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CHAPTER 9

Research impact at South African UoTs: stepwise cognitive progression in applied doctoral pedagogy

Hesta Friedrich-Nel and Ryk Lues

Abstract

The societal impact of new knowledge and the role of Universities of Technology (UoTs) in its generation is the focus of this chapter. It argues that while the roles of UoTs have become more complex, the guiding principles for postgraduate education knowledge generation role has remained rooted in 'classical university' pedagogy. The concern of the chapter is that in developing economies there is a growing debate on the relevance of 'traditional knowledge creation' versus 'practical applications' knowledge creation. By applying the concept of 'permeable universities' to make its point, the chapter examines whether UoTs in South Africa have fully embraced the need to revise and reshape their doctoral pedagogies to generate knowledge relevant to their immediate societal contexts.

Keywords: Higher education, universities of technology, cognitive progression, graduate attributes, doctoral pedagogy

9.1 Introduction

Doctoral graduates play an important role in advancing research and innovation (Baptista, Frick, Holley, Remmik, Tesch & Åkerlind, 2015). As such, academic institutions, industries, and research organisations prefer candidates with a doctoral degree, specifically to lead innovative research projects. It is assumed that these candidates possess attributes, skills, and competencies, such as creativity and innovation that make them attractive to the work environment (Van Schalkwyk, Van Lill & Cloete, 2021). Inevitably, the government sector is looking for graduates in the science, technology, engineering, and mathematics (STEM) fields to drive their policies and specific initiatives.

The demand for more doctoral graduates in South Africa stems from the National Development Plan (NDP, 2011), which has prioritised an increase in doctoral graduates aiming to reach 5,000 by 2020. This drive is spearheaded by the contribution of doctoral graduates to the knowledge economy, to boost research and develop higher-order skills, as well as to renew the aging professoriate in South Africa (Cloete, Mouton & Sheppard, 2016). Understandably, academic institutions prefer candidates with a doctoral degree for their contribution to the fitness of and fitness for purpose, as well as to add to the bigger picture in higher education, namely research, teaching, and community engagement. Doctoral candidates are therefore favoured for their academic leadership and potential contribution to global research initiatives, collaboration and partnerships, and for contributing to socio-economic wellbeing. By introducing quality doctoral graduates into society, constitutes a pivotal element of achieving permeability – defined as "…an approach, a method for the redevelopment of the higher education environment, a way of doing which institutions, governing bodies and sector organisations can use to re-find purpose and values, to educate, to research and to engage more widely…" (The

Permeable University: The purpose of universities in the 21st Century - A Manifesto (University of Lincoln, Bayford Pool, Lincoln). Permeability has been given momentum through an increasing focus on participatory and action-oriented research methodologies. For example, doctoral researchers at technological institutions in particular, have been engaging with communities and stakeholders to co-create knowledge and address real-world predicaments.

In addition to their knowledge contribution, doctoral candidates have through millennia been sought after by society for their attributes (Tshuma & Bitzer, 2023). One of these attributes is academic writing, specifically writing proposals for new research and funding. In addition, there is mention of communication, critical thinking, innovation, and problem-solving. In section 5 below, we further explore these attributes. As such, critique of the traditional doctoral pedagogy and the need for transformation is spearheaded by the assumed misalignment of the current basic research completed at the Universities of Technology (UoTs). This misalignment points to the attributes of doctoral graduates and the response of research outcomes to address societal demands.

After offering the rationale and research methodology, this study presents a backdrop to the higher education landscape in South Africa, and its historical legacies and complexities are provided. The expectations of doctoral graduates are viewed through the lenses of the South African Qualifications Authority (SAQA) level descriptors and Bloom's Taxonomy. Recommendations regarding the limitations of doctoral graduates' scientific knowledge, skills, and attributes are based on the Council on Higher Education (CHE) report on doctoral education (CHE, 2022). Based on design thinking methodology, a systematic approach to instil cognitive progression toward applied doctoral pedagogy is proposed. The intended outcome is a refocus, transformation, and application of research findings to enhance

scientific knowledge, skills, and doctoral attributes, specifically at a University of Technology (UoT). Ultimately, the chapter aims to contribute to societal challenges through high-quality applied research that culminates into innovative and tangible outcomes and products. The critical theory research paradigm was used as the theoretical lens (Asghar, 2013) as this research paradigm drives social change through rigorous scientific inquiry. Critical theorists scrutinise knowledge and methodologies, recognising the influence and potential power phenomena or systems under investigation. Through critical theory, the actors and those who have agency to enable change are identified.

It is against this setting that this chapter engages four primary components: Firstly, it starts by discussing the rationale for the study; the chapter then describes the UoT concept and mandate, it explores and dissects various components of doctoral pedagogy and associated curricula to guide the doctoral pedagogy transformation. Finally, it concludes by proposing innovative interventions to enhance and facilitate applied research outcomes.

9.1.1. From ideation to applied outcome

South Africa is increasingly experiencing an array of societal and economic challenges whereas research endeavours at current research entities are not adequately responsive to such needs. In the University World News 2023, Ben Daniel listed some of the issues and expressed the need for research methodology to be more innovative. As such, and in line with the CHE doctoral review recommendations (CHE, 2022), the chapter aims to propose a pedagogy that facilitates the value chain from idea to applied outcome, is responsive to the developmental context, and specifically articulates the mandate of South African UoTs. To capture the complex and holistic nature of the applied doctoral pedagogy process that could potentially address the range of skills required of doctoral students, the ‘twin’ concepts of design and action

linked to doctoral pedagogy are referred to in this chapter (Danby & Lee, 2012:5). Danby and Lee (2012) argue that this pedagogy aligns with formulating ideas and translating them into practice. As such, to illustrate the actions, making connections, and responding to the social context of doctoral pedagogy, these authors refer to it as 'pedagogy-in-action' (Danby & Lee 2012:7).

While basic research is fundamental to scientific progress and understanding, acknowledging its shortfalls is key to fostering a balanced and effective research landscape. Balancing the pursuit of knowledge with practical applications, ethical implications, and effective communication is essential for ensuring that basic research continues to contribute meaningfully to a collective understanding of the world. The nuanced role that basic research plays in the broader scientific endeavour should be appreciated, and pave the way for responsive, innovative, and impactful research endeavours. The above-mentioned broad backdrop exposes an obvious elephant in the room: How do UoTs respond to this predicament in terms of its doctoral pedagogy, as principal enablers of the process, specifically, when dissecting the components of applied doctoral pedagogy as an enabler of the scientific method?

The fundamental research question guiding the chapter is articulated as follows: What are the desired and unique attributes required by doctoral graduates that exit in Universities of Technology, and what strategies should be implemented to achieve such attributes? This overarching question permeates into the following aims:

- to delineate the desired traits, attributes, and competencies that should be instilled in doctoral graduates to unlock the students' agency in terms of societal responsiveness, social justice, and decolonisation;

- to identify tangible enablers UoTs should implement to reshape and transform doctoral pedagogy;
- to conceptualise tangible strategies that UoTs should implement to realise the reshaped doctoral pedagogy in enabling the desired traits and attributes such as innovation and creativity; and
- to consider and propose cognitive progression as a mechanism to ensure the effectiveness of applied and responsive research outcomes.

9.2 Research design

A qualitative approach, desktop analysis, and critical literature survey methodology were used in extracting information from purposeful and targeted literature on doctoral pedagogy and doctoral education. The following steps guided the authors: A critical literature survey methodology was followed to extract and interpret information from the literature. Specific skills and attributes to be instilled in doctoral graduates were identified using design thinking methodology. The verbs based on Bloom's taxonomy were critiqued to enable responsive actions. Against the backdrop of existing basic and applied practices, and leaning on design thinking methodology, tangible initiatives, procedures, and guidelines are proposed to enable innovative doctoral pedagogy as a mechanism to achieve permeability. Stepwise cognitive progression is proposed as a novel approach to facilitate applied research outcomes and unlock doctoral graduates' agency.

9.2.1. Critical literature survey methodology

The critical literature survey methodology was selected for this chapter, based on various considerations. The methodology of conducting a critical literature survey stands as a fundamental aspect of academic

research, providing a systematic approach to comprehend existing knowledge, pinpoint gaps, and guide further investigations. It serves as a pivotal initial stage in research endeavours across various fields, aiding researchers in navigating the extensive realm of scholarly literature. One of the strengths of this methodology is that it encourages reflexivity while also rendering a more subjective and evaluative approach. The critical review approach was further deemed appropriate by being less structured, allowing for a more nuanced interpretation of the findings. This section explores the essence of critical literature survey methodology, elucidating its importance, essential components, and recommended practices (Farrukh & Sajiad, 2023).

A critical literature survey involves an assessment of scholarly contributions and existing literature pertinent to providing a deeper understanding of a specific research topic, in this case, cognitive progression in applied doctoral pedagogy. It lays the groundwork for informed decision-making, allowing researchers to position their work within a broader intellectual discourse. By engaging with diverse perspectives, theories, and methodologies, the authors gleaned insights that shaped their conceptual frameworks. Although the limitation of this methodology is subjectivity, it may be difficult to repeat and there is a potentially narrow view of existing literature (Chukwuere, 2023) it assisted the authors in documenting the research landscape, innovations, and limitations, related to higher education, specifically UoTs.

The initial phase of the critical literature review process entailed identifying relevant sources of information, including academic journals, books, conference proceedings, dissertations, and other scholarly publications. Utilising advanced search techniques such as database queries and citation tracking facilitates comprehensive literature retrieval. Search engines such as EBSCOhost, ScienceDirect, and Google

Scholar were accessed via the university's library portal to search for publications in English. Amongst others, keywords, Boolean operators and algorithms via the Google Scholar and Science Direct platforms, such as: 'doctoral education'; 'doctoral pedagogy', 'cognitive progression', 'graduate attributes' and 'creativity and innovation' were used. No specific time frame was linked to the search. The crux of the literature survey methodology lies in the critical evaluation of collected literature. The authors scrutinised the quality, relevance, and credibility of each source, considering factors such as author credentials, publication venue, methodology, and theoretical foundations. Frameworks such as the Currency, Relevance, Authority, Accuracy, and Purpose (CRAAP) test aided in assessing the trustworthiness of literature (Central Michigan University Libraries, 2023).

Synthesising diverse viewpoints and findings from the literature was paramount in fostering a defined understanding of the UoT research landscape. The contextual framework, underpinned by existing studies within the broader socio-cultural, historical, and theoretical context, enhanced the interpretative value and underscored the implications of interpreting the research questions. In addition to the critical literature survey, the principles of design thinking were included to further explore the implications and recommendations of cognitive progression in doctoral pedagogy, specifically at a UoT.

9.2.2. Design thinking approaches

In today's dynamic landscape, organisations encounter multifaceted dilemmas that necessitate inventive resolutions. Design thinking emerged as a methodology for problem-solving, harnessing principles from design to cultivate creativity, empathy, and collaboration. Also, design thinking has been widely reported as an effective tool in curriculum development (Duarte, Nobre, Pimentel & Jacquinet, 2021). This section of the chapter explores the significance of design thinking

methodologies in reaching conclusions and formulating novel concepts and strategies, illustrating how they enable individuals and organisations to address diverse challenges with originality and efficacy.

Fundamentally, design thinking is anchored in a profound commitment to crafting solutions that significantly impact people's lives. Design thinking epitomises a human-centred approach to innovation, prioritising empathy, ideation, prototyping, and iteration. It advocates for a mindset characterised by curiosity and experimentation, urging scientists to challenge assumptions and view failure as a stepping stone for learning. Typically, design thinking methodologies encompass iterative stages, including empathising with users, defining problems, ideating solutions, prototyping concepts, and testing and refining ideas based on user feedback (Goff & Getenet, 2017). Central to design thinking is the emphasis on identifying with end-users to gain profound insights into their needs, preferences, and challenges. By engaging user experiences through feedback loops, design thinking develops a distinct understanding of the contextual backdrop in which problems arise and identifies veiled needs and missed opportunities. This iterative approach enhances comprehension of the problem domain and contemplates interventions that are both feasible and desirable. Collaboration lies at the heart of design thinking, drawing together individuals from diverse disciplines to co-create solutions. By embracing an inclusive and interdisciplinary approach to problem-solving, design thinking leverages the collective intelligence of teams, tapping into a broad spectrum of perspectives, skills, and expertise. Cross-disciplinary collaboration fosters creative synergies, catalysing the generation of innovative concepts and strategies that transcend conventional boundaries. The implementation and application of design thinking methodology are presented in section 9 of this chapter.

9.3 Innovation and research in higher education

The landscape of higher education in technology is diverse, encompassing global institutes of technology renowned for their innovation and research prowess, as well as South African UoTs striving to meet the unique educational needs of the nation. This chapter explores the distinctions and similarities between these two categories of institutions, shedding light on their respective roles, strengths, and challenges.

9.3.1. Institutes of technology

Global Institutes of Technology (GITs), situated in various countries, are celebrated for their innovative research, advanced facilities, and international collaboration. These institutions attract top talent from around the world, fostering a diverse and dynamic academic environment. Known for their emphasis on science, engineering, and technology, global institutes of technology contribute significantly to global innovation and progress. The likes of Massachusetts Institute of Technology (MIT), Stanford University, and ETH Zurich stand as exemplars of excellence, setting benchmarks for research output, technological advancements, and academic impact.

As beacons of excellence and ethical conduct, GITs play a pivotal role in fostering international cooperation and creating a brighter and more sustainable future for humanity. As one of the primary mandates of GITs is to promote international collaboration and knowledge exchange, these institutes serve as hubs where researchers, scientists, and scholars from around the world converge to share ideas, methodologies, and findings. These institutes of technology thrive on international collaboration, engaging in research partnerships and knowledge exchange with institutions worldwide. This collaboration enriches the

academic experience and enhances the global impact of research outcomes. Through their collaborative efforts, these institutes contribute to the collective knowledge pool, address pressing global challenges, and drive technological advancements. Collaborative research projects undertaken by GITs often involve multidisciplinary teams, fostering a rich and diverse intellectual environment. This collaboration enhances the quality and impact of research outcomes by incorporating varied perspectives and expertise. These institutions boast state-of-the-art research facilities, laboratories, and infrastructure, enabling groundbreaking research across various technological domains. Global institutes attract and retain top-tier faculty members who are experts in their fields, contributing to the institution's academic reputation and research output.

9.3.2. Catalysts for global innovation and research

GITs are equipped with state-of-the-art facilities, innovative laboratories, and top-tier faculty, fostering an environment conducive to groundbreaking discoveries. The research mandates of GITs prioritise innovative research and technological innovation. So, they are at the forefront of addressing global challenges through their research initiatives and play a crucial role in shaping the landscape of global innovation and research. As such, these institutions are dedicated to pushing the boundaries of knowledge and technology (Krishna, 2019).

The focus on innovation extends beyond academic research to the development of new technologies, products, and processes that have practical applications in various industries. GITs often collaborate with industry partners, further bridging the gap between academia and real-world technological advancements. Amongst others, solutions to challenges such as climate change, sustainable development, public health crises, and technological disruptions are investigated. As mentioned, GITs leverage their international networks to assemble

teams of experts capable of tackling these issues on a global scale. The research conducted at these institutes contributes not only to the advancement of knowledge but also to the development of practical solutions with the potential to benefit societies worldwide.

GITs emphasise the importance of ethical and responsible research practices. As global leaders in technology and science, these institutes set standards for research integrity, transparency, and ethical conduct. GITs not only produce knowledge but also instil in their researchers a sense of responsibility towards society and the environment. This commitment to ethical research ensures that advancements in technology are made with careful consideration of their societal implications.

9.3.3. South African Universities of Technology

The South African UoTs play a dynamic role in addressing the specific educational, societal, and developmental needs of the country. With an emphasis on the implementation of scientific knowledge, these universities contribute to the advancement of knowledge, the development of skilled professionals, and on addressing unique societal challenges in applied learning. The UoTs ensure that graduates are well-equipped with practical skills that align with industry needs, fostering employability. As such, the focus is on applied knowledge, skills development, and industry relevance (Garraway & Winberg, 2019). Examples are the Central University of Technology, Free State, Cape Peninsula University of Technology, Durban University of Technology, Mangosuthu University of Technology and the Tshwane University of Technology. These UoTs emphasise practical and vocational education, preparing students for real-world challenges through, for example, the avenues of work-integrated learning (WIL) (Jacobs & Dzansi, 2015). UoTs play a crucial role in addressing socio-economic challenges specific to South Africa.

Research at UoTs focuses on application, with an emphasis on professional and technical skills and close ties with the industry. By itself, students may have the opportunity to work on industry-related projects and collaborate with industry and businesses. Since UoTs are relatively young institutions (ca. 30 years), they cannot compete with traditional universities based on factors, such as the research track records, the supervisory capacity and available funding for doctoral graduate research (see section 7). In developing countries and South Africa particularly, the perceptions about universities of technology, have been clouded by components of exclusivity and quality, partially informed by the evolution of the former Technikons into UoTs, and mergers with PDIs (CHE, 2016). Unfortunately, rather than embracing their specialist and sought-after niches, despite the purpose of UoTs being outlined in national policy documents, they have aspired to become like traditional universities (CHE, 2016). The aspirations of UoTs to be similar to traditional universities reiterates their concept of subservience, whereas challenges related to governance have unfortunately also contributed to such perceptions. This has brought about difficulties for UoTs to engage on national and international authoritative platforms, and more specifically the ability of students and academics to articulate amongst institutions, the latter being seen as less able because of poorer and resource-deprived histories.

Paradoxically, UoTs have replied to several narratives as the partners of choice in responding to the various challenges. The graduates from UoTs have increasingly been identified as having skills beyond those from traditional, comprehensive universities, necessitated by responses to their deprived and often limited-resourced backgrounds. Skills such as creativity, application, and resilience are but some of these competencies. The reality is that such individuals are vilified and oppressed in terms of their competencies and forced into processes perceived as traditional and superior. Moreover, UoTs have increasingly

pursued the methodologies, systems, and processes of traditional universities, with a principal outcome being to diversion from their original purpose. Sadly, staff and students at UoTs still inculcate a narrative of subservience, and ultimately society is being deprived of responsive and applied solutions to its predicaments. While acknowledging the distinct strengths of the South African UoTs, they also face challenges driven by national traditional university governance and policy structures, such as funding and resource constraints, waning reputations, and the need for continuous adaptation to remain relevant.

9.4 Exploring research methodology curricula

The term "curriculum" is a multifaceted and evolving subject because it encompasses a wide array of interpretations and philosophies that reflect differing educational goals, values, and cultural contexts. At its core, a curriculum is designed to outline what students are expected to learn and how that learning will be achieved, but the way this is conceptualized and executed can vary considerably. Contestation about flexibility and scope that can differ between institutions, regions, educational philosophies, cultural and political influences and pedagogical approaches has led to ongoing debates on what should be taught, how it should be taught, and why certain educational goals should be prioritized over others.

Lange (2017:32) explains that *curriculum* is “the process of engagement of students and staff with knowledge, behaviour and identity in different disciplinary contexts. Research methodology curricula serve as the bedrock of academic inquiry, providing students with a systematic framework to conduct meaningful and rigorous research (Williams, 2007). Rooted in established principles and practices, these curricula play a pivotal role in shaping the research skills of students across various disciplines. This section of the chapter delves into the

components, objectives, and significance of traditional research methodology curricula, examining how they lay the foundation for scholarly exploration and contribute to the advancement of knowledge.

Research methodology curricula provide a solid foundation for students pursuing advanced degrees or engaging in scholarly research (Ullah & Rafiq, 2023). The skills acquired through these curricula are transferable across various academic disciplines. By equipping students with the tools and techniques needed to conduct rigorous research, traditional curricula contribute to the generation of new knowledge. This is vital for the continuous advancement of academic fields and the broader society. Beyond academia, the research skills cultivated through traditional research methodology curricula prepare students for professional practice. Whether in the private or public sector, graduates with a strong research foundation are better equipped to navigate complex challenges and contribute to evidence-based decision-making.

9.4.1. Conventional research methodology curricula

Although traditional approaches are still constituting the foundations of research methodology across the South African Higher education landscape, particularly amongst the older established traditional and comprehensive institutions, contemporary trends in doctoral research methodologies have been emerging. This is reflected by a dynamic shift towards greater interdisciplinary integration, methodological flexibility, and technological advancement. These evolving practices highlight the increasing complexity and scope of doctoral research in today's academic landscape. The integration of digital tools such as artificial intelligence and supporting platforms also facilitates innovative forms of data visualization and dissemination, rendering research findings more accessible and impactful.

Research methodology curricula often commence with an exploration of philosophical underpinnings, introducing students to epistemological considerations, ontological perspectives, and the fundamental paradigms that shape research approaches (Bentley *et al*., 2015). This foundational knowledge helps students understand the nature of knowledge and the various lenses through which research questions can be approached. Traditional research methodology curricula serve as the cornerstone of academic exploration, providing students with the skills and knowledge essential for conducting meaningful research. As the landscape of research continues to evolve, these traditional foundations remain crucial, offering a time-tested framework that empowers students to contribute to the ever-expanding body of knowledge across diverse disciplines. The enduring significance of traditional research methodology curricula lies in their ability to shape inquisitive minds, and critical thinking, foster ethical research practices, and cultivate the next generation of scholars and researchers (Liamputtong & Pranee, 2019).

Research designs and models

A critical component of conventional research methodology curricula is the study of research design. This includes discussions on experimental, non-experimental, qualitative, and quantitative research designs. Students learn to choose appropriate methodologies based on the nature of their research questions, forming a robust framework for their studies.

Data collection and sampling

Traditional curricula guide students through diverse data collection methods, ranging from surveys and interviews to observations and archival research. Emphasis is placed on the selection of the most suitable method for a given research context and the ethical considerations associated with data collection.

Statistical analysis: For quantitative research, traditional research methodology curricula typically include an introduction to statistical analysis. Students learn to interpret data, apply statistical tests, and draw meaningful conclusions. This component equips them with the skills needed to analyse and interpret quantitative findings accurately. Aligned with quantitative analysis, traditional curricula also delve into qualitative research methods. This includes coding, thematic analysis, and narrative inquiry, enabling students to explore the depth and nuances of qualitative data.

Research ethics and integrity: There has been a growing awareness of ethical considerations and the need for research integrity. Contemporary doctoral research places stronger emphasis on ethical issues such as data privacy, informed consent, and the responsible use of technology. Researchers are increasingly mindful of the potential impact of their work on participants and society, striving to uphold high standards of ethical practice throughout the research process. Because ethical considerations are integral to research, traditional curricula have focused on instilling in students a strong understanding of ethical guidelines and practices (Pillay & Qhobela, 2019). This ensures that research is conducted responsibly and with respect for the rights and well-being of participants. Methodological rigour has been fundamental to the credibility and validity of research findings. Researchers must design their studies carefully, selecting appropriate methods and techniques for data collection and analysis. Whether qualitative, quantitative, or mixed-methods approaches are employed, it is essential to ensure that the chosen methods are rigorous, reliable, and suitable for addressing the research objectives. Furthermore, researchers should adhere to ethical guidelines and standards to protect the rights and well-being of research participants.

Validity and reliability: These are principal components needed for drawing accurate conclusions and making meaningful interpretations. Researchers must employ strategies to ensure the reliability and validity of their data, including proper sampling techniques, data collection procedures, and data analysis methods. Furthermore, transparency and openness in reporting methodologies and findings enhance the credibility of research outcomes, allowing other scholars to replicate and verify the results. Bias can compromise the objectivity and reliability of research findings significantly. Researchers must be vigilant in identifying and minimising sources of bias throughout the research process. This includes bias in study design, data collection, analysis, and interpretation. Strategies for minimising bias may include randomisation, blinding, controlling for confounding variables, and using validated measurement instruments. Moreover, researchers should reflect on their assumptions, perspectives, and preconceptions critically to avoid letting personal biases influence the research outcomes.

Peer review: Peer review plays an essential role in ensuring the quality and objectivity of research. By subjecting research manuscripts to scrutiny by independent experts in the field, peer review assists in identifying errors, weaknesses, and potential biases in the research methodology and findings. Peer-reviewed publications are generally considered more credible and reliable, as they have undergone rigorous evaluation by qualified peers. Moreover, researchers should welcome constructive feedback from peers and collaborators, using it to improve the robustness and validity of their research.

Effective communication: Traditional research methodology curricula emphasise the importance of clear and effective communication of research findings. Students learn to draft research proposals, academic papers, and reports, enhancing their ability to disseminate knowledge

within the scholarly community. Amidst increasing disinformation globally, the skills to present and defend research findings on written, social or scientific platforms has become a key competency requirement among researchers and scientists.

9.5 Research in the developing context

Basic research, also known as fundamental or pure research, forms the bedrock of scientific inquiry, aiming to expand our understanding of the natural world without immediate practical applications in mind. While basic research has contributed immensely to scientific advancements, it is not without its shortfalls. This section explores some of the inherent challenges and limitations associated with basic research, shedding light on the complexities researchers face in their pursuit of foundational knowledge (Bentley, Gulbrandsen & Kyvik, 2015).

Research projects can be resource-intensive in terms of time, money, and manpower. The exploration of fundamental questions may require long-term commitments, sophisticated equipment, and specialised expertise. As a result, research initiatives often face challenges in securing sustained funding and maintaining the momentum necessary for successful completion. Basic research may therefore face challenges in competing for funding when compared to applied or translational research, limiting the opportunities for scientists to explore fundamental questions that may not yield immediate benefits. A primary disadvantage of research that is basic in nature, is its lack of immediate practical application. Basic research often engages theoretical aspects that may not have direct, real-world applications in the short term. The nature of basic research involves exploring the unknown, and as such, outcomes can be uncertain. Researchers may invest substantial time and resources without a guarantee of discovering groundbreaking insights. This unpredictability can make it difficult to

justify the allocation of resources, especially in contexts where immediate and tangible results are prioritised. One of the disadvantages of superimposing a Eurocentric approach to research in the developing milieu is that basic research findings are often communicated in technical language. As such the broader public, policymakers, and scientists from other disciplines often have trouble comprehending the significance and application of the research. This communication barrier can hinder the translation of basic research into practical applications and limit its impact on society.

9.6 Applied research: Translating theoretical knowledge into actionable strategies

As a country, South Africa faces a range of social and economic challenges that demand targeted and practical solutions (Muller, 2021). Although there are arguments to contradict the clear distinction between basic and applied research (Gulbrandsen & Kyvik, 2010), it is assumed that applied research plays a vital role in translating theoretical knowledge into actionable strategies. By addressing these challenges through applied research, South Africa can work towards building a more equitable, resilient, and sustainable society.

Collaboration between researchers, policymakers, and communities is essential to ensure that the findings of applied research are implemented effectively to bring about positive social and economic change. A few current-day national challenges that would benefit from applied research include access to quality healthcare and education, novel and alternative service delivery, climate change and sustainability, and socio-political solutions. Applied research can, for example, contribute by evaluating healthcare delivery models, assessing the impact of interventions, and proposing innovations to improve access, especially in rural areas. Disparities in the education system, including

unequal access to quality education and limited educational resources, contribute to social inequality. Applied research can propose innovative teaching methods, technology integration, and policies that enhance educational opportunities and outcomes for all. In addition to the mentioned challenges, South Africa grapples with high crime rates, affecting both personal safety and economic stability. Applied research can inform evidence-based crime- prevention strategies, community-policing models, and interventions that address the root causes of criminal behaviour.

High levels of unemployment, particularly among the youth, is another significant challenge in South Africa. Research outcomes that focus on identifying sectors with growth potential, developing skills training programs, and supporting entrepreneurship to create sustainable employment opportunities are highly sought-after. Persistent economic and social inequality is another pressing issue in South Africa where applied research can explore policies and interventions that promote inclusive economic growth, address disparities in education and healthcare, and create pathways for marginalised communities to participate in the economy.

9.7 South African perspectives

In South Africa, doctoral pedagogy lends itself to flexibility, with a variety of models of 'teaching' or supervision. This may vary between the apprenticeship and the cohort supervision models. Currently, 23 of the 26 public universities and five private higher education institutions in South Africa offer doctoral degree programmes (CHE, 2022). The public universities are classified as being traditional (mainly research-intensive), comprehensive (a combination of a traditional university and one or more UoT), or universities of technology (former Technikons) (CHE, 2016). Cloete *et al*. (2016) argue that the traditional university

sector makes the largest contribution to doctoral student outputs. These universities have the advantage of a longer history, an existing research reputation; thus an advantage to access and compete for funding, specifically based on the research outputs (CHE, 2016).

Traditional universities are known for their focus on academic research and exploring theories in a wide range of disciplines This includes philosophy, literature, and sciences. In addition, these universities have a long history and evidence of the research track record, locally and internationally. They provide students with strong academic networks and potential global connections. The existing footprint in the higher education landscape provided them with a historical reputation of adequate supervisory capacity (Cloete *et al*., 2016). The South African CHE has benchmarked postgraduate research outcomes on the masters level, in principle as demonstrating competency and mastery of the research methodological process, while the outcomes on a doctoral level are defined as a new contribution to science. This specification paves the way for a differentiation between cognitive levels of argument, rather than volume or repetition. One therefore assumes that the bulk of responsibility and expectation of novel innovations and concepts that bring about the implementation of findings resides at the doctoral level. Guided by the revised Higher Education Qualifications Sub-framework (DHET, 2014). two types of doctoral degrees are supported. Both on level ten, the first is the doctoral degree with the focus on the preparation for the academic career and research, either discipline-based or multi-disciplinary (PhD). The other is the professional doctoral degree, which is career oriented. This qualification has a professional or career-oriented context and typically integrates theory and practice through the application of theory context (e.g. Doctor of Pharmacy).

Given the diversity in the higher education landscape, the conundrum that a potential doctoral graduate must deal with is whether to pursue doctoral studies at a university or a UoT. At the heart of this debate is the initial or historical differentiation of the higher education landscape in South Africa, specifically after announcing the mergers. No longer was the differentiation linked to indicators such as the advantaged and previously disadvantaged. Additional indicators were applied, such as institutions with a research function and those established with a different purpose. Technikons (now universities of technology) fell within the latter category (CHE, 2016). This 'classification' had several implications, such as identity, funding formulas, and teaching and learning practices. Also, consider the historical factor that the Technikon/UoTs purpose was not initially research-focused (Cloete *et al*., 2016). As such, some of the considerations that a potential student might use to choose the appropriate academic home for doctoral studies are linked to the focus of the study, the discipline, the reputation of the university, and the personal preferences and career goals of the doctoral candidate.

In 2020 and 2021 the CHE and the National Research Foundation (NRF) undertook a review to promote and enhance the quality of doctoral offerings at higher education institutions in South Africa. This review took a holistic view of doctoral offerings in South Africa, such as institutional contexts, the purpose of the qualification, funding to support doctoral studies, supervision, assessment, and graduate attributes. Although some institutions and scholars have questioned the standards used in the review, the doctoral review report (2022) highlighted several challenges in doctoral pedagogy. One challenge is the graduate attributes at doctoral level. Previously the Academy of Science of South Africa (ASSAf) and the South African Regional University Association released reports on doctoral education, in 2010 and 2012 respectively. These reports, in addition to the HEQSF (2014)

emphasise that doctoral studies entail more than drafting the thesis. To present the work to the scientific community, writing and communication skills are required. Research results need to be applied, and creatively linked to innovations (Lategan, 2017).

9.7.1. Attributes infused through doctoral pedagogy

Barrie (2006) indicated that the quality of a university's graduates is an indication of the role and purpose of that university. Like the case studies from Australia, this role and purpose remain an institutional rather than a national approach. Many universities in South Africa have adopted the South African Qualifications (SAQA) level descriptors (SAQA, 2012) at levels nine and ten as a benchmark for the knowledge, competencies and attributes that their master's and doctoral levels must attain in the absence of specifically identified attributes at these levels. However, Barrie (2006) highlighted the variety of definitions and attributes in the Australian context. It is therefore not surprising that, based on these required competencies at the doctoral level (level ten), several other authors also reported on the limitations identified in doctoral theses, the difficulties that doctoral students encounter as well as in the competencies that they attain. Cloete *et al*. (2016) emphasised the importance of higher education and specifically doctoral education in preparing future academics as well as high levels of skills for the knowledge economy. In addition, Barnett (2012) reminds the higher education community that the world of work for which graduates must be prepared is uncertain and complex. For this reason, a look at the kind of doctoral graduates, their research outputs and the attributes of these graduates is needed.

As indicated previously, the CHE (2022) reported on the attributes expected of a doctoral candidate. The report highlighted the inconsistent formulation of the graduate attributes across institutions, a lack of knowledge on this topic among students and supervisors, and

insufficient monitoring of these attributes in the absence of assessment criteria and assessment tasks. The CHE report (2022) reminds us that graduate attributes involve knowledge attributes and skills attributes; thus both the knowing and the knowers. The responsibility to reflect on their becoming and being (Green & Lee in Bitzer *et al.*, 2014) must be linked to the graduate's agency and therefore involves a self-assessment. Although not mentioned in these documents, our addition to this pedagogy is the agency of the doctoral student. These expectations align with the South African Qualifications Authority (SAQA) level ten descriptors (SAQA, 2012).

The purpose of SAQA's level descriptors is to guide learning coherence and progression and to facilitate assessment (SAQA, 2012). The philosophical underpinning is applied competence and is based on the outcomes-based theoretical framework. SAQA (2012) explains that applied competence has three elements, namely foundational, practical, and reflexive competence. Practical competence involves intellectual and/or academic skills of knowledge based on the higher-order thinking levels in Bloom's Taxonomy (Bagchi & Sharma, 2014) of analysis, synthesis, and evaluation and includes the concept of operational context. Lastly, reflexive competence emphasises the graduate's autonomy, taking ownership of the research project outcomes and showing agency to pursue the desired attributes. Ten categories are used to describe the applied competencies across each of the ten levels. The ten competencies linked to the ten levels are the scope of knowledge, knowledge literacy, method, and procedure, problem-solving, ethics, and professional practice, accessing, processing, and managing information, producing, and communicating information, context and systems, management of learning, and accountability (SAQA, 2012).

The knowledge attribute is an in-depth knowledge of the scientific field or a specific area. While the CHE (2022) report mentioned the doctoral candidate's ability to interconnect the research topic and other fields within and across the discipline, Trafford and Leshem (2012: 40) refer to the term ‘doctorateness’. Graduates are expected to show evidence of their original contribution to the study field, or discipline. Evidence of achieving this attribute is captured in the innovations in research methodology, the application of theory, and new techniques or practices proposed (Trafford & Leshem, 2012). The last attribute linked to the knowledge attributes is the doctoral candidate’s ethical awareness and professional conduct. Ethical awareness is linked to the research subjects and communities included in the research, as well as research integrity. Plagiarism, data manipulation, and acknowledgement in their publications are linked to research integrity.

The skills attributes refer to how a doctoral candidate selects and applies the appropriate research approach, the ability to work independently, conceptualise, and reflect critically, Communication skills, to show competence at an advanced level, and the ability to share or disseminate the research findings with both expert and non-expert communities. This relates to sharing information verbally and in writing. Critical and analytical thinking and intellectual competence are essential for applying problem-solving skills in diverse contexts, in both familiar and unfamiliar contexts.

9.7.2. Contemporary constructs and explorations

A shortcoming in the doctoral pedagogy and theses is the fact that most of the graduate attributes, except for the writing skills, might not be evident. There is an argument that a viva would be a vehicle for the doctoral candidate to show evidence of the acquired graduate attributes such as verbal communication, critical thinking and problem-solving. Although the viva has been implemented at some of the traditional

universities, there is a current drive to include such in the assessment policies of all the universities – also based on the CHE doctoral review report (CHE, 2022). Another shortcoming is the ability of the student to evaluate and synthesise the information and to link the findings to enhance current practices or address social responsiveness, showing 'doctorateness' (Trafford & Leshem, 2012).

In this section, doctoral pedagogy initiatives to respond to the recommendations in the CHE review report (2022), to align with the graduates' limitations mentioned and enhance their cognitive progression, and link to the 'pedagogy-in-action' principles aimed at the UoT landscape, are proposed and discussed. The planned pedagogy proposes a shift and refocuses on the doctoral graduates' scholarly knowledge, and skills. In addition, this pedagogy should encourage graduates to unlock their agency and develop the attitudes, and attributes required, and holistically, they learn to become socially responsive and engage in research with a societal impact. As Green and Lee (1995) (in Bitzer *et al*., 2014:234) eloquently say, 'understanding pedagogy as coming to know and coming to be'.

The one change imperative is responding to the demands for larger numbers of doctoral graduates (Cloete *et al*., 2016; Boughey & McKenna, 2021). The other imperative discussed here, is to reshape, shift, and innovate doctoral pedagogy, to equip the graduates with scholarly knowledge, skills, attitudes, and attributes as an enabler in enhancing their employability (Bagchi & Sharma 2014). Furthermore, Taylor (2023) argues that pedagogy must focus on the graduates' preparation to become a researcher inside academia, but also outside academia. Hoon *et al*. (2021) emphasise the importance of 21st-century skills. These authors highlight attributes such as self-management, critical thinking, flexibility, adaptability, innovation, and creativity.

Tshumu and Bitzer (2023) advocate for initiatives to promote doctoral attributes and at the same time shorten doctoral completion times.

Cloete *et al*. (2016) share student preparedness to conduct and complete the doctoral journey in a minimum stretch of time. Students experience a range of difficulties such as conceptualising the project, constructing a theoretical framework, supporting the methodology, synthesising findings, creating coherent responses in line with the problem statement, demonstrating self-discipline, and being able to communicate in writing. Hoon, Narayanan and Abdullah (2021) add the graduates' difficulty in constructing theoretical frameworks. As such, Cloete *et al*. (2016) ascribe this challenge, as well as the difficulties with writing and conceptualisation, to the graduates' lack of prior reading, not being in command of their field, not being familiar with the current academic debates, and a lack of academic rigour. Wellington (2010) refers to the barriers in writing and mentions that the reading limitations result in graduates being familiar with the academic writing styles and rules of academic writing. In addition, graduates then struggle to interpret the supervisors' feedback and constructive critique to adjust their writing.

There are external complexities to consider in proposing the desired doctoral pedagogy. As such, Taylor (2023) and Boughey and McKenna (2021) remind us of the diversity of the student population brought by massification, internationalisation, and the demand for larger numbers of graduates. As such, we must bear in mind that larger numbers of students study part-time and as such, have additional responsibilities, such as family and work. Several authors support initiatives such as interdisciplinary collaboration. It is argued that through interdisciplinary research projects, graduates learn to engage with diverse methodologies and different perspectives. As such, doctoral graduates learn to collaborate with different departments, including industry and

so broaden their problem-solving approaches in academia and beyond. Socratic seminars, regular workshop sessions, colloquia, and critical review sessions at regular intervals in the doctoral journey provide an opportunity for doctoral students to collaborate, present their work, engage in discussions, and challenge each other's viewpoints, arguments, and assumptions. At these events, graduates are sensitised to the importance of evidence-based reasoning and dialogue (Tshuma & Bitzer, 2023). During these sessions, students analyse, critique, and review each other's work and opinions and foster a culture of constructive feedback, almost as a community of practice. In addition to the scientific knowledge, Tshuma and Bitzer (2023) maintain that these sessions are important to promote the doctoral attributes and are reflected in the activities in which t doctoral graduates engage. McKenna and van Schalkwyk (2023) also promote the collaborative and structured approach in doctoral pedagogy. They argue that the nurturing space and community create mutual support and this action increases the doctoral graduates' commitment and accountability. These authors maintain that doctoral graduates develop a larger range of skills when they work together. A culture of collegiality, creativity, and supportive criticality is created, and graduates are better equipped to engage in critical discussions. In this environment, peers and supervisors appraise their work.

Sykes and Azfar (2019) align the development of doctoral attributes, such as critical thinking and questioning, and abstract thinking skills to the higher-order levels of Bloom's taxonomy or framework. The ideal doctoral pedagogy must facilitate creativity – the ability to think beyond, identify gaps in the current knowledge, foster curiosity, and contribute to the current academic debate - through discussions, feedback, and collaborative projects. Carragher and Brereton (2022) support a journal club to develop deep learning approaches and engage doctoral graduates in analysis and conceptual skills. Through the journal club

activities, critical thinking is scaffolded. Linked to Bloom's Taxonomy, activities are specifically related to the level to apply, as well as the higher-order levels to analyse, evaluate and create. Reflective practice, such as journal clubs encourages self-assessment. They learn to document their learning experiences, the challenges, insights gained, and strategies developed for improvement. And so, graduates gain the attribute of becoming resilient.

El Gaidi (in Bitzer *et al*., 2014) emphasises developing scientific knowledge, skills, and attributes. The doctoral graduates' ability to contribute to the academic debate, the knowledge attributes, and specialised knowledge in the field – and skills and attributes to work independently and think critically and analyse is also in line with the SAQA level descriptors (SAQA, 2012). Skills and attributes such as critical thinking, creativity, and critical judgement are developed through design-based research strategies. Graduates learn to identify shortcomings in their work and how to propose improvements. Through design-based research strategies, graduates learn to systematically analyse information to solve complex real-world problems with evidence-based solutions (Goff & Getenet, 2017). As such they learn to be socially responsive by using these principles to identify research activities beyond the present study.

Doctoral graduates writing and language competencies and skills benefit from visiting the writing centre and attending focused writing sessions (Cloete *et al*., 2016). Wellington (2010) adds that doctoral graduates' writing benefits most from a group approach. In addition to the writing sessions, actions such as formative feedback have the intention to develop the doctoral graduate agency and attitude and will develop writing skills. New developments such as Chat GPT and artificial intelligence (AI) have revolutionised the higher education environment. Infusing doctoral pedagogy with Chat GPT and AI offers numerous

benefits and could bring about innovative and transformative changes in the way doctoral education is delivered (Verma & Rawat, 2023). As such, ethical considerations, data privacy, and ensuring a balance with human interaction should be carefully addressed. Added to this, ongoing training both for educators and students will be essential to make the most of these technologies and/or tools.

The doctoral student can use Chat GPT and AI to generate feedback on their work, answer questions; thus enhance the learning experiences. When used appropriately, these tools can guide the doctoral graduate in formulating the research question, and assist in the literature review, data analysis, and research design. It is however important that the doctoral graduate must have a thorough knowledge of their field, to view the information generated with the relevant criticality. We previously mentioned the importance of collaboration. Chat GPT, AI and social media make it possible for a doctoral graduate to collaborate virtually and share ideas globally (Wang, Reis-Jorge, Crosta, Edwards & Mudaliar, 2018). By doing so, the research environment becomes dynamic and inclusive. Communication difficulties and limitations could be addressed as Chat GPT offers language support and an opportunity to develop academic writing and communication skills. For this reason, doctoral graduates might not only have to rely on the writing centre's support for language corrections, sentence constructions, and improvements. Sharing their work with the communities of practice may therefore become easier. Doctoral graduates can also use these tools to assist in giving feedback to their peers.

Two additional attributes are relevant here, namely critical thinking skills and ethical behaviour. Chat GPT could potentially increase the supervision capacity and assist the supervisor in engaging the doctoral graduates in critical thinking exercises, challenging students with thought-provoking questions and scenarios. This promotes deeper

reflection and enhances the development of critical thinking skills; thus aligning their learning with the higher-order Bloom's taxonomy. Since funding to attend conferences, specifically internationally, has become a challenge, doctoral graduates could be exposed to such an environment, albeit simulated, by creating a virtual conference platform. However, it is essential to emphasise the ethical use of these tools. Being transparent and discussing the ethical implications of AI in research, ensures doctoral students are aware of responsible AI use in their work. However, at the heart of innovative and transformative practices at the doctoral level, being socially responsive, and being an active and responsible citizen, is the doctoral student's agency.

9.8 Creativity and innovation

Creativity is a key competency to enable innovation and application. Creativity enables various outcomes that realise the transfer of research findings in innovative applications. Innovation often involves finding new solutions to existing problems or addressing emerging challenges. Creativity allows individuals and teams to think creatively, explore unconventional ideas, and come up with novel approaches to tackle these problems effectively. Creativity is also essential for generating a wide range of ideas. In the process of innovation, there is a need to brainstorm and explore various possibilities. Creative thinking enables individuals to produce diverse ideas, which can then be evaluated and refined to identify the most promising ones (Vergara & Serna Rodriguez, 2019).

In competitive environments, innovation helps organisations stand out from the crowd. Creativity allows for the development of unique products, services, or processes that differentiate a company from its competitors. This uniqueness can be a key driver of success in the market. In today's fast-paced world, change is constant. Creative

thinking enables individuals and organisations to adapt to change more effectively by exploring new ways of doing things, anticipating future trends, and proactively innovating to stay ahead. Innovation is not simply about radical breakthroughs; it also involves incremental improvements. Creativity plays a crucial role in identifying opportunities for enhancement and innovation in existing products, processes, or services, leading to continuous improvement over time. Creativity has the power to inspire others and foster a culture of innovation within organisations. When individuals see creativity being valued and rewarded, they are more likely to feel motivated to contribute their innovative ideas and initiatives. Many of the challenges we face today are complex and multifaceted. Creativity allows for the exploration of interconnected issues from different angles, leading to more holistic and effective solutions.

9.8.1. Traits and attributes of creativity

Both innovation and creativity are complex and multifaceted traits and can manifest in various forms. While there isn't a one-size-fits-all formula for creativity, certain skills and attributes tend to be associated with fostering a creative mindset (Fetrati & Nielsen, 2018). Creativity is a skill that can be developed and enhanced over time. It also is a highly individual and personal trait; so, what works for one person may not work the same way for another. Embracing a combination of these skills and continually cultivating a creative mindset can contribute to fostering creativity in various aspects of life.

Creative individuals are typically open to new ideas and perspectives. They are willing to consider unconventional or unorthodox solutions to problems. A curious mind drives exploration and the desire to learn, and creative people tend to ask questions, seek information, and have a natural curiosity about the world around them. Creative thinkers are adaptable and can adjust their thinking and approach when faced with

new information or challenges. They are not rigid in their ways and are open to change. The ability to imagine and visualise possibilities is crucial for creativity. This involves thinking beyond the obvious and envisioning novel concepts or solutions. Creativity often involves finding innovative solutions to problems. Being able to approach challenges with a problem-solving mindset is a key aspect of creativity. Creativity often requires stepping outside of one's comfort zone and taking risks. This can involve trying new things, experimenting with ideas, and not being afraid of failure.

Creative endeavours often face setbacks and challenges; hence persistence and resilience are essential for overcoming obstacles and continuing to pursue creative goals. Effectively expressing and communicating ideas is crucial for creativity. Whether through writing, speaking, or other forms of expression, being able to convey thoughts and concepts is vital. Collaboration is an important outcome of effective communication, with creative individuals often benefiting from collaboration and teamwork. Sharing ideas with others, receiving feedback, and working collectively can lead to more innovative outcomes. Paying attention to details and being observant of the world around you can inspire creative ideas. Noticing patterns, connections, and anomalies can spark new thoughts and insights. Balancing creativity with productivity requires effective time management. Creative projects often involve a combination of inspiration and discipline. The ability to shift between different modes of thinking and consider multiple perspectives is important for creativity. This cognitive flexibility allows for a more comprehensive approach to problem-solving.

Many of the traits and attributes referred to are prevalent among developing societies due to the demand to survive in under-resourced environments. However, traditional, and Eurocentric pedagogies have through recent centuries advanced the idea of specialisation and

uniqueness. This was a result of westernised educational institutions not having to collaborate, or negotiate resources, to achieve results but simply having the benefit of delegation. In the developing context, and responding to the decolonisation narrative, the time has come to appreciate and explore the variety of traits and attributes inherent in our students and scientists (Weiner, 1997). We previously emphasised that applied research and innovative pedagogies play a crucial role in translating theoretical knowledge into practical solutions that address real-world problems. However, the effectiveness of applied research outcomes heavily relies on the cognitive progression of researchers and ideally, the doctoral graduates.

9.9 Stepwise cognitive progression: A contemporary approach

The content of the current chapter thus far is intended as a backdrop for the prototype described in the next section (see Table 1). The dichotomy with the proposed methodology lies in the fact that one should endeavour to instil skills and competencies in doctoral graduates to enable tangible outcomes. The stepwise cognitive progression model that is presented below, has therefor been conceptualised through the Stanford design thinking methodology. Cognitive progression refers to the continuous advancement of knowledge, skills, and cognitive abilities among researchers, which in turn enhances the quality and relevance of their work.

9.9.1. Cognitive progression and knowledge acquisition

The cognitive progression begins with the acquisition of foundational knowledge. According to Piaget's theory of cognitive development (Thompson, 2019), individuals progress through stages of cognitive

development, each characterised by distinct ways of understanding the world. In the context of applied research, researchers need to acquire a solid understanding of theoretical frameworks, methodologies, and empirical evidence relevant to their field of study. This foundational knowledge serves as the basis for conducting meaningful research and generating innovative solutions. For instance, in the field of public health, researchers need to understand epidemiological principles, statistical methods, and health behavioural theories to design and implement interventions aimed at improving population health outcomes effectively (Glanz, Rimer & Viswanath, 2015). Without a strong foundation in these areas, researchers might struggle to develop evidence-based interventions that have a measurable impact on health outcomes.

9.9.2. Cognitive progression and analytical competency

In addition to knowledge acquisition, cognitive progression involves the development of analytical skills necessary for critically evaluating information, identifying patterns, and making informed decisions. Researchers must be able to apply analytical thinking to interpret research findings, assess the validity of conclusions, and identify potential limitations or biases in study designs. Critical thinking, a key component of analytical skills, enables researchers and doctoral students to question assumptions, consider alternative explanations, and draw logical conclusions (Vergara & Serna Rodriguez, 2019). By continuously refining their analytical skills, researchers and doctoral students enhance their ability to generate novel insights and solutions to complex problems (Baptista, 2015). For example, in the field of environmental science, researchers employ various analytical techniques to assess the impact of human activities on ecosystems and develop strategies for sustainable resource management (Levin, 2006).

Through cognitive progression, researchers refine their analytical skills, enabling them to conduct rigorous analyses and produce reliable evidence to inform policy decisions and conservation efforts.

9.9.3. Cognitive progression and creativity

Creativity is yet another essential aspect of cognitive progression that facilitates innovation and problem-solving in applied research. Creativity involves the generation of novel ideas, approaches, and solutions that depart from conventional thinking (Sternberg & Lubart, 1999). In the context of applied research, creativity enables researchers to develop original interventions, methodologies, or technologies that address unmet needs or challenges in society. For instance, in the field of engineering, researchers often rely on creative thinking to design new technologies or improve existing ones (Sawyer, 2012). By fostering cognitive progression, researchers can cultivate creativity through exposure to diverse perspectives, collaboration with experts from different disciplines, and experimentation with unconventional approaches.

9.9.4. Cognitive progression and adaptability

Cognitive progression entails the ability to adapt to new information, technologies, and methodologies. The pace of scientific advancement is rapid, and researchers need to continuously update their knowledge and skills to stay relevant in their field. This adaptability is particularly crucial in applied research, where emerging trends, technologies, and societal needs constantly reshape research priorities and methodologies. For example, advancements in digital technologies have revolutionised data collection, analysis, and dissemination in various fields, such as healthcare, education, and environmental science (Topol, 2019). Researchers who embrace these technologies and adapt their

research practices accordingly are better positioned to produce timely and impactful outcomes that address contemporary challenges.

9.9.5. Design enablers

The previous sections of this chapter serve as a backdrop informing the 'empathise' and 'define' components of the Stanford model of design thinking (Auernhammer and & Roth, 2021.), whereas this section, introduces the concepts related to 'ideation' (Figure 9.1).

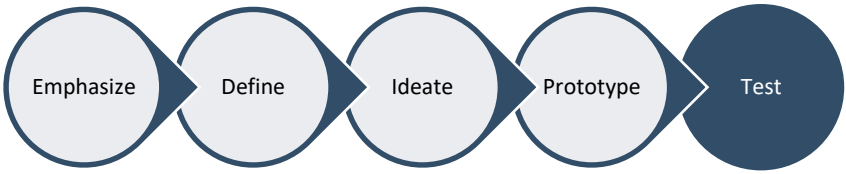

Figure 9.1: The Stanford design thinking process (adapted from Auernhammer and Roth, 2021)

Table 9.1 below relates to the 'prototype' component to inform a practical model or formula to assist with the interpretation and implementation of the data and findings generated through research. Although the blueprint proposed below focuses on data processing, interpretation, and application, similar steps may likely be utilised to inform the remaining components of the research and innovation value chain. The chronology to utilise the proposed model (indicated by the arrows) is essential for its effective application, as the suggested cognitive verbs can be considered a brick wall for instance, where the lower levels are required before engaging the next.

The chronology aspect of the proposed formula is also vital to prevent the compilation and reporting of large volumes of data without in-depth engagement of the actual findings. This phenomenon, which is often

incorrectly considered as having merit because of the perceived volume of work of a doctorate compared with a master's, should largely be addressed if the stepwise formula is strictly followed. Another predicament that also often emerges in especially doctoral research, is that the descriptive and inferential statistics that are required to provide a clear picture of the study outcomes are often under-represented when compared with the volume of empirical data collected. Strictly following the 'explain' element, with its sub-verbs, should largely mitigate this.

Table 9.1: A stepwise cognitive progression model to facilitate the flow of thoughts and arguments to enable maximum utilisation of empirical data and its culmination into tangible outcomes (adapted from Bagchi & Sharma, 2014)

Step	Ele-ment	Verb level 1	Verb level 2
1	Explain	Visualise	Generate, create, calculate, augment, repeat, expand
		Organise	Analyse, separate, group, optimise, categorise, arrange, order, articulate
		Summarise	Delineate, simplify, prioritise, select, restrict, omit, flow
2	Discuss	Elaborate	Differentiate, classify, distinguish, identify, verify, assess
		Comprehend	Synthesise, compare, integrate, understand, realise, ideate, innovate
		Evaluate	Appraise, judge, value, critique, contradict, discriminate, dispute, defend, challenge
3	Conclude	Recapitulate	Acknowledge, focus, prioritise, outline, recap, revisit, reconsider, reiterate
		Apply	Solve, align, extrapolate, relate, execute, perform, amend, improve, adjust, fix, establish, ideate, test
		Recommend	Inform, present, suggest, propose, establish, promote, endorse, facilitate, collaborate, prospect, advise

Challenge-oriented approaches

One of the cognitive verb elements included in Table 1 that may justify additional deliberation is 'challenge', which resorts under the 'evaluate' verb level 1, and the 'discuss' element. This terminology links with the broader concept of problem-based and, more recently phrased 'challenge'-oriented learning. This component extends the candidates' cognitive approach not only to their thinking and inward reflection, but also provides opportunities to engage with peers, experts, and mentors.

Challenging the outcomes and thought patterns by proposing alternatives and viewpoints that test the status quo and invite considerations that may advance the horizons' of existing knowledge, is a strong catalyst for solving problems and responding to challenges. Such challenges are not only articulated by peers and mentors but are also posed by our current societal demands and needs.

Formative assessment

Also described in section 9.7, the essential component of formative assessment, is constructive formative feedback using scaffolded learning opportunities. Through scaffolded learning opportunities, doctoral students could be guided and supported in their learning and research journey. By scaffolding the activities as manageable sections, doctoral students are empowered to manage tasks, grasp ideas, and reflect on solutions. In addition, doctoral students will be enabled to take responsibility and implement new and innovative ideas (Friedrich-Nel & Mac Kinnon, 2015).

Peer participation

Peer participation is mentioned as an innovative pedagogy at doctoral level. Authors such as McKenna and van Schalkwyk (2023) and Tshuma and Bitzer (2023) emphasise the relevance of exposing students to collaborative learning activities and opportunities, specifically to

encourage deep learning. In activities such as journal club, colloquia, and student presentations, doctoral students learn to analyse, critique, evaluate, and review other's work. In addition to this, students learn to give constructive feedback, as well as to interpret such feedback.

9.10 Conclusion

The doctoral curriculum is a specialized educational framework designed to cultivate advanced expertise and original contributions in a particular field of study. Within this framework, certain forms of knowledge and types of knowers are both legitimated and valorised, reflecting the norms and values of the academic community. At its heart, the doctoral curriculum legitimates knowledge that is original, rigorous, and methodologically sound. This knowledge is often characterized by its contribution to the field's existing body of research, advancing theoretical understanding or practical applications. Doctoral programs emphasize the creation of new knowledge, rather than merely reproducing or summarizing existing literature. This emphasis requires candidates to engage deeply with their chosen subject, conduct extensive research, and generate findings that push the boundaries of current understanding. As such, the curriculum upholds knowledge that is both innovative and supported by robust empirical or theoretical evidence. Ultimately, the doctoral curriculum legitimates knowledge that is original, methodologically rigorous, and theoretically significant, while valuing knowers who exhibit deep expertise and scholarly integrity. This framework shapes the production of advanced research and the development of academic professionals, guiding them to contribute meaningfully to their fields while adhering to established standards of scholarly practice.

Pursuing doctoral research is a formidable journey marked by rigorous research, intellectual growth, and academic achievement. However, for students in developing countries, studying at UoTs or Previously Disadvantaged Institutions, PDIs as they are labelled in South Africa, this journey is often overloaded with unique challenges. From limited resources to institutional constraints, doctoral students face numerous hurdles in producing high-quality, applied research outputs. This chapter explores these challenges and suggests strategies to empower them for impactful scholarly contributions. Access to resources such as libraries, laboratories, and academic databases is often limited in developing countries. This impedes the ability of doctoral students to conduct comprehensive literature reviews and access innovative research tools. Related to resource challenges, financial constraints pose a significant barrier to research in developing countries. Doctoral students often struggle to secure funding for their studies, research materials, conference attendance, and publication fees. Inadequate infrastructure, including unreliable internet connectivity and outdated research facilities, hampers the progress of doctoral research projects in developing countries. This affects data collection, analysis, and dissemination efforts. Governments and academic institutions need to prioritise investment in research infrastructure, including modern laboratories, well-equipped libraries, and access to online databases. This will provide doctoral students with the necessary tools to conduct robust research. Scholarships, grants, and research funding programs should be expanded to support doctoral students in developing countries. Moreover, initiatives to waive publication fees and conference expenses can alleviate financial burdens and facilitate greater participation in academic discourse.

Many doctoral students in developing countries face a dearth of experienced supervisors or promotors and academic support systems. The absence of guidance and constructive feedback hinders their

research progress and academic development. Publishing in reputable academic journals is crucial for doctoral students to disseminate their findings and establish credibility in their field. However, students in developing countries often encounter barriers such as language barriers, unfamiliarity with publishing norms, and a lack of access to prestigious journals. Academic institutions should establish mentorship programs pairing doctoral students with experienced researchers or faculty members. Mentorship can provide valuable guidance, support, and networking opportunities, fostering the professional growth of students. Workshops and training sessions on research methodologies, academic writing, and publication strategies can equip doctoral students with essential skills for producing high-quality research outputs. These workshops should be tailored to address the specific needs and challenges faced by students in developing countries. Encouraging interdisciplinary collaboration and partnerships between institutions, both domestically and internationally, can enrich the research environment for doctoral students. Collaborative projects offer access to diverse expertise, resources, and perspectives, enhancing the quality and impact of research outputs.

All the above-mentioned initiatives, irrespective of their intent, still serve as enablers, rather than motivators and competencies. The fulfilment that a master's or doctoral candidate experiences, after hours of tough studying and laboratory work, presented by a discovery that stretches the horizons of the imagination, and promises tangible contributions to society, is incomparable. The satisfaction derived from solving a complex problem is unparalleled, akin to conquering a formidable mountain peak after a strenuous ascent. It is a euphoric blend of relief, accomplishment, and intellectual fulfilment that resonates deeply within. With each hurdle overcome and every puzzle piece fitting into place, a sense of agency, empowerment, and mastery washes over the mind.

The journey through the labyrinth of challenges, uncertainties, and setbacks transforms into a testament to perseverance, resilience, and ingenuity. Whether it is unravelling a perplexing mathematical theorem, devising an innovative solution to a real-world problem, or navigating through intricate logical puzzles, the moment of clarity and resolution ignites a spark of triumph that fuels the spirit and reinforces the belief in one's capabilities. In that moment, amidst the exhilaration of triumph, lies the sweet satisfaction of knowing that one has not only solved a problem but has also expanded the boundaries of knowledge and possibility. Also, the social responsiveness of the research outcomes may be an additional sweet spot. It is anticipated that the strategies, concepts, and mechanisms presented in this chapter, will contribute to achieving exactly that.

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