytics	An investigation into the barriers and enablers of the adoption of Big Data analytics in developing countries.
Kibria, Nguyen, Villardi, and Ishizu, (2018)	Big data analytics, machine learning and artifical intelligence in next-generation wireless networks	A presentation of the data sources and drivers for the adoption of the data analytics, machine learning, artificial intelligence in making wireless networks intelligent, self-aware, self-adaptive, proactive and prescriptive.
Levin, Garion, Kolodner, Lorenz, and Barabash, 2019	AIOps for a Cloud Object Storage Service	Developing AIOps capabilities for IBM Cloud Object Storage. AIOps as a promising technology for alleviating operational complexity of IT systems and services.
Mohanty and Vyas 2018	IT Operations and AI	An exploration of how AIOps can assist in alleviating IT operations challenges in the digital transformation era
Nedelkoski, Cardoso and Kao, 2019	Anomaly detection and classification using distributed tracing and deep learning	Research on detecting anomalies based on distributed tracing records that contain detailed information for the availability and the response time of the services.
Paddy, Kayak and Enzo Signor, 2018	AIOps for Dummies	An overview of AIOps and how they can transform IT operations, with useful case studies
Qi, Wu, Li and Shu, 2007	Artificial intelligence applications in the Telecommunications industry	An examination of the application of AI in the telecommunications industry

Author (s)	Title	Description
Thankachan, 2017	Data driven decision making for application support	A paper discussing the design of a solution to enable data driven decision making in the process of supporting and maintaining business applications.
Qi, Wu, Li and Shu, 2007	Artificial intelligence applications in the Telecommunications industry	An examination of the application of AI in the telecommunications industry

4.3 AIOps CONCEPTUAL FRAMEWORK

The study looked at AIOps and the barriers and enablers that affect its implementation in the higher education sector. This study adopted a multiple case study approach in the higher education sector. The study is located in the IT field, focusing on the IT operations area. Within IT operations, the study focused on the areas of artificial intelligence, machine learning, big data analytics and automation. The focus was on how these elements can yield an automated IT operation functionality that is driven by artificial intelligence.

The technology-organization-environment (TOE) framework as articulated by Sun, Cegielski, Jia and Hall (2018:194) is a useful foundation for a conceptual framework of AIOps and understanding how organizations may consider AIOps as well as the barriers and enablers towards adopting it. The framework takes the approach that an organization's ability to adopt technological innovation is affected by three elements, which are technology, organization and environment. The technology aspect focuses on issues such as equipment and processes, with the organization focusing on resources, organizational size, structure, management structure and employee skills. The environment elements focus on partners, competitors, the macroeconomic context and the regulatory requirements. This framework was used as a basis of understanding the barriers and enablers of the implementation of AIOps as well as the analysis of the data that was collected. The framework points to a convergence of organizational factors supported by technological factors and the macro environmental context leading to a better opportunity of successful adoption of innovations like AIOps. The TOE framework is reflected in the diagram below.

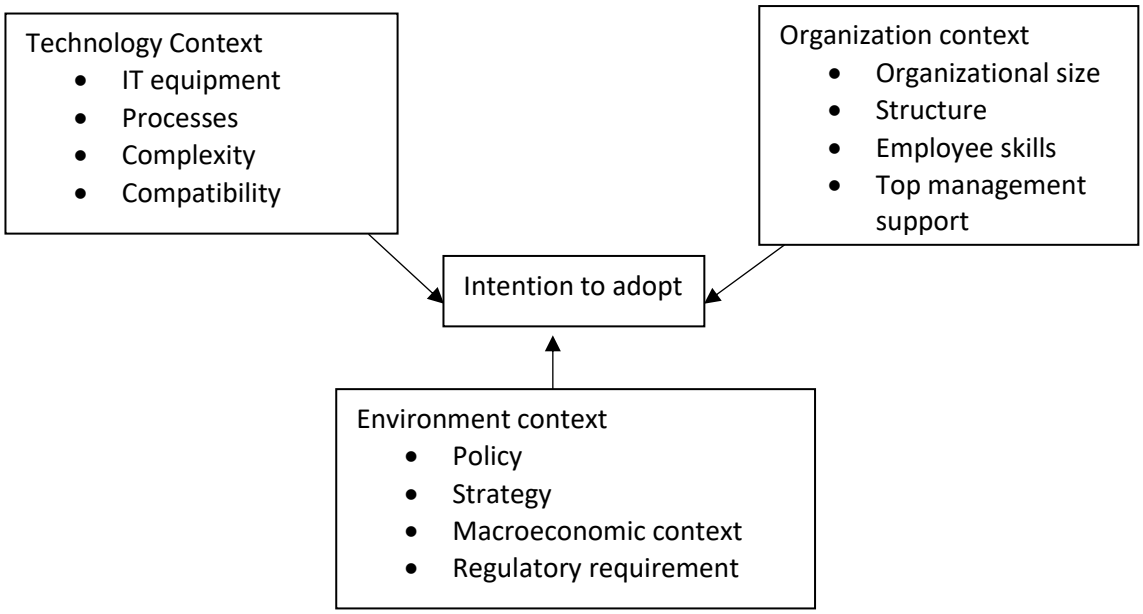


Figure 5: The TOE framework, (Adapted). Source: Sun, Cegielski, Jia, & Hall (2018)

The Technology Organization Environment (TOE) framework was chosen to understand the enablers and barriers to the implementation of AIOps in the higher education sector. Current research indicated that the TOE framework was capable of being applied broadly and has the potential to explain a number of technological, industrial and national / cultural contexts about the enablers and barriers that affect innovations such as AIOps (Baker, 2011:186). The framework has been used to explain the adoption or lack of adoption of a number of significant innovations such as websites, electronic commerce and cloud computing. Hoti (2015:6) contends that there is potential for the TOE framework in understanding the adoption of IS as well as a solid theoretical basis.

A disadvantage of the TOE framework highlighted by Kotze and Mudzana (2015:109) is that the framework focuses on the organizational level and ignores the individual level. The individual level is important in the adoption of technological innovations. Hoti (2015:1) points out that the TOE framework has not been developed in the last few years, pointing to a disadvantage of the framework. The following table presents some of the studies in the literature which are similar to this research study that have relied on the TOE framework.

Table 6: Studies that have used the TOE framework

Author and Year	***Type of study***	***IS/IT adaption***	***Focus and influencing factors***	***Methods***	***Data and context***
(Alam & Noor, 2009)	Qualitative and Quantitative	IT adoption and usage	Relationship between ICT adoption in SMEs and perceived	Cross sectional Survey addressed	**180 SMEs in Malaysia**

Author and Year	*Type of study*	*IS/IT adaption*	*Focus and influencing factors*	*Methods*	*Data and context*
			benefits & cost, ICT knowledge, external pressure and government support	to the owner and/or manager of SME	
(Buonanno et. al., 2005)	Quantitative	ERP adoption	Identification of business and organizational factors (such as: business complexity and organizational change) influencing ERP adoption	Questionnaires and interviews adressed to top managers	**366 companies of any size (SMEs & large)**
(Grandon and Pearson, 2004)	Quantitative	E-commerce adoption	Examiniation of determinant factors of adoption such as: operational support, managerial productivity, and strategic decision	Internet survey of top managers	**100 surveys in USA**
(Scupola, 2009)	Qualitative	B2B E-commerce adaption and implement ation	Proposing a TOE model of E-commerce adoption and implementation	Literature review, questionnaire and face to face interviews with CEOs	**4 Danish and 4 Australian SMEs**
(Ramdani & Kawealek, 2009)	Quantitative	ERP, CRM, SCM and e-procurem ent adaption	Develop a model that can be used to predict which (SMEs) are more likely to become adopters of enterprise systems	Direct interviews, logistic regression	**102 SMEs in Northwest England**
(Oh et. al., 2009)	Qualitative and Quantitative	E-trade adoptin	Examine what factors are associated with the adoption of E- trade by Korean SMEs	Questionnaires, regression, factor analysis, cronbach alpha, discriminant analysis	**193 SMEs in South Korea**
(Shiau et. al., 2009)	Quantitative	ERP adoption	Development of measures to assess the ERP adoption of SMEs	Survey data were analysed by structural equation modelling (SEM)	**126 SMEs in Taiwan**
(Haug et. al. 2011)	Qualitative	IT readiness/ IT adoption	Presenting a framework for analyzing 'IT readiness'	3 longitudinal case studies, Literature review	**3 SMEs**

Author and Year	*Type of study*	*IS/IT adaption*	*Focus and influencing factors*	*Methods*	*Data and context*
(Federici, 2009)	Qualitative and Quantitative	ERP adoption	Ex post evaluation of an ERP system adoption. Collection of actual achievement, advantages and context/project characteristics	Direct interviews with SMEs' managers	**50 SMEs in Italy**
(Gutierrez et. al. ,2009)	Quantitative	IT and business alignment	5 attributes are ranked for each of the following alignment factors: communication, competency/value measurement, governance, partnership, architecture and scope and skills.	Online and telephone survey, ANOVA	**104 surveys from organizations all over the globe**
(Chao and Chandra, 2012)	Quantitative	IT adoption and strategic alignment	Impact of owner's knowledge of IT on business, IT strategic alignment and use in the small firm context. Resource-based view as a theoretical foundation	Email survey to the owner of the small business	**217 small manufacturers and financial Services firms in the USA**
(Zeiller and Schauer, 2011)	Qualitative	Adaption of social media initiatives for team collaboration	Analyse the adoption, implementation, motivation of team members, benefits and success factors of social media utilization for team collaboration.	In-depth analysis of multiple case studies	**6 case studies of European SMEs**
(Esteves, 2009)	Qualitative	ERP usage	Develop a benefits realisation road-map for ERP usage in SMEs	Direct interviews	**48 MBA students and 87 business Managers**
(Raymond and Bergeron, 2008)	Qualitative and Quantitative	E-business and business strategy alignment	E-business and business strategy alignment in SMEs in terms of Miles and Snow's strategic typology, including prospectors, analysers, and defenders	Contingency theory perspective, correlation analysis	**107 Canadian manufacturers**
(Loh and Koh, 2004)	Qualitative	ERP implementation	Examine critical elements of successful ERP implementation in SMEs	Literature review and interviews	**8 SMEs in the UK**
(Aguila-Obra and Padilla-Melendez,	Qualitative and Quantitative	Internet adoption	Explore factors affecting the implementation of Internet technologies and the extent	Innovation adaption theory, questionnaire	**280 companies**

Author and Year	*Type of study*	*IS/IT adaption*	*Focus and influencing factors*	*Methods*	*Data and context*
2006)			to which company size, as an organizational factors, influences the process.		
(Kaynak et. al., 2005)	Quantitative	E-commerce adoption	Factors affecting the willingness of SMEs to adopt E- commerce usage	Composite index of the usage frequency of 14 EC application tools (managers were asked)	**237 manufacturing SMEs in Turkey**
(Doom et. al., 2010)	Qualitative	ERP implementation	Examine the critical success factors of ERP implementations in Belgian SMEs and to identify those success factors that are specific to a SME environment	Survey + multiple case study. Structured interview technique	**4 SMEs in Belgium**
(Jeon et. al., 2006)	Qualitative and Quantitative	Adoption of E-business	Determining factors for the adoption of E-business in Korea	Principal component analysis, empirical analyses (t-tests), linear probability model, logit model	**Survey of 1200 Korean SMEs**
(MacGregor and Vrazalic, 2005)	Qualitative and Quantitative	E-commerce adoption and implementation	Develop a basic model of E-commerce adoption barriers to small businesses located inregional areas of developed countries	Empirical survey, data analysed by correlation matrices and factor analysis	**477 small businesses in Sweden and Australia**
(Gibbs and Kraemer, 2004)	Quantitative and qualitative	E-commerce use	Determinants of scope of use among E-commerce adopters	Telephone survey, stratified random sample	**2,139 establishments from three industries across 10 countries**
(Evangelista et. al, 2010)	Qualitative and Quantitative	Adoption of Knowledge	Shed light on the KM practices in small firms.	Empirical investigation, questionnaire survey through	**18 SMEs located in Naples City (Italy)**

Author and Year	*Type of study*	*IS/IT adaption*	*Focus and influencing factors*	*Methods*	*Data and context*
		Management Systems		interviews with managers	
(Alshamaila, 2013)	Qualitative	Cloud computing adoption	Contribute to a growing body of research on cloud computing, by studying the small to medium -sized enterprise (SME) adoption process	Semi-structured interviews	**15 SMEs and service providers in the north east of England**
(Wamba S.F. and Carter L, 2014)	**Quantitative**	**Social Media adoption**	**Assess the impact of organizational, manager and environmental characteristics on SME utilization of the Facebook Events Page**	**Hierarchical logistic regression**	**Survey of 453 SME**

Source: Hoti, 2015.

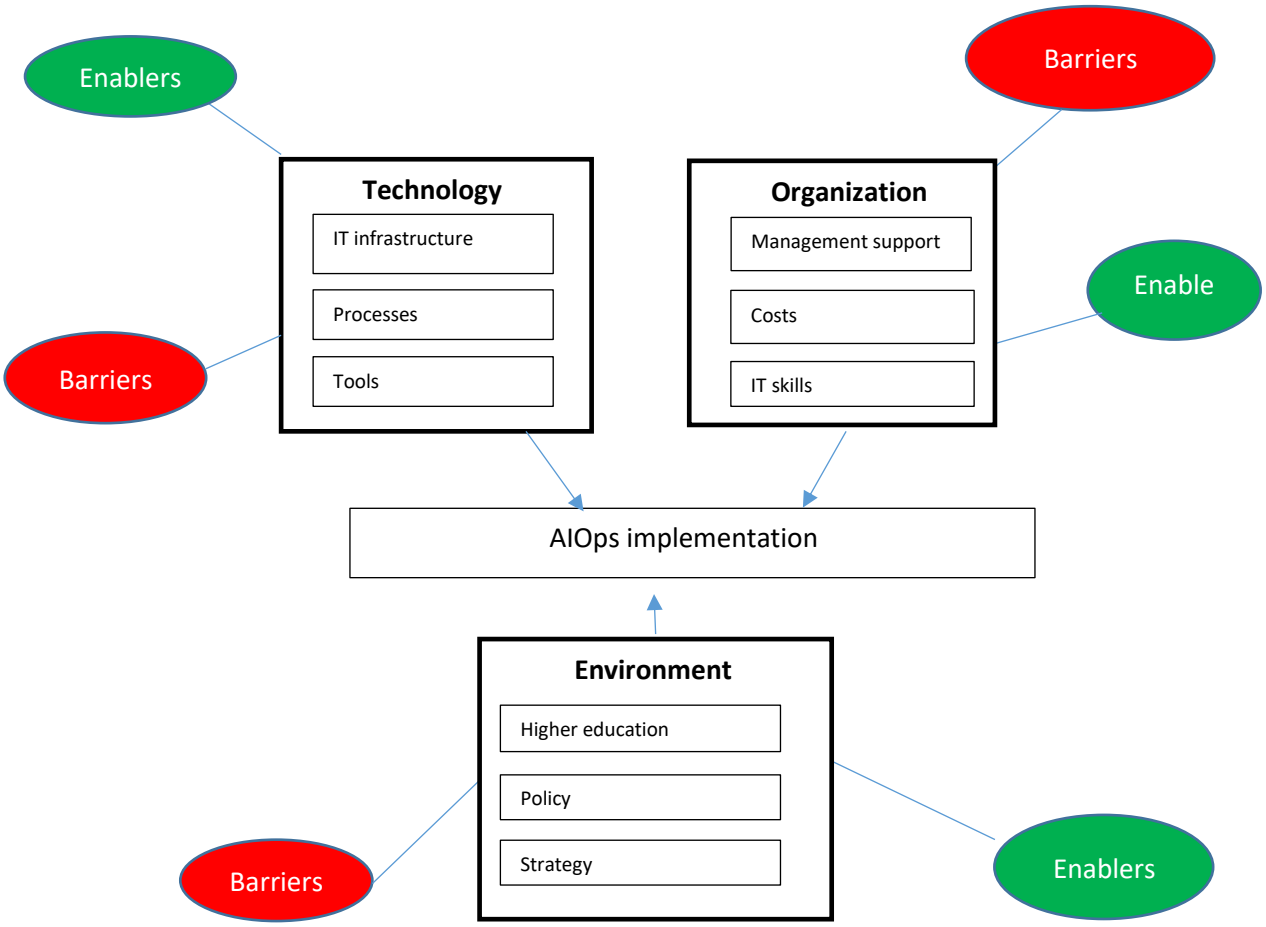
4.4 APPLYING THE TECHNOLOGY-ORGANIZATION-ENVIRONMENT FRAMEWORK TO AIOps

Organizations and business are being challenged to respond to the digital technology and transform their business models and operations. Their response to the digital transformation demands aims to provide better opportunities for the organization to grow, to serve their customers better, relate to their suppliers efficiently and improve internal stakeholder management and expectations. Padhye, Nayak & Signore (2018:4) assert that "To succeed as digital companies, businesses need to rethink their entire IT stack and operational strategy". As mentioned by Loom Systems (2017) AIOps is a response to the digital demands. It is not a solution or philosophy, it is a framework on how to respond to the demands of IT complexity, a response that will transform the IT operations function.

Enablers to the implementation of AIOps relate to considering the issues that can facilitate the implementation of AIOps such as money while barriers are those issues that impede such implementation such as lack of skills. Reflecting on the ability of AIOps to transform IT operations, Tarun (2017: 1) argues that business commitment is critical in the implementation of AIOps because of the need to align processes and people. Applying the technology-organization-environment framework (TOE) in the research topic considered the barriers and enablers in the three spheres of the framework as they apply to IT operations in the higher education sector. A university that has an IT operations environment that is driven by AIOps is in better position to compete for students and generate income to compensate state subsidies. Universities need to innovate the manner in which they choose, use and optimise

information technology to support academic and support programmes. They need to consider the potential of big data. Below is a framework adapted from the TOE, which was used to understand the enablers and barriers to the implementation of AIOps in the two identified higher education institutions. It focused on the factors that are relevant to IT operations in a university setting.

Figure 6: AIOps barriers / enablers framework



4.5 CONCLUSION

It is useful to consider a conceptual framework of AIOps since there is an integration of a variety of concepts that contribute to the product of AIOps, such as artificial intelligence, machine learning, big data, data analytics and automation. The key concepts that give rise to the phenomena of AIOps and their relationships were highlighted. Since the study concerned the enablers and barriers to the implementation of AIOps in the higher education sector, the technology-organization-environment (TOE) framework provided a useful foundation for a conceptual framework of AIOps. The investigation of the possible barriers and enablers was based on this framework, focussing on technology, organizational and environmental areas. The areas relating to IT operations and the possible barriers or enablers were to be identified. Questions for the interviews were based on these areas.

5. RESEARCH FINDINGS AND DISCUSSION

5.1 INTRODUCTION

From the previous chapters, the research methodology that was adopted for this research was discussed. It is a qualitative case study research strategy using two higher education institutions. Data was collected through interviews with representatives from the IT operations department or unit. The conceptual framework of AIOps was also considered in the preceding chapters, focusing on research conducted on AIOps and the possible enablers and barriers that may affect the implementation of AIOps. Lastly, the Technology-Organization - Environment (TOE) framework as it applies to AIOps was used as a model to guide the research.

The literature review considered the terminology and concepts relevant to the research. It provided a background to guide the determination of the enablers and barriers to the implementation of AIOps. It looked at the possible application areas of AIOps, the major IT incidents that happened in situations where there is no AIOps implemented. It also gave an indication of the evolution of the AIOps concept, examples of organizations that have embraced AIOps, the financial returns, what have been the benefits and challenges as well as the current research done. Following from the previous chapters, this chapter is a presentation and analysis of the data collected from the IT operations teams at two institutions of higher education, which are identified as Organization A, and Organization B respectively.

5.2 DATA COLLECTION PROCEDURE

The participants were selected based on their role as part of the IT operations team as well as their ability and knowledge to respond to the research questions. They were targeted in terms of eliciting information about possible barriers and enablers to the implementation of AIOps. All the interviews followed the same structure and were conducted over one day per institution. Organization B was done on the 6th February 2020 and Organization A on the 21st February 2020. Invitations with the questions and the institution's approval were sent to the relevant managers in the respective IT operations departments.

The managers of the two institutions engaged with the relevant teams and confirmed the interview dates. The approval letters and the consent forms were also distributed and are attached as **Appendix A and B**. After the interviews were conducted, they were recorded and transcribed accordingly. Sample transcripts are provided as **Appendix C**. The interviews were guided by the research questions, in order to present a structure and consistency, although the participants were allowed to raise any issues they wish to raise, within the scope of the research. The questions considered the following from the participants:

- Personal details, current position and their role in the organization.
- An understanding of the technological issues relating to the institution's readiness for AIOps. An understanding of the organizational issues relating to the institution's readiness for AIOps.
- An understanding of the environmental issues relating to the institution's readiness for AIOps.

The biggest challenge with the interviews was securing the availability of the participants from both institutions. Some managers perceived the questions as some form of assessment of their environment. They had to be convinced that the study was only interested in their perceptions of the potential role of AIOps and also the related enablers and barriers for its uptake in higher education organizations in order to secure their participation. The interviews were open and semi-structured which facilitated the deduction of themes. The interviews were conducted in face-to-face interactions and took between 20 – 30 minutes each. Some respondents were elaborate in their responses, while others were short and straightforward. The interview guide is contained in **Appendix D**.

5.3 DATA ANALYSIS AND INTEPRETATION

Below are the steps and approach taken to analyse and interpret the data collected.

5.3.1 FAMILIARIZING WITH THE DATA

Advising researchers on conducting thematic analysis, Maguire and Delahunt (2017:3355) emphasise step 1 of the data analysis process, which is getting familiar with the data, consisting of reading the transcripts several times and being familiar with the entire body of the data. The important point emphasised is that researchers need to apply themselves in their data and understand it very well. This process assists in searching for meanings, trends and themes from the data collected. Since the interviews were recorded and transcribed, they have been read and listened to several times in preparation for this research.

5.3.2 CODING

This is the second step of the thematic analysis process as outlined by Maguire and Delahunt (2017:3355) and other researchers. It involves the organization of data in a meaningful and systematic way. The researchers point out that there is no one way of coding, rather there are different ways based on one's perspective and the research questions. In this research, themes were organized around the research questions, questions that were informed by the TOE. The table below illustrates a sample of the result of such a process. The full coding results are attached in **Appendix E**.

Table 7: Sample Coding

Theme : IT Infrastructure	**Theme : Automated tracking & monitoring**	**Theme : Correlation**
Codes There are constraints, so I can't see that really happening No, I don't think we are ready for that.. In the process of implementing architecture making sure that we are ready for that	*Codes* Yeah, it shows. It shows there perfect and then is there…not perfect Yeah. We have got tools. That we are currently deploying and testing From my point of view IT operations know until the tool is easy to use…	*Codes* So far, we never experience the problem because we work as a team. Yeah in my view actually we are still at struggling with that concept. There is a correlation but we probably aware we don't really have any…

5.3.3 IDENTIFYING THEMES

Maguire and Delahunt (2017:356) describe a theme as "a pattern that describes something that is significant or interesting about the data and/or the research question". They point out that there are no strict rules that relate to the identification of themes. Themes are characterised by their importance to the data and/or research question as a result they may be an overlap of the coding and the identification of themes. In this research, the codes were examined and grouped in themes based on the grouping of the research questions, which resulted into three themes of Technology, Organization and Environment. The themes are informed by the theoretical framework that the study adopted, being the TOE model / framework. Thus, the data collected was then coded and assigned to the relevant themes as well as sub themes within the themes. The themes are generally descriptive of the participant's response to the questions and indicate the codes associated with them, identified as sub themes as illustrated in the tables below.

Table 8: Identifying themes

Theme : Technology
Sub theme : IT infrastructure
There are constraints
We are not ready
Process of implementing
Not equipped
Chance, but not 100%
Still early days
Still in transition
Sub theme : Diagnostic Tools
Capability there
Our section has
Predictive no
Not at this stage
At the moment nothing
Tool is new
There is none
Sub theme: Automated tracking
Not perfect
We've got tools
Currently testing
Tool not easy to use
Manual, no tool
Sub theme : Automated correlation
Work as a team
Struggling with the concept
We don't really have
Very strong team
Quality Assurance Team
We are fire fighting
No collaboration
Sub theme: Log analysis
Planning to do
There is a process
Generate a lot of logs
Record our logs & review
I don't know

I wouldn’t know
Theme: Organization
Sub theme: Management support
They do support
Management support is good
There is a gap
Most definitely
Benefit of the doubt
Management is really trying
Hundred percent
Sub theme : IT skills
Not there
Not at this stage
Some team members are ready
Maybe one or two, not the unit
Need investment
Not as we stand
Sub theme : Data analysts
No
Not there
They are at MIS
No data analysts
Not in the department
Different department
Sub theme: Budget
Too little
I’m not sure
Not at this stage
My answer is no
Budget is not moving forward
Not enough
I wouldn’t know
Sub theme : IT team awareness
Know about it
They know
Don’t’ know
There is that awareness
Pretty good

Theme: Environment
Sub theme: Policy
We have our policies
There is that policy
We have policies
Currently active
They exist
Policies are quite good
Sub theme: IT strategy
There is
Partially
One hundred percent
Very strong digitization drive
Yes, there is
Sub theme: Governance
Have an IT governance
There is that
It is good
There is governance & planning
I have no comment
There is a lot of governance

5.3.4 RESEARCHER' BIAS

As mentioned in the research methodology chapter, the research philosophy chosen for this study is not positivist but interpretive. The researcher does not see himself as an outsider looking into the research problem. He has a relationship and some understanding of the research topic. The objective of the research is not to provide an explanation, but an understanding of the research topic, from the qualitative data collected. The research is therefore subjective, where results can be influenced by the opinion of the researcher, based on the qualitative data collected. However, the researcher endeavoured to describe the participants' experience as objectively as possible.

5.4 PROFILE OF THE ORGANIZATIONS

Universities in South Africa are divided into three categories, which are traditional universities, those that provide academic programmes, technical universities, those that provide technical / vocational programmes and combined universities, those that provide a combination of academic and technical programmes. The case study organizations are going to be referred

to as Organization A and Organization B. Organization A is a traditional university which offers mainly contact learning and a few distance learning classes while Organization B is a technical university offering mainly distance learning classes and some contact learning. A high level profile of Organization A and B in terms of student enrolment, staff complement is found below.

Student enrolment: Organization A

Race	Number
African	26, 453
Chinese	213
Coloured	1658
Indian	4813
White	6766
Unknown	50
Total	39, 953

Source: Organization A, Annual Report, 2018.

Student enrolment by course: Organization A

Category	Number
Undergraduate	25 639
Honours Degree	1879
Master's Degree	7774
Doctoral Degree	2160
Post Graduate Diploma	2271
Occasional Student Postgraduate	230
Total	39 953

Source: Organization A, Annual Report, 2018.

Staff enrolment: Organization A

Employment Category	Number
Academic staff	1112
Top management	6
Senior management	34
Professionally qualified	1677
Skilled technical	1031
Semi-skilled technical	976
Unskilled	982
Total	5818

Source: Organization A, Annual Report, 2018.

IT Department: Organization A

Category	Number
IT staff complement	110
IT budget	R400 million

Source: Organization A, Annual Report, 2018.

Student enrolment by race: Organization B

Race	Number
African	63 605
Coloured	425
Indian	212
White	1678
Total	65 920

Source: Organization B, Annual Report, 2018.

Staff enrolment by category: Organization B

Employment category	Number
Instruction/research professionals	936
Executive/management professionals	59
Support professionals	164
Technical staff	47
Non-professional administrative staff	1 357
Crafts/trades staff	18
Service staff	618
Total	3 199

Source: Organization B, Annual Report, 2018.

Student enrolment by course: Organization B

Student category	Number
Total undergraduates	62 347
Postgraduate to master's level	795
Master's	2 049
Doctors	455
Occasional students	274
Total	65 920

Source: Organization B, Annual Report, 2018.

IT Department: Organization B

Category	Number
IT staff complement	115
IT budget	R350 million

Source: Organization B, Annual Report, 2018.

An interesting observation from the above tables is that Organization A has a less total number of students enrolled but with more staff members as compared to organization B. Organization B has more students enrolled but less staff members. It may be the case of financial resources or that a big number of Organization B's students are distance learning students.

5.5 PARTICIPANTS CHARACTERISTICS

The interviews were scheduled individually with nine (9) employees in the IT operations environment at each of the two institutions, giving a total of 18 participants. All of the interviews with the participants were successfully conducted. The profile of the participants is outlined by the graphs below.

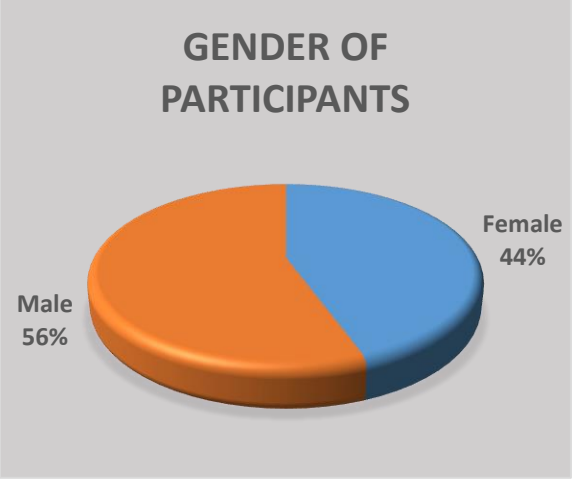


Figure 7 .Gender of participants

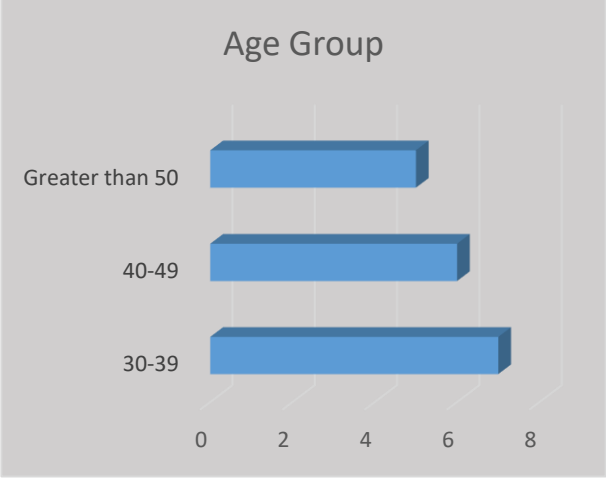


Figure 8. Participants age groups

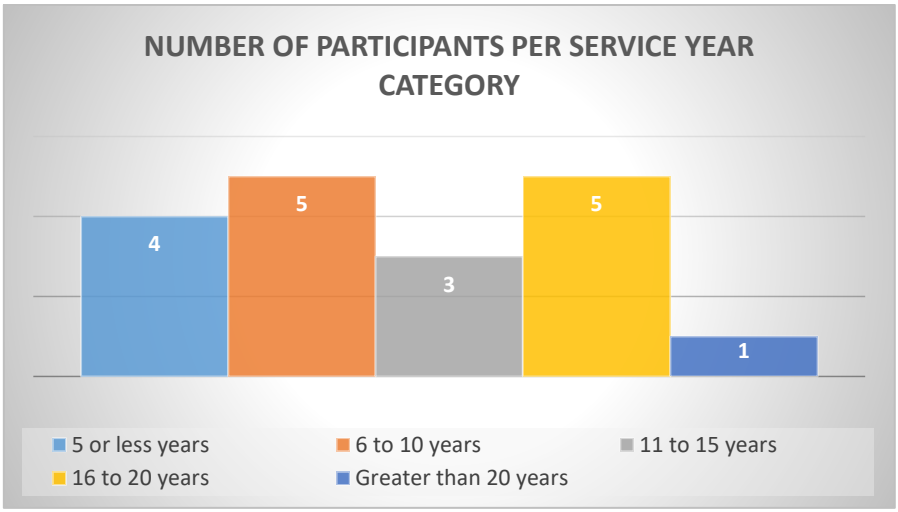


Figure 9. Participants number of years service at the institution

Figure 10. Participants work positions

5.6 ANALYSIS AND DISCUSSION OF THE RESEARCH RESULTS

This subsection deals with the analysis of the themes and sub themes as extrapolated from the data collected. It must be pointed out that the researcher observed that the participants have different levels of expertise and understanding about the research questions. This was indicated by the levels of elaborations as well as engagement. Some participants tried to present a positive picture with little substantiation while others presented a negative one. The researcher had to moderate between these extremes. The analysis is presented in relation to the literature review of the research as outlined in chapter 3. The analysis is arranged according the TOE categories of Technology, Organization and Environment.

5.6.1 TECHNOLOGY

The technology aspect deals with the IT architecture/ infrastructure, automated diagnostic and predictive tools, automated mechanism of tracking, monitoring and resolving incidents, automated correlation between the infrastructure and applications teams as well as the analysis of logs. The study has established from Paddy, Kayak & Signor (2018) that current IT architectures are organized in silos, which presents a challenge for the IT operations team. With these silos, the IT operations team is unable to correlate data from the different domains to provide insights that the IT operation's teams require to manage the environment proactively.

5.6.1.1 IT Architecture / Infrastructure

With regards to the IT architecture / infrastructure of Organization B's readiness for AIOps, the Microsoft Enterprise Specialist said "he cannot see that happening", while the Deputy Director ICT Infrastructure said, "currently we are not ready for that, but we are working towards that". At Organization A, the ICT Support Manager said,

"I'd say yes. I do think that the systems we have now are able to integrate with artificial intelligence and the latest technologies. The reason why I am saying so is at the moment from an audio visual perspective, we have implemented a smart class room, you know, whereby we are using Creston. Obviously, it's a device whereby it can tell you that a certain device has gone down. You know, and obviously that pulls in from other systems. So we already have that type of integration initial to put Artificial Intelligence on top of it obviously if possible. Also, from what I understood from the providers of such. In these days they can relate to just put it on top and then people integrate. So yes, I do believe we have, we can do that. There is that capability".

This is an interesting remark considering that the readiness of an IT architecture to implement AIOps is more than one tool and audio-visual integration. However, it is noted that the remark does acknowledge the significance of integration of solutions in order to build a foundation for AIOps. The IT operations environment at Organization B is generally at an entry level with regards to the implementation of AIOps. The IT architecture / infrastructure is not ready for artificial intelligence, data analytics, big data and machine learning. A few participants have expressed that they are unsure of the readiness of their organization to implement AIOps. At Organization A, the IT architecture / infrastructure was described as capable of integrating AI, machine learning and data analytics, especially from an audio visual perspective. Another lso confirmed the same position and added that further investment would be required. There were some participants who were unable to respond to the IT architecture question but overall it looks like the university is partially ready.

The IT architecture / infrastructure element of the research in both institutions reflected a picture of not being ready to a picture of being in the process of preparing for implementing AIOps. The "readiness of IT architecture" aspect is informed by comments from respondents that included the use of terms such as: we are not equipped, we are not ready, and there are constraints, still early days. The more optimistic views included points such as: we were starting to implement, there is a chance but not 100% and we are still in transition.

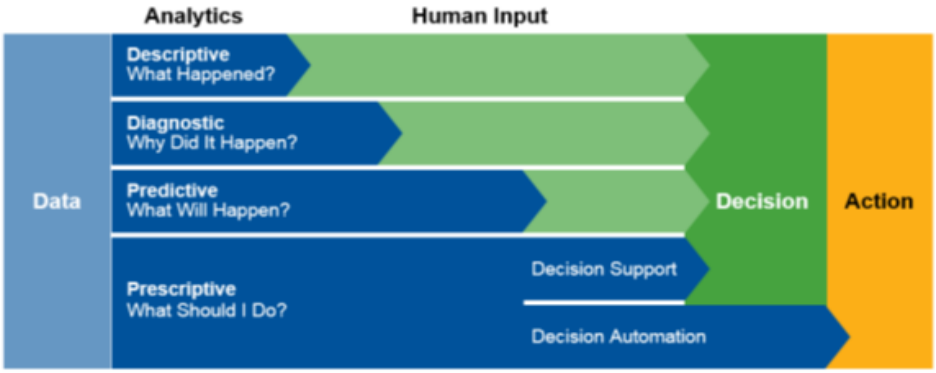
According to Organization's A 2018 annual report, the infrastructure and new technologies required to support the new digital strategy have been implemented, the infrastructure has been improved, classroom technologies have been upgraded as well as laboratories and the training of the academic staff. This indicates a plan being implemented for a solid foundation once the implementation of AIOps is considered. The overall feedack though is that the IT infrastructure is not ready for AIOps implemenation, which points to this aspect as being a barrier. It reflects the silo approach, which Paddy, Kayak & Signor (2018) pointed out as the reason for IT operations teams being unable to correlate data from different domains

to provide the required insights. Elliot and Andrews (2017) emphasise the need for infrastructure and operations leaders to priorities architecture if they want to succeed in transforming the service desk to incorporate machine learning, big data and other artificial intelligence technologies. They argue that those who do not take this approach will become increasingly irrelevant. Mohanty and Vyas (2018) who contend that an AIOps IT infrastructure should break the silo based tools and integrate data related to events, metrics, logs, job data, tickets, monitoring, etc support the same view.

5.6.1.2 Automated diagnostic tools

"So, in the IT ops environment at the moment, I'm reluctant to say there is none. We have just installed or implemented the core ATSL[1]. Therefore, our service desk is equipped. In addition, obviously the tool is new but we would like to use the tool in a way whereby we could start automating most often such puzzle pieces, you know, so it is early days. But the tool is able to do so. But what I'd say is that lets implement it to use it. Then we'll talk about automating. All the things that can be automated by that team. Simple and complex. So, that is what I know."- ICT Support Manager, Organization A.

This finding is consistent with literature in terms of the location of diagnostic tools at the service desk. Such a location enables the tools to interact with the service desk agents. Andenmatten (2019:334) concludes that 40% of all large companies will combine data and machine learning functions to replace the service desk partially. According to Elliot and Andrews (2017), the service desk needs to be transformed into a proactive function through artificial intelligence. Davenport and Ronanki (2018:6) reported on a service desk that was equipped with diagnostic tools, which enabled it to learn from previous logged problems, and solutions provide. The diagram below from Gartner (2017) illustrates how diagnostic and predictive tools work. The tools work hand in hand with humans with humans taking a bigger role during the descriptive phase and the tools taking over from the diagnostic to predictive phases up to the resolution phase.



Source: Gartner 2017

[1] Advanced Technology Systems Laboratory

Capacity planning in section 2 of the research illustrates the significance of diagnostic tools when it comes to AIOps. Currently most IT operations teams perform capacity planning manually. They rely on existing specifications and analyse performance related shortcomings based on these specifications. This becomes an ineffective approach for large institutional environments such as Organizations A and B, characterised by large, complex, multi-tier applications and different service providers. Without diagnostic tools, the IT operations team is estimating the number of CPU cores required, the amount of RAM storage required and the network bandwidth required.

On the automated diagnostic tools the situation from both Organization A and B is generally not optimal. There are silo tools here and there, for example in the network environment. There are no predictive tools used across the IT operations space. As highlighted in section 2, where Mohanty and Vyas (2018:174) refer to AIOps as, "a set of diagnostic and predictive tools, automation and humans-in-the-loop capabilities that will enable operation teams to embrace change". Organization A and B need to consider the implementation of automated diagnostic tools as a foundation for the implementation of AIOps. There is a change aspect required for the successful implementation of the diagnostic tools. The IT operations teams need to be taken through a change management process that affect the way and approach they have been used to.

5.6.1.3 Tracking and monitoring

"The only thing that we use is a manual system. That is how we track every movement but we don't have something that is predictive. Or that works behind. Around every system". Learning Technologist, Organization A.

From the data collected, there are many unknowns with regards to tracking and monitoring. There are elementary disparate tools utilised, for example, at Organization B, the network team uses Clear Pass for the Wi-Fi monitoring. According to Tarun (2017), distributed environments are characterised by different applications running on different platforms, which presents a challenge in tracking problems, resulting in downtime, which affects organizations negatively. The organizations interviewed in this study face this challenge. Artificial intelligence offers the opportunity to overcome IT operations challenges relating to monitoring, alerts, redundancies, downtimes, slow response and others (Janakiram, 2017).

An interesting aspect is that the interviews at Organization A were delayed due to a downtime incident that affected the whole institution. There were teams running around trying to diagnose and fix the problem. There was pressure on the IT operations teams since there were tests scheduled for that morning. It became apparent that tracking and monitoring was

not at the required levels as it took some time to resolve the incident. As mentioned in the literature review, where tracking and monitoring is not optimal, there will be endless downtimes and wastage of resources, which will eventually frustrate the end users. Tarun (2017) who pointed out confirms this point that distributed environments are characterised by different applications running on different platforms, which presents a challenge in tracking problems, resulting in downtime, which affects organizations negatively. Smile and Regalado (2017:68) stated that some faculties and lecturers in the higher education environment have expressed reluctance in adopting online learning management systems due to the impact of IT performance. No university wants to cancel an examination due to the IT downtime. In a complex environment with too many points of failures and many access points, Mohanty and Vyas (2018:176) advise that one needs a hugely automated way of tracking, monitoring and resolving issues before they result in downtimes.

5.6.1.4 Correlation

"Yeah.Yeah. There is, there is. A little bit. Yeah, we need some improvement. Yeah you see there is a process especially on applications that is managed by us. But because there are now many other pieces managed by another company. So, we rely on one another. Yeah but on our applications there is a process which we should upgrade". Deputy Director : ICT Infrastructure Organization B.

Correlation in the AIOps environment is described as the collection of data from different sources (servers, network, operating systems, databases, etc.) and consolidating this data to determine relationships between infrastructure and applications, (Padhye, Nayak & Signore (2018 :11). There is an indication of a lack of understanding of the kind of correlation required for the implementation of AIOps from the participants that were interviewed. Correlation between the infrastructure and applications teams is at a basic level. Instead of proper correlation, the participants referred to teamwork. Correlation requires an improvement. Organization A's IT operations team is still struggling with this concept. From the Loom Systems (2019) study of an organization's implementation of AIOps over three years, it became apparent that correlation is critical. The implementation of AIOps facilitated a correlation of tickets and consolidation of incidents before they could escalate which resulted in the reduction of downtime, saving the organization more than $4 million over three years.

It is an interesting observation that correlation from both institutions seems to be very low in both understanding and execution. Since the environments are complex at both institutions, it would be expected that correlation would be central in the IT operations management approach. As outlined by Paddy, Nayak and Signore (2018:6) correlation covers the data about the application performance, events logs, transasctions and more, including the network

and storage resources dealing with the delivery of the application. Without this information, the IT operations teams is operating with insufficient information and has limited understanding of what is happening with the applications.

5.6.1.5 Log analysis

"This is what we do on the set. So, we monitor, we use an interpret team and they run our firewalls so that is the two ways that we do. So, analysis. It's all manually it's not automated but. But I believe all the new products will have an application like that and then we start with some of that". Information Security Specialist, Organization B.

The analysis of logs from an IT operations team's perspective is linked to data analysis. Where there is no culture of analysis of data, there will be very little analysis of logs for the purposes of managing the environment optimally. Janakiram (2017) maintains that log analysis is the obvious place to introduce artificial intelligence. He points out that every component of the IT operations stack, hardware, software, operating system, servers, applications, databases generates logs that can be analysed by machine learning algorithms. This can assist the IT operations in identifying problems proactively before they get reported.

Log analysis at Organizations A and B also follows the same pattern as correlation in as far as the lack of understanding in relation to the implementation of AIOps. It is at an elementary stage. There is a plan in place to improve. It is not applicable in all areas. Log analysis is about the analysis of the data generated by the logs. The IT operations teams rely on these logs in order to get an understanding of the performance and health status of the different IT components. This process requires significant human intervention, with the teams analysing these logs and determining the root cause of the problem or potential problem as well as determining the intervention approach. AIOps introduces machine-learning algorithms, which can proactively find problems and potential problems before they happen, (Thankachan 2017:716).

5.6.2 ORGANIZATION

From Werner's (2016) book on organizational behavior, organizations require a plan of management in order to achieve goals and objectives. Such plans include organizational design, choosing a management team and having a plan to interact with people and their working environment. The point made here is that organizations operate according to a plan, utilizing people and other resources to achieve certain objectives. The same principle applies to the IT operations environments of both institutions.

The combination of the roles does provide a representative cross section of the IT operations environment. Organizations who are operating in this era, the era of digital transformation will

have to consider artificial intelligence in their IT operations. If they aim to survive, they need to address increasing volumes of data, have teams to analyse this data, automate it and predict issues before they happen. From the collected and analysed data, the organizational aspect consists of management support for AIOps, skills set of the IT operations team, the awareness levels of this team, the utilization of data analytics and the budget allocation for IT operations. “The ability to adopt AIOps depends not only on the availability of monitoring data and automation systems, but also the alignment of people and processes”, Tarun (2017:1).

5.6.2.1 Management support

“I think management actually care that they want to go on a certain direction on IT. But I think they do have a clear plan on how to get there. And yeah so. So, I think I got a feeling that support is there in principle, but we don't have a plan that is in place. You know the plan is to be co-created between management and operations”. Research Computing, Organization A.

IT operations, as mentioned in the literature review, is essentially a management function that is driven by various processes to ensure availability and performance of IT functions. For such a function to succeed, the support of management is required. IT operations play a crucial supportive role. A healthy IT organization provides key competitive advantages for organizations in a fast-paced market (Tarun, 2017). Reporting on strategic IT projects that involved significant changes and deployment of technology that had not been successful, Chaffey (2009:595) highlighted the need to check top management support that has to be delivered in a practical and public way. Mason (2002:1) asserts that IT often finds itself on the defensive as an expensive cost centre when Executive Management considers budget cuts.

Management support comes in the form of allocation of the required resources, human and financial as well as ensuring that stakeholders play their roles to achieve efficient IT operations. In some cases, management also requires to undergo changes and training to understand and support the implementation of AIOps. Management support at both educational institutions was perceived as being generally positive. There is room for improvement as in sometimes management does not understand some of the IT concepts. As mentioned, management support is often a prerequisite to the successful implementation of strategic projects such as AIOps. There is evidence that Organization A’s management is supportive of the development of the infrastructure and new technologies required to support the digital strategy, which will enable better IT support, access to broadband and faster Wi-Fi connections, the development of smart classrooms, simulation laboratories and the training of academics to participate in the digital era. They do have some challenges regarding the network related to the upgrade project, which has taken longer to complete with performance

issues. These challenges are being addressed. An internal oversight and management committee was established to address ongoing or new challenges, and to ensure that the project remains on track until it is completed.

5.6.2.2 IT Skills

"We have no knowledge of that. Not there yet right now, there are no data analysts in the environment, the IT environment people who deal with the analysing data are not really qualified for that. I think that is one of the reasons we are speaking of this. We can always do with more than what we are getting from the government, in terms of funding. We do the best we can. But we are not there yet" Microsoft Enterprise Specialist, Organization B.

At the skills level, the skills required for AIOps are not at the required level at both institutions. Both organizations report that there is a need for up skilling. AIOps skills are an enhancement of the current IT operations teams skills set. Such skills will evolve over time to include knowledge of machine learning / algorithms, programming and security. A few individuals are at the right levels but not the whole unit. Mohanty and Vyas (2018:174) point out that, "Today's IT landscape is too complex for any single person or even a team to manage on their own; instead, the skills required consist of multiple specializations (full-stack engineers)". Hess (2016:128) argues that skills required for the digital transformation should be developed within the organization to enable the development of the digital mind set. Alharthi, Krotov and Bowman (2017:288) conclude that the lack of appropriate skills is one of the reasons that organizations are not utilizing big data to their advantage.

The overall analysis of the skills of the IT teams at both institutions is that they do not exist. Comments such as: not there, not at this stage, some team member have but not the whole unit and need investment were used by the participants as part of their response to the interview questions. The skills aspect of the two institutions thus represents a barrier to the implementation of AIOPs.

5.6.2.3 IT Operations' Team Awareness

"Yeah, so, there is the awareness and I think it is based on us coming to the strategy session years ago. When we sat down, we said where we are going to. Where is the world now and how do we get there. And we sat down we considered and know what things are coming up. We looked at the process situation and so forth and we started looking at even where the skills are set whether they are enough to move across. That's how we began to understand what we have today and what we really have in the future. Sure. So, we are definitely aware and we keep on you know researching. You know and always look at the technology high curve. Just to see what, what is coming up so we can plan? And be ready

for what's coming up next. So, we are definitely with it". ICT Support Manager, Organization A.

On the IT operations team's awareness, both institutions recorded positive feedback. Concluding on the importance of planning for AIOps, Mohanty and Vyas (2018:186) emphasised that there are no easy steps to implement AIOps. There is a need for the IT operations team to keep up with developments, focus on supporting the business and also transform as a team as well. Chaffey (2002:589) argues that a high lelvel of awareness creates a receptive climate for change. Alharthi, Krotov and Bowman (2017:289) point out organization culture as affecting the adoption of big data. Organizational culture is linked to staff awareness. The authors argue that in organizations where there is overall lack of understanding of the value of big data and AIOps, the staff will see little value in executing these initiatives. The implementation of AIOps would require a receptive envrinment as well as a strong change management programme. Although both institutions recorded positive results on awareness, there is an indication that there is a long way to go before these teams can be confirmed as being aware of transformation they need to undertake to be closer to a better understanding of the requirements of AIOps.

5.6.2.4 Budget

"My answer is no and I think when you look at the traditional approach of universities. And the fact that we're now to a cloud, these two things don't talk to each other not only that I think the issue is also that um, there is more online classes coming. Now there are more night classes. But you find the budget is not moving forward whether they should even talk about tools for analysis to ensure that the data is protected. Given POPI[2] is going to be in effect soon. Moving to the cloud safe guarding and so forth. And the money that is required we are still saying, can we have that? And the answer is always there is no budget. And it is more even last year if I'm not mistaken. We had a couple of posts that we were looking for. I don't even think we got the money. With budget cuts" Senior Manager Business Solutions, Organization A.

University budgets in South Africa are under pressure due to a variety of factors such an increase in the number of students enrolling for higher education, the no fees policy for a certain group of students and the fast developments in technology. In such circumstances, IT operations normally take a back seat when it comes to budget allocations for projects such as implementing AIOps. Universities are satisfied with just keeping the lights on when it comes to IT operations. This will affect IT operations negatively in the end. In a university funding fact sheet, Universities South Africa (2016:8) reported the following, "Universities remain

[2] Protection of Personal Information Act 4 of 2013.

dependent on state support, which continues to decline… This has all happened within the context of a weakening Rand where institutions are hard-hit in the areas of imported research equipment, electronic and other library resources as well as ICT equipment and software licences, etc." The budget is generally viewed as inadequate for a move towards AIOps. There is a strong view that the budget partially addresses what is required for a university in the digital transformation era. Thus, budgetary constraints are deemed as a barrier towards AIOps.

5.6.2.5 Data Analysts

"Yeah, the data analysis is being done at the Management Information Systems (MIS). It is not in the same place in the IT environment, it's another department in different division, it is another department outside IT. It is another strategy, yes". Deputy Director: ICT Infrastructure, Organization B.

The issue of Data Analysts is an interesting one. Participants from both institutions acknowledge the importance of such skills in the IT operations environment. However, both organizations have none. The IT operations team needs training and education in AIOps and big data analysis. There will be a need to consider involving data scientists to augment the team with the necessary big data skills.

There is an interesting case study reported by Larsen (2015) about a barbecue business that adopted big data analysis in order to salvage a business that was struggling. They discovered that the challenge to moving to big data is getting the right people with the right data analytical skills and who are ready to be innovative and think out the box. The company had 11 staff members of which two were dedicated analytical staff. The business was turned around. Alharti, Krotov and Bownam (2017: 185) argue that most organizations across the world are unable to take advantage of big data analytics due to a number of barriers such as skills and infrastructure. Quoting a Gartner report, Saran (2018) contends that by 2025, 70% of IT infrastructure teams will not be in a position to support the business and only a quarter of IT infrastructure leaders would have teams that have the right skills and working experience to support the requirements for IT operations needed within the next two to three years. On the higher education side, Daniel (2015) who conducted research on big data and analytics in higher education supports the above scenario. He concluded that although there was work in higher education regarding data management structures and governance, there were a number of uncertainties.

5.6.3 ENVIRONMENT

The last theme of the research questions deals with the environment, which covers the policy provisions that govern the university's IT operations, the IT strategy as well as governance. From a policy perspective, students at universities are exposed to the technological developments of the digital transformation era, which includes mobility and exposure to a series of applications. They tend to be more proactive and demanding of IT resources such as bandwidth, availability and support. It is against this background that universities have to formulate policies that meet the student and staff demands in a manner that is cost effective while not hindering developments and advancements. Based on the current legislation, universities carry the risk of being held liable for the actions of students, employees and guests who are using the university's local and global technology networks. To manage these risks, universities from time to time formulate various policies and review these policies regularly to ensure compliance.

5.6.3.1 Policies

"They exist, but then I've forgotten the terms that was used then but essentially, it needs to be said that they exist but they need constant update. They need to be a living document but it needs to be relevant to the university's circumstances. Relevant to big data, machine learning. We have a very strong digitization drive. So yes, we approve". Senior Manager Business Solutions (ERP), Organization A.

Organization A reports within its 2018 annual report that information security and the cyber security policies that were approved have been implemented. It further reports that the Council paid more attention to the revision of policies, with focus on IT and compliance with a view to improve the governance framework. This has been reflected from the data collected from the participants. What is missing is an understanding that one needs technological tools in order to implement policies successfully, especially in a large, complex environment. It is one thing to have a revised policy and another thing to have a successfully implemented policy. The institutions have a gap when it comes to the tools that are required for a successful implementation of IT policies.

From the collected and analysed data, the policy element at both institutions is positive. Participants have responded with comments such as: we have our policies, there is that policy, we have policies, currently active, they exist and policies are quite good. This is a positive reflection and is recorded as an enabler.

5.6.3.2 IT Strategy

"Yeah, we definitely use them to build that team. So, we said like you know adopting that we can improve. Our processes in the services we deliver. But we also don't have finances so it is a challenge to be adopted in our current environment. Given that we are under staffed we don't have enough even the staff they are not properly skilled. To look at it and a lot of you take people away because it's new. So, one of the things I think we try to stay better ahead in that sort of focus point. If I look at it. And then but some of the universities have the resources. It's a question of how do you utilize them." Information Security Specialist, Organization B.

The IT strategy is also an important indicator of the university's readiness or willingness to undertake the implementation of AIOps. As mentioned, artificial intelligence has the potential to assist organizations, however, it is not simple, and it is complex and requires the development of a comprehensive strategy in order to realize its benefits. Davenport and Ronanki (2018:8) pointed out that there is a need for organizations to take incremental steps with the currently available technology while planning for transformational change in the not-too-distant future. This is a reflection of the importance of considering AIOPs as part of the strategy for the provision of IT services. The feedback on IT strategy was positive for both institutions. There was an acknowledgment of its existence, in some cases partially, in some cases hundred percent with the digital drive being prominent.

Organization B reported in their 2018 annual report that the Office of CIO and Executive Director has delivered on The Digital Transformation Strategy, which aims to unify technology plans through a redesigned enterprise architect framework, and redeveloped business processes to support a digitised environment. This is an indication of IT strategic objectives being supported at Executive level, which is a positive development. The organization plans to be a leading university of technology on the continent, embracing the rapidly changing, technology-enabled and technology-driven world. For such ambitious strategic plans, Organization B needs to consider AIOps to succeed.

5.6.3.3 Governance

"I think it is very good in governance. And again, it's also like managing perceptions as well. A lot of people that do really hard work at ICT doesn't get recognized at the same time our failures get more plastered out of proportion. And IT management doesn't really show anymore and that type of things. So, it's a mixed bag. With good governance you get happy customers". Research Computing, Organization A.

Governance deals with the planning arrangements that ensure IT resources and services meet the needs of the students and staff in an efficient and economic manner, while complying with

legal and regulatory requirements. To implement governance, universities investigate best practice models and frameworks for IT, especially those that are adopted by higher education institutions, (Bianchi and Sousa 2015:7). As universities have many unique characteristics, governance normally reflects such characteristics at particular times. There is no one model that fits all universities, (Universities South Africa, 2016).

Feedback from the collected and analysed data reflected a good position for governance from both institutions. There is an indication of having IT governance, governance and planning as well as defined governance structures. In some cases, governance is viewed as delaying decision making but necessary. This is another enabler. At Organization A, a new operational model which involves the conclusion of service level agreements (SLA's) between IT and various other units within the institution has been established with the objective of managing IT's performance in this regard. Several structures were created to manage risk, security, compliance and efficiencies around the use of ICT infrastructure.

5.7 VERIFICATION OF FINDINGS

The findings of the research were verified with the senior managers at both institutions. There was agreement that the findings reflect the true nature of the situation and circumstances. There was also acknowledgment that some of the participants reflected more of their personal perspectives than the reality on the ground. However, this was balanced with the reality of the IT operations performance at both institutions.

5.8 CONCLUSION

The chapter above presented the findings of this research as well as a discussion on the findings that were extracted using the thematic analysis approach. Themes related to AIOps and IT operations such as IT architecture, diagnostic tools, correlation and others were discussed and analysed in detail. The general findings on the themes are consistent with existing literature in terms of the difficulties and complexities of implementing AIOps. There is a recurring theme of the significance of implementing AIOps not being understood and perhaps not being treated as a priority. It was evident from the findings that although the benefits of implementing AIOps are understood, the barriers confirmed that a long way needs to be travelled before such implementation could be realized. In the following chapter, the researcher provides a summary of the findings, concluding remarks and a suggestion for future research.

6. RECOMMENDATIONS AND CONCLUSIONS

6.1 INTRODUCTION

This is the last chapter of the research thesis, which concludes the study by highlighting the main elements of the findings of the study. The chapter summarises how the research questions were addressed, the key findings of the research, the contributions of the study, the summary of the methodology used, the limitations of the study and suggestions for future research.

6.2 ADDRESSING THE RESEARCH QUESTIONS

The primary research question, “What are the barriers and enablers to the implementation of AIOps in the higher education sector?” has been addressed. The barriers and enablers to the implementation of AIOps at the two institutions of higher learning where the research was conducted are reflected. The enablers identified in the study are IT skills, IT operations team awareness, management support, IT strategy, policy and governance. It must be noted that these enablers were common from both institutions. The barriers identified include IT architecture / infrastructure, automated monitoring and tracking, predictive diagnostic tools, correlation, log analysis, budget and data analysts. The interesting aspect of these findings is that the enablers consist of the soft issues while the barriers consist of the technological issues. There are more barriers than the enablers that came out of the interviews.

The secondary question of, “How can an understanding of the barriers and enablers assist in the implementation of AIOps?” has also been addressed. The understanding of the enablers and the barriers at both selected institutions of higher learning provides an insight into the issues that need to be addressed when one is considering the implementation of AIOps. One would need to consider the barriers as risks that need to be addressed when launching a project to implement AIOps.

In reflecting on the research questions about the technology aspect, the data indicates that IT architecture / infrastructure is still organized in the silo, domain centred approach. This mirrors what has been said in the literature by Paddy, Kayak & Signor (2018), Mohanty and Vyas (2018) and Chaffey (2009). This silo approach has been attributed to long downtimes, which affect organizations negatively. However, the data contrasted the literature in terms of response to downtimes. The data indicated that the IT operations teams felt that they are managing the environment well and are able to respond to major issues on time. This may be attributed to the perception that they have been doing things like this and we have managed to maintain the availability and performance of the IT environment. It may also be attributed to a lack of strategic thinking in terms of planning for the IT operations.

On the organization aspect, the data indicated that both organizations are not familiar with what artificial intelligence can do for them and they are uncertain of how and where to start in implementing AIOps. This mirrors what has been said in literature by researchers such as Elliot and Andrews (2017), Davenport and Ronanki (2018) and Alharthi, Krotov and Bowman (2017). While this is the situation, there were initiatives such as the smart classroom and automated audiovisual functionality, which pointed to a foundation for AIOps implementation. This may be attributed to a lack of the overall skills required for the implementation of AIOps and thus the organizations choose the initiatives where there are existing skills to make a successful implementation. It may also be a reflection of the organization's knowledge of the complexity and levels of effort required to implement AIOps.

On the environment aspect, the data indicated that both organizations have solid governance processes and structures as well as documented policies and strategies. This is a reflection of an understanding of the demands of the digital transformation era. This mirrors what has been said by organizations such as the Loom Systems (2017), and researchers such as Dang, Lin, Huang (2019), Mohanty and Vyas (2018) and Tarun (2017). However, the data contrasted the literature in terms of the implementation of the documented policies and strategies. This may be attributed to budget constraints as reflected in the research. Below are the barriers and enablers emanating from the interviews.

Table 9: Barriers to AIOps implementation

Barrier	Key findings
IT architecture / infrastructure	The overall feedack noted is that the IT infrastructure is not ready for AIOps implemenation, which points to this aspect as being a barrier.
Automated tracking	Firstly, the participants from both institutions did not seem to understand the concept of automated tracking and monitoring. Secondly, it became apparent that there was no automated tracking and monitoring taking place, although it was acknowledged that such functionality is a requirement.
Diagnostic tools	Diagnostic tools seem to be deployed across the IT environment on an ad hoc basis, reflecting the silo approach AIOps is trying to address.
Correlation	The situation of correlation is similar to that of automated tracking and monitoring. The lack of coordinated correlation places the implementation of AIOPs further down the line. Without such correlation the IT operations teams is unable to effectively manage workloads, performance and downtime.
Log analysis	Log analysis seems to be the most recognizable functionality from both institutions. This can be explained by the fact that every technology

Barrier	Key findings
	layer, whether hardware, software, operating system, servers, applications and databases do generate some sort of logs. These logs can be collected, stored and analysed into meaningful data. What was missing from both institutions was a coordinated log analysis program that will consider all these disparate sources of the logs, consolidate the data and proactively identify anomalies where they exist.
Data analysts	The finding on the issue of data analysts is a reflection of the traditional approach to IT operations from both institutions. The traditional approach is the one that utilizes the silo approach for IT service provision. Both institutions do not have data analysts in their respective IT departments, but there are data analysts in the Business Intelligence and Management Information Systems sections of the institutions.
Budget	The budget was deemed inadequate without enough substantiation. It was more like the economics of demands and wants. The researcher did not find any indication or understanding from the participants that AIOps would assist them in compiling accurate budgets. With AIOps, IT operations teams can accurately forecast the cost of infrastructure through analyzing the workloads and their usage patterns.

Table 10: Enablers to AIOps implementation

Enabler	Key findings
IT skills	IT skills were deemed an enabler based on the participants' responses. The employees of both institutions are skilled when it comes to the running and operating the traditional IT operations environments. However, there is a need for up skilling and change of approach when it comes to preparing for the implementation of AIOps.
IT awareness	IT awareness was found to be at the right level at both institutions. The participants were fairly aware of the requirements of the digital transformation era and the subsequent implications.
Management support	Management support has recorded as positive and thus categorized as an enabler. There is a consensus that management is going all the way to support the IT operations team under trying circumstances. There is a view expressed that things were going to be better if management had better understanding of IT and its contributions to the organization
IT strategy	The IT strategy finding was deemed an enabler due to its consideration of the technology developments as well as the institutions willingness to move

Enabler	Key findings
	toward the digital transformation era. However, it is noted that strategy needs to be operationalized.
Policy	From the collected and analysed data, the policy element at both institutions is positive. Participants have responded with comments such as we have our policies, there is that policy, we have policies, currently active, they exist and policies are quite good. This is a positive reflection and is recorded as an enabler.
Governance	The findings indicated that governance was an enabler from both institutions. The organizations have clearly documented and implemented governance and reporting structures.

6.3 MANAGEMENT RECOMMENDATIONS

In the findings of this research, there are recommendations that can be derived for management and IT operations practitioners to consider when they intend to implement AIOps. This section provides such guidelines for consideration by management and IT operations practitioners as informed by the research findings. The guidelines are based on the Technology, Environment and Organization model as used in the research and the barriers and enablers identified from the data collected. It is an expectation that the guidelines will assist and prepare management and IT operations practitioners in the implementation of AIOps. The table below presents the guidelines.

Table 11: Management recommendations to AIOps implementation

Components	Management Recommendations
Technology	Management and IT operations practitioners should plan for the replacement of the traditional domain based IT architectures with the consolidated unified architectures that include cloud computing, virtualization, agile development. Such a plan should be accompanied by the required diagnostic predictive tools, tracking and monitoring as well as how the correlation of data will be achieved. It is recommended that management and IT practitioners should implement effective and optimal log analysis as a foundation for the implementation of AIOps.
Organization	It is recommended that management and IT operations practitioners establish a project to raise awareness on AIOps across the organization. There is a need to allocate a sustainable budget to prepare for the implementation of AIOps that will include training, workshops, tools and pilot initiatives for AIOps.

Components	Management Recommendations
	Senior management, the Executive, the academics and students should be made aware of the potential value and benefits that AIOps will provide to the teaching and learning processes. It is recommended that management and IT practitioners should establish formal initiatives to understand manage and leverage on the data that is being generated from the IT operations environment as a preparation for the implementation of AIOps.
Environment	It is recommended that management and IT operations practitioners consider linking up with industry to develop an understanding of the context, trends and tools that relate to AIOps. Management should consider implementing a pilot project that will automate the enforcement and execution of policies as a precursor to the implementation of AIOps. Management and IT operations practitioners should consider approaching the Department of Higher Education in an attempt to secure funding for the implementation of AIOps across the higher education landscape.

6.4 RESEARCH CONTRIBUTIONS

6.4.1 Researcher's contributions

The study contributed in highlighting the weaknesses and shortcomings of the traditional IT architecture of the institutions of higher education in terms of implementing AIOps. The findings indicated that the IT operations teams of the relevant instructions seem oblivious to the weaknesses and shortcomings. These weaknesses cascade to the tools and processes used to manage the IT operations. There are no diagnostic and predictive tools, there is no proper tracking and monitoring and there is very little effective correlation being undertaken.

The study also indicated that while technical foundations required for the implementation of AIOps are weak, there are high levels of enthusiasm and awareness within the IT operations teams. There are future looking policies and strategies which enhance the environment's ability to move forward. This can be used as building blocks in establishing a foundation for the implementation of AIOps.

From the study, others can learn the impact of budget constraints to the IT operations area at universities. They can learn how a low to a non-existent relationship between the educational institutions and the industry when it comes to AIOps contributes to the barriers. They can learn that certain major incidents, which resulted in devastating downtimes, could have been avoided with the implementation of AIOps.

The study added to the literature in terms of noting the complexity and effort required to implement AIOps in higher education as a factor that needs to be considered. AIOps needs to be simplified and operationalized for the benefits of the IT operations teams in universities. Most of the research literature on AIOps has focused on an overview of AIOps, how AIOps solutions are built and how they can transform IT operations generally. This study adds to the literature the context of barriers and enablers affecting the implementation of AIOps in institutions of higher learning.

6.4.2 Theoretical contributions

Current research indicates that the TOE framework is capable of being applied broadly and has the potential to explain a number of technological, industrial and national / cultural contexts with regards to the enablers and barriers that impact innovations such as AIOps (Baker 2011:186). Theoretically, the study is an example of how the TOE theory may be applied towards understanding the complex issues surrounding the adoption and implementation of AIOps in higher education. Additionally the study adds to the academic literature on AIOps which authors such as Dang, Lin and Huang (2019), Qi, Wu, Li and Shu (2007) and Andenmatten (2019) have highlighted is required.

6.4.3 Methodological contributions

The methodological contribution of the study is the experience gained from the execution of a multiple case study in the data collection phase and the use of the interpretive research approach. The study was a qualitative case study using two higher education learning institutions. The literature indicates that case studies are beneficial to understanding ICT integration processes of educational institutions by examining the participants through the interviews or observations, Yin (2003), Myers and Avison (2002), and Unluer (2012).

6.4.4 Practical contributions

On a practical level, the study offered several guiding principles and recommedations for IT management and executives to consider when implementing AIOPs. These principles cover the technology, organization and environment apsects that impact the implementation of AIOps.

6.5 LIMITATIONS OF THE STUDY AND FUTURE RESEARCH

This study was limited to two institutions of higher learning. Future studies should consider conducting the same study at multiple organizations in multiple sectors. This would assist in better understanding the dynamics surrounding the adoption and implementation of AIOps. The study was based on the assumption that AIOps is understood to assist institutions in

transforming their IT operations. Further studies on the level and extent of organization's understanding of the AIOps' ability to transform IT operations would be useful. The study assumed that institutions are aware of the fact that their traditional IT operations models are no longer providing effective IT operations and supporting the organizations. Future research should involve defining the baseline technological readiness for AIOps and how this could assist organizations in transitioning from the traditional IT operations models.

There was not enough extensive literature on AIOps and its implementation, especially in higher education found in the extant literature base. There is a need for further development of research in this area. Future studies would be useful in looking at the relationship between higher education institutions and the industry in relation to AIOps. Such a relationship has a potential to develop further research on the adoption and implementation of AIOps in higher education. This will also address the feature of AIOPs being a new concept. Additionally, this study followed the interpretive, qualitative and case study approach. Future studies may be considered the topic from the perspective of other research strategies.

AIOps is not about the replacement of the current tools the IT operations teams are currently using. Such tools may be a useful platform to build a foundation for the implementation AIOps. It is suggested that future research should consider how universities IT operations teams manage and handle the tools that manage data. Andenmatten (2019:341) reminds us that AIOps is only good as the data captured in the system.

6.6 CONCLUSION

In this chapter, the research effort is concluded by looking at how the relevant chapters contributed towards addressing the research question. Chapter 1 introduced the reader to the research question that focused on the enablers and barriers to the implementation of AIOps in institutions of higher learning. The chapter outlined the significance of AIOps, being a new concept in the IT operations environment. The case for AIOPs was made stronger by the high impact incidents of downtimes that were reviewed which led to negative consequences for certain organizations. It was concluded that due the non-implementation of AIOps, these organization's IT operations teams were unable to diagnose and resolve the incidents on time.

Chapter 2 introduced the reader to the concepts that are related to AIOps. The chapter presented the case of artificial intelligence in IT operations and other business management processes. It looked at the implications of developments such as cloud computing, virtualization, big data analytics and digital transformation in the IT operations environment. Having gained an understanding of the concepts and their relationships, the chapter

concluded that implementing AIOps is able to optimize IT operations to respond to the digital transformation demands.

Chapter 3 presented the philosophical assumptions that underpin the research. The interpretive research approach was adopted in order to establish a better understanding of the factors that affect AIOps implementation and the dynamics that exist at institutions of higher learning. The case study methodology was used as a vehicle for the collection of data. Thus, the chapter dealt with the research design used as well as the data collection method.

Chapter 4 introduced the conceptual framework of AIOps and the utilization of the technology-organization-environment (TOE) model to understand the enablers and barriers to the implementation of AIOps. The chapter concluded that the investigation of enablers and barriers would be based on the TOE model.

Chapter 5 presented the data analysis and the findings from the collected data. The chapter covered the interviews in detail as well as the method used to analyse the data, which is the thematic method with coding and the identification of themes. Having analysed the data, it was concluded that the two institutions involved were at an early stage in terms of implementing AIOps. There were more barriers than enablers identified. It was also concluded the barriers constituted the critical elements required in implementing AIOps.

This final chapter concluded the research journey through reflecting on the lessons derived from the study, the limitations were acknowledged and opportunities for future research studies were highlighted.

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APPENDICES

APPENDIX A: TEMPLATE OF THE APPROVAL LETTERS

Date:

To whom it may concern

I, .::……

, as delegated authority of .::…… hereby give permission to

the primary researcher Thabo Sakasa of the School of Information Technology, at the University of Pretoria the following:

1. To engage (survey/interview) with the employees of the above mentioned Department. I have reviewed the questionnaire / interview questions given to me by the researcher. I hereby give my approval for using the questionnaire / interview questions by the researcher.

This authorization is based on a mutual understanding that the ..…... name can be mentioned anywhere in his project.

The information provided by the employees or any other means (such as company's archived documents or reports) of the above mentioned University is purely for academic purposes and cannot be used for any other purpose.

Regards,

Signature: ---------- Date: 30 July 2019 ----------

Name & Surname: ……

Position/Delegation of Authority: (e.g. CEO, Director) ……..

Tel/Email address: ……

APPENDIX B: CONSENT FORM

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Informed consent form

(Form for research subject's permission)

(Must be signed by each research subject, and must be kept on record by the researcher)

1 Title of research project: The impact of Artificial Intelligence, Machine Learning and Big Data Analytics on IT operations in tertiary education.

2 I …… hereby voluntarily grant my permission for participation in the project as explained to me by ……..

3 The nature, objective, possible safety and health implications have been explained to me and I understand them.

4 I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purposes of publication.

5 Upon signature of this form, you will be provided with a copy.

Signed: … … … … … … … … … … … … … … … . Date:……

Witness:…… Date:……

Researcher:…….. Date:…….

APPENDIX C: RESEARCHER DECLARATION

APPLICATIONS MUST INCLUDE THE FOLLOWING STATEMENTS

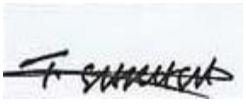
Hereby I, Thabo Sakasa (21249212) in my capacity as Masters (MIT) Student declare that,

1 Research subjects will be informed, information will be handled confidentially, research subjects reserve the right to choose whether to participate and, where applicable, written permission will be obtained for the execution of the project (example of permission attached).

2 No conflict of interests or financial benefit, whether for the researcher, company or organization, that could materially affect the outcome of the investigation or jeopardise the name of the university is foreseen.

3 Inspection of the experiments in loco may take place at any time by the committee or its proxy.

4 The information I furnish in the application is correct to the best of my knowledge and that I will abide by the stipulations of the committee as contained in the regulations.

5 Signed:  Date: 6 March 2019

APPENDIX D: INTERVIEW QUESTIONS AND PROFILE OF PARTICIPANTS

Personal checklist

1. What is your role in the organization?
2. How long have you been employed at the organization?
3. How long have you been working in IT?
4. What are your qualifications, certification and experience, undergraduate, postgraduate?

	Question	TOE Framework	Category
1	Describe the current IT architecture focusing on whether it is capable of integrating artificial intelligence.	**Technology**	IT infrastructure
2	Outline any automated, diagnostic and predictive tools that are used in IT operations.	**Technology**	Tools
3	Is there an automated way of tracking, monitoring, and resolving issues? If yes, please elaborate	**Technology**	Processes
4	Reflect on automated correlation of application services with infrastructure.	**Technology**	Processes
5	How is log analysis performed on the data generated by the logs?	**Technology**	Processes
6	Describe the management support for IT operations to adopt artificial intelligence, machine learning, and data analytics?	**Organization**	Management support
7	What skills does the IT operations team possess that may facilitate the implementation of AIOps?	**Organization**	IT skills
8	Are there data analysts that form part of the IT operations team?	**Organization**	IT Skills
9	Describe the budget allocated for the improvement of IT operations to respond to the digital transformation requirements?	**Organization**	Costs
10	To what extent is the IT operations team aware about AIOps and its potential?	**Organization**	Management support
11	Describe the policy that governs the provision of IT services such as Internet, Wi-Fi etc.	**Environment**	Policy
12	Is artificial intelligence or related concepts part of the University's IT strategy?	**Environment**	Strategy

13	Outline the governance and planning arrangements that ensure IT facilities and services meet needs, are efficient and economic, and address legal and regulatory needs	**Environment**	Higher Education

INTERVIEW SCHEDULE : ORGANIZATION A

Participant	Job Title	Role
1	ICT Support Manager	Responsible for supporting the Information Technology Director in providing information and direction about the IT resources necessary for a strategic IT technology framework to enable the ITS to achieve the IT- objectives, in support of the University's business objectives.
2	ICT Student Support	To manage and control the service delivery and availability of geographical allocated student computing laboratories where Computer based testing is conducted
3	Incident Manager	Responsible for the effective operation and quality service delivery of the Help desk, the Campus Support Teams and ensuring the development of strong relationships with all user groups across the Institution.
4	Network Manager	To ensure the effective and efficient management of the data and telephone network, associated cabling, and Internet service provisioning.
5	Network Manager (Collaboration)	To ensure the effective and efficient management of the data and telephone network, associated cabling, and Internet service provisioning.
6	Systems Engineer (UNIX)	To provide a specialist service for the management of infrastructural software applications on enterprise-level servers
7	Snr Manager Business Solutions (ERP)	To configure, maintain and operate business applications, ensuring its availability, the following of business processes, data integrity, security and business continuity.
8	Infrastructure Senior Manager	Operational management and control of the Infrastructure group in order to meet the requirements of the various Operational Level Agreements (OLAs).
9	IT Operations, Senior Manager	Responsible for ensuring optimal functioning of the IT operations through the provision of dependable and highly available systems and technology.

INTERVIEW SCHEDULE : ORGANIZATION B

Participant	Job Title	Role
1	Microsoft Enterprise Engineer	Responsible for the various Microsoft platforms, from research, deployment, support and training for both students and staff
2	Network Support	To ensure that there is constant connectivity to the network and available services by providing second level support to all UP users, design of network extensions, and solving of complex network problems.
3	Network Engineer	To ensure the effective and efficient management of the data and telephone network, associated cabling, and Internet service provisioning.
4	Deputy Director : Support Services	Responsible for the Service Desk and all the related processes
5	Head : Internet Services	Responsible for the provision of Internet Services to both students and staff and the underlying processes
6	Deputy Director : ICT Infrastructure	Responsible for ensuring optimal functioning of the IT operations through the provision of dependable and highly available systems and technology.
7	Information Security	to provide life cycle management of the information security environment by architecting, planning, acquiring, implementing, maintaining and retiring strategies, policies, procedures, systems and equipment to ensure a secure and auditable data processing, storage and communication environment.
8	Web Developer	Responsible for the development of web allocations , maintenance and support as well user training
9	Business Analyst	Analyse business processes and relate them into IT solutions to improve the workflow or expand systems to serve improved services

APPENDIX E: SAMPLE TRANSCRIPTIONS (RAW DATA)

ORGANIZAION A

INTERVIEWER: Yes, perfect. Now we can start with the research questions. There are only thirteen. So, in your view I would like you to elaborate for me whether you think the current IT architecture / infrastructure is ready to adopt artificial intelligence, machine learning & data analytics in your view.

PARTICIPANT A: On this campus?

INTERVIEWER: On this campus yes.

PARTICIPANT A: No, I don't think we are ready for that.

INTERVIEWER: Please elaborate?

PARTICIPANT A: Currently we are firstly driven by single applications that is no best, you need a solid foundation first of all, and given the best are out there.

INTERVIEWER: Yes.

PARTICIPANT A: Second there is no human resources at that capacity.

INTERVIEWER: Yes.

PARTICIPANT A: And yeah that's the two issues which I think contribute to our position.

INTERVIEWER: Fair enough ,fair enough.

PARTICIPANT A: And also, there is quite a lot going on in the university and the faculties and IT department.

INTERVIEWER: I see.

PARTICIPANT A: And what contributes to the value of the university are the relationships.

INTERVIEWER: It's stronger?

PARTICIPANT A: Yeah.

INTERVIEWER: Yes.

PARTICIPANT A: So, because we have a lot of people doing the theory on that side.

INTERVIEWER: Yes.

INTERVIEWER: Yes, still was there.

PARTICIPANT A: Yeah but it is like its only like there, we try our best, but very little happens.

INTERVIEWER: Are there any automated diagnostic and predictive tools that are used within the IT operations space?

PARTICIPANT A: At the moment nothing.

ORGANIZATION B

INTERVIEWER: Yes, thank you my brother. So, let's come to the questions now. So, first question is basically your understanding or description of whether the current IT architecture / infrastructure.

PARTICIPANT B: Okay.

INTERVIEWER: Whether the IT Architecture / Infrastructure is capable of integrating with artificial intelligence in the way need to move towards that direction, the direction of AIOps.

PARTICIPANT B: Sure.

INTERVIEWER: Yes.

PARTICIPANT B: So, your question is do, I think.?

INTERVIEWER: Do you think that current IT environment is capable of integrating artificial intelligence applications within the teaching and learning the environment , which would need to maintained and supported via AIOps?

PARTICIPANT B: I'd say yes. I do think that the systems we have now are able to integrate with artificial intelligence and the latest technologies.

INTERVIEWER: Correct.

PARTICIPANT B: The reason why I am saying so is at the moment from an AV (audiovisual) perspective.

INTERVIEWER: Yes.

PARTICIPANT B: We have implemented a smart classroom, you know, whereby we are using Creston and Creston. Obviously, it's a device whereby it can tell you that a certain device has gone down.

INTERVIEWER: Yes.

PARTICIPANT B: You know, and obviously that pulls in from other users, so already we have that type of integration initial to put AI (artificial intelligence) on top of it obviously as possible and.

INTERVIEWER: Yes.

PARTICIPANT B: Also, from what I understood from the providers of such.

INTERVIEWER: Yes.

PARTICIPANT B: Is that these days they can relate to just put it on top and then people integrate? So yes, I do believe we have, we can do that.

INTERVIEWER: There is that capability.

PARTICIPANT B: Yes,

INTERVIEWER: Perfect.

PARTICIPANT B: Yeah.

INTERVIEWER: Question number two. Please outline any automated diagnostic or predictive tools that are in use currently in the IT operations environment?

APPENDIX F: WORD CLOUD FOR COLLECTED DATA

APPENDIX G: SAMPLE CODING RESULTS

Theme : IT Infrastructure

Codes

There are constraints, so I can't see that really heppening
No, I don't think we are ready for that..
In the process of implementing architecture making sure that we are ready for that
I don't think we equipped for it; it would take some investment.
Within the IT operations I can say there is that chance and but it is not 100%
No, its early days. Still early days. We still in transition, the way I see it

Theme : Automated tracking & monitoring

Codes

Yeah, it shows. It shows there perfect and then is there…not perfect
Yeah. We have got tools. That we are currently deploying and testing
From my point of view IT operations know until the tool is easy to use…
The only thing that we use is a manual tech tool.
Yes, so basically, we got like a system

Theme : Correlation

Codes

So far, we never experience the problem because we work as a team.
Yeah in my view actually we are still at struggling with that concept.
There is a correlation but we probably aware we don't really have any…
There is very strong team
I think that's all-in order, there is because all the senior programmers correlate with Infrastructure
We got the quality assurance team.
No, It's more down like firefighting level and more than a process
There is no collaboration there is no communication there is no…

Theme : Diagnostic tools

Codes

Capability is there. Not implemented.
There are from our section.
Sort of predictive no, no.
Yeah not at this stage.
At the moment nothing.
And obviously the tool is new but we would like to use the tool in future
There isn't. No.
There are a few tools. But I don't think we are using them to…

Theme : IT Ops Skills

Codes

We are not there on that knowledge. Not there yet right…
No. Not in this stage. Not at this stage.
You know actually what I can say is the team is ready and e… Maybe one or two, but not as a unit. So, they don't.
It will take some investments to get there.
Not as we stand it's a skill set that I don't think so.

Theme : IT Ops Awareness

Codes

We know about it.
Yes. But it's like I said no programme yet, they know.
But we don't know now what level should we be at for now.
Yeah so. There is that awareness. There is…
Pretty good.
Yeah people are generally aware
I think we all aware
Yeah, we always go and research and update,
They are aware as well. The young guys…

Theme : Log Analysis

Codes

We are planning to do that is series five of the...
Yeah you see there is a process especially on applications that are in…
Yeah, we do generate a lot of logs.
Yeah basically when we record our logs, we review the, the. …
Ask Ernest I don't know.
I wouldn't know.
.Ill lie to you

Theme : Management support

Codes

Yeah, they do support it. As long as it's a more advanced.
So far you know so far, the management support it is good.
The, the re…
I think there is a gap so maybe at our EMC or VC level because meet with… Because sometimes they don't understand as to management yes. They do…
The Management's support most definitely there from an IT management.
Yeah, I give them the benefit of the doubt.
I'll say there is support in terms of that…
I think the management is really trying.
I think management actually care that they want to go on a d…
Okay, so I would say hundred percent

Theme : Policy

Codes

We have our policies in place.
Yeah there is that policy where not anyone can get into our network.
Yes. We do have a policy that does that there.
In terms of policies we are we have policies.
Yeah now we currently active on that so we renew the policies every the…
They, they exist, but they I've forgotten the term that what use…
I think the policies are quite good. Because you know with the…
The policy is fine I think there's more policy than there us…

Theme : IT Strategy

Codes

Yes. There is. Yeah. Within the university…
I can say, I can say partially.
Yes. Currently yeah I… One hundred percent.
So, we look at our ICT… We've got a very strong digitization Drive
Yeah there is you can see that there is strategy.

Theme : Data analysts

Codes

No.
Yeah, the data analysist is being done at the MIS.
At MIS yes.
We have one data scientist. Yes, But it's o…
Not in the IT department but in the BR department.
Yes, there are in the business side right.
So, it is a different department but I understand they had data…

Theme : Governance

Codes

Okay yeah, we have an IT governance comity that actually it's a sub co…
My understanding there is that I don't know how to put it.
I think it's, its good it's because we are looking at okay as an examp…
So, there is a. Governance and planning. So, we do…
I think. Yes, we are doing well on that as well.
No, that one I could say the governance is good generally because…
I think is very good in governance.
Yeah, yeah, yeah, yeah, okay so there is a lot of governance I…