



Affordances of Digital Simulations in Training Wastewater Treatment Practicals for Process Controllers in Technical Vocational Education and Training Institutions.

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Declaration

I hereby declare that this research report is my own work. It has been submitted exclusively to the University of the Witwatersrand in partial fulfilment of the requirements for the Master of Education Degree (MEd).

Signature : 

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LIST OF ABBREVIATIONS

AC	Abstract Conceptualisation
AE	Active Experimentation
AFT	Affordances Framework Theory
BOD	Biological Oxygen Demand
CE	Concrete Experience
DVD's	Digital Video Disks
ELT	Experiential Learning Cycle
GDP	Gross Domestic Product
HRT	Hydraulic Retention Time
ICT	Information Communication Technology
PC	Process Controller
PST	Primary Settling Tanks
RO	Reflective Observation
SA	South Africa
SCADA	Supervisory Systems and Data Management Systems
TVET	Technical Vocational Education and Training
UNESCO	United Nations Educational, Scientific and Cultural Organization
W&WW	Water and Wastewater
WAS	Waste Activated Sludge
WBL	work-based learning
WEST	Worldwide Engine for Simulation, Training and Automation
WWR	Wastewater Recycling
WWTP	Wastewater Treatment Processes (WWTP)

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ABSTRACT

In South Africa, Technical Vocational Education and Training (TVET) institutions train process controllers in various training programmes that rely on on-the-job training at wastewater treatment plants. TVET institutions are urged to include ICT into all training practises, which may necessitate curriculum updates and adjustments. The aim of this study determined how the WEST simulator can be used to enhance practical training for wastewater process controllers. This study followed a qualitative research approach and a thematic data analysis technique. In their perceptions, the participants recognised the teaching and learning affordances of the simulator such as replication of the process overview and problem-solving abilities. The study found that the participants were able to construct a comprehensive WWTP utilising WEST simulation, indicating that the affordances can be replicated and designed in actual situations. Although the WEST simulator offers various affordances, this research found a few minor limitations with its use, such as the computer requirements, which required a RAM speed of 1500 MHz. Based on the findings, it is recommended that facilitators should have skills and knowledge in the field to perceive affordances, and their existence and to actualise them to apply them in practical training online.

1 CHAPTER 1 INTRODUCTION

1.1 Background and Motivation

Knowledge and skills have become the most important force driving modern economies and countries are investing increasing amounts of their Gross Domestic Product (GDP) in TVET education and digitalisation (Stewart, 2015). Digitalisation and innovation are affecting how people work and there is an emergence of new types of employment and workforce required. The TVET is increasingly becoming the driver for innovation and technological developments have necessitated the need to provide opportunities in e-learning for effective learning.

The use of information communication technologies (ICT) tools by learners has become important for learning and skills development. Agbo and Okwuddili (2018) mentioned that in Nigeria, the use of ICT in TVET education has become essential as they are exploiting modern opportunities such as e-learning and the demand has increased rapidly in TVET spaces. According to Nystrom and Ahn (2020), the use of ICT tools is placing new demands on TVET institutions, as some aspects of vocational knowledge is learned during work-based learning (WBL). Furthermore, there is a need for TVET institutions to use simulators as a possible solution to address the need for practical learning in the curriculum and to make it possible to imitate the complexity of the vocational practice in cases where human contact is prohibited.

Water and Wastewater (WW) process control is an engineering discipline that is concerned with the infrastructural intricacies for maintaining the output of specific processes within the desired range of a treatment plant. (Energy Water Sector Education Training Authority; 2014). In the context of the South African (SA) water and wastewater sector, a Process Controller (PC) is defined as any person who has achieved the relevant competencies to effectively operate a unit process at a waterworks. Technical Vocational Education and Training (TVET) institutions train process controllers through Learnership programmes that rely on workplace training that is conducted on the waterworks sites. In cases where human contact is not

possible, this becomes a challenge. According to Eggers (2021), new technologies have the potential to deliver significant learning outcomes in the water sector.

The use of digital simulations can enable learners to receive training online vocational skills. This would facilitate the creation of pedagogical practices that TVET needs to prepare their learners for the industry. The practical skills training is developed in workshops/laboratories or through WBL. Scholars (Kulkarni, Appasaba, Gokhale, & Tigadi, 2022) have shown how training programmes have benefited from digital simulations and how they were useful in training practicals. According to surveys conducted by UNESCO (2020), many countries with TVET providers stated that they are also not providing or assessing practical skills training, they are only focusing on theoretical coursework when using Online platforms. There have been some attempts to close the gap of practical training by using YouTube videos and tutorial videos however, the issue with videos is that they are not interactive and do not allow the learner to troubleshoot. To qualify, learners enrolled in the Water and Wastewater (W &WW) Learnership are expected to demonstrate knowledge and understanding of the treatment of water and wastewater process, distributing of water, troubleshooting in terms of the process, and interpreting water laboratory test results.

1.2 The Research Problem

The application of Digital simulation in practical training can assist facilitators in the teaching and learning process. Even for technical courses requiring practicals, TVET facilitators are expected to deliver high-quality online instruction. However, TVET face-to-face instruction is more practical than virtual instruction (Razak, Noordin & Khanan, 2022). The TVET institutions are currently conducting the W &WW Learnership by providing theoretical training online using ICT tools like Teams and Zoom Applications. The TVET facilitators (teaching process controllers) have challenges with providing learners in the Learnership with practical skills training in these online platforms (Razak *et al.*, 2022). As a result, learners lack practical training, and the learners cannot be deployed to the industry to offer a meaningful contribution to the workforce. It is a requirement by employers that learners complete practical training prior to

deployment to the business (Ghavifekr & Yulin, 2021). Practical training is an essential component of the qualification and if learners are not found competent in practical training, they will not be able to practice their skill and contribute to the eradication of the water sector challenges in SA. This study explored the affordances that may be presented by integrating digital simulations into the virtual learning platforms to close the gap of practical training for the W& WWT in the TVET environment (Gebreheat, Whitehorn & Paterson, 2022; Wood, Zegwaard, Fox-Turnbull, 2020).

1.3 Aim of the Study

Therefore, the aim of this research investigated how facilitators (teaching process controllers) use a digital simulator for practical training of wastewater process controllers.

1.4 Research Objectives

1. To determine the perception of facilitators towards digital simulations affordances.
2. To explore the affordances of digital simulations that epitomize the features of WWT.
3. To determine how the affordances of digital simulations can improve practical training of Wastewater Treatment Processes.

1.5 Research Questions

Main Research Question: How can the affordances of digital simulations be used for Wastewater Treatment process practical training in TVET? The following sub-questions were posed to answer the main research question:

1. How facilitators perceive the affordances of digital simulators, specifically in the context of WWPC training using WEST simulator?

2. What are the affordances of digital simulations that can epitomize the features of WWT?
3. How do the affordances of digital simulations can improve practical training of Wastewater Treatment processes?

1.6 Significance of the Study

The world of learning has progressed greatly, and ICT tools are used to facilitate training online; this has detached learners from learning centres and placed them in their own environment. However, the necessity for practical training is still vital in developing competent Wastewater process controllers. Santos, Figueiredo and Vieira, (2019) identified the following approaches to teaching; 1) mixed approaches with ICTs association; 2) digital simulation; 3) approaches employed in large classes. Embedding simulations in education helps the move to a student-centred approach, where students have greater discretion over how and when they study. The simulator's capacity to boost student engagement and encourage deeper learning was proved in this study (Santos *et al.*, 2019).

Recent technological advancements have brought significant disruption to the education sector, and one of the most promising technologies (Akour & Alenezi, 2022). Litvinenko, (2020) found that many countries around the world have been actively exploring and utilising digital simulations for practical training across various fields. These simulations can help improve the training of WWTW process controllers and engineers by providing a safe and cost-effective way to gain hands on experience. Scholars such as Wang, Homer, Dyer, White-Hull, & Du, (2005) highlighted that the United States Environmental Protection Agency has advocated for the use of digital simulations for WWTP training to aid with certification. Whilst Canada adopted digital simulations tools for WWTW training as part of their curriculum. According to Sewilam, Nacken, Breur, & Pyka (2017), Germany places a significant emphasis on environmental sustainability and WWTP. They integrate digital simulations into the educational programs of various technical colleges and institutes to educate the next generation of WWT experts. Additionally, the researchers underscore the significance

of employing digital simulations in WWTP and advocate for continued exploration and innovation in this field.

This study contributed to both the water sector, TVET institutions and Public Universities that are currently facilitating practical training in Wastewater Treatment processing online. Furthermore, if a positive outcome is achieved, the study increases awareness in both sectors (Water and TVET) on the use of digital simulations for practical training and this may also lead to an increased understanding of digital simulations. An example of a successful implementation of digital learning in TVET is of a Public University of Malaysia (Razak *et al.*, 2022). Public higher education stakeholders might utilise the findings to create a framework in TVET digital learning to foster the provision of high-quality and effective online teaching and learning content (Razak *et al.*, 2022).

There are limited studies done in SA that address the need for training of WWT process controllers using simulations and this study can contribute to the field. The findings will be shared with both the TVET institutions and the Water Sector, to provide them with information on how digital simulations may contribute to skills development and holistic practical training. Ngila, Matheri, Muckoya, Ngigi and Ntuli, (2020) stated the following contributions to the South African wastewater treatment fraternity are made through the application of digital simulations: conduct site inspection of the WWTPs process units, as well as mathematical modelling and simulation, to gain a better knowledge of each treatment unit. Also, simulations will ensure the comparability of acceptable findings, adjust variables, and evaluate empirical data using quality of forecasting (prediction performance).

1.7 Chapter Organisation

Chapter 1 Introduction: This chapter focused on a general introduction and context with the following sub-sections: 1.1) introduction, 1.2) background to the problem, 1.3) problem statement, 1.4) aim of the study, 1.5) research objectives, 1.6) research questions, 1.7) significance of the study, 1.8) chapter organisation, and 1.9) conclusions.

Chapter 2 Literature review: This chapter focused on descriptions of relevant concepts, provides comprehensive thematic conceptualisation and relevant theoretical perspectives.

Chapter 3 Research Methodology: This chapter provided details of the methods and research design followed. The methods selected were based on a qualitative approach.

Chapter 4 Data Presentation: This chapter presented data in two sections (Section A Demographics and Section B Data presentation).

Chapter 5 Data Analysis and Findings: This chapter provided the analysis and discussion/findings from the data.

Chapter 6 Conclusions and Recommendations: This chapter included the conclusions and recommendations made from this study.

2 CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter focused on the theoretical framework and conceptualisation of key concepts that are used in this study. The theoretical framework included theories such as the affordances framework theory (AFT) and experiential learning cycle (ELT). These theories provided a framework to explore research objectives and provide perspectives to answer the main research question "*How can the affordances of digital simulations enhance Wastewater treatment process control practical training in TVET Institution?*" The conceptualisation consisted of the following main concepts or constructs: Wastewater treatment process; training and the application of ICT in practice; affordances and perceptions; and affordances of digital simulators to enhance practical training.

2.2 Theoretical Framework

The primary objective of this research is to explore the affordances of using the Worldwide Engine for Simulation, Training and Automation (WEST) digital simulator in training practicals for wastewater process controllers (Figure 3) and the research questions are designed to delve deeper into different aspects of this objective, including perceptions, affordances, and the overall improvement of practical training in WWTP. The affordances theoretical framework and Kolb's theory of experiential learning were used in this study. This section represents the theories that served as the study's foundation. The primary goal of this study was to investigate the use of digital simulations in training practicals for wastewater treatment process controllers. The setting for this study was influenced by the experiential learning theory and the affordance framework theory. Integrating Experiential Learning Theory (ELT) and Affordance Framework Theory (AFT) provided an integrated approach to investigating the efficacy and influence of digital simulations in wastewater treatment training (WWTT). ELT focuses on learning aspects, but the AFT explores into individuals' perceptions and interactions with technology, making it a more holistic approach to the

research. The theories that served as the study's framework are represented in this part. The ELT and the AFT influenced the study's setting.

2.2.1 Experiential Learning Theory (ELT)

Kolb (1984) described ELT as the process through which experience is transformed to knowledge. Knowledge is the product of grasping and transforming experience (Kolb, 1984). The ELT model below depicts two dialectically related modes of grasping experience, concrete experience (CE) and abstract conceptualisation (AC), as well as two dialectically related modes of transformation, reflective observation (RO) and active experimentation (AE) (Kolb *et al.*, 2014). Concrete experiences are the foundation of observations and reflections in the four-stage learning cycle depicted in Figure 1 below, which are assimilated and extracted into abstract concepts from which new implications that can be actively tested and serve as guides in creating new experiences for action can be drawn. This theory played an important role in the observations for this study.

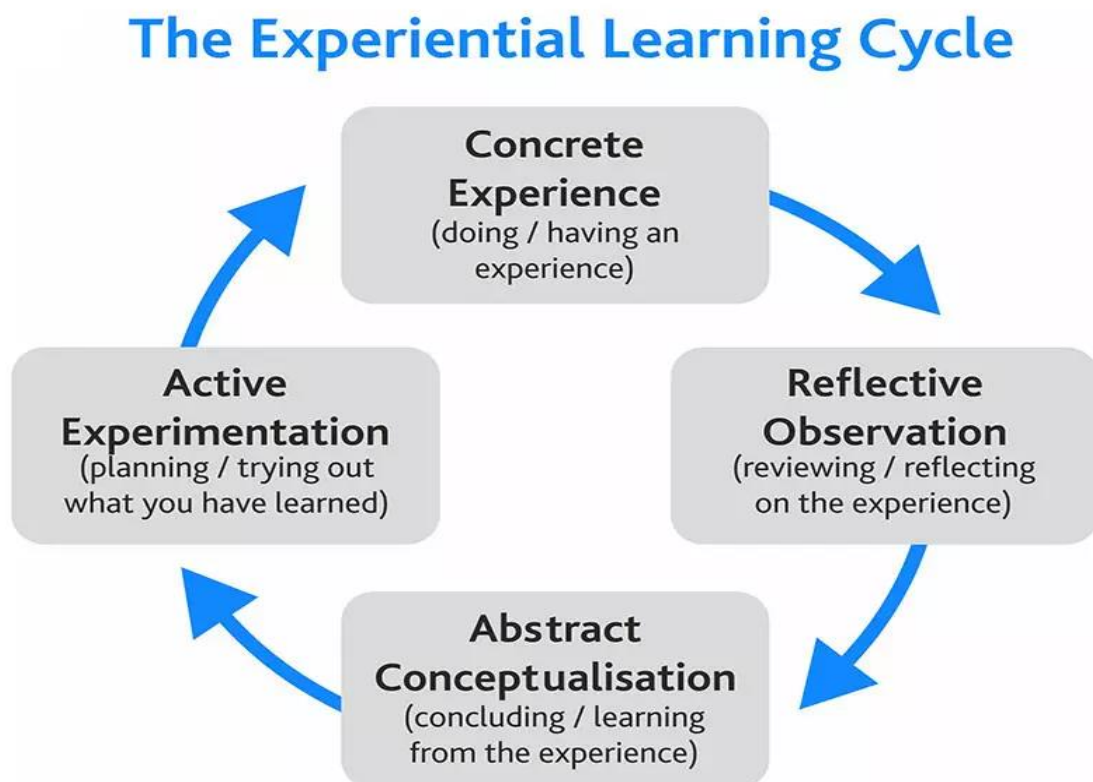


Figure 1: Kolb's Experiential Learning Theory

In the context of WWTT, the CE phase holds significant importance as it fosters active engagement and provides the initial exposure to the simulator. During this phase, participants immerse themselves in practical, hands-on experiences where they actively interact with the simulation software. They make decisions and execute tasks that are directly related to WWTP. Following their involvement with the digital simulator, participants transition to the RO stage. During the RO phase, participants examine their experiences by reflecting on the affordances they encountered, the challenges they encountered, and how their decisions within the simulation impacted the final outcomes. The RO stage promotes critical thinking and self-assessment, enabling participants to extract valuable information from their learning experiences. After completing the RO stage, participants progress to the AC phase which encourages the development of theoretical understanding. During this stage, participants may aim to extract more extensive principles and concepts from their simulation experiences. Additionally, they might engage in discussions and conceptualise strategies related to WWT based on the knowledge they have acquired. The final stage, known as AE, involves the practical application of the insights and knowledge gained through reflection and conceptualisation. In this phase, participants have an opportunity to apply what they have learned from the digital simulator to tackle problems.

2.2.2 Affordances Framework Theory

In this study, the concept of affordance provides an understanding of the link between technology and human actors as demonstrated in Figure 2 below. Gibson (1994) defined affordances as "action possibilities" and believed that environmental information is readily available in the environment and may be immediately perceived. Norman (1999) applied the Gibson theory of affordances to human-computer interaction and technology design and defined affordances as the perceived and actual characteristics of the objects, especially those fundamental properties that influence how the object may be utilised. Hutchby (2001) adapted the principle of affordance from the environment to technology, interpreting affordances as an interaction between IT artefacts and humans. Furthermore, Hutchby (2001) claims that

affordances are not exclusively characteristics of artefacts; they are embedded in the interactions between users (Figure 2).

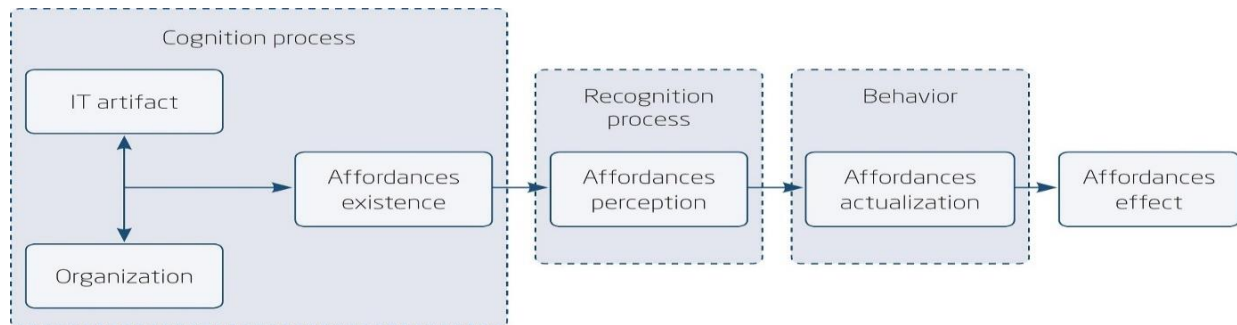


Figure 2: *Affordances Theoretical Framework (Hutchby, 2001)*

Figure 2 illustrates the model's four stages, which are based on the link between affordances' existence, perception, actualisation, and outcomes. The first cognitive step of affordance existence is the point at which users recognise that they may have the ability to act while interacting with a technological item. According to Hutchby (2001), affordances exist where IT artefacts interact with the organisation/group. The arrow connecting the IT artefact and the organisation demonstrates that affordances are rational, which means they are not exclusive aspects of both the item and the organisation (Markus & Silver, 2008). The artefact and the user have a perfect correlation.

The process of recognising the existence of an affordance that is modified by information observed by actors is described as affordance perception (Markus & Silver, 2008). Additionally, Markus and Silver (2008) stated that affordances perception is influenced by Information Technology artefact qualities that originate from the designer's goals and the capabilities of the actor's purpose. What the user/actor perceives as existing affordances is not the same as what is available. As the user engages with the artefact, they may see affordances that the artefact could provide; but, after engaging with the artefact, they may discover that the existing affordances are not what they perceived and discover new existing affordances. The actualisation notion was described by Volkoff, Johnson, Tulu, and Strong (2014) as the action performed by actors as they take advantage of affordances through their

use of technology to create immediate and tangible effects in support of corporate goals.

Strong *et al.* (2014) stated that actualisation is a goal-oriented and interactive process, which means that goal-oriented actors can interact with the IT artefact and take actions to actualise affordances that will achieve immediate and concrete outcomes to support organisational goals, as well as provide feedback to adjust actions. Many consequences may be obtained and witnessed by the actors/users through the process of affordances actualisation, and these impacts are referred to as immediate concrete outcomes (Strong *et al.*, 2014). The concrete outcomes are the outcomes that can assist support the organisation's goals and are identified through interaction between the IT objects and the user.

2.3 Conceptual Framework

The conceptual framework was used by enabling the facilitator to identify the learning outcomes and thereafter engage with the WEST digital simulator to identify affordance perceptions. The trainer then performed actions/tasks to actualise the affordances they perceived of the WEST simulator and determined if the actions they performed with the simulator yielded the outcome. The trainer utilised Kolb's experiential learning theory as a guideline to determine whether the WEST simulator provides effective training approaches by evaluating if the affordance identified can support practical through the four stages of the cycle (Figure 4). The researcher observed the trainers as they apply the affordances identified to ascertain if the affordances can be actualised.

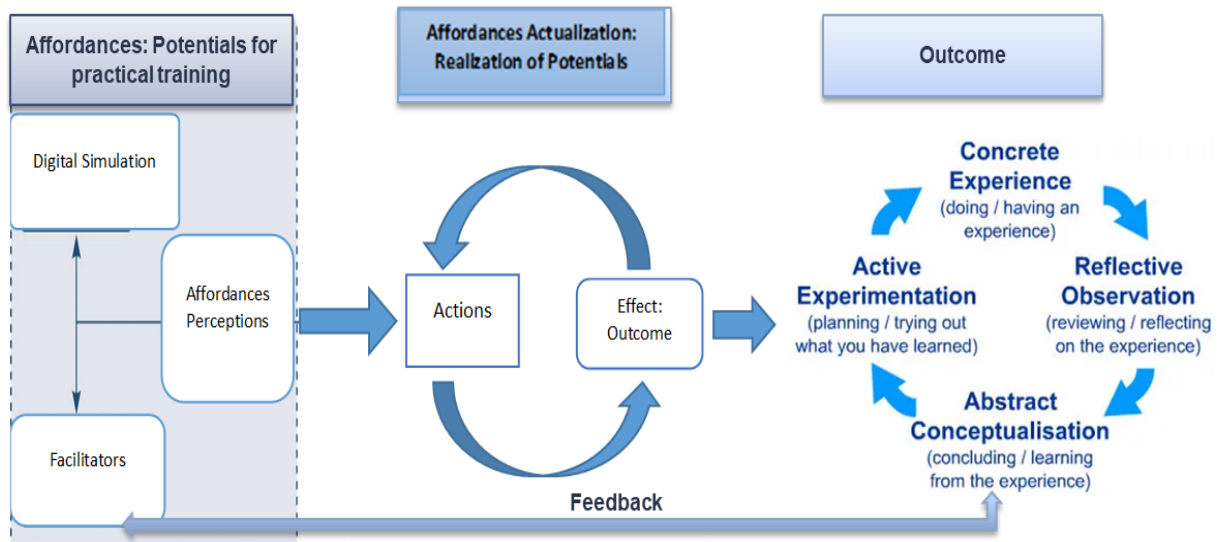


Figure 3: *Application Theoretical Framework*

The AFT focuses on participants perceptions and interactions with simulator to identify and actualise the affordances in the learning process. Additionally, the theory aims to view how users engage with the simulator capabilities and affordances. Whilst the ETL provides a structured framework of the learning process. It highlights the significance of CE, RE, AC and AE while emphasising the importance of practical engagement and critical thinking in the learning process. These two theories offer a comprehensive understanding of how digital simulations are encountered, comprehended, and applied in the practical training.

2.3.1 Wastewater Treatment Processes (WWTP)

South Africa is a water-scarce country, and therefore it is essential to protect water resources and the environment, thus wastewater must be treated and released to the environment as purified water appropriate for agriculture to enhance the environmental situation and groundwater sources. The key objective of wastewater treatment is to eliminate solids from wastewater, which can be organic or inorganic, and to discharge treated water without harming public health or when reused (Al-Suod, 2016; Ranjit *et al.*, 2021). Ranjit, Jhans and Reddy (2021) described wastewater as water that has been used in a household (domestic water), a company (municipal wastewater), or as part of an industrial process (industrial wastewater). This water also differs depending

on the source from which it is discharged. The WWTP is also regarded as a water reclamation process since treated wastewater may well be utilised for various purposes such as farming and industrial usage if all pollutants are removed to the required standards (Metcalf and Eddy, 2003). From literature it has become evident that unit processes of WWTP were simulated using digital programming to explore the behaviour wastewater treatment facilities (Andrews, 1993; Koyuncuolu & Erden, 2021).

According to Ranjit *et al.* (2021), the WWTP consists of four key steps: preliminary treatment, primary treatment, secondary treatment, and tertiary or advanced treatment. The preliminary treatment is defined as a phase in which floating debris such as leaves, papers, wood pieces, twigs, tree branches, diapers, fats, oils, grit, and so on are removed using specially designed equipment like screens, grit chambers, and skimming tanks (Ranjit *et al.*, 2021). The second stage of the WWTP is the primary treatment, which is used to remove small-sized inorganic matter and large-sized settleable organic matter, which can range from 60-65% of suspended solids to 30-35% of biological oxygen demand (BOD) (Ranjit *et al.*, 2021; Koyuncuolu *et al.*, 2021). To further treat the primary effluent from the Primary Settling Tanks (PST) by removing residual organics and suspended solids in the form of biodegradable dissolved and colloidal solids through a combination of biological processes in anaerobic, anoxic, and aerobic conditions (Ranjit *et al.*, 2021; Koyuncuolu *et al.*, 2021).

The velocity of the wastewater is reduced during primary treatment to allow for the settling of heavier organic solids and the floatation of lighter materials such as fats, oil, and grease in tanks known as clarifiers or primary settling tanks (PST) (Ikumi, Matimba, Modiri, Coothen, Nsengiyumva, Naidoo & Power, 2019). Moreover, Ikumi *et al.* (2019) highlighted that the suspended particles in PSTs are sticky and tend to flocculate spontaneously, therefore depending on the process design, chemicals may not be necessary to coagulate the solids unless greater removal efficiencies are required. Variations in organic solid properties such as size, specific gravity, and shape cause this floating and settling of solids. PSTs are typically circular or rectangular basins that are 3 metres deep and have a hydraulic retention time (HRT) of 1-2 hours (Ranjit *et al.*, 2021; Koyuncuolu *et al.*, 2021). The HRT is the amount of time that the dissolved or suspended stays in the PST.

In the wastewater process, there are two main types of secondary treatment systems: aerobic treatment units and biofiltration systems. These systems are also commercially available as pre-manufactured units designed to treat domestic wastewater produced by residences and, in some cases, non-residential facilities (Krzeminski, Tomei, Karaolia, Langenhoff, Almeida, Felis, E & Fatta-Kassinou, 2019). The secondary treatment, also known as the activated sludge process, involves the growth of natural microorganisms that metabolise the organic materials in the wastewater, resulting in additional microorganisms and inorganic end-products (Krzeminski *et al.*, 2019; Ranjit *et al.*, 2021; Koyuncuolu *et al.*, 2021). Moreover, Ranjit *et al.* (2021) stated that these types of activated sludge systems combine different processes (anaerobic, anoxic, and aerobic) in several compartments depending on effluent needs. The tertiary treatment enhances the quality of secondary and secondary effluent before it is discharged into the receiving environment (Metcalf and Eddy, 2003). In addition, the tertiary treatment eliminates a significant amount of biodegradable organic waste, heavy metals, phosphorus, nitrogen, and harmful microorganisms as explained by (Gedda Gangaraju, Kolli Balakrishn, Randhi Uma & Kinjal J Shah, 2021). Filtration, reverse osmosis, disinfection, and maturation ponds may also be included in these treatment processes.

The residues formed during the WW process are referred to as sludge. The amount of sludge generated is directly proportional to the amount of wastewater treated (Gedda *et al.*, 2021). According to Davies (2010), this sludge must still be treated before it is disposed of or used to ensure that the environment is not polluted, as the amount of sludge generated during primary treatment ranges from 0.25% to 0.355 by volume of wastewater and increases to 1.5% to 2.0% after the activated sludge process. According to Garner, Davis, Milligan, Blair, Keenum, Maile-Moskowitz, and Pruden (2021), the general goals of sludge treatment are stabilisation for controlled degradation of organic constituents and odour removal, volume and weight reduction, elimination of pathogenic organisms, and improvement of sewage sludge characteristics for further use or disposal. Additionally, the fundamental sludge treatment process is classified as a preliminary treatment, which is the initial step of

the process, thickening, stabilisation, conditioning, dewatering, and reduction (Garner *et al.*, 2021).

The preliminary treatment step of sludge treatment comprises techniques such as screening, grinding, grit removal, blending, and storing, which are often performed to deliver a homogenous mixture to downstream operations and processes while safeguarding downstream equipment or facilities (Davies, 2010). Sludge thickening is performed immediately following preliminary treatment to enhance solids concentration by removing a portion of its liquid content, resulting in a reduction of sludge volume to be delivered to other facilities while enhancing their operating efficiency (Garner *et al.*, 2021). Stabilisation is the process of stabilising sludge to minimise infections, eliminate disagreeable odours, and reduce or eliminate decomposition, whereas conditioning is the physical and chemical treatment of sludge to enhance its dewatering properties (Koyuncuolu *et al.*, 2021).

The optimal sludge dewatering technique is determined by several parameters, including the qualities of the sludge to be dewatered (i.e., pre-thickened, primary sludge, or WAS), available space, and the required moisture content of the sludge cake. Chemical conditions, such as the inclusion of a polymer, can improve dewatering (Garg, 2009). The last step of the reduction comprises operations implemented to create the most stable form of residue and to minimise the amount of residue; these processes include composting or thermal reduction techniques such as incineration drying (Koyuncuolu *et al.*, 2021).

In an earlier study, several different types of models that may be used to describe the dynamic behaviour of wastewater treatment facilities are explored. Among these are visual, linguistic, mental, physical, mathematical, and fuzzy models (Andrews, 1993). Most dynamic models can only be solved by computer simulation. Recent improvements in the hardware and software of personal computers have produced low-cost, user-friendly systems that may be used by businesses of all sizes, as well as by independent professionals (Andrews, 1993). The performance of wastewater treatment facilities might be significantly enhanced by increased consideration of dynamic behaviour during both plant design and operation, according to a previous

study on dynamic models and control techniques by Andrews (1974). Using modern control systems for dynamic behaviour alteration and written operating instructions based on rapid response analysis to improve manual operation (Andy, 1974). In a recent study, conducted by Koyuncuolu and Erden (2021), demonstrates data collected from WWTP in Russia, Finland, and Canada demonstrated that preliminary and primary WWT eliminates 92-93% of waste when functioning correctly.

The overall WWT consists of all the processes outlined and requires strong process measurement. Process controllers supervise and regulate the WWT, but they must also have the experience and ICT skills to manage the process, therefore they must be trained in both theories ,practice and ICT. To ensure that wastewater is treated to the required standard, education and training for water processing professionals must be implemented, and TVET institutions are critical for providing youth and adults with the necessary skills and competencies to assist the economy in dealing with labour markets and rapid development (UNESCO, 2012). The wastewater facilities employ technical operational people who need be trained (UNESCO, 2012), and there is now a shortage of capacity and experienced specialists for effective water management in South Africa.

2.3.2 TVET and the Application of ICT in Practice

UNESCO (2020) defines TVET institutions as educational entities that focus on the attainment of practical expertise, attitudes, understanding, and knowledge to develop competent professionals for the workplace. Okeye (2015) stated that the TVET institution is aimed at the acquisition of practical and applied skills as well as scientific knowledge and that the TVET institution's main purpose is to become a self-employment instrument for individuals who have been developed through experiential learning that is perceived in real-life problem solutions. TVET is offered at different levels of educational systems, which include technical and further education institutions, like universities, public and private and non-government providers of education and training (Chappel, 2003).

Additionally, TVET emphasises competency-based learning programmes, which are primarily concerned with learners receiving theoretical and practical training in the workplace (Okeye, 2015). The competency-based programme is a type of training delivery that prepares learners for jobs or self-employment. The competency-based training strategy is designed to provide training and evaluation with the goal of reaching a specified objective and supporting individuals in acquiring certain skills and knowledge (Okeye, 2015). According to Thang and Park (2017), the Education 2023 Framework for Action, which outlines how to put the global commitment into action, recognises the enormous potential of ICT in TVET that promotes lifelong learning. Furthermore, TVET has emerged as a critical platform for ensuring students' lifelong learning and the use of ICT in vocational education plays an essential role in improving the outcomes of vocational students through practical learning (Ghavifekr *et al.*, 2021).

Olakulehin (2007) stated that ICT is a set of technologies employed in the collection, storage, editing, retrieval, and transport of information in various formats. The use of ICT has developed and transformed our society, fundamentally altering how people think, work, and live. According to Thang *et al.* (2017), when used in learning and teaching, ICT can increase flexibility in lifelong learning, improve learning engagement and social learning, provide authentic and simulated learning, and encourage reflective learning and knowledge generation. They also highlight the need of using ICT to strengthen education systems and aid in enhancing knowledge diffusion, broadening access to information, improving the quality and effectiveness of learning, and delivering additional services.

Gushu (2012), described practical training as an essential aspect of the early growth of one's professional career while pursuing a higher education certificate, and it provides the opportunity to acquire knowledge outside the academic field. In layman's words, practical training demonstrates an understanding of how to accomplish something or complete a task. The TVET sector is one of the most important sectors of higher education where ICT integration may improve productivity (Ghavifekr & Yulin, 2021). This is because practical and vocational education is an important pathway for higher education students' skill development. Mohamad *et al.* (2020) found that a technology-based teaching system can assist TVET teachers in

better implementing practical instruction and ICT does not only assist teaching in the TVET integration process, but it also improves teachers to increase their technological self-confidence and teaching quality. Simultaneously, Zulnaidi and Majid (2020), examined the Malaysian TVET curriculum and discovered that as technology advances, Malaysian vocational education would confront new problems.

Tawafak (2021), believed that the use of ICT in the process of teaching and learning can effectively improve the academic performance of college students. The rational use of technology can effectively stimulate the interest of college students in learning. At the same time Tawafak (2021), also found through research that ICT helps to stimulate middle school student's interest in learning English. The rational use of ICT can make college students' courses more flexible, and they can arrange their own practice more reasonably. According to Shaikh and Sharma (2021), whenever a country's overall ICT level rapidly develops, it is advantageous to the country's overall economic development. TVET programmes are essential for creating a skilled workforce, especially in industries that stimulate economic growth, as stated by (Okoth 2023). Furthermore, he pointed out that SA could promote TVET as a High-Value Industry (HWI) to alleviate the skills gap in sectors including manufacturing, construction, and technology.

According to Allais & Wedekind (2020), SA can make sure that graduates are well-prepared for the labour market by integrating TVET with HWI. This may lead to more employment possibilities, lower unemployment rates, and improved standards of life. HWI frequently relies on innovative developments and technology. to educate individuals about these technologies, promote innovation, and keep SA technologically competitive, TVET may play a critical role (Vale, Finestone, Magadla, and Strugnell 2022). People gradually incorporate ICT into different disciplines, such as industries, public and private sectors, economic development, and education, as ICT technology advances. Chinien (2003) emphasised the relevance of ICT in learning as well as its role as a driver of the new economy. Furthermore, country studies referenced by the International Labour Organisation (2001) revealed that the introduction of ICTs may contribute to both up-skilling and de-skilling of employees;

nevertheless, it was also noted that ICT can degrade skills competency to single-task machine-tending.

2.3.3 Affordances And Perceptions

Osmundsen, Meske, and Thapa (2002) described affordances as attainable possibilities in the context of (IT) objects and a goal-directed actor. They also suggest that affordances are not considered as characteristics of the artefact or the actor, but as possible actions that emerge in the actor-artefact relationship. Bernardi *et al.* (2019) and Faik *et al.* (2020) argue that affordances are impacted by perception and that these perceptions focus on actors working alone and interacting with artefacts to fulfil their goals. According to Bernhard, Recker and Burton-Jones (2013), affordance theorists frequently argue that users realise affordances through a two-stage process that begins with affordance perception, which characterises the time a user becomes aware of the presence of an action possibility based on the information available to them, the user sees an affordance. The second stage is affordance existence, which is an actor's ability to recognise the presence of an affordance. The third stage is actualisation, which refers to the steps individuals take to realise their action potential. (Strong, Volkoff, Johnson, Pelletier, Tulu, Bar-On, & Garber, 2014).

According to the affordance literature, whether affordances are actualised or not is determined by the actualisation efforts, or the degree of difficulty involved with actualising the affordances (Bernhard *et al.*, 2013). Strong *et al.* (2014) describe the major components as “individual abilities and preferences,” which all lead to distinct self-actualisation actions. Additionally, how users progress from perception to actualisation remains a mystery (Lehrig, Krancher & Dibbern, 2017). Moreover, Lehrig *et al.* (2017) said that they discovered three types of affordance perception processes in their data: 1) imitating, 2) investigating, and 3) transferring. These types of affordances are explained as follows: 1) imitating is defined as an affordance perception in which the user perceives the possibility of using the technology for a new purpose by learning about it as another person uses it; 2) investigating as a perception in which the user perceives the possibility of using the technology for a new purpose by interpreting the symbolic expressions of the technology, and 3) transferring as a

perception in which the user perceives the possibility of applying the user's existing way of using it (Lehrig *et al.*, 2017).

Affordance actualisation processes occur when users participate in a range of activities to actualise observed affordances. These processes are often split into two phases which consist of 1) configuration and 2) initial usage (Lehrig *et al.*, 2017). Delegated configurations configure the technology based on the user's requirements, guided configurations require a user to configure the technology under the step-by-step guidance of some other person, and autonomous configurations require a user to configure the technology without the step-by-step guidance of another person (Lehrig *et al.*, 2017). In this context of this research, the concept of affordance actualisation was implemented by recognising that users possess different degrees of familiarity and comfort with technology. It was acknowledged that some users may require adaptable configurations choices to accommodate a diverse range of participants. In this study, the individuals, including both experienced and those dealing with complex technologies, employed guided configurations. Moreover, training sessions included a systematic, step-by-step approach to configuring the simulation.

Démuth (2013) defines perception as a cognitive feature of human behaviour in which humans organise and interpret their sensory perceptions to offer meaning to their environment. He also argued that perception is our way of comprehending things and people. Different people with different perceptual abilities may attribute different interpretations to the same thing. Perception, according to Osgood (2017), is an active process in which we select, organise, and interpret information from both external and internal sources. According to Norman (1998) cited in Moll, Dlamini, Ndlovu, Drennan, Nkambule, and Phakathi, (2022), perception creates affordances, regardless of whether they are genuine qualities of the object, and the meaning or worth of a thing is determined by what it provides. Moreover, Bernardi (2020) defines perception as an occurring actor-artefact interaction that is dependent on the features or properties of the artefact as well as the abilities and aims of the actor. These artefacts contain some traits and attributes that provide the actor with information about the action options

that are available to them, enabling the actor to interpret and hence perceive the affordances.

According to Bernardi *et al.* (2019), perception is also a subject that is influenced by factors such as sociocultural and organisational circumstances. Lanamaki *et al.* (2016) argued that affordances are designed into artefacts and that affordance perception is based on conformity, implying that designers embed affordances in the artefact through intuitive design based on anticipated interpretation. This meant that the artefact's design should guarantee that affordances are highly noticeable to users. According to Rico and Xia (2018), the user's specific cultural background has the power to influence affordance perception, leading to a non-conformity grasp between affordances designed in the artefact and the perceived usage of the object. The range of opinions on the nature of affordances, as well as which elements impact affordance perception and how demonstrates the inconclusiveness of affordance theory's relational character.

According to Lu and Cheng (2013), humans' perception and action capacities are intended to examine the scope of the application of objects, which is especially significant in cross-cultural designs. Furthermore, they argued that individuals think differently in various locations or nations, and affordances may be clearly observable in some cultures, in which people will behave well on affordances, but not in others. Additionally, Lu *et al.* (2013) stated that the circumstance may hinder a person's ability to effectively interact with affordances and that it should be considered when establishing perceptions since it could influence the process of affordances perception and realisation. Van der steen (2019) also stated that what we view as affordances that are meaningful to ourselves may not be perceived as affordances by others. Before engaging with the simulator, facilitators (participants) in this study reported their perceptions about the affordances of the digital simulators.

2.3.4 Affordances Of Digital Simulators in WWTP Practical Training

Simulation, according to Sauv , Renaud, Kaufman, and Marquis (2007) is a simplified and exact representation of reality that allows users to make tough scenarios, explore

options and actions, experience the effects, and adjust their behaviour without danger of injury. According to Pellet (2015), a simulation is a dynamic depiction of a process, and a digital simulator, often known as a computer simulator, is a simulation implemented in a computer. Computer simulation is a unique type of simulation description and abstract simulation, consisting of a hardware material and procedural system made up of wires, plastics, electrical circuits, processors, microchips, and so on, and described as an information processing system, a sequenced programme execution, or running (Winsberg, 2015).

Although Gibson's focus is on understanding how humans make sense of our physical surroundings and see the situations in which we live as meaningful and manageable, his affordances theory has had a significant influence in other fields as well. The concept of affordance has played a significant role in studies of human-technology interaction. Sociologist Ian Hutchby makes an important contribution in this field by applying the concept to his examination of the cultural practices that arise as new technology enters our daily lives (Kelly, Hopwood, Rooney, and Boud 2016). Berthelsen and Tannert (2020) extend Gibson's concept of affordances to describe virtual mediated social affordances as possibilities to engage with people through virtual artefacts, which they define as a type of software perspective, all digital technologies provide users with certain virtual possibilities and interaction that cannot be reduced to the corresponding physical actions.

Kelly *et al.* (2016) mentioned that digital simulators are increasingly being utilised to bridge the gap between theory-practice and have been considered as effective for providing practical and experiential learning prior to practicum experiences (Fischetti *et al.*, 2021). Simulations are used to engage students in more practical instruction in both virtual and in-person settings (Bondie *et al.*, 2021). Simulation-based learning, according to Albaqawi, Dayrit, Gonzales, Algahtani, Alboliteeh, Albagawi, and Alshammari (2020) provides users with access to a technology that can be built to replicate real-life scenarios, allowing them to function in environments that closely match genuine settings. Albaqawi *et al.* (2020) also confirmed that a simulator can be used to simulate actual real-life event. Therefore, it is critical to comprehend

customers' attitudes regarding simulation-based learning experiences and their educational benefits (Dittrich, Aagaard, & Hjukse, 2022).

Dittrich *et al.* (2022) refer to educational affordances as correlations between educational intervention qualities and instrument properties that assist learning. As Norman (1999) pointed out, an artefact's affordances are described by what the user perceives. The simulation-based learning experience provides educational gain and can thus enrich and augment the practical experience by providing students with opportunities to apply theoretical knowledge prior to practice in classrooms (Dittrich *et al.*, 2022). Additionally, educational scholars believe that simulation technologies provide a secure environment for students to practise certain abilities and receive constructive feedback (Dawson & Lignugaris-Kraft, 2016; Dieker *et al.*, 2014; Judge *et al.*, 2013).

Digital artefacts, such as simulation technologies are created by humans for specific reasons inside a specific cultural-historical context (Aagaard & Lund, 2020,). Such goals might include "facilitating communication and intersubjective knowledge development" (Trausan-Matu & Slotta, 2021,). This raises our awareness of both learning processes mediated by simulation technology and learning processes assisted by social contact. Educational affordances are "relationships between the attributes of an educational intervention and the learner's traits" that facilitate learning (Kirschner *et al.*, 2004). Unlike in traditional classrooms, the opportunity to pause the simulation for assistance from educators and peers, as well as to repeat practice on specific abilities, welcomes additional educational possibilities.

Students can develop focused abilities in a lower-complexity context, aided by a learning community that provides constructive feedback (Grossman *et al.*, 2009a). These disclosed educational affordances are especially significant for online student teachers, who seldom exchange practice experiences with colleagues or teacher educators while they do fieldwork among numerous schools around the country. Simulation-based learning design resulted in social engagement, which students constantly valued. During educator-led debriefings, this included peer and expert comments, as well as debates and meta reflection during peer-led group discussions.

The induced social engagement was based on the situational experience of practising or observing peers. Moreover, learning settings that allow for social interaction may influence learning results (Kirschner & Erkens, 2013). We discovered that students explored practice difficulties collectively and related simulation experiences to past teaching experiences. It was also acknowledged that the simulation-based learning experience was significant to the learning outcomes, and meta-reflexion on issues from the simulated practise took place.

Dalinger *et al.* (2020) found that while most participants in their study regarded the simulation to be realistic, some were surprised by the spontaneous character of the simulated interactions and others found it difficult to ignore reality completely. The findings imply that real-time engagement, as provided by the interactor, helps to bring the experience to life through natural, believable replies (Dalinger *et al.*, 2020). Having the ability to practise numerous times in the classroom simulation would aid in both preparation and familiarity. This might also help to minimise the anxiety that comes with being observed by classmates, instructors, and researchers (Dalinger *et al.*, 2020). Lajane, Lamiri, Bouzoubaa, Abidi, and Khyati, Qaisar (2020) stated that students believe that the education offered by a digital virtual simulator is effective and that it increases their professional understanding.

Gebreheat *et al.* (2022) stated that digital simulation is an emerging innovation with the potential to address the limitations of traditional simulation by improving learners' engagement and allowing participants to adopt a flexible approach and revisit. With the ongoing advancement of computer power, simulation has evolved as an increasingly important tool in decision-making processes in engineering, science, and economics, among other fields (Resul, 2020). Furthermore, simulation is not a technology for replacing or enhancing real-world encounters with guided experiences, typically immersive in nature, that elicit or replace significant features of the actual world in a fully interactive form (Gaba, 2004). Simulations approaches differ, from industry to industry, some use the DVDs focusing on workplace interactions, from web-based programs to well-developed simulated environments (Patrick, Peach, Pocknee, Webb, Fletcher & Pretto, 2008).

Wood *et al.* (2020), also mentioned that the simulations are useful for many environments and are often advanced in disciplines where it is not desirable to practice in live contexts, while there are other works of literatures stating that the use of simulations in learning results in supportive student learning environments with greater control over a range of activities (Chernikova, Heitzmann, Stadler, Holzberger, Seidel, & Fischer, 2020). According to Wood *et al.* (2020), simulated environments can be conducted in a broad range of settings from complex purpose-built training facilities such as clinics, restaurants, or even online spaces that are built with the use of second life and virtual reality. Furthermore, simulations exist on a spectrum of complexity, making it challenging to determine the transition from simulation to reality, as when a purpose-built environment is established that operates in student simulation mode at times and as a conventional or ordinary workplace at others (Wood *et al.*, 2020).

According to Singureanu and Woinaroschy (2019), in recent years, technologies utilised for WWT have significantly developed and introduced the use of simulation and modelling technologies, resulting in new ways of managing WWTP. According to Ngila *et al.* (2020), it is critical to identify the simulations to be used in WWTP by first identifying the problem, and the stakeholders, identifying key performance indicators of the chosen options, and modelling the obtained solution to obtain impartial results. This is accomplished by modelling the WWTP using the digital simulator. According to Langergraber, Rieger, Winkler, Alex, Wiese, Owerdieck, and Maurer (2004), WWTP is a valuable instrument for increasing specific information on process and system behaviour for optimisation studies, training and education, and model-based process control. Furthermore, Langergraber *et al.* (2004) stated that dynamic modelling not only became an essential tool for the scientific community but also showed its utility in practical wastewater treatment practice. In South Africa, WWTP modelling, or simulation software is classified into two types; namely, 1) dynamic and 2) static models (Ngila *et al.*, 2020). Dynamic simulation is a numerical simulator that investigates the behaviour of a system without doing or performing a limited number of experiments, and they consider time as a variable, whereas the static model is a physical model (Dipl-Ing.M & Schon, 2009).

According to Kincaid, Hamilton, Tarr and Sangani (2003), simulations have historically been a significant element of training in specific disciplines. However, as the cost of computers decreases, simulations are making their way into training for additional fields. Furthermore, Kincaid *et al.* (2003) stated that the world is progressively shifting away from traditional training methods and towards virtual training systems. Modelling and simulations are new concepts in the training and development space and developing technological skills in the TVET area is now a must. However, even as the cost of computers drops and they become a viable medium, economics alone do not completely account for the increased inclusion of modelling and simulations in education and training.

Mathematical modelling and simulation are becoming critical for describing, forecasting, and controlling the complex interactions of wastewater treatment processes (Jeppsson, 1996). The models are idealised representations of an actual physical wastewater treatment system (Ngila *et al.*, 2020). Mhlanga, Foxon, Fennemore, Mzulwini, and Buckley (2009) stated in South Africa that the WEST simulator model was designed for a WWTP and calibrated against plant operation, and it was used as a tool for evaluation. The WEST model used can represent the performance of the WWTP, while treating the combined influent received from the influent. Mhlanga *et al.* (2009) also noted that the modelling of wastewater treatment systems has progressed from fundamental notions to mathematical models.

The effectiveness of knowledge acquisition remains a persistent concern, whether in online or face-to-face practical training. Therefore, it is crucial to incorporate Kolb's ELT into the training process (Korucu-Kış, 2021). As stated earlier in the chapter, ELT highlights the significance of acquiring knowledge through firsthand experiences and active involvement. The integration of this theory into the study has contributed to rendering training more interactive and participative, resulting in a more profound comprehension of the subject matter and better knowledge retention. Furthermore, the theory acknowledges that people have different learning styles which include RO, AC, CE, and AE. These identified phases within the theory are acknowledged for their capacity to enhance the effectiveness of training for a wider range of participants.

2.4 Conclusion

Theoretical framework includes two theories: namely, the ELT and the affordances framework theory (AFT). The ELT and AFT, respectively give guidelines to evaluate the learning cycle and the affordances from the cognitive process until the affordance effect. The conceptual framework explains the unit processes and operations of a wastewater treatment facility, which is the basis of the WEST simulator. The TVET and ICT concepts refer to the learning environment and the required practices considered to be implemented. Affordances refer to achievable opportunities in the context of information technology (IT). The concept of perception explains the way participants interpreted their experiences and perceptual abilities towards the same thing.

3 CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This Chapter outlines the research design and the research design and methodology, including research approaches, sampling, data collection, and analysis. The chosen approach is qualitative, aimed at exploring- people's beliefs, experiences , attitudes , behaviour, and observations. This aligns with the interpretivist philosophy, using interviews and observations as data collection instruments.

3.2 Research Approach

The focus of this study was to investigate the affordances of using digital simulations in training practical aspects of Wastewater treatment processes. Williams (2007) identifies three types of research methodologies: quantitative, qualitative, and mixed methods. According to Creswell (2002), as cited in Williams (2007), the quantitative research method entails gathering, analysing, interpreting, and reporting the findings of a study, whereas the qualitative research method entails grouping, analysing, and reporting information in a way that is unique from the conventional approaches of quantitative methods. The reason for adopting this qualitative approach was its ability to be flexible to follow unexpected ideas during the research (Shank,2002). Furthermore, its ability to take place in realistic settings, as well as the fact that it may be utilised to answer questions regarding experience from the participant's perspective and to further comprehend people's perspectives, experiences, attitudes, behaviour, and interactions, the qualitative method is being used (Pathak *et al.*, 2013). According to Kumar (2011), a study design is a methodological approach that the researcher uses to respond to research questions with validity, objectivity, accuracy, and efficiency (Du Plooy-Cilliers *et al.*, 2017).

As a result, the research design may be characterised as a thorough strategy that includes the whole research effort. Researchers must observe essential study design concepts such as linking research questions to procedure methods, considering data collection and analysis concerns, and being explicit about the research's goals

(Haradhan, 2018). According to Leedy and Ormrod (2001), as quoted in Williams (2007), there are various approaches for performing qualitative research, including the following: A case study, an ethnographic study, a grounded theory study, a phenomenology study, and a content analysis study are all examples of research designs. The basic comparative study design allows the researcher to assess the relationships between independent factors and their impact on dependent variables (Williams, 2007). This study explored the affordances of digital simulations through interviews and observations, and interpreted, and analysed data in a deliberate manner (Williams, 2007). The latter research design methods are qualitative research qualifications (humanistic or idealistic approach); so, this investigation employed a qualitative approach (Du Plooy Cilliers *et al.*, 2017).

3.3 Research Paradigm

The study used the Interpretivism Paradigm to recognise the subjective view of the world of the facilitators being monitored (Guba & Lincoln, 1989). Additionally, the Interpretivism Paradigm emphasises understanding the individual and their perception of the world around them, and it recognises that interaction between the researcher and his or her study participants is unavoidable. The Interpretivism Paradigm was used in the study because it was considered that knowledge is created by the results and that contextual elements must be considered in the pursuit of understanding. In this study, the researcher embraces the interpretivist paradigm by recognising that the participants have their own unique perspectives and interpretations of how the digital simulations affect the training of WWTP and aimed to understand and interpret these subjective viewpoints.

3.4 Target Population and Sample size

In qualitative research, selecting an adequate sample size is a source of conceptual disagreement and practical ambiguity. As a result, sample size rules, standards, and instruments have been developed to enable researchers to set and justify the acceptability of, their sample size. This is an indication that the topic is an important indicator of the quality of qualitative research (Vasileiou *et al.*, 2018). In qualitative

research, selecting an adequate sample size is a source of conceptual controversy and practical uncertainty. As a result, sample size rules, standards, and instruments have been developed to enable researchers to set and justify the acceptability of, their sample size. This is an indication that the topic is an important indicator of the quality of qualitative research (Vasileiou *et al.*, 2018). The study included a total of four participants, all of whom were facilitators in the field of WWT. This sample was considered representative of the facilitators involved in the study, as indicated in Figure 5 and detailed in Table 1 below.. This sample size was adequate to respond to the research objectives formulated for this study, which provided comprehensive and in-depth knowledge of the affordances of digital simulations when training WWTP (Figure 1).

Table 1: Demographics of target population

Criteria	Participant 1	Participant 2	Participant 3	Participant 4
Company	A	B	A	B
Area of specialisation	WW&W	WW&W	WW&W	WW&W
Years of experience	12	12	12	8
WEST simulator experience	1	2	1	2
Qualifications	NQF 8	NQF 8	NQF 8	NQF 10
NQF Level facilitating	NQF 3	NQF 2	NQF 4	NQF 4 & 5
All companies are in the water and sanitation sector.				

3.5 Purposive sampling

The non-probability sampling method was chosen for this research because it may be employed when a study's findings do not need to be generalised to a wider population, such as in exploratory and qualitative investigations (Du Plooy Cilliers *et al.*, 2017).

The study employed pseudonyms as a measure to safeguard the anonymity and privacy of the participants, thereby upholding the credibility and transparency of the research. Pseudonyms were thoughtfully selected to carry no resemblance to the participants actual names while remaining memorable and pertinent to their roles in

the study. Consistency in the use of these pseudonyms was maintained throughout the research, in strict adherence to ethical guidelines and regulations governing the field of study. Purposive sampling was used for this study because it allowed the selection of participants and institutions who would offer the data needed to properly answer the research objectives. Purposive sampling, according to Etikan (2016), entails the researcher having a clear notion of which individuals would be employed rather than relying on relevant volunteers to come forward. This approach has the advantage of ensuring that each component of the sample that assisted the researcher in answering research questions since each component be a good match with the demographic characteristics of the study. If an element is inappropriate, it can be ignored (Du Plooy-Cilliers *et al.*, 2017).

3.6 Data Collection

Qualitative researchers refer to a “whole-world experience” and are concerned with the spectrum of human experience, which includes all the personal and subjective individualities connected with experiences. As a qualitative researcher, it is critical to remember that the goal is to investigate, comprehend, and describe rather than to explain, measure, predict, or quantify as quantitative researchers do (Du Plooy-Cilliers *et al.*, 2017).

Interviews – This method allowed the researcher to ask participants questions to learn about their perspectives, ideas, and beliefs about a given phenomenon. The method was a structured dialogue with the primary goal of gathering information, based on open-ended inquiries (Du Plooy Cilliers *et al.*, 2017). Face-to-face conversations are the most prevalent, however, telephone interviews are increasingly being used to remove geographical barriers between participants and investigators (Barrett, 2018). A semi-structured interview is a common approach in qualitative research in which the investigator freely questions key components of the phenomena under investigation. As a result, an efficient semi-structured interview ensures that data is captured in critical areas while allowing participants to add their own personalities and opinion to the dialogue (Barrett, 2018). The researched tool in Addendum A consists of two parts that were used for the Observations as well as for the In-depth interviews. The

interviews were arranged using the Teams Application, and each interview was scheduled to last a maximum of one hour. Furthermore, during these interviews, participants were asked to respond to research question number 1, which aimed to understand how facilitators perceive the affordances of digital simulators, particularly within the context of WWPC training using the WEST platform.

Observations – The use of observations in this study was prompted by their capacity to provide direct access to the studied phenomenon as well as their flexibility in the application by allowing the researcher to watch what happens in a natural situation (Gill, Stewart, Treasure & Chadwick, 2008). The researcher compiled an observations checklist to observe each participant as they actualise the affordances by creating a learning environment. The researcher made notes of actions demonstrated by participants. Observations were used to assess and confirm the application of Kolb's ELT. The observations were conducted in accordance with two research objectives. The first objective aimed to identify the characteristics of digital simulations that can represent the features of WWT, while the second objective aimed to assess how digital simulations can enhance the practical training of WWTP operations.

3.7 Data Analysis

According to Flick (2014), data analysis is essential in qualitative research since it has an influence on the results of each research. The study used a technique that describes data analysis's three components as "data reduction," "data presentation," and "drawing and confirming findings" (Punch, 2013).

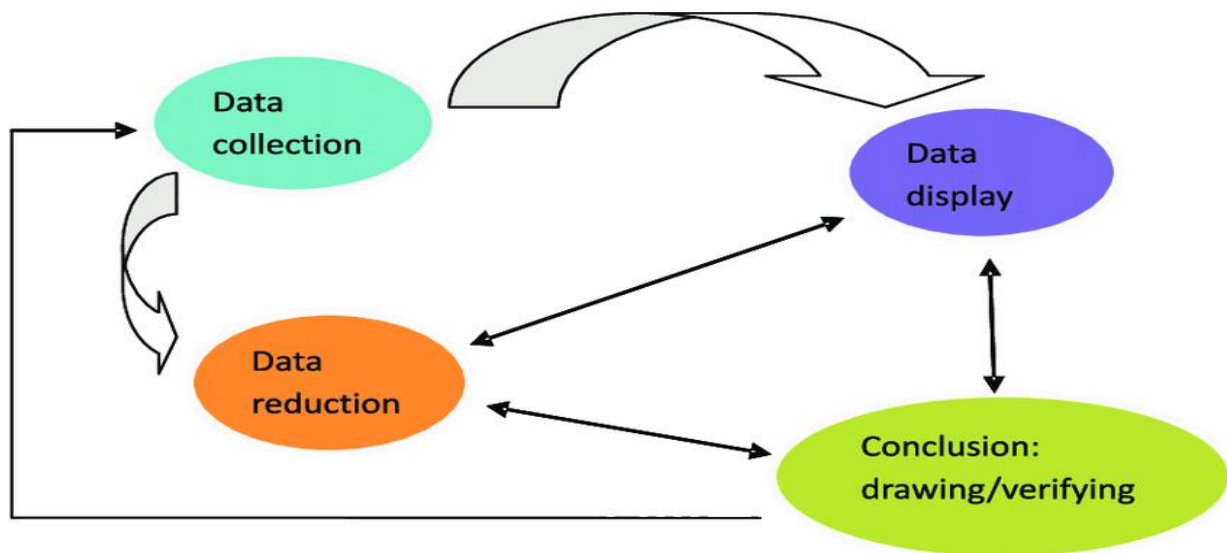


Figure 4: *Data Analysis Interactive method*

Source: Miles and Huberman, in Punch (2009).

Data collection – Through the purposive sampling technique, a selected number of participants were interviewed using structured interview questions. Observations were conducted using pre-determined questions. Data display – Data sets collected from participants are presented in figures (demographics), tables and coding grouping. Data reduction was conducted through thematic grouping and analysis. Conclusion drawing or verifying was conducted from thematic discussions and findings and interpretation of data. Raw data from interviews and observations were gathered, and common trends were found and used as themes. After reduction, the data was presented in tables and graphs to provide a more realistic picture of the research. In this study, graphs were employed with the aim of recognising patterns and succinctly summarizing the results to convey essential insights. The results were drawn from recognised patterns, and links in the data that may support or produce a new idea (Bogdan, & Biklen, 2003). The researcher used the process demonstrated above by collecting data, analysing the data, reducing the data through thematic analysis, and drawing conclusions and findings to answer the research questions.

3.8 Trustworthiness

Daniel (2019) developed an equal set of criteria for qualitative research trustworthiness, which are credibility, transferability, dependability, and confirmability.

The study was carried out with thorough record-keeping, demonstrating a clear decision, and ensuring that data interpretations are consistent and transparent. Additionally, it is suggested that while qualitative research techniques vary, no commonly accepted criteria exist to determine validity in qualitative research investigations. In this study data, was recorded and kept in both Microsoft Excel and Word documents. Data interpretations were conducted consistently and transparently in an Excel spreadsheet. To ensure transparency, all responses were interpreted using the same criteria such as coding and themes.

Credibility and Transferability – the researcher's correctness or precision in interpreting data gathered from participants. When adequate time is spent studying the perspectives of participants, as well as when more than one research method is used, for example, when in-depth interviews are paired with focus groups, credibility is strengthened (Lincoln & Guba, 1985 cited in Du Plooy Cilliers *et al.*, 2017). Transferability deals with the ability to use findings in a similar situation to create similar findings or results. This is the stage at which analysis and outcomes may be employed outside of the individual research endeavour, allowing for technique generalisation and the generation of generalised findings (Lincoln & Guba, 1985 cited in Du Plooy Cilliers *et al.*, 2017). To ensure credibility, the researcher interpreted the data of all participants with precision and correctness. This means that the responses used in this study, are the actual responses of participants. To ensure transferability, the researcher facilitated the identification of corresponding outcomes within the data by offering a comprehensive depiction of the research context. This entailed encompassing details about the study's environment, participants, and any distinctive features, thus enabling readers to comprehend the circumstances in which the research took place.

Dependability and Confirmability – refer to the quality of an integrated method that was used for data collection, data analysis, and data-generated theory (Lincoln & Guba, 1985 cited in Du Plooy Cilliers *et al.*, 2017). Confirmability deals with how well-gathered facts support the researcher's results/interpretation, as well as how well efficient findings resonate with data. As a result, it is critical that the researcher provides a detailed description of the procedure so that others may study the research

and/or reach comparable findings when analysing the data (Lincoln & Guba, 1985 cited in Du Plooy Cilliers *et al.*, 2017). The researcher focused on dependability by means of integrating theories and data as well as applying the concepts when discussing the data. The researcher used research findings and discussions from similar studies to support the results and findings of the study. These gathered facts to support findings from the study were selected from recent studies (mostly sources from the last 5 years).

3.9 Ethical Considerations

Ethics are crucial in research because they safeguard not just the researcher's personal reputation and credibility, but also all other stakeholders in the study process (Du Plooy-Cilliers *et al.*, 2017). To ensure all aspects are addressed, the following ethical considerations were followed: (create a personal ethical code of conduct as a researcher); being honest in reporting data, findings, techniques and processes, and publication status. No data was falsified or misrepresented; objectivity – try to be objective in experimental design, data analysis, data interpretation, peer review, personnel choices, grant writing, expert testimony, and other aspects of research. Integrity entails fulfilling promises, acting truthfully, and aiming for consistency of thinking and conduct. Transparency share data, outcomes, ideas, tools, and resources. Be open to new ideas and constructive criticism. Bear in mind the possible harm that unethical behaviour by a researcher might do to the rest of the research community (Du Plooy Cilliers *et al.*, 2017).

The University of the Witwatersrand's ethical clearance forms and templates were completed and submitted. Participants were made aware that they are participating in a research project and were informed of what was expected of them as well as how the data was going to be used. Participants in research have the following rights: 1) privacy; 2) anonymity and confidentiality; 3) consent and the ability to withdraw; 4) informed consent; and 5) not to be damaged. The researcher guaranteed overall integrity by not being selective in reporting and by being objective in data analysis and interpretation. Furthermore, the researcher also kept in mind various limitations that may occur due to the nature of this study; however, alternative

mitigations were considered: 1) availability of senior officials to conduct in-depth interviews during the research period and therefore considers alternative approaches for interviews were discussed in the method section; some data and information might be protected.

In the study the importance of data storage practices to ensure the reliability of and longevity of the research data. To address this, the study employed a multifaceted data storage approach. First, all raw data, including interview transcripts and observation notes were securely stored in password-protected digital folders on a dedicated research server. Furthermore, to facilitate easy retrieval and organisation of the data, the researcher maintained a detailed data inventory which documented the type of data, its location, access permissions ,and any relevant data. The researcher designed tools for collecting the required data information to achieve all objectives. Processes to obtain permission were followed to use the contact details of prospective students according to the Promotion of Personal Information Act (POPI Act 2 of 2000).

3.10 Limitations of the study

The researcher would have liked to interview 8 facilitators; however, this was not possible because of the facilitators' unavailability in the Wastewater field who have experience with digital simulators. The study was meant to record observations during the actualisation of affordances; however, this was not possible due to the limitations imposed by the simulator's intellectual property rights.

3.11 Concluding remarks

A qualitative research approach was followed using interviews and observations data collection instruments. To interpret in-depth interviews, the interpretivist paradigm is described for this study, since it focuses on perceptions and viewpoints. This study required participants with specific competencies, backgrounds, and qualifications; therefore, the purposive sampling technique was applied. To ensure the trustworthiness of this study, good record keeping, demonstration of clear

decision-making, and transparent data interpretations was applied. Various ethical practices were considered in this study to protect participants (e.g., personal information, identity, and their willingness to participate in this study). All demographic information associated with participants was kept anonymous (e.g., companies A and B). In the forthcoming chapter, the study will explore the presentation of data, providing a detailed examination of outcomes derived from the interviews and observations conducted.

4 CHAPTER 4: DATA PRESENTATION

4.1 Introduction

This chapter presents the data obtained from participant interviews and observations. This section presented data on how facilitators perceive the affordances of simulations; what affordances digital simulations bring to WWT Process practical online training and assess the development of knowledge construction by using Kolb's ELT. **Section A** provides the participant demographics such as company, area of specialisation, years of wastewater treatment experience, WEST simulator experience, qualifications, and the Water and Wastewater NQF level they facilitate at their respective companies. **Section B** presents data for affordance existence, affordance perception, affordance actualisation and effects.

4.2 Section A: Demographics

The participants were from the Gauteng province-based companies A and B. The selection of participants from these companies was made possible by their extensive expertise in training Process Controllers in the wastewater treatment process and their use of the WEST simulator in the day-to-day operation of the process. Due to a scarcity of facilitators who are familiar with how the WEST simulator operates, participants were chosen from two distinct companies. In the following table, information about the number of individuals linked to companies A and B, the specific fields of expertise among participants, their years of experience in WWT, experience with the WEST simulator, their NQF facilitation levels, as well as the qualifications held by the participants.

Using the selected group of participants (or a purposeful selection approach) added significant value to this study in terms of gaining different perspectives, various experiences, and a wide range of in-depth knowledge about wastewater treatment practices, as well as different approaches towards the application of the WEST simulator. In addition to adopting the criterion of sampling that was acceptable for the

research, the study used identification and selection of participants who can supply information related to the study. Table 2 below shows the demographic data for companies of participants, area of specialisation, years of experience, WEST simulator experience, and qualifications.

Table 2: *Demographic data of participants*

Facilitator Names	Area of specialism	Company	Years of training experience	Experience with WEST digital simulator	NQF Level facilitating	Qualification
Participant 1	Water and Wastewater Treatment process and Facilitation.	A	12	2	NQF Level 3	Honours Degree in Water Care
Participant 2	Water and Wastewater Treatment process and Facilitation.	A	12	2	NQF Level 2	Honours Degree in Water Care
Participant 3	Water and Wastewater Treatment process and Facilitation.	B	12	1	NQF Level 4	Honours Degree in Water Care
Participant 4	Water and wastewater Treatment process Research	B	8	4	NQF Level 4 & 5	PhD in Water studies

When participants were selected for this study, it was crucial that they had the proper experience in both wastewater treatment process, facilitation, and experience with the WEST simulations (refer to figure 1 in the previous chapter). The participants are full-time employed at two companies (A and B) within the water and wastewater sector. These companies have recently incorporated simulation technologies as part of their training practices.. The areas of specialisation are closely related to the fields of water and wastewater. Most participants specialised in treatment processes and facilitation, while one participant specialises in research. All participants are highly skilled professionals in their respective areas of specialisation.

The recorded years of experience were 12 years for the three participants and 8 years for the one participant. This range of experience, spanning from 8 to 12 years,

suggests that the participants possess a substantial level of expertise and competence, especially in the context of process optimisation. Participants' years of experience in using the WEST simulator are relatively lesser when compared to their overall experiences in wastewater treatment as illustrated in the previous diagram. The WEST simulator experience varied between 1 to 2 years. All participants have qualifications at a postgraduate level, with 3 Honours Degrees in Water Care and 1 PhD in Water Studies. These qualifications show that participants have advanced knowledge in the fields of water and wastewater. Furthermore, the participant facilitates several NQF levels ranging from Level 2 to Level 5.

4.3 Section B: Data Presentation

The data was reviewed using both the affordances theory and Kolb's ETL, which assisted in understanding the relationship between technology and the human actor. The cognitive process of affordance existence is the initial stage in the theoretical framework of affordances. It demonstrates the existence of affordances because of the interaction between the IT artefacts and the goal-oriented actor. The second stage is recognition, which requires the goal-oriented actor to perceive or recognise the IT affordances. The third stage observes the activities presented while using the WEST simulator affordances to create a practical learning experience. The researcher employed ETL lenses to determine whether the required practical learning environment could be realised. While creating activities, the ELT elements focused on the participant's ability to use concrete experience (CE), reflexive observations (RO), abstract conceptualisation (AC), and active experimentation (AE). The purpose of this analysis was to highlight significant themes related to the interaction between technology and the learning process, specifically within the framework of the WEST simulator. These themes, namely affordance perception, affordance existence, and affordance actualization, were grouped to address the research questions effectively.

4.4 Affordance Perception

Affordance perception is influenced by the properties of IT artefacts that stem from the designers' objectives and capabilities. To ascertain the participants' perceptions regarding the capabilities and possibilities linked to the WEST simulator, particularly concerning its applications in learning or practical contexts, the following question was posed to the participants: "What did you anticipate the WEST simulator would enable you to accomplish?". The participants' initial perceptions were positive, while impressions were relatively similar because 100% of them were able to identify possible affordances of the simulator. These affordances may benefit them in them in operating WWTP. Participants replied 1, 2 3, and 4 as follows,

Participant 1 ; *The simulator has the potential to assist with optimising of the plant.*

Participant 2 ; *The simulator may enable me to run a WWTP based on the information input.*

Participant 3 ; *I think I can be able to see the whole plant on the system.*

Participant 4 ; *The simulator may assist us with plant monitoring.*

As stated by Participant 1, the perceived affordance of plant optimisation implies that the simulator can improve the final water quality for the WWTP and ensure continued performance. Furthermore, if the WWTP is optimised, the process controllers followed the appropriate operational practises and to monitor the overall process which was mentioned by Participant 4. Plant monitoring and operation is an essential task in WWTP because it allows the process controller to use tools and techniques developed to monitor the operation of the WWTP. Participant 2, on the other hand, mentioned that the simulator may enable them to perform a WWTW based on the information provided, which means that the simulator may allow data collected, such as plant sizes, to be captured in the simulator and replicate the real process. Participant 3 perceived affordance was aligned with Gibson's (1994) concept of affordance, which states that digital technologies offer students virtual affordance and interactions that are like physical actions of the WWTP. The process overview acted as a visual aid which enabled the students to view an entire WWTP in the simulator.

Furthermore, the simulator affordance was perceived as providing participants the possibility of enhancing their classroom education. For instance, Participant 2 stated,

I believe digital simulators may assist us with enhancing classroom instructions and access to the process overview.

Simulators can replicate the actual events, problems, processes, or skills required to achieve a specific instruction goal. This means that classroom instruction has the chance to improve as the simulator may place students in situations where they can actively solve WWTP challenges and gain skills. When asked the question ,” In what way did the utilisation of the simulator contribute to understanding of the process?’

Participants did not only identify the possible educational affordance, but they also identified possible safety affordance that can be brought by the WEST simulator, Participant 2 mentioned that,

To improve learner safety, a thorough and successful practical training programme is essential, and it is my belief that the simulator can provide both for our students. The simulator could be the answer to our dilemma; I find it fantastic that our students can now finish their practicals without us having to worry about their safety.

Participant 2 mentioned that using the simulator provided students with practical training that can improve overall safety. Given that it is hosted on a computer rather than an actual WWTP, the simulator offers a risk-free training environment which is seen as an affordance by the participant.

It is evident that affordance perceptions are dependent on an individual’s capacity to act on them since an individual must first perceive the affordance based on the intentions before interacting with the artefact. Because of these abilities, participants have confidence in the WEST simulator. The approach of affordances is flexible, displaying the range of possibilities as perceived by participants.

4.5 Affordance Existence

The second stage of the affordance theory is the determination of affordance existence which is a cognitive process where the participants recognised the existence of affordances in the WEST simulator. All participants believed that the affordances offered by WEST simulator are practical and considered to be advantageous. The following aspects were identified: modelling, process design, and problem solving. These aspects were identified through analysis of the interactions between participants and the simulator. This analysis aimed to reveal how the simulator created possibilities for action and engagement. The researcher closely examined how participants perceived and utilised the simulator's functionalities. The participants were asked the question "What did the WEST simulator enabled you to do when interacting with it?" And what did you do with the simulator? The responses from participants 1, 2 & 3 were,

Participant 1 ; *It can be used for modelling and designing where you look at what to expect and solving complex problems within the process.*

Participant 2 ; *It caters different mathematical models which model the process, i.e., the activated sludge and the biofilter.*

Participant 3 ; *I like that I could Manipulate the results and predict the performance of the plant by creating scenarios.*

The recognised affordance of modelling and plant design mentioned by Participant 1 means that the simulator affords more possibilities for improving the process and aiding the process controller in better understanding the WWTP. Modelling is an essential component in designing a WWT system because it enables the process controller to simplify a complicated system to a comprehensive explanation of how it operates, which then influences the design approach. It is advised that WWTP utilise modelling tools to summarise and improve knowledge of complex systems, as well as to forecast the response to process disturbance. Participant 2 recognised the

simulator's mathematical modelling affordance, which is its ability to predict how the WWTP would perform under various operating situations. Determinist data is added to the simulator programme to transform inputs into outputs, which means that possible predictions are introduced to the software to predict the plant's possible performance as mentioned by participant 3. When queried about the advantages of utilising the WEST simulator, the participants conveyed positive feedback. The three participants (1,2,&4) cited similar and pertinent affordances, indicating a consensus regarding the benefits of using the simulator as seen below.

Participant 1 ; The key benefit of the WEST simulator may be its capacity to let users create various scenarios while demonstrating the process and the impact they can have on it, allowing them to alter the outcomes and forecast the performance of the WWTP.

Participant 2 ; I believe that my team will be able to understand the decisions that were made and the effects of those actions. The daily operation of the process significantly improved as mistakes were made less frequently.

Participant 4 ; I liked the fact that I might be able to accomplish all these tasks without being inside the physical simulator, and I would even like to run a report on how the plant can perform.

Scenarios in WWTW training are commonly used to address student knowledge and skills gaps. This is accomplished by defining the specific outcomes that must be achieved. The scenario is then developed based on the specific outcomes, and the student is required to respond to the situation to demonstrate their skills and understanding of the concepts of the problem. Participant 1 recognised this affordance in the WEST simulator. While operating a WWTP, decisions are made to determine the optimum process performance and the correct approach to optimise the process. After interacting with the simulator, Participant 2 recognised this affordance of decision-making. Participant 4 also praised the simulator's potential to generate plant performance data. Record keeping on the day-to-day performance of the process is

important when operating a WWTP for tracking and assessing trends or plant disturbances so that the process controller may maximise plant performance.

The WEST simulator's designers intended for the participants to establish the existence of these affordances as well (DHI, 2020). When asked the question “ would you recommend the use of the WEST simulator in the real WWTP?”. The responses of participants show that the affordances of the simulator are essential for their training objectives. According to Kolb's theory, it is important to illustrate the process during practical training sessions, which makes it possible for learners to develop concrete experiences. Participants 3, and 4, respectively stated that simulators' capacity to recreate WWTP situations affordance can assist students with an understanding of WW concepts, they have said,

Participant 3 ; The simulator can strengthen students' understanding of the process and visualize what is happening in the real process.

Participant 4; Easier and more effective to explain the process prior to the real process and it makes it easier for the learners to understand the process.

WWTP is challenging to explain in a classroom setting since it requires learners to fully comprehend the concepts to understand what is going on in the process. For example, it is challenging to explain a concept such as primary tank by orally expressing it; therefore, visual representations are necessary for students to comprehend the concepts, as mentioned by Participants 3 and 4. The above-mentioned simulation affordance can be applied during practical training to enable learners with abstract conceptualisation, which is important for practical training because the learner needs to think about new ideas and be able to modify current ones, as well as visual representations can assist them. Furthermore, participants 1,2, and 3 acknowledged that one of the affordances of the WEST simulator was its ability to facilitates risk mitigation through prediction. They stated that prediction could be integrated into daily operations to decrease operational risk and human errors when discussing the advantages of using the simulator in practical training, Participants expressed:

Participant 1 ; *With the WEST simulator, one might be able to observe the entire process, add, or remove what you need, see how the plant can improve or not, and have a general notion of how your process will fare in real life.*

Participant 2 ; *The team and I think we can be able to integrate the scenarios we had prepared on the simulator into the process without compromising the process, which can help us predict the process and eliminate risks.*

Participant 3 ; *I was able to modify and enhance the conditions at the plant. I expanded my plant with process units and can already see the effects.*

WWP is a complex method that uses microbiological reactions to remove pollutants from wastewater. To achieve appropriate pollutant removal, the process controller must undertake several tests. The simulator's prediction functionality may enable the process controller to give valuable analysis, therefore eliminating the risks associated with poor plant management. Furthermore, because all trials and predictions may be conducted on a computer, plant operators may not need to physically enter the WWTP while utilising the simulator.

The participants recognised affordance according to the data presented above. Designing, modelling, problem-solving, plant monitoring, predictions and risk eliminations, and scenario creation were highlighted as examples that confirm the existence of affordances.

4.6 Affordances Actualisation (Observations of participants)

The WEST software offers different platforms for modelling and simulation of water quality systems such as WWTP, rivers, sewers and urban catchments and uses mathematical models as a reliable representation of real-world systems. However, for this research, the WEST player for WWTP was used. Prior to the observations, the participants were trained on how to operate the WEST digital simulator. Additionally, the participants were expected to log in to a digital simulation software to create a

practical learning experience while the researcher observed, which may be used to train process controllers. The session yielding the following observed actions, as documented in the table provided below:

Observations
1. Does the trainer interaction with the simulator show that they understand how it work? If so , how? If not, what could be the problem?
2. Do the basic specifications of west simulator as mentioned by the trainer exist? If so, what are those? If not, what are the specifications?
3. Application of the Kolb's experiential learning theory. a) concrete experience – I will observe if the learning experience has occurred after the training. b) Reflective observation – I will observe reflection on the experience. c) Abstract Conceptualism- I will be observing how they reason by looking at their interaction with the simulator.

The participants were trained on comparable activities related to the WWTP because of the training that took place prior to the research. The researcher noticed the design below as illustrated by Participant 1 (Figure 5).

Participant 1 designed the activity depicted below by integrating affordances such as modelling, design, plant monitoring, scenario creation, and problem-solving (Figure 5).

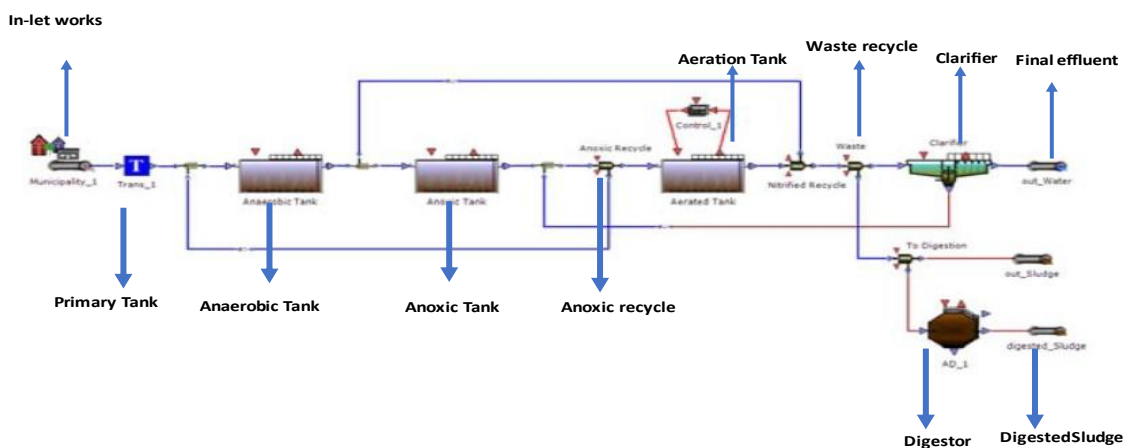


Figure 5: Process Overview: Created by the participants.

An illustration showing the processes of a typical WWTP, created by the participant.

The above figure was created by the participant using the University of Cape Town concept template, which was found in the WEST simulator's library of templates. The overall figure depicts the wastewater process from the municipality block to the Wastewater treatment facility inlet works, then from the WWTP to the PST where suspended solids and other nutrients such as Chemical oxygen demand are decreased. The biological process is introduced, which has three stages: anaerobic, anoxic, and aerobic. The transformer blocks are used to transport the returned sludge from the beginning of the anoxic tank to after it. The procedure also includes a clarifier and modifies the sludge extraction mechanism by discarding activated sludge after the aeration tank. Between the nitrified recycling and the clarifier, Participant 1 additionally included a waste block. This allowed them to install the sludge treatment line, which transports sludge through the waste block. The participant used all the affordances in developing this exercise, including modelling, pant design, scenario creation, problem-solving, and plant monitoring (Table 3).

PARTICIPANT 1: Observation Checklist

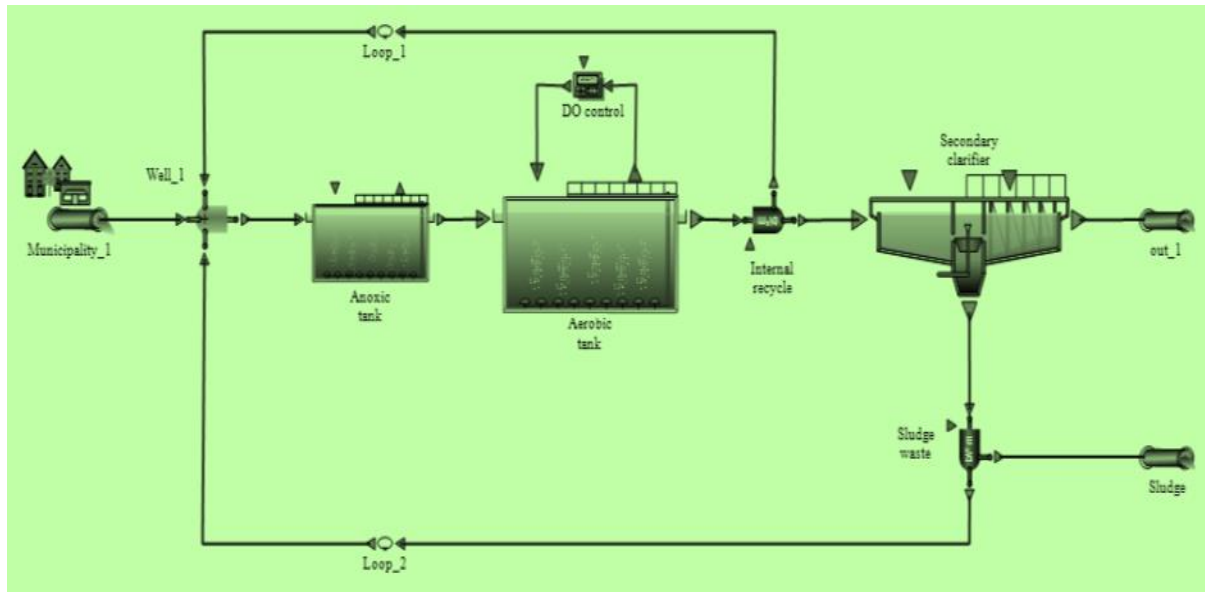
Table 3: Observation of Participant 1 actualisation of affordances.

Observation: Participant 1	Observations Remarks	Comments
1. Does the participant understand how the simulator work?	Yes,	The participant was able to navigate through the simulator to access the activities they wanted to design.
2. The facilitator's ability to interact with the simulator.	Yes,	The facilitator was able to develop the WWTP process. To meet the needs of the facilitator, the WWTP was modified during modelling and design.

3. Application of Kolb's ELT elements application such as ✓ Concrete Experience, ✓ Reflection observation, ✓ Abstract ✓ Conceptualization, and ✓ Active experimentation	Concrete experience The facilitator was able to use their experience gained to create new knowledge by designing a comprehensive process. Abstract conceptualisation. The participant was able to form new ideas such as adding another aeration tank to stabilize the process. Active experimentations. The participant was competent in creating scenarios and design WWTP that showed an overview of the process.	The participant started with CE, passed RO, and then proceeded to AC and AE. CE was accomplished by initiating interaction with the simulator, where adjustments were made to parameters such as flow rates, chemical dosages, and aeration processes. This allowed for an exploration of how these adjustments impact the WWTP. During the RO stage, the researcher observed the participant meticulously reviewing the data collected during their interactions with the simulator. They closely examined the outcomes of various actions taken within the simulator. Additionally, the participant seeks to validate the simulator's behaviour by comparing the results to establish WWTP and real-world processes. In the AC phase, the participant began constructing a theoretical framework to comprehend WWT. They posed questions aimed at establishing connections between their practical experience using the simulator and the broader conceptual aspects of WWT. AE was evident through the participant development of hands-on activities tailored for their students. These activities were designed to actively engage the RO is considered a critical step in experiential learning because it allows learners to reflect on their experiences and transform them. Yet, there are a variety of factors that might impact the decision to skip RO, such as personality type, adaptive abilities, education specialization, and the student's educational level.
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The ability of the participant to actualise the recognised affordances as evidenced by the above. The participant was able to show the application of the CE, AB, and AE of Kolb's ELT. The RO was not applied; according to the Kolb ETL, RO can only be attained when the learner reflects on their activity and discusses the experience with others, which was not demonstrated by the participant when designing the learning environment. Participant 2 designed the activity depicted below activity (Figure 6).

Figure 6: *Plant optimisation created by participants.*



Plant optimising by controlling Dissolved Oxygen and Activated sludge recycling
(Created by Participant 2)

The figure above displays the WWTP designed by participant No. 2 using the simulator. The participant selected the subsequent blocks from the block library and dropped them on the layout sheet, following a logical arrangement of the units such as municipal pipelines, anoxic tank, aerobic tank, clarifier, and affluent. This was done with the goal of connecting the networks in the final arrangement in figure 2 easier. The participant then resizes the blocks to approximate their relative importance in the pattern as well as their actual sizes in a real plant (Table 4). He then renames the blocks to more relevant names so that future learners may easily identify them. Furthermore, data was captured for the desired Dissolve oxygen (DO) that is required in the aerobic tank to imitate aeration, and a DO meter was also included to manage the DO levels in the tank (Table 4).

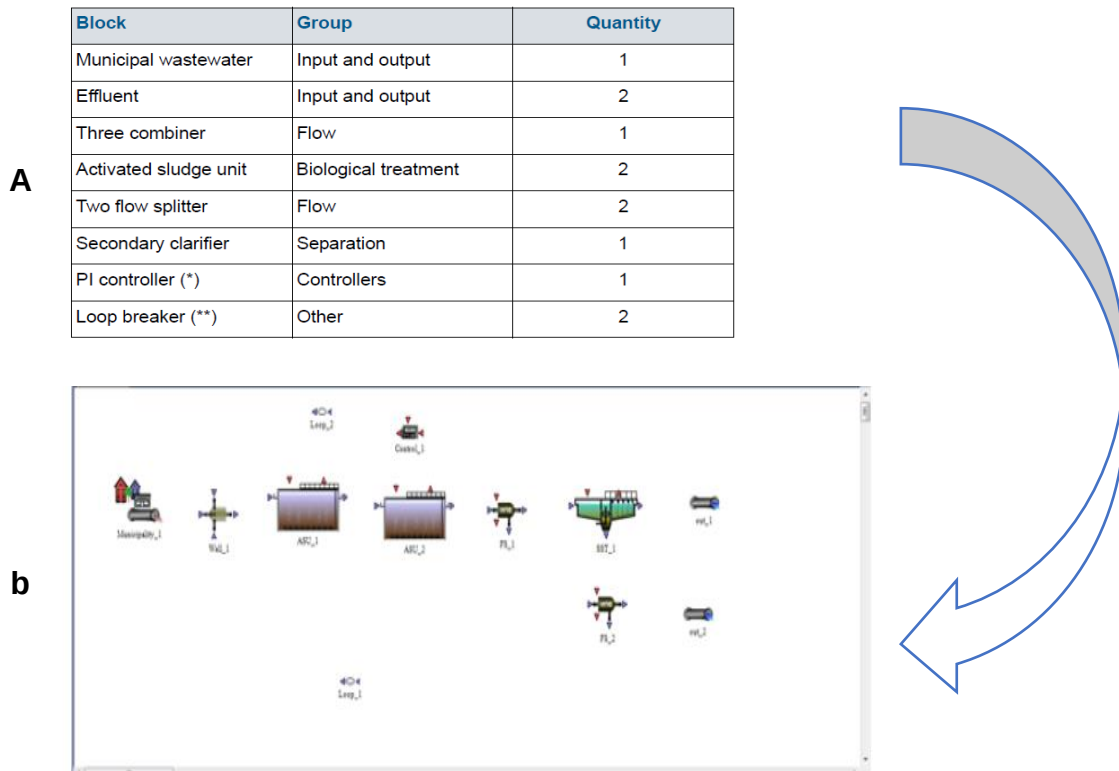
Table 4: Observation of Participant 2 actualisation of affordances.

Observation: Participant 2	Observations Remarks	Comments
If they understand how the simulator work.	Yes,	It was demonstrated by their ability to interact with the tools and access their different features.
The facilitator's ability to interact with the simulator.	Yes,	They were able to actualise the affordance they have identified.
Application of Kolb's ELT elements application such as ✓ Concrete Experience, ✓ Reflection observation, ✓ Abstract Conceptualization, and ✓ Active experimentation	Concrete experience- the facilitator was able to use their experience gained to create new knowledge by designing a comprehensive process. Reflection observation – the participant repeated the tasks a couple of times, as reflective observation and noted in the simulator “repetition is a form of reflection” and noted in the activity that a discussion session will be planned. Abstract Conceptualisation Evidently, the participant demonstrated an understanding of how the simulator operates. This was observed in the way they are interpreting the experience through problem-solving. Active experimentations. The participant could develop scenarios and construct WWTP that could be implemented to improve training. The process designed was a replica of an existing process	The activities designed by Participant 2 centred on “doing,” which is the first preparation and consultation, before moving on to review, which included creating notes in the learning environment that the learners will debrief/share feedback, which may be done between facilitator and peers. The participant proceeded on to the AC stage, where learning was complete and active experimentation allowed them to try out what they had learned.

The 52 opinions from Participant 2 above reveal that the person used all four aspects of Kolb's ELT. Throughout the actualisations, the RO was used by repeating the

assignment by making notes on the activity and emphasising the importance of group discussion. Participant 3 designed the activity depicted below activity (Figure 7).

Figure 7: Block units for the plant layout of the WWTP.



The two figures (a and b) above reflect the activity created by Participant 3. This figure depicts the data input captured when modelling a WWTP (Figure 7). As seen above, the block names, the group to which they belong, and the number of units necessary to set up a WWTP are all documented. They also incorporated the controllers needed to regulate the process as well as the loop breaker, which aids in process control and changes. The goal of the exercise was to teach students how to model and develop their own processes (Table 5).

Table 5: Observation of Participant 3 actualisation of affordances.

Observation: Participant 3	Observations Remarks	Comments
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If they understand how the simulator work.	Yes,	This was demonstrated by the ability to access the different features of the simulator.
The facilitator's ability to interact with the simulator.	Yes,	It was demonstrated by their ability to interact with the tools and access its different features and made captured the data accurately.
Verification of the affordances they recognised and perceived.	Affordance Actualised ✓ Modelling and designing of the process. ✓ Data capturing ✓ Reporting ✓ Troubleshooting ✓ Creating different scenarios ✓ Monitoring of the process ✓ Plant Overview ✓ Problem-solving	The affordances recognised and perceived exist.
Application of Kolb's ELT elements application such as: ✓ Concrete Experience, ✓ Reflection observation, ✓ Abstract Conceptualization, and ✓ Active experimentation	Abstract Conceptualisation Yes, the participant was able to demonstrate a comprehensive understanding of how the simulator works by classifying concepts and concluding on the activities performed. Concrete experience- the facilitator was able to use their experience gained to create new knowledge by designing a process that covered sludge management. Active Experimentations. The participant was in actualised all the affordances and created an overview of WWTP.	Participant 3 began with Abstract Conceptualisation. AC is essential for aiding learners in mastering the application of information and skills to satisfy performance expectations. He then went on to CE and AC. The ETL can be entered at any point throughout the cycle, but it must be completed (Kolb, 1984). In this case, participant did not complete the cycle as RO was not covered.

As seen above, the participant recognised and experienced affordances. The participant's ability to show the application of Kolb's ELT's CE, AB, and AE. The RO, like Participant 1, was not used during actualisation. The participant began the Kolb ETL cycle at AB and actualised all the recognised affordances. Participant 4 designed the activity depicted below activity.

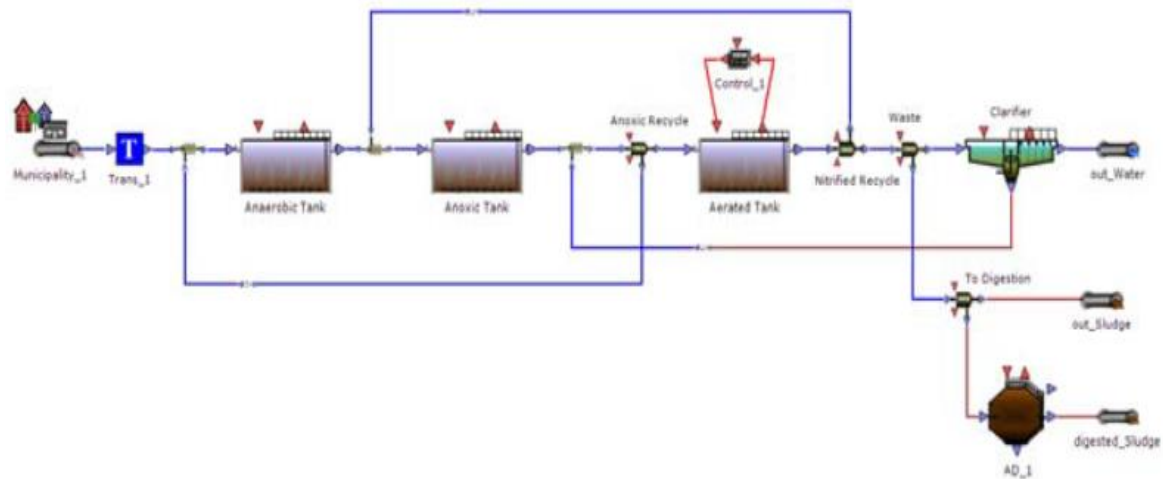


Figure 8: WWTP phosphates removal

The UCT three-phase plant-wide dynamic model, seen above, was created to optimise and enhance the current plant. The above-mentioned activated sludge process begins at the municipal works, where raw sewage is sent to the WWTW system, followed by anaerobic, aerobic, and anoxic-aerobic digestion of raw sewage sludge, which includes waste-activated sludge (Figure 8). The model above employs twenty particle components, the majority of which are precipitates generated during aerobic digestion. This model requires strict mass balance, which must be maintained over the transformation process being modelled (Table 6).

Table 6: Observation of Participant 4 actualisation of affordances

Observation: Participant 4	Observations Remarks	Comments
If they understand how the simulator work.	Yes,	This was demonstrated by the ability to access the different features of the simulator.
The facilitator's ability to interact with the simulator.	Yes,	It was demonstrated by their ability to interact with the tools and access its different features and made captured the data accurately.

Application of Kolb's ELT elements application such as ✓ Concrete Experience, ✓ Reflection observation, ✓ Abstract Conceptualization, and ✓ Active experimentation	Abstract Conceptualisation Yes, the participant was able to demonstrate a comprehensive understanding of how the simulator works by classifying concepts and concluding on the activities performed. Concrete experience- the facilitator was able to use their experience gained to create new knowledge by designing a process that covered sludge management. Active Experimentations. The participant demonstrated the AC by creating scenarios that are possible in the real-life WWTP and showing how they can be solved.	Like Participant 3, Participant 4 started with abstract conceptualisation. AC is essential for enabling students with understanding how to apply knowledge and skills to reach performance standards. This could be since they both assist Level 3 and Level 5 learners who are more advanced with their studies and experience.
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Because the participants were trained using the same tools and taught to conduct similar activities within the simulator, the data are comparable. Nonetheless, all participants began by creating and modelling the process since having a visual WWTP to work on is important. After designing, the participant completed different tasks in their own preferences but eventually, everyone actualised the same activities. As illustrated by the above, the participant was able to realise the experienced and recognised affordances. The participant's ability to demonstrate the application for Kolb's ELT's CE, AB, and AE was seen. However, not all the participants applied the RO elements. Based on the observations above, participants 1, 3, and 4 were not using the RO element. Kolb's (1984) learning cycle emphasises the need of reflection because it allows students to process what happened throughout the experience. Reflection is important because it allows learners to explain circumstances, such as what works and what does not.

Initially, Participant 1 *"thought that the simulator had the potential to help them with plant optimization"*. During observations, Participant 1 was able to monitor the plant and evaluate plant performance, which would aid them in optimising the process.

Participant 2 *“believed that the simulator would allow them to execute a WWTP based on the information supplied,”* and this perception was realised. This was proved by the participant’s ability to engage with the tools and access their many features, as well as accurately enter data to operate a WWTP simulation. Participants 3 and 4 *“perceived that the simulator may aid them in plant monitoring and plant overview of the WWTP”* as a potential of the simulator affordance. Both affordances were realised by the participants, and additional ideas, such as report preparation and plant prediction, were also generated.

4.7 Concluding remarks

In conclusion, data presentation has shed valuable light on the affordance of digital simulations. The findings from these chapter highlighted the transformative potential on incorporating digital simulations into learning process. The data has demonstrated the ability and affordances of WEST digital simulators.

5 CHAPTER 5: DATA ANALYSIS AND FINDINGS

5.1 Introduction

This chapter provides an analysis of data from which the findings of the research are drawn. The 4 participants' responses served as the basis for the interpretations. Three research sub-questions are presented together with one main research topic in the study. The participant responses assisted with addressing each sub-question and the main research question. The chapter is divided into three sections, each to address a specific research question. Data analysis and findings focused on how participants perceive the affordances of digital simulations; examine how the affordances of the digital simulator apply to Wastewater Treatment Plant (WWTP) practical training; and examine how the affordances of the digital simulators can improve Technical Vocational Education and Training (TVET) institutions' practical training.

5.2 Affordances Perception

The perceived affordances of the WEST simulator described by participants were influenced by characteristics of IT artefacts originating from the designer's intentions and by actors'(participants') aims and skills. This study assessed the perceived affordances of the facilitators towards the WEST simulator. Egessa *et al.*, (2021) mentioned that perceived affordance is dependent on individuals' preconditioned actions, which their occurrence may not be guaranteed. According to the findings of the study, all the participants' perceptions regarding the WEST digital simulator were positive and seemed to have goals that the simulator would be able to assist them to accomplish. The goals were influenced by their experience. However, Singh and Kumar (2016) as well as Enezi and Fadley (2022) also mentioned that the Perceptions from the same situation may vary between individuals due to differences in their beliefs and experiences.

Positively perceived affordances are constructive because they provide an opportunity for action and realisation. Previous research conducted by Alinier and Oriot (2022) and Egessa *et al.* (2021), stated that affordances are basically potentials for action to

achieve an outcome, and it is important for the affordance to be actualised by the goal-oriented actor (Alinier and Oriot, 2022 and Egessa et al. 2021). This study's findings confirmed that perceived affordances were potentials that the WEST simulator could provide and that they have the potential to be realised.

5.3 Affordance Existence

The participants recognise the existence of affordances and the potential for achieving them through interaction with the Simulator. The study investigated the existence of those perceived affordances. The study's findings revealed that the recognition of the existence of affordances was dependent on the individual's skills and previous experience. The demographic information of the respondents exhibited that they had experienced between 12-10 years in the water sector and that they were qualified WW specialists with post-graduate degrees as a minimum qualification. Having skills and experience has enabled them to recognise the existence of affordance. Enezi and Fadley,(2022) supported the findings by stating that affordance recognition was a cognitive process, an individual's skills and experience is important for the affordances to be recognised.

The above viewpoint is also consistent with Norman's affordance theory, as cited in (McGrenere and Ho, 2000), which argues that affordance recognition is dependent on the actor's experience and skills. Furthermore, the findings of this study revealed that the identified affordance existence has assisted them in improving their practical instructions, which was supported by Alinier and Oriot, (2022) who mentioned that simulation-based learning allows teachers to improve their practical instructions without risking the lives of their learners.

The participants were convinced by the prospect of WEST simulators to support them in enhancing WWTP practical training online. They applauded the simulator for its ability to generate and model the WWTP using mathematical models (Participant 1), while (Participant 2) praised the simulator for its ability to graphically display the WWTP layout, which can promote a good learning environment. The WEST simulator, according to DHI (2018) and Binsfeld and Gerlach (2022), has user-friendly properties

and provides a platform suitable for modelling and simulation of WWTPs, as well as applying mathematical models that are a reliable representation of real-world systems. Additionally, the WEST simulator offers features that enable the validation of design alternatives and the evaluation of different plant layouts using scenarios. Modelling is a necessary component of the design and operation of wastewater treatment systems (Vanhooren, Meirlaen, Amerlinck, Vanghelewu, & Vanrolleghem, 2003).

The participants in the study reported that the simulator afforded them an opportunity to better comprehend and visualise the processes. This is aligned with Henze *et al.* (2004) that modelling a WWTP is a great way to summarise and better understand complicated interactions in biological systems in a WWTP and that it can be used to forecast the system reaction to different perturbations. Morgenroth, Van Loosdrecht, and Wanner (2000), had opposing views by stating that the practical application of dynamic modelling of WWT is extremely restricted because of the expensive cost of the models and the difficulty of calibrating the models in real-world settings. Vanhooren *et al.* (2003) stated that models created for designing or visualising WWTPs should include sufficient system representation to forecast system reactions. Furthermore, (Vanhooren *et al.* 2003) emphasised the importance of modelling to simplify the complexity of a simulation. The digital simulator certainly enhances understanding and visualisation of the WWTP; however, the costs of the model and the challenges with calibration should be considered and planned for to provide adequate representation.

Another benefit revealed by the study is the simulator's ability to solve problems using experiments and decision-making abilities which assisted in knowledge acquisition as stated by Participant 1, Participant 2, and Participant 3. The problem-solving affordance is also asserted by Kassen, Tammen, Zarte, and Pechmann,(2021), who suggested that simulation models can enable problem-solving through experiments to acquire information about the performance of the systems. Additionally,, they mentioned that simulations can assist with making decisions. It was also found during the study that the participants recognised the affordances, as all four of them acknowledged the simulator's potential to perform short-term and long-term evaluations of the WWTP, which they claimed can be carried out by operating scenarios for different situations. According to DHI (2018), the WEST simulator has

the potential to optimise operations and is extremely flexible and adjustable, enabling a plant operator to model different unit processes and have configurations independently to further help with an understanding of the WWTP. Furthermore, DHI (2020), stated that the WEST can enable the testing of complicated control scenarios, running of sophisticated experiments, estimate parameters and simultaneous simulations. Based on the affordances discussed above, it is evident that the WEST digital simulator can exemplify the characteristics of the WWTP.

5.4 Affordances Actualisation and Effects (Observations)

The actualisation of affordances is explored in this section to establish whether the participants have realised the affordances identified. The Kolb's ETL elements were used to assess the participants and they were provided with access to the WEST simulator software. *Strong et al.* (2014) described actualisation as the actions performed by actors when they use technology to take advantage of one or more affordances to accomplish immediate concrete outcomes in support of organisational goals. Furthermore, the actualisation process is iterative because individual acts yield results, and these immediate concrete outcomes, in turn, offer feedback for individual actions and give rise to affordances. (*Strong et al.*, 2014). The findings from the observed actualisation of affordances are discussed further below.

5.4.1 Perceived Affordance (Concrete experience)

According to Kolb (1984), the first component of the experiential learning cycle is concrete experience; he goes on to say that this experience could either be something completely new or a reimagined event that has previously occurred. Participants 1 and 2 in this study began their actualising of an experiential learning environment with concrete experience which can be either is lower-order understanding or higher-order understanding. In the stage, the participants engaged in hand-on with the WEST simulation which provided them with practical experience in managing and troubleshooting WWP, which is essential for lower-order skills such as basic technical proficiency and procedural knowledge. The concrete experience also serves as a

foundation of higher -order thinking , as it allows participants to encounter complex scenarios and make initial observations. The participants can begin to grasp the underlying principles of WW through these experiences. Both participants (1 and 2) facilitate NQF Level2 and NQF Level 3 PC as seen in table 1.

Loo, (2004) mentioned that a person who is a concrete experienter takes a hands - on approach to see if their ideas was effective and starts from detail to constructively work towards the big picture, which were observed with Participants 1 and 2 as their activities were introduced constructively with a lot of explanations. Participants 3 and 4, on the other hand, began their tasks with abstract conceptualisation rather than CE. This might suggest that they had a different approach to presenting concepts to their audiences, or that the target group for whom they were designing the content was advanced.

5.4.2 Reflective observation

The ability to become aware of affordances while interacting with the artefacts is provided in the reflection which can be seen as lower-order understanding. Participant 2 was the only one who applied RO in their activities during actualisation. Based on the demographic, Participant 2 is responsible for training NQF Level 2. They are entry-level students who still require assistance, and it is critical that they reflect on the task, ask questions, and share their experiences with others. The participant reflected on their concrete experiences , which enhanced their higher -order understanding by helping them analyse and evaluate their experiences critically.

Pamungka et al.,(2019) stated that communication is vital at this stage because it allows the learner to identify gaps between their knowledge and the experience itself. The other participants have not employed the RO element in their activities, which might be due to simulator constraints or because the audience of learners they serve to does not require RO.

It was also noticed that participants actualised identified affordances without providing an explanation or expressing a desire to learn how specific actions could occur, which was also mentioned by Falloon (2019) in a recent study. Despite the lack of explanations from the participants, the researcher as an observer assisted participants to achieve reflective observation by questioning them about the difficulties they have encountered using the WEST simulator and how they perceived those challenges. The questions posed prompted participants to reflect further on their experience in the exercise. The enquiry process, which is related to real-world situations, is vital throughout learning because it enables learners to develop practical solutions, has clear and meaningful roles as well as responsibilities in learning (Morris, 2020). Participants also exhibited descriptive thinking by performing what they have experienced in real life when interacting with the simulator (e.g., statements like “*my plant has this additional process, let me add and see if it will work here, designing problematic scenarios they experienced in their real process*”). Additionally, participants were able to resolve complex problems during actualisation, which indicates their ability to apply critical thinking (e.g., responses like “*but where have the component gone?’ why do we need to add another aerator?*”).

5.4.3 Abstract Conceptualisation

Participants 3 and 4 when creating their activities in the experiential learning environment started with abstract conceptualisations which allow learners to make sense of the events that took place. In this stage, there is the classifying of concepts. At this stage the participants demonstrated both lower and higher-order understanding as they begin to conceptualise and generalise the knowledge gained from their experience which promoted the development of theoretical knowledge and delve deeper into their theoretical foundations of WWT, fostering higher-order thinking by encouraging them to make connections between different concepts and principles.

As seen from figure 4 in chapter 4, the participant created an activity that required learners to classify concepts and make conclusions from the previous activities that occurred. Based on the demographic data, Participants 3 and 4 are facilitating for level 4 and 5 learners, which are learners that are experienced and have been exposed to

the WWTP in the previous levels. The learners might be able to interpret the experience and make comparisons to their current understanding on the concept.

Participants 1 and 2 also displayed the ability to implement the notion of abstract conceptualisation, which demonstrates of critical reflections on contextually rich concrete experiences. Pamungka *et al.* (2019) described abstract concepts as a process that emphasises the importance of individuals understanding basic ideas in general by referring to concrete experience and reflective observations. Furthermore, they argued that abstract conception needed an individual to apply logical thinking to understand problems. The participants developed new ideas on how to predict potential technical glitches that may occur and created mitigations to resolve these technical glitches.

5.4.4 Active experimentation

All the participants used the active experimental element of ELT in their activity. Active experimentation is described as the phase in which individuals can make predictions based on the theory developed during the abstract conception (Pamungka *et al.*, 2019; Salimon, 2019). Knowledge was developed, according to the researcher's findings, by conveying constructive processes and component knowledge throughout their interaction with the WEST simulator. Furthermore, the participants were able to conceptualise learning experiences, make decisions, and improve their cognitive skills by using analytical skills. The participants have also demonstrated that they have acquired new experiences from the simulator, that allowed them to improve what they were doing. Yet, the participant's ability to actualize all the affordances on the simulator does not indicate that they will implement the concepts in real life. All participants provided graphical confirmation of implementing the identified affordances. By actively experimenting with different approaches to WWTP, they cultivated higher-order understanding through the development of critical thinking and ability to adapt to novel situations. Kolb (1984) believes that a person may completely demonstrate active experimentation by implementing the concepts in real life and seeing the effects. The results of this study were only visible on the simulator and were not implemented in a real-world WWTP.

5.5 Concluding remarks

Based on the data analysis and findings made from this study, the following concluding remarks are made: 1) Participants' perceptions towards the digital simulator varied, which can be attributed to the demographics of the study's target audience; 2) This research found that perceptions are closely related to people's experiences and areas of specialisation; 3) The perceived affordances towards digital simulations are positive and the participants are aware of their existence. The participants recognised the affordances of the digital simulator that exemplify WWTP aspects, such as an overview of the WWTP, troubleshooting, demonstration of different phases, problem-solving, and even parameter monitoring. Observations indicated that the digital simulator could improve practical training by achieving and demonstrating the components of Kolb's ELT while using the simulator. In response to the main research question, the WEST 'simulator provided the participant with a replica of a real-life process that allows them to learn abstract concepts, identify different processes, create different scenarios that exist in the real process, and allow interaction between the user and the simulated plant. The ability of the simulator to improve the user's skills and knowledge is the most significant affordance because that is the objective of practical training.

6 CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In South Africa, TVET institutions are among the key educational service providers that focus on the training of process controllers for water and wastewater. This study focused on wastewater treatment practices and the affordances of digital simulations in vocational training. TVET institutions are encouraged to include ICT in all training practices, which also requires revisions and amendments to their curriculum. Despite the encouragement to promote ICT practices in TVET, the education sector is still facing various challenges to actualise technology-based learning. Therefore, this study explored how the affordances of digital simulations enhance wastewater treatment process practical training online in TVET. A comprehensive literature review provides background information about theoretical- and conceptual frameworks. The theoretical framework consists of theories that allow the researcher to explore the objectives to answer the research questions. The ELT follow a full learning cycle: concrete experience (participants obtain experience), reflective observation (participants were able to reflect on their experience), abstract conceptualisation (participants demonstrate what they have learned), and active experimentation (participants applying and trying out what they have learned). The AFT is applied to evaluate affordances, following the cognition process, recognition process, behaviour, and affordance effect. The theories were applied and assisted in achieving the objectives of the study.

In concluding the demographics, participants' qualification is also shown, which gives an indication of their level of knowledge and skills that makes them capable to not only using or applying the WEST technology but also interpreting the data and information generated by this simulator. Section B presents the results obtained for each objective in chronological order, following; 1) the perceptions of facilitators towards affordances of simulation; 2) affordances of digital simulations; and 3) the use of digital simulations to enhance practical training. Results for observations are also presented in a table format for each objective with a detailed summary followed by the direct responses obtained from each participant. The results presented in this chapter are aligned with

the objectives and research questions. The concluding remarks for this are based on the objectives of this study. The perceptions of participants were favourable since they were able to perceive, affordances related to their goals and were influenced by the experience.

The participants in the study demonstrated a clear and effective understanding of the affordances offered by digital area simulator, and they successfully put these affordances into practice. These affordances are focused on process design and modelling features, which are also explained and confirmed by recent studies. Participants were able to demonstrate their abilities through practical application and interpretation of data and information obtained by the WEST simulator. This means that participants can design and model a wastewater treatment plant, simple complex systems and optimise unit processes. Although the WEST simulator has many affordances, there are also a few minor limitations identified by this study, which may include financial constraints for learning institutions where finances are already a challenge. It has also become evident from this study that a person operating this technology needs to have sufficient knowledge and skills in computer programmes. The facilitators have shown in different ways that the digital simulator can be used for training practicals for process controllers. It was also noted that the simulator could run “worst-case” settings that would be impossible to accomplish in real life. Furthermore, forecasting is another option for the simulator to avoid possibly dangerous situations that may emerge in a wastewater plant. The application of the WEST simulator can therefore be used to simulate everyday plant operations to reduce operational risks and human mistakes. The WEST simulator enables operators to do short- and long-term plant assessments (e.g., perform operating scenarios) and perform cost assessments to determine the financial implications. The WEST simulator also enables facilitators and students who lack practical wastewater treatment experience to better understand how plants operate.

Given the data, it was found that the participants were able to use the simulator to enhance practical training. This was achieved by their ability to create an experiential learning platform that integrated the ELT elements that are necessary for practical training. Furthermore, because experiential learning is all about interacting and

collaborative experiences, the participants were able to demonstrate the ability to include practical tasks that did not require theory but practice. The use of digital simulations for training concepts proved to be effective since it enables individuals to experiment with different outcomes. Nevertheless, the use of Reflection observation was recognised as a gap during actualisation utilising Kolb's ETL components. Only participant 2 demonstrated the application of RO, as it is critical that they evaluate and think about their experience and why certain things happened. One significant affordance of digital simulations recognized by the researcher is the ability to generate virtual experiments that may be repeated several times without having to perform the experiment each time. Liu and Su (2011) supported the researcher's statement by stating that by using computer simulations, learning activities may be repeated without having to physically conduct the experiment each time. Given that the nature of work makes it impossible to replicate an experiment more than once without needing to complete the entire experiment, affordance may be the major component that enhances practical training for WWTP.

6.2 Recommendations

The researcher recommends to the TVET college sector to consider the following when implementing practical training using digital simulation: 1) create real-life scenarios that learners can relate to, 2) design activities that allow learners to engage with the simulator, and 3) set up an evaluation and feedback strategy as well as self-assessment tools for users/learners. Most importantly, create an environment where active experimentation can be applied in a real-life process to achieve tangible outcomes. Additionally, the research focused on the benefits of digital simulations for enhancing practical training, and the following recommendations are crucial and should be considered when determining whether practical training was achieved applying the Kolb ELT. Trainers/facilitators providing practical training using digital simulators, including the Kolb learning cycle, must consider the teaching style, learner level, and associated practical approach required for the subject taught before adopting the entire theory. Furthermore, since Kolb's theory was initially offered in the mid-1970s, various studies have suggested that one should adapt the theory to meet their requirements.

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8 APPENDICES

A. Trainer/Facilitator interview questions

Structured Interview Question	
a) How long have you been involved in Wastewater treatment process?	
b) What did you think of the WEST Modelling simulator before interacting with it?	
c) What did you use the WEST Modelling of wastewater treatment plants simulator for?	
d) What are the basic standards of the WEST simulator?	
e) What did the WEST simulator enabled you to do when interacting with it?	
f) How did the use of the simulator help with your understanding?	
g) Can you apply the concept from the WEST simulator in real Wastewater Treatment Process?	
h) Would you recommend the use of Simulation software when training Wastewater Treatment Process controllers?	
i) Any recommendations of how trainers could use simulator in their teaching for wastewater treatment process?	

B. Observation Schedule

The participants were be trained on how to use the simulator prior to the observation session and assess them. The emphasis on experience in experimental learning means that there are a diverse number of ways that the simulator can be used to teach.

Questions	Notes
1. Does the trainer interaction with the simulator show that they understand how it work? If so , how? If not, what could be the problem?	
2. Do the basic specifications of west simulator as mentioned by the trainer exist? If so, what are those? If not, what are the specifications?	
3. Application of the Kolb's experiential learning theory. a) concrete experience – I will observe if the learning experience has occurred after the training. b) Reflective observation – I will observe reflection on the experience. c) Abstract Conceptualism- I will be observing how they reason by looking at their interaction with the simulator.	

C RESEARCH CONSENT FORM FOR INTERVIEW AND OBSERVATION

Title of Research project: Affordances of digital simulations in training Practicals for Process Controllers in Technical Vocational Education and Training.

Name of the researcher : Makhawukani Dawn Maluleke.

I,.....agree to participate in this research project.

I agree to the following:

NB: Please circle the relevant options below.

- | | |
|--|-----------|
| 1. The research study was explained to me. I understand what this study is about. | YES
NO |
| 2. I understand that I can volunteer to take part in the study. | YES
NO |
| 3. I agree that the interview and the observation session may be audio recorded. | YES
NO |
| 4. I agree that direct quotations from my interview may be used by the researcher in their research report. | YES
NO |
| 5. I agree that my participation will remain anonymous (my name will not be used by the researcher in their research report) | YES
NO |
| 6. I agree that other researchers may use the information I provide in my interview (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on. | YES
NO |

Name of participant :	Name of Researcher:
Signature:	Signature:

D Ethics Certificate



SCHOOL OF EDUCATION ETHICS COMMITTEE

CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE

PROTOCOL NUMBER: 2022ECE048M

PROJECT TITLE

Affordances of digital simulations in training
Practicals for Process Controllers in Technical
Vocational Education and Training.

INVESTIGATOR

Maluleke Makhawukani Xilavi Dawn

SCHOOL/DEPARTMENT OF INVESTIGATOR

WSoE

DATE CONSIDERED

10 August 2022

DECISION OF THE COMMITTEE

Approved unconditionally

RISK LEVEL

No Risk

EXPIRY DATE

Date of submission of the Research Report

ISSUE DATE OF CERTIFICATE

CHAIRPERSON 
Dr. Batseba Mofolo-Mbokane

cc: Dr. N. Ndlovu and Dr. K. Mbatha

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature _____

Date _____

E: REQUEST TO CONDUCT RESEARCH

Dear Sir/Madam,

Re: Permission to conduct research at Rand Water (Capacity Building Department)

Rand Water is currently sponsoring me to study Master's in Education, specializing in Information Communication Technology (ICT) at the University of the Witwatersrand. I am seeking permission to do research at Rand Water's Capacity building department focusing on the Technical Training Section.

My research topic is focusing on the "Affordances of digital simulations in training Practicals for Process Controllers in Technical Vocational Education and Training". One of the research objectives is to investigate the affordances of using digital simulation when facilitating Water and Wastewater process controllers online. The study aims to determine if the use of digital simulations will improve practical training for the Process Controllers.

The research entails collection of data from the four Technical Trainers (Participants) under the technical section and which will be collected in a form of interviews and observations while using the digital Wastewater simulation. I request permission to get access to the Technical Training section to conduct interviews and observations while they interact with the simulation. The study requires that I engage with each of the four Technical Trainer for four hours, which will be split into two different days via Teams or ZOOM platforms. The sessions will be recorded, and the participants will be required to give a written consent before the research begins.

The Technical Trainers responses will be treated confidentially, and their identities and that of the organization will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study. The results will be shared with the organization and be published in the dissertation. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their participation at any time during this research project without any penalties. There are no foreseeable risks in participating in this study and the participants will not be paid for this study. All research data will be destroyed after the research has been concluded.

I therefore request permission in writing to conduct my research at your department. Please let me know if you require any further information and I look forward to your response as soon as is convenient.