“A study of the doctoral pipeline: Time-to-degree in selected disciplines at South African Universities”

by

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Abstract

Over the past decade, there has been a clearly articulated interest, both on a national and institutional level, to identify strategies that would increase the number of doctorate graduates in South Africa. Currently, however, the pipeline leading up to the attainment of a doctoral degree is a long and leaky one. The study set out to explore whether doctoral time-to-degree differs across five academic disciplines at South African public higher education institutions. Using a mixed-methods design, a secondary analysis of the HEMIS student data showed that doctoral graduates in education record the shortest average time-to-degree. Descriptive indicators, such as growth rates of doctoral enrolments and graduates, the pile-up effect and completion rates aided in focusing the hypothesis that the nature of academic disciplines is associated with doctoral completion times.

It was also this study's objective to identify factors which are correlated with a shorter time-to-degree. Using Cross' *chain of response model,* I investigated the role of selected student demographics and contextual institutional, situational and dispositional factors in doctoral time-to-degree. Using a multiple linear regression model, I found that younger age is a predictor of shorter completion times, although it is more pertinent in disciplines such as physics and electrical engineering. Students' mode of enrolment was found to be a predictor of completion times with part-time students recording a statistically significantly longer time-to-degree when compared to full-time students. A student's nationality was also identified as a statistically significant predictor of time-to-degree with international students recording shorter completion times than domestic students. Lastly, I found that the academic discipline is a significant predictor of doctoral time-to-degree.

Examining the role of institutional factors in time-to-degree reported a negative correlation between higher institutional throughput rates and shorter time-to-degree of academic institutions in electrical engineering, but a positive correlation was found for institutions in education, the clinical health sciences, physics and sociology. A survey showed that the immediate degree progression from a master's to a doctoral degree is associated with a shorter time-to-degree. Respondents who were employed full-time during their doctoral studies estimated a longer completion time than those who were not employed, while students who considered discontinuing their studies similarly predicted longer candidacy times. Survey respondents' satisfaction with their doctoral supervision was found to have a correlation with shorter completion times.

Although shorter time-to-degree can be considered an indicator of efficiency, it is imperative to consider wider contextual factors in thinking about the efficiency of doctoral students. It is the recommendation of this study that institutional efforts towards combating student attrition and prolonged candidacy times be tailored for academic disciplines. Additionally, students should be enabled and encouraged to pursue doctoral studies full-time.

A novel contribution of this study is a model predicting factors that explain differences in doctoral time-to-degree which has been widely neglected in the South African context. Through the integrative use of quantitative and qualitative data, this study is one of the most comprehensive studies of doctoral time-to-degree in the South African context.

Opsomming

Daar was die afgelope dekade ’n goed verwoorde belangstelling, op nasionale sowel as op institusionele vlak, om strategieë te identifiseer wat die aantal doktorale gegradueerdes in Suid-Afrika sal vermeerder. Die pyplyn wat tot die verwerwing van ’n doktorsgraad lei, is egter nou nog besonder lank en vol lekplekke. Die doel van hierdie studie is om te bepaal of daar ’n verskil is in die doktorale tyd-tot-graad in vyf akademiese dissiplines by Suid-Afrikaanse openbare inrigtings vir hoër onderwys. Die meting van doktorale tyd-tot-graad dien as ’n doeltreffendheidsaanwyser om die pad na ’n doktorsgraad te beskryf. Doktorale onderwys is egter nie monolities nie en daar bestaan dissiplinêre verskille in tydige voltooiing. Met behulp van ’n gemengde-metodesontwerp het ’n sekondêre analise van die HEMIS-studentedata getoon dat doktorale gegradueerdes in die onderwys die kortste gemiddelde tyd-tot-graad het. Beskrywende aanwysers, soos die groeikoers in doktorale inskrywings en gegradueerdes, die ophopingseffek en voltooiingsyfers, het gehelp om die hipotese te vestig dat die aard van akademiese dissiplines verbind kan word met doktorale voltooiingstye.

Die doel van hierdie studie was ook om faktore te identifiseer wat korreleer met ’n korter tyd-tot-graad. Met Cross se *ketting van responsmodel* het ek die rol ondersoek van uitgesoekte studentedemografieë en kontekstuele institusionele, situasionele en disposisionele faktore in doktorale tyd-tot-graad. Deur ’n meervoudige lineêre regressiemodel te gebruik, het ek bevind dat ’n jonger ouderdom ’n aanwyser is van korter voltooiingstye, hoewel dit meer relevant is in dissiplines soos fisika en elektriese ingenieurswese. Daar is bevind dat studente se inskrywingswyse ’n deurslaggewende aanwyser kan wees vir voltooiingstye, met deeltydse studente wat statisties ’n aansienlik langer tyd-tot-graad benodig as voltydse studente. ’n Student se nasionaliteit is ook geïdentifiseer as ’n statisties beduidende aanwyser van tyd-tot-graad, met internasionale studente wat korter voltooiingstye as plaaslike studente het. Laastens het ek bevind dat die akademiese dissipline ’n belangrike aanwyser van doktorale tyd-tot-graad is.

Die ondersoek na die rol van institusionele faktore in tyd-tot-graad het ’n negatiewe korrelasie getoon tussen hoër institusionele deursetkoerse en ’n korter tyd-tot-graad by akademiese instellings in elektriese ingenieurswese, maar ’n positiewe korrelasie is gevind vir instellings in die onderwys, kliniese gesondheidswetenskappe, fisika en sosiologie. ’n Opname het getoon dat die onmiddellike vordering van ’n meestersgraad na ’n doktorsgraad verband hou met ’n korter tyd-tot-graad. Respondente met voltydse beroepe het langer geneem om hulle studies te voltooi as dié wat nie in ’n voltydse beroep was nie, terwyl studente wat oorweeg het om hulle studies te beëindig, eweneens

langer studeer het. Dit is bevind dat respondente wat aan die peiling deelgeneem het se tevredenheid met hulle doktorale toesig korreleer met korter voltooiingstye.

Alhoewel korter tyd-tot-graad beskou kan word as ’n aanwyser van doeltreffendheid, is dit noodsaaklik om breër kontekstuele faktore te oorweeg wanneer doktorale studente se doeltreffendheid oorweeg word. Dit is die aanbeveling van hierdie studie dat institusionele pogings om ’n afname in studente en lang studietye te voorkom, aangepas behoort te word vir akademiese dissiplines. Studente behoort ook in staat gestel en bemagtig te word om hulle doktorale studies voltyds te doen.

’n Belangrike nuwe bydrae van hierdie studie is ’n model waarmee faktore voorspel word wat die verskille in doktorale tyd-tot-graad verduidelik. Só ’n model word oor die algemeen afgeskeep in die Suid-Afrikaanse konteks. Die integrerende gebruik van kwantitatiewe en kwalitatiewe data maak van hierdie studie een van die mees omvattende studies van doktorale tyd-tot-graad in die Suid-Afrikaanse konteks.

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AAG	Annual average growth
AIC	African, Indian/Asian and coloured
ARIMA	AutoRegressive Integrated Moving Average
ASSAf	South African Academy of Sciences
BCM	Business, commerce and management
CESM	Classification of Education Subject Matter
CGS	Council of Graduate Schools
CHE	Council for Higher Education
CHET	Centre for Higher Education Trust
CMSA	Colleges of Medicine of South Africa
CoE	Centres of Excellence
CPUT	Cape Peninsula University of Technology
CREST	Centre for Research on Evaluation, Science and Technology
CSD	Centre for Science Development
CSIR	Council for Scientific and Industrial Research
DHET	Department of Higher Education and Training
DoE	Department of Education
DoH	Department of Health
DRI	Dental Research Institute
DST	Department of Science and Technology
ECD	Early Childhood Development
FRD	Foundation for Research Development
FTE	Full-time equivalent
GDP	Gross Domestic Product
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institution
HEMIS	Higher Education Management Information Systems

HEQSF	Higher Education Qualification Sub-Framework
HESA	Higher Education South Africa
HPCSA	Health Professions Council of South Africa
HRC	Hanover Research Council
HSRC	Human Sciences Research Council
NCHE	National Commission on Higher Education
NDP	National Development Plan
NMU	Nelson Mandela University
NPHE	National Plan for Higher Education
NPRL	National Physical Research Laboratory
NRF	National Research Foundation
NSF	National Science Foundation
NWU	North-West University
OECD	Organisation for Economic Co-operation and Development
POPI	Protection of Personal Information
PSET	Post-School Education and Training
RoA	Rest of Africa
RoW	Rest of the World
RU	Rhodes University
SAAAS	South African Association for the Advancement of Science
SAIP	South African Institute of Physics
SARChi	South African Research Chairs Initiatives
SCISTIP	DST/NRF Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy
SED	Survey of Earned Doctorates
StatsSA	Statistics South Africa
STEM	Science, Technology, Engineering and Mathematical
THRiP	Technology and Human Resources for Industry Programme
TTD	Time-to-degree
TUT	Tshwane University of Technology

UFH	University of Fort Hare
UFS	University of Free State
UJ	University of Johannesburg
UK	United Kingdom
UKZN	University of Kwazulu-Natal
UNISA	University of South Africa
UNIVEN	University of Venda
UP	University of Pretoria
UL	University of Limpopo
UNIZULU	University of Zululand
UWC	University of Western Cape
WITS	University of the Witwatersrand
WSU	Walter Sisulu University

Chapter 1 | Introduction

Globally there has been an increase in the production of doctorates (Guerin, Jayatilaka & Ranasinghe, 2015; Kitazawa & Zhou, 2011). South Africa has followed suit in emphasising the need to escalate the number of doctoral graduates. Over the past decade, there has been a clearly articulated interest, both on a national and institutional level, to identify strategies that would increase the number of doctoral graduates while also transforming the pool from which potential graduates are sourced. This initiative is propelled by a concern for the diminishing academic capacity resulting from the gentrification of academia (Mouton, 2017).

Currently, the pipeline leading up to the attainment of a doctoral degree is a leaky one with low progression and completion rates (Cloete, Mouton & Sheppard, 2015). The case is not unique to South Africa as there is a widespread fascination with student success, from, for example, the United Kingdom (UK) (Brooks, 2012; Higher Education Funding Council for England [HEFCE], 2005; 2013), the United States of America (USA)[1], Canada (Elgar, 2003), Australia[2], Norway (Hovdhaugen, Frølich & Aamodt, 2013; Mastekaasa, 2005), New Zealand (Scott, 2005), the Netherlands (Van de Schoot, Yerkes, Mouw & Sonneveld, 2013) and Spain (Lassibille & Navarro Gómez, 2008). With this concern for increased student success is the identification of its barriers and enablers. Many scholars, both internationally and locally, have identified factors that are related to both shorter completion *times* and higher completion (graduation) *rates*. There is a consensus that factors affecting student retention, progression and completion are numerous, complex and interrelated.

Preliminary readings on doctoral success highlighted that there exist differences in timely degree attainment between disciplines. In other words, graduates in some disciplines record shorter times-to-completion than their counterparts in other fields. It was found that there exists a large body of scholarship on the differences between disciplines and the consequential differences in departmental, faculty and cultural *habitus.* Evidence in support of disciplinary differences in degree

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[1] See Bourke, Holbrook, Lovat & Farley (2004a), Bourke, Holbrook, Lovat, Dally, Kiley & Mullins (2004b), Cantwell, Scevak, Bourke & Holbrook (2012), Council of Graduate Schools [CGS] (2010), Crede & Borrego (2013), Gardner (2009a, 2010), Golde (1998), Hoffer & Welch Jr. (2006), Mervis (2005), Pascarella & Terenzini (1983), Sowell (2008) and Tinto (1989; 1993; 2006).
[2] See Carroll, Ng & Birch (2009, 2013), Crosling, Heagney & Thomas (2009), Evans, Macauley, Pearson, Tregenza, (2003), Gale & Parker (2013), Jiranek (2010), Mcmillan (2008), Olsen (2007).

attainment highlights the importance of acknowledging disciplinary differences in studying doctoral education (Baird, 1990; Biglan, 1973b; Gardner, 2009a; 2009b; Neumann & Becher, 2002).

> The doctoral education experience is not monolithic. Doctoral education is experienced differently within and among different disciplines. Disciplines have their own particular qualities, cultures, codes of conduct, values, and distinctive intellectual tasks that ultimately influence the experiences of the faculty, staff, and, most especially, the students within their walls. Therefore, while studies of the undergraduate experience as related to success often occur at the institutional level, the discipline and the department become the central focus of the doctoral experience, rather than the larger institution. (Gardner, 2009a)

The existing scholarship on doctoral education in South Africa, however, is limited to identifying general factors that affect the successful completion of a doctoral degree with very little reference to disciplinary differences (Herman, 2011a; Letseka & Breier, 2005; Letseka & Maile, 2008; Portnoi, 2009; South African Academy of Sciences [ASSAf], 2010). By exploring timely completion of doctoral students within disciplinary fields, this study aims to bridge this gap through an in-depth analysis of the differences between disciplines in South African universities pertaining to doctoral education, and specifically how these differences affect time-to-degree.

In the remainder of this chapter, I discuss the rationale and background of this study. I briefly state the overall aims and objectives of this study as well as the research design and data sources used in the empirical components. I briefly introduce the theoretical and conceptual framework that informed this study. Finally, I give an outline of the remainder of the study where I discuss the contents of each chapter.

1.1 Background and rationale of the study

I discuss the background and rationale for this study in two parts. First, a renewed interest in the expansion of education, in the policy sphere, calls for a focus on efficiency, particularly of doctoral education. Secondly, I discuss some of the unintended consequences of an inefficient system, primarily on an institutional level.

1.1.1 Expanding doctoral education: a policy overview

Over the past ten years, we have seen a new emphasis, on the part of policymakers, on increasing the number of doctoral graduates in South Africa. However, the concern with efficiency dates back to the White Paper on Higher Education (1997) which articulated a need to improve student success through increased student throughput and retention (Department of Education [DoE], 1997; Watson, 2009). The National Plan for Higher Education (NPHE) (2001) echoed this sentiment in calling for a prioritisation of the efficiency of graduate student production (DoE, 2001). More recently, in its Ten-Year Innovation Plan, the Department of Science and Technology (DST) set targets for doctoral production to support and provide for a knowledge-based economy (DST, 2008; Mouton, 2017). The Innovation Plan of 2008 set out to increase doctoral production five-fold during the next ten to 20 years. Similarly, the Consensus report on the PhD, produced by ASSAf, called for "… an escalation of the number of graduates, increased funding for full-time doctoral students, targeting specific institutions with capacity to produce more PhDs and advocating for public support amongst the public for a better understanding of the value of the PhD" (ASSAf, 2010; Mouton, 2017). In 2011, the 2030 Vision of the National Development Plan (NDP) set a target to increase the number of doctoral graduates to a 100 per one million of the population by 2030. This translates to approximately 5 000 graduates in 2030 (NDP, 2011). Of these 5 000 graduates, 3 000 should be in the fields of science, engineering, mathematics and technology (STEM). Additionally, the number of African and female postgraduates, particularly at the doctoral level, should be increased significantly.

The aforementioned objectives form part of a strategy to position South Africa as a leading innovator and to align the doctoral output of South Africa to international standards. At the same time, the aim is to "normalise staff demographics" through transformation and to ameliorate the research and innovation capacity of the country. This is envisioned by a concomitant objective to double the percentage of staff members who hold a doctorate in the higher education sector. The target calls for 75% of higher education personnel to have a PhD. Although not explicitly stated as an objective, the 2030 Vision also calls for efforts to "… establish South Africa as a hub for higher education and training in the region capable of attracting a significant share of the international student population" (NDP, 2011:278). In summary, the 2030 vision calls for a significant growth in doctoral graduates, particularly African and female students, a significant increase in the proportion of university personnel with PhDs, a transformation of human resources within the higher education sector, and to secure South Africa as an attractive option for international students.

The targets outlined in the 2030 Vision of the NDP are ambitious, yet vague. There is little indication of the specific ways in which these targets are to be met. Some of the suggestions include the promotion of university enrolment to facilitate increased participation rates and to promote a differentiated university system which builds on the strengths of individual universities. These suggestions call for institutions to set enrolment and graduate targets at five-year intervals while thinking about "… which type of institution contributes most effectively to which skill level" (NDP, 2011:290).

Cloete, Mouton and Sheppard translate these objectives into the four policy discourses that surround doctoral education today (Cloete, Mouton & Sheppard, 2015; Mouton, 2017). These include growth (increasing doctoral output), efficiency, transformation and quality. The four discourses that constitute the "ecology" of doctoral education are entwined and arguably contradictory. A number of scholars have criticised the 2030 Vision regarding its objectives for higher education and suggested that the unintended consequences of these aims, specifically a rapid increase in doctoral production without a concurrent increase in capacity, are likely to outweigh the benefits (Du Toit, 2012; HESA, 2012; Mouton, 2017).

In expanding doctoral education, the 2030 Vision calls for efforts to address the leaky pipeline. "The current high student drop-out rates highlight the need to focus on improving the quality of teaching and learning support throughout the higher education system" (NDP, 2011:291). Since then, two pertinent studies concerned with student retention and attrition have emerged. The first study, commissioned by the DST in 2013, explored retention, completion and progression rates of *postgraduate* students in South Africa (Mouton et al., 2015). The most recent study, conducted by the Department of Higher Education and Training (DHET) in 2018, reports on the success rates, including throughput rates, of *undergraduate* students in South Africa (DHET, 2018). Both these studies found high drop-out and attrition rates, and low progression rates among both undergraduate and postgraduate students.

In a similar fashion, the PhD Consensus report by ASSAf determined that there exist significant blockages in the road leading to the doctorate. The study found that the pipeline leading up to the doctorate is a leaky one. In 2007, the ratio of matriculants who successfully completed the national senior certificate, to PhD enrolments, were 443:1 (ASSAf, 2010:68). Although the idea of student efficiency has been included in the discourse surrounding higher education for some time, the number of studies on this topic, particularly at a doctoral level, is limited. The majority of studies over the last 15 years focus primarily on identifying barriers towards the desired expansion of higher education (including doctoral education).

1.1.2 A leaky pipeline

Within the South African policy landscape surrounding doctoral education we find an emphasis on increasing both the effectiveness and the efficiency of doctoral production. The former refers to the system's ability to reach the proposed targets of doctoral students, i.e. graduating 5 000 doctorates by 2030. The latter refers to the system's ability to produce these graduates within acceptable timeframes and without high levels of attrition. Why then is it important to measure the efficiency of doctoral production? Universities are under increased pressure to distribute and utilise resources effectively. Funding is competitive and linked to performance indicators and accountability measures (Abiddin & Ismail, 2011). Institutions incur financial losses when student attrition is not managed sufficiently. When students drop out, universities lose investments made in terms of tuition fees, support services, fee revenue, etc. An Australian study conducted by Adams, Banks, Davis and Dickson estimates (at the time of the study) that every 1% drop in attrition would save Australia's public universities almost one billion dollars, or up to AUS $2.6 million per university (Adams et al., 2010). Ampaw and Jaeger also emphasise the high cost of attrition.

> High attrition rates imply that departments must recruit more students each year, and thus lose the experience and knowledge that continuing doctoral students bring to the classroom and research projects. Doctoral students who leave before completing their respective programs also lose their investment of time and money as well as suffer the emotional cost of non-completion. (Ampaw & Jaeger, 2012:641)

The use of concepts such as student attrition and retention are often problematic in that the definition and measurement of the aforementioned varies significantly across countries and institutions. Similarly, the use of these statistics is multifarious. Measuring student success is difficult as the number of observable phenomena is restricted. "In order to enhance retention and student success, colleges and universities are challenged with understanding the process and dynamics of educational attainment. This is especially true given the difficulty of accurately measuring student goals, plans, expectations, and motivations" (Allen, 1999). Student "success" also refers to different goals at different levels of study in that a doctorate moves beyond that of simple degree attainment and requires the development of research, writing and critical thinking skills (Ampaw & Jaeger, 2012; Gardner, 2009a). The concept of student success, Gardner suggests, also differs across academic departments and institutions (Gardner, 2009a).

In the current South African political climate, where there is a call to expand access to tertiary education, the higher education system needs to be efficient. In other words, we need to produce the most number of graduates for the least amount of resources.

> The National Treasury raised the issue of eliminating deadweight losses, arguing that the question is whether, and to what extent, the PSET system produces graduates efficiently ... A key indication of success is the extent to which enrolled students graduate and find gainful employment. Measured against this goal, indicators from South Africa's PSET sectors are demonstrating an inefficient post schooling system. (Marire, 2017:118)

Here, I define efficiency as making optimal use of means, in other words, reducing waste. Put differently, it is the state of attaining the maximum productivity with the least amount of resources spent. Recently, identifying indicators along which to measure the efficiency of higher education in South Africa has gained prominence as a response to the objectives set out by the 2030 Vision. Prolonged enrolment increases the risk of attrition, particularly when the duration of funding instruments and average completion times are not aligned. This shortfall often leads to candidates dropping out since it often forces them to seek alternative sources of funding, which in almost all cases, include some form of employment (Herman, 2011a). In the present study, I then specifically consider doctoral time-to-degree within the broader context of efficiency indicators. It is, however, important to emphasise that in my conceptualisation of efficiency as an indicator, I do not include a discussion on the *qualit*y of graduates produced. In Chapter 12, I briefly refer to the conditions under which both the effectiveness and efficiency of doctoral education should be addressed.

1.1.3 The prominence of disciplinary differences in degree attainment

Preliminary readings revealed that the majority of research on doctoral education focuses on identifying barriers to the expansion of doctoral education with little or no attention given to specific disciplines. Existing studies which have a disciplinary focus often do so within broader disciplinary groupings, such as the social sciences, natural sciences, engineering and technology fields, and so forth. Existing empirical studies provide evidence in support of observable differences in time-to-degree and completion rates among graduates across academic disciplines. It is, therefore, one of the main objectives of this study to consider the nature of a discipline as an important factor within the doctoral experience.

Contained within the nature of a discipline is the rationale or value associated with a doctorate and there are significant disciplinary differences in this regard. Du Toit (2012) suggests that policy imperatives in support of doctoral expansion ought to take these differences into consideration if effective and meaningful progress is to be achieved.

> Current higher education policy imperatives calling for a drastic increase in the overall production of the number of PhDs in South Africa will be dangerously misconceived unless serious prior consideration is given to the nature and function of the PhD degree. A substantial increase in the number of current South African PhDs by research dissertation only will most certainly not satisfy either the urgent needs for upgrading the 'academic' sector itself or the demands of the economy and society for an increased number of advanced graduates with a 'general' knowledge base and transferable intellectual skills. Instead, the most likely consequence of a substantive increase of the number of PhDs based on the current higher degrees structure is both a significant slump in academic standards as well as a probable backlash against the universities from different sectors of the economy and society: a substantial number of the new PhDs will be unable to find appropriate employment while outside institutions will remain frustrated when looking to these PhDs to satisfy their specific and general needs. (Du Toit, 2012)

This sentiment echoes Gardner's cautioning against treating the doctoral candidacy as a monolithic process (Gardner, 2009a). The present study is of the first to explore doctoral education, *vis-à-vis* time-to-degree as an efficiency indicator across specific disciplines in the South African context. Below, I briefly state the research objectives of the study and the methodology used in studying them.

1.2 Research problem and design

The primary objective of the study is to learn about doctoral time-to-degree in five disciplines at South African universities. The selected disciplines include education, electrical engineering, the clinical health sciences, physics and sociology. Additionally, this study sets out to identify factors that are associated with timely completion. Below, I discuss the overall aims of this study which are embedded in three research questions.

1.2.1 Research questions

The research objective statement above translates into three research questions.

1. First, what is the profile of doctoral graduates in the selected disciplines? What are the disciplinary differences, specifically with regard to student demographics, pile-up effect, completion rates and time-to-degree (Chapter 6)?

2. Second, how do different contextual factors relate to doctoral time-to-degree in the selected disciplines? What is the influence of the discipline (Chapter 7), student demographics (Chapter 8), institutional factors (Chapter 9) and student situational and dispositional factors (Chapter 10)?
3. Third, is it possible to predict which factors explain differences in time-to-degree in the selected disciplines (Chapter 11)?

1.2.2 Research design and methodology

The research design of the study is a mixed-methods approach. In calculating the time-to-degree of doctoral students in South Africa, I undertook a secondary analysis of the Higher Education Management Information Systems (HEMIS) student database of all doctoral enrolments and graduates between 2000 and 2016. The DHET provided the HEMIS microdata (both student and staff data), but not all the captured information was made available to the researcher. The number of factors included in the database is limited to student demographics, academic institution and mode of enrolment. Subsequently, it was decided that an electronic survey of the experiences of enrolled doctoral students at South African universities, originally constructed for a project on student retention/attrition, would be included in the study. The survey not only increased the number of factors to be studied, but open-ended survey questions were used in providing qualitative data in contextualising the results from the statistical analysis of the HEMIS data.

The synthesis of the quantitative and qualitative data rendered the design a convergent or concurrent mixed-methods design as the data were collected and analysed side-by-side as an integrated analysis of two data sources (Bergman, 2008; Cresswell, 2014). By combining qualitative and quantitative approaches, the mixed-methods design enabled a more nuanced understanding of the research problem.

A primary objective of the study is to describe doctoral education in five disciplines with the aid of selected indicators. The use of descriptive indicators such as growth rates, pile-up effect, completion rates, throughput rates and supervisory capacity is useful in formulating hypotheses about doctoral time-to-degree. Theoretical frameworks and findings of existing empirical studies, particularly on the relationship of the nature of the discipline on doctoral completion, guided the quantitative analysis of the study. I argue throughout the study that reducing the complexities of doctoral education to a number of indicators could compromise an accurate and contextualised interpretation of the experiences of students. However, the integrative use of both the quantitative and qualitative data enabled a more comprehensive analysis of doctoral students' experiences regard to enablers and barriers towards timely completion.

1.2.3 Theoretical and conceptual framework

I briefly discuss some of the theoretical and empirical scholarship that informed the study. An important task is deliberating a definition of academic disciplines. Consequently, I drew on the works of prominent scholars in a four-fold definition of a scientific discipline. These include Michel Foucault, August Comte, Thomas Kuhn, Stephen Toulmin, Carl Pantin, Clifford Geertz, Richard Whitley, Tony Becher, Warren Hagstrom and so on (Becher, 1981; 1987; 1994; Comte, 1865; 2000, Foucault, 1970; 1972; Geertz, 1973; Hagstrom, 1965; Kuhn, 1970; Pantin, 1968; Toulmin, 1972; Trowler & Becher, 2001; Whitley, 1980; 1982; 1984). I considered four approaches towards a disciplinary definition which attempts to capture the essence of the theory surrounding academic disciplines. None of the approaches proved more favourable or offered a more accurate depiction of a discipline than the other, but rather offered complementary perspectives in thinking about the dimensions that constitute an academic discipline.

Included in the discussion of academic disciplines is the classification of the sciences. Many scholars suggest that scientific knowledge, and by extension, disciplinary fields, can be classified on the basis of different criteria. Here, I considered Plato and Aristotle's notions of *technê* and *epistêmê* as differentiating between types of knowledge (Barnes, 1986; Plato, 1850). Subsequently, I discussed Comte's *law of the classification of sciences* (Comte, 2000) and more contemporary works which include Kuhn's differentiation between paradigmatic and pre-paradigmatic sciences (Kuhn, 1970), and Pantin's separation of the restricted and unrestricted disciplines (Pantin, 1968). The most prominent classification includes Biglan and Kolb's multidimensional framework between "hard"/"soft", "pure"/applied" and "life"/"non-life" systems (Biglan, 1973b; 1973a; Kolb, 1981; 1984). Biglan draws from Storer's (1967) original hard/soft dichotomy, while also drawing on the basic/applied distinction termed by Bush (1945). While cognizant of the taxonomies' shortcomings, I argue that the widespread application of Biglan and Kolb's model renders it a useful approach in compartmentalising academic disciplines.

Theoretical models explaining withdrawal and degree attainment of scholars are widespread and I considered studies of scholars such as Tinto, Astin, Bean, Summerskill and Spady (Astin, 1984; Bean, 1980; 1983; Spady, 1970; Summerskill, 1962; Tinto, 1988; 1993). Many of these authors drew on the work of Durkheim on suicide in explaining student drop-out and consider "social fit" imperative to student success. Using a revised classification of the barriers in degree completion as introduced by Cross in her *chain of response model*, I grouped together factors associated with student success into five categories (Cross, 1982; Morgan & Tam, 1999). These include epistemological factors, student demographics, institutional, situational and dispositional factors which scholars argue, underlie doctoral success. These frameworks and their applications are discussed in more detail in the chapters that follow.

1.3 Chapter outline

Chapter 2: Disciplinary differentiation: a theoretical framework

In this chapter, I reflect on the notion of an academic (scientific) discipline and how such an understanding came about. Why do we classify disciplines and in which ways have scholars attempted to do so? What are the limitations associated with these classifications and how does it shape my understanding of the five selected disciplines? I argue, towards the end of the chapter, that the specific classificatory frameworks and the reasoning behind them are not consequential, but rather the manner in which these disciplines have subsequently been institutionalised and reproduced. This academic socialisation of the accepted truths and methods within a discipline then determines how graduate education is manifested and the implications thereof on, for example, doctoral completion.

Chapter 3: Conceptualising and measuring doctoral success

In this chapter, I discuss the findings of existing literature on the conceptualisation and measurement of doctoral success. I discuss some of the shortcomings of existing studies on doctoral education in South Africa along with how this study aims to address them. Drawing from existing studies in the South African context, I present an overview of doctoral education in South Africa. Subsequently, I briefly review the state of doctoral education in the five selected disciplines in South Africa. Following the discussion of doctoral education in South Africa, the discussion moves to studies done internationally. I discuss the literature on doctoral time-to-degree as determined in the USA, UK, Canada, Australia, New Zealand, Europe and so forth. The chapter concludes with a synthesis of the main findings concerning doctoral degree attainment in South Africa and that found elsewhere.

Chapter 4: Determinants of student success

The fourth chapter is assigned to a discussion of factors that influence the timely completion of the doctoral degree. The chapter starts with a brief discussion on the theoretical models which deliberate student withdrawal and degree attainment. The chapter continues with a discussion of existing empirical studies which identify pertinent determinants of degree attainment. Using a revised classification of barriers listed in Cross' (1982) *chain of response model*, I distinguish between epistemological factors, student demographics, institutional, situational and dispositional factors which scholars argue, underlie doctoral success. Within each of these categories, I review the pertinent literature. The chapter concludes with an overview of the perceived shortcomings of the studies reviewed.

Chapter 5: Methodology

In this chapter, I discuss the methodology used in this study. First, I restate the research problem of the study. I list the central research question as well as sub-questions after which I discuss the research design and the theoretical assumptions underlying the data sources and analyses. A brief review of the rationale for a mixed-methods approach is discussed. Subsequently, I discuss the data sources used. I report on the strategies used in the survey of doctoral students which includes a discussion of the sample, the questionnaire as a data collection instrument, response rates and the profile of respondents. I define and operationalise the primary indicators used throughout the data analysis after which I discuss first, the statistical methods used in the analysis of the HEMIS and survey data, and second, the thematic analysis of the qualitative survey data. I include a discussion of the limitations associated with doing secondary analyses and the use of quantitative indicators. Finally, I consider the ethical implications of the study.

Chapter 6: A profile of doctoral students in South Africa

In this chapter, I present a profile of doctoral students in the five selected disciplines. I address the first research question of this study by investigating the profile of doctoral students in the selected disciplines. I describe doctoral enrolments and graduates at the hand of demographic factors which include gender, race, nationality, age and academic institution. Each disciplinary profile includes an overview of annual and periodic trends compared with the national data. Subsequently, I describe doctoral students with the help of three indicators which include the pile-up effect, average completion rates and time-to-degree.

Chapter 7: The role of the discipline in time-to-degree

This chapter marks the first of five chapters that examine the relationship of selected contextual factors on doctoral time-to-degree. It is one of this study's hypotheses that epistemological factors, i.e. the nature of a discipline and the manner in which it has been institutionalised, is associated with variances in timely completion. Using the Biglan-Kolb classification of disciplines, I explore first, whether there exist significant differences in average time-to-degree between hard and soft disciplines of the five disciplines selected. Second, I similarly consider disciplinary differences in time-to-degree between pure and applied disciplines. In both cases, I include a qualitative analysis of the survey data in contextualising why there exist disciplinary differences in timely degree attainment.

Chapter 8: The role of student demographics in time-to-degree

In this chapter, I seek to explore which student demographics are associated with shorter or longer time-to-degree. Doctoral time-to-degree is compared within and across the five disciplines by demographic variables which include gender, race, nationality and age. Intra- and interdisciplinary comparisons examine whether there are statistically significant differences in average time-to-degree of demographic subgroups.

Chapter 9: The role of institutional factors in time-to-degree

In the fourth analysis chapter, I investigate the association between selected institutional factors and doctoral time-to-degree. Throughput rates are used as a rough measure of efficiency to determine the proportion of doctoral graduates to enrolments nationally, across disciplines and per academic institution. As a proxy for institutional efficiency, I investigate whether there is a correlation between average institutional throughput rates and time-to-degree. I also determine doctoral supervisory capacity within the selected disciplines and of academic institutions and explore whether there is an association between supervisory capacity and the timely completion of doctoral studies.

Chapter 10: The role of situational and dispositional factors in time-to-degree

In this chapter, the two pertinent research questions addressed are which situational and dispositional factors have an influence on doctoral time-to-degree. An analysis of the survey data is used to investigate the relationship of contextual situational factors on respondents' estimated time-to-degree. The first includes an analysis of progression trends as well as whether students changed fields between their master's and doctoral degrees and its effect of expected time-to-degree. I also include an analysis of the employment status of students as a situational factor. Finally, I consider student satisfaction as a dispositional factor in exploring doctoral time-to-degree.

Chapter 11: Towards an exploratory model of doctoral time-to-degree

In the final analysis chapter, I construct a model predicting timely completion. I run a pooled multiple linear regression model to identify the relationships of student demographics and mode of study on doctoral time-to-degree. I consider the interrelatedness of factors on timely completion and synthesise the results with that of the descriptive analyses and the findings of existing empirical studies.

Chapter 12: Conclusion

In the concluding chapter, I discuss the study's primary empirical findings under the relevant research questions. I synthesise the findings of the study with the pertinent literature and theory discussed in Chapters 2, 3 and 4. Subsequently, I reflect on the theoretical and policy implications of the study as well as the contribution of the present study. Finally, I consider future research that may arise from the study as well as ways in which the study could be improved on.

Chapter 2 | Disciplinary differentiation: a theoretical framework

Our rendition of an academic discipline is a well-accepted and seldom contested one. The experiences of those working in academic professions are irreversibly constructed by their affiliations to academic disciplines without an overt consciousness of the process. A substantial number of scholars, however, have superseded their disciplinary membership in an attempt to study disciplinary differences on various levels. This has resulted in a consequential amount of literature on disciplinary differences and their invariable consequence on learning, teaching and doing research.

I have traversed the philosophy of knowledge, and subsequently scientific knowledge, in an attempt to grasp the origins and nature of academic disciplines. In this chapter, however, it is not my purpose to present a comprehensive, or even superficial, synopsis of the origins of scientific knowledge, but rather to identify relevant classificatory frameworks that shape our understanding of an academic discipline. These theoretical foundations informed both the hypothesis of the study and the subsequent empirical analyses.

In this chapter then, I ask how do we understand an academic (scientific) discipline and how did such an understanding come about? Why do we classify disciplines and in which ways have scholars attempted to do so? What are the limitations associated with these classifications and how do these shape my understanding of the five selected disciplines? I argue, towards the end of the chapter, that the specific classificatory frameworks, and the reasoning behind them, should not be the primary focus, but rather the manner in which these disciplines have subsequently been institutionalised and reproduced. This academic socialisation of the accepted truths and methods within a discipline determines how graduate education is manifested and the implications thereof on, for example, doctoral time-to-degree. It is this idea on which I based the primary research question of this study.

In the first section of this chapter, I set out to define the notion of an academic discipline. I discuss an academic or scientific discipline along four lines of reasoning. The first of these argues a disciplinary field to be the result of social and historic processes. The second perceives disciplinary fields as organisational forms, while the third defines disciplines along their cognitive structures. The final argument is for disciplines to be defined as discursive communities.

I continue the discussion on the efforts of various scholars to classify academic disciplines. I discuss the classificatory frameworks of authors such as Pantin, Kuhn, Comte, Storer, Bush, Kolb and Biglan (Biglan, 1973a; 1973b; Bush, 1945; Comte, 1865; 2000, Kolb, 1981; 1984; Kuhn, 1970; Pantin, 1968; Storer, 1967). In the conclusion of this section, I discuss how these frameworks are to be used in the empirical contribution of the study in light of the limitations associated with them. In the final section of this chapter, I focus on the five selected disciplines. I briefly discuss the origins of, particularly physics and sociology as academic disciplines. I accordingly discuss what the practical implications of applying the aforementioned theoretical classifications are in relation to the selected disciplines.

2.1 Defining an academic discipline

When defining an idea we are constructing the conceptual delineations within which we proceed to research the topic at hand. This exercise is often a complex and cumbersome one but is imperative. In this section, I, therefore, attempted to provide an overview of the definitions associated with an academic discipline. The literature on academic disciplines provides bounteous demarcations and for the sake of clarity, I group this discussion into four sections. In the first section, I discuss the formation of academic disciplines as **historical,** social orderings. I draw on the writings of Foucault and Toulmin in their understanding of scientific fields as the result of epistemic development. The second approach views academic disciplines as an **organisational form.** The manner in which disciplines have been institutionalised is central to this argument. The discipline is then a reflection of a particular reality at a particular point in time. From this argument, academic disciplines are seen as a social construct organised by market and labour demands.

The third definition views academic disciplines as organised around a **body of knowledge** or cognitive structures**.** This approach places the *nature* of the discipline as the defining dimension of the discipline. This includes the theories, concepts, commonly accepted truths and laws which are central to the existence of the scientific field. In the final section, I present arguments that posit an academic field as a **cultural practice** or discursive community. This approach presupposes a discipline as a community with a body of shared values and norms. Central to this argument is the reproducibility of fields through disciplinary socialisation.

2.1.1 Academic disciplines as historical social orderings

> A profound historicity penetrates into the heart of things, isolates and defines them in their own coherence, imposes upon them the forms of order implied by the continuity of time … *(Foucault, 1970:xxv)*

The first definition of scientific fields regards academic disciplines as a result of social and historical processes. In other words, the way in which disciplines exist today is shaped through their history. This is Foucault's primary argument in *The order of things* (1970) and *An archaeology of knowledge* (1972) where he claims that the organisation of academic disciplines, as we know it today, is the result of **social processes**. Foucault states that the "… human sciences did not inherit a certain domain, already outlined … they appeared when man constituted himself in Western culture as both that which must be conceived of and that which is to be known…" (Foucault, 1970:xxiv). He maintains that the order, on the basis of which we think today, is different from that underlying the scholars in the preceding eras (Foucault, 1970: xxiv). In other words, each era has a distinct *episteme*. This episteme consists of an underlying, and, therefore, not conscious, truth or discourse that influences how knowledge is perceived and produced. The result then is that each epoch has its own knowledge system. For Foucault, the episteme is not limited to any specific discipline, but is universal across the sciences.

Throughout the chapter, I also explore the ideas of Thomas Kuhn (1970). Kuhn argues that throughout the evolution of science, there were a number of *paradigm shifts* which reconstituted the knowledge system. This idea is shared by Foucault where both authors argue that ideological shifts (in the episteme) result in the reformulation of accepted truths. Foucault suggests that the episteme underlying the ordering of knowledge during the Renaissance was based on similitude[3]. In other words, phenomena (natural objects) were grouped together on the basis of their resemblances. Throughout the classical period, the episteme shifted and was typified by representation, ordering, identity and difference (Foucault, 1970). Here, an emphasis was given to the observation and verification of ideas. The modern episteme, conversely, has turned inward. For Foucault the modern episteme positions man as the subject of knowledge. Therefore, the modern episteme saw the development of the human sciences.

Foucault's account of the formation of academic disciplines is a highly critical one through which he questions the objectivity of our knowledge systems. He negates the cumulative nature of

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[3] Foucault talks about four similitudes: convenience, emulation, analogy and sympathy.

knowledge and suggests that the evolution of knowledge is shrouded by an arbitrariness (Bevir, 2002). He overlooks the role of humans as autonomous, rational beings in their efforts to produce knowledge and suggests that they are unwittingly compelled by the episteme. Critics of Foucault argue that the idea of a single, universal episteme guiding all scientific endeavours is dismissive of the variety of ideas and perspectives present at that time (Bevir, 2002). One could, therefore, make the case of the episteme as the *dominant* set of ideas, rather than the sole set.

Toulmin follows Foucault's line of reasoning when he contests the idea of defining disciplines through their content; i.e. theories, concepts or conceptual systems, as he warns against mistaking the part for the whole (Toulmin, 1972:146). He claims that these theories, concepts or conceptual systems are "transitory products" or "cross-sections" of historically developing sciences where "… the unity and continuity of these sciences must reflect, not just the formal relationships within any such cross-section, but also the substantive relations embracing the entire succession of developing ideas …" (Toulmin, 1972:146). Each development within a science is, therefore, a result of the relationships with nature (its scientific phenomena) and society at a given time in history.

Toulmin argues that the later phases of a science, therefore, the organisation of sciences today, are linked by continuous affiliations. In other words, how do we know whether the shape of the sciences we know today are *legitimately* linked to its affiliated predecessor? In any moment that predecessor could have fragmented through social processes and resulted in a form of scientific discipline unfamiliar to us today. One must, therefore, question the rational continuity of a discipline within the historical processes. Unlike Foucault, however, Toulmin highlights the role of the *scientist* in the evolution of ideas. He suggests that solely attributing the problems of science to the nature of the world takes away the agency of the researcher. For Toulmin the nature of a scientific (intellectual) discipline "… always involves both its concepts and also the men who conceived them …" (Toulmin, 1972:154). I elaborate on the role of the practitioner in the forthcoming discussion of academic disciplines as cultural entities.

It is clear that both Toulmin and Foucault consider the archetype of the intellectual discipline as a historical entity which "… reflects the continuity imposed on its problems by the development of its intellectual ideals and ambitions …" (Toulmin, 1972:155). In other words, both the scientific discipline and the scientist who interprets its truths, are forged by the trends and intellectual fashions of each epoch. Phenix stresses the dynamic nature of disciplines as "species of knowledge" (Phenix, 1965:49). We should understand scientific disciplines as structures of enquiry which have emanated from epistemic development. They are thus neither fixed nor ordained in their present forms (Phenix, 1964:49). Toulmin regards a discipline as an intellectual micro-institution which is a result of the procedures present in shaping (or institutionalising) its current form. I discuss this institutionalisation in the next section.

2.1.2 Disciplines as organisational forms

The second approach towards defining an academic discipline positions disciplines as a response to market demands through the division of labour. This approach views disciplines as a **social construct which** simply reflects a particular reality at a given point in time and hence, is something that can be more transient. This interpretation echoes the arguments for thinking about disciplines as historical, social orderings. Along this argument, the social contexts surrounding the institutionalisation of academic fields directly influenced the configuration of disciplines today. Whitley defines this social context "… as the organised arrangement of the sorts of background factors" (Whitley, 1980:301). Whitley emphasises the changing nature of scientific knowledge as a "… process of acquiring and changing understandings …" (Whitley, 1980:301). Scientific disciplines then develop(ed) individually as a result of the processes and relations surrounding it. For Whitley, the activities of the practitioner of a discipline can, and has, influenced the organisation of scientific fields (Whitley, 1982).

Edgar Morin defines an academic discipline simply as an organisational category of scientific knowledge (Morin, 2003; Younès, 2006). Turner defines an academic discipline as an objective ordering which he describes as a "branch of instruction" or "department of knowledge" (Turner, 2006). At the same time, Turner views disciplines as artificial constructs as "… they are not naturally occurring intellectual divisions that might refer to divisions of the mind … [but] are socially constructed perspectives constituting a particular slice of reality and as such they can always be transformed, relocated or destroyed …" (Turner, 2006:185). Hagstrom argues that the spatial organisation creates an environment in which emerging disciplines can become established (Hagstrom, 1965). Although he views a scientific discipline as one surrounding a shared ideology, Hagstrom claims that a well-established discipline requires a consigned university department (Hagstrom, 1965). For Whitley, the educational institutionalisation of disciplines lies at the heart of the social and cognitive identity of scientific fields (Whitley, 1980).

Bridges acknowledges the social construction of academic disciplines but argues that the institutionalisation of disciplines enables practitioners of disciplines to function in a relatively stable and delineated fashion.

> No one imagines the disciplined pursuit of knowledge and understanding to be entirely free from entanglement with structures designed or developed to maintain and legitimate certain orders of power. This is precisely why its more sophisticated practitioners seek to operate under conditions which reduce these influences to a minimum e.g. by defending the autonomy of their institutions against political interference or fighting off institutional attempts to suppress research which might be damaging to the interests of the institution itself; by submitting to ethical codes which govern their rights in relation to the powerful and their obligations in their relations with the weak; by submitting to methodological and epistemological requirements which force critique of their taken-for-granted assumptions, expose the ideological underpinnings of their work and enable non-participants to challenge structural bias in the enquiry or in its conclusions. (Bridges, 2006: 269)

Krishnan similarly defines an academic discipline as a "… technical term for the organisation of learning and the systematic production of new knowledge …" (Krishnan, 2009:9). In accordance with Bridges, Krishnan argues that the professionalisation of knowledge gives academics the freedom to follow their academic pursuits and interests. He argues that through the definition of disciplines, disciplines become "… units of labour market definition and control, and of intellectual production and validation …" (Krishnan, 2009:26). For him, the division of labour is a "… defining characteristic of modernity and is an expression of the increasing rationality of societal organisations …" (Krishnan, 2009:28). In other words, this division of labour is a rational and efficient endeavour which results in the specialisation of certain professions. Krishnan maintains that, with reference to the professionalisation of academia, the more established disciplines are more likely to be seen as distinct professions (Krishnan, 2009). Pierre Bourdieu, similar to Foucault, claims that some disciplines (in the 1970s[4]) have more esteem, and, therefore, influence than others (Bourdieu, 1988). Bourdieu shows that disciplines that are more established, such as medicine and law, have the most scholarly faculties and clear links to professions outside the academic world. Less homogenous disciplines, such as the social sciences (science and arts), are less influential both within and outside the university. This idea of a "scientific hierarchy" is discussed in a later section.

From an organisational perspective, academic disciplines also serve as an administrative unit. Dividing academic departments into disciplines shapes the supply of knowledge to market demands and internal organisational requirements. "Faculty must be 'placed', their salaries must be located in some departmental budget, teaching loads and student credit hours must be assigned and balanced, [and] performances must be evaluated" (Baker, 1997:59). Disciplinary "structures", from a

[4] Bourdieu studied four faculties at French universities.

management perspective, are seen as administrative units to which resources must be allocated. From the management perspective, if a department no longer serves the need of the society, due to constant societal change, universities need to address the problem accordingly. Faculties will, therefore, either close a department or merge different departments. This then has a direct influence on the functioning of the disciplines housed in these departments. "… Universities are under increasing pressure to respond to the changed market by creating new courses and research programmes that are more competitive …" (Krishnan, 2009:38). These market-driven changes are, however, difficult to implement because "… of the resistance that the professionalised disciplines and affected departments can organise …" (Krishnan, 2009). This is then often how interdisciplinary programmes or new disciplines come into existence.

Thompson Klein claims academic disciplines to have first been conceptualised in the late Middle Ages (Thompson Klein, 1990). Three disciplines were the result which include theology, law and medicine. The formation of these disciplines was due to a need for specialists in the context of industrialisation and the advancement of technology. These "disciplinary mechanisms" were, according to Foucault, the formalisation of knowledge that already existed in monasteries, armies and workshops (Deacon, 2002; Foucault, 1995). Foucault claims that the invention of disciplines was encouraged by the Enlightenment during which liberties (human emancipation) and intellectual development came to the fore. Thompson Klein similarly argues that external demands led to the specialisation into academic disciplines. At the time of the twentieth century "… science and the pursuit of scholarly and new knowledge had become an institutionalised and highly systematic endeavour" (Thompson Klein, 1990:20; Krishnan, 2009).

The majority of the social sciences were institutionally established in the late nineteenth and twentieth century. The establishment of sociology, anthropology, psychology, political science and economics was due to the growing complexity of society and a need to understand their guiding institutions. Each discipline was established to study a particular object or topic not observed in any other (established) discipline. These divisions were primarily pragmatic and lead to the development of stable identities among these disciplines. Foucault claims that the establishment of the social sciences was due to the need to gather information on the population for those in power, i.e. the upcoming bourgeoisie (Foucault, 1995).

> This concerted cultivation, spread and generalisation of the disciplines were motivated both negatively, by anxieties about the real and imagined contagion and disorder prevailing as feudal society disintegrated, and positively, by a need to support emerging bourgeois social and political structures. (Deacon, 2002: 445)

Not all disciplines established during the earlier years, however, survived (e.g. phrenology, physiognomy, ethnogency) (Krishnan, 2009). Historically, academic disciplines have evolved while some disciplines have displayed great continuity, whereas others have progressed or encountered a Kuhnian "paradigm change" (Krishnan, 2009:31). The discipline of anthropology finds its origins in natural history and psychology, and as a discipline, from philosophy and medicine. The progression of boundaries between disciplines has either led to the disappearance of a discipline altogether or the emergence of a new altered state of an older discipline. Krishnan (2009:50) offers three ways in which disciplines have (and could have) evolved. This includes (1) turning inward and strengthening boundaries, (2) forming strategic alliances with stronger disciplines, and (3) reconstituting the discipline in a newer and larger field of study. Examples of the latter include cultural studies which have evolved from sociology, or security studies from political studies. These changes usually occur within a wider societal context (Krishnan, 2009).

As a result of the fragmentation and broadening of disciplines over time, subject areas have increasingly started to overlap. Many disciplines are increasingly identified through their methodologies rather than their topics of interest (Whitley, 1980). This is particularly true for disciplines such as sociology and anthropology where the boundaries in subject matter have become blurred in a post-colonial era (Krishnan, 2009).

There has been a shift away from the traditional organisation of disciplines towards a more interdisciplinary approach. Krishnan contends that the traditional division of academic disciplines into departments is an outdated practice which often results in duplication and overstaffing of many scientific efforts which have become removed from the societal trends of knowledge production (Krishnan, 2009). Gibbons et al. argue that "… traditional discipline-specific knowledge production within academic departments (mode one) is becoming increasingly obsolete and less relevant for society …" (Gibbons et al., 1994). Krishnan suggests that knowledge production today is, and should be, more heterogeneous and interdisciplinary (Krishnan, 2009).

Traditionally, disciplinary instruction has been the norm in higher education institutions (HEIs). "Disciplines provide the comfort of some stability in curricula and provide some general structure for the organisation of teaching" (Krishnan, 2009:43). This "coherence" has been argued to make it easier for students to learn and master a discipline. Krishnan further argues that this coherence greatly influences students' attitudes towards learning and educational success. Abbot (2001) believes that through the arrangement of scientific knowledge into disciplines, it prevents knowledge from becoming too abstract or overwhelming, particularly to students. Research on education shows competing views regarding the advantages and disadvantages of interdisciplinary learning (Holley, 2009; Krishnan, 2009; Morillo, Bourdons & Gomez, 2003; Thompson Klein, 2006; Weingart & Stehr, 2000). There is, however, some consensus that disciplinary instruction is important at an undergraduate level and thereafter interdisciplinary instruction may be suitable. Training in disciplines, however, is imperative to prepare graduate students for economic participation in the labour market (Krishnan, 2009:45).

> An academic degree used to be a 'corporate certification of accomplishment in a field of knowledge. This means that curricula should convey knowledge' and skills that are considered relevant to employers. Disciplinary instruction allows potential employers to have some idea of the particular training a graduate has undergone and the particular skills and knowledge the graduate might have. (Krishnan, 2009:45)

I do not elaborate on interdisciplinarity or argue for its applicability here as I have selected five "traditional" disciplines in the present study and it would, therefore, distract from the argument. It is important to note, however, that in the South African doctoral education landscape, there has been a movement away from field-specific doctorates (such as D.Litt. or D.Comm., etc.) towards the general degree of Doctoral of Philosophy[5].

There is another important point to make about the institutionalisation of academic disciplines. The arrangement of disciplinary fields at higher education institutions, many scholars argue, is a result of historical and social processes. The varying specificities of these processes, therefore, culminated in different orderings in, for example, the USA, the UK, Germany and France[6].

[5] In 2013, the CHE and the Higher Education Qualification Sub-Framework (HEQSF) called for the revision of naming of doctorates. There was a decision to streamline the naming of doctorates to a general Doctorate of Philosophy (PhD) (with the exception of doctorate of law [LDD]) - given that the use of varying names were confusing, inconsistent and unclear to users outside of universities. This decision was therefore a technical one rather than an ideological one. The specific titles, such as D.Litt., D.Comm., D.Ed., D.Med. are reserved for professional doctorates, or secondary doctorates (Afdeling Institusionele Navorsing en Beplanning, 2013; Benamings van doktorale kwalifikasies en programme and die Universiteit van Stellenbosch, 2013).

[6] The American system, Abbott argues, has experienced stability in the twentieth century notwithstanding the changes that the cultural structures – the thinking about knowledge production – has undergone (Abbott, 2001). Abbott suggests that since its creation in the late nineteenth century, the departmental structure has remained largely unchanged. Biology has experienced the most changes, compared to the humanities and social sciences. What makes the American system unique is its "… groups of professors with exchangeable credentials collected in strong associations…" (Abbot, 2001:123). The German model, originally, was aimed at "… personal cultivation through intense scholarship, subordinating all to the research enterprise…" (Abbot, 2001:123). University faculties and research institutes were under the management of extraordinary professors in individual chairs. Doctorates were often taken in generic fields, rather than in disciplinary specialties, to make faculty members more employable across the wide range of institutions in Germany. It was also not uncommon for faculty members to change fields with new employment opportunities. In comparison with the American model, "… the German system produced intense research dedication, but nothing resembling the American disciplinary division

It is imperative to take cognizance of the social and historical currents that formed the disciplinary landscape at South African higher education institutions. It is also important to consider what the implications are for these disciplinary delineations. One can spend a considerable amount of time debating the relevance or applicability of boundaries between disciplines. In my empirical analysis, however, I studied doctoral education of five disciplines across the South African landscape which comprise of a number of universities and universities of technology. The organisation of disciplines within these institutions indubitably varies. I argue, then, that the specifics surrounding the institutionalisation of these academic fields not be debated, but rather focus on what this institutionalisation *means* for doctoral education. In other words, *how* doctoral education takes place within these disciplinary orderings should be considered. The transference of a disciplinary identity along with the rules and structures that make up one's association within a discipline, I suggest is more important than where the boundaries of disciplines are drawn.

In the next section, I discuss how academic disciplines are considered as a cultural community along with the importance given to academic socialisation within this context.

2.1.3 Disciplines as cognitive structures

The third definition of an academic discipline views disciplines as organised around a **body of knowledge**. This approach posits a discipline as an epistemological metaphor where a discipline consists of common theories, concepts or commonly accepted truths or laws. One can, therefore, presuppose a sense of permanency of a discipline insofar as the body of knowledge remains constant.

Hagstrom claims that every established discipline possesses an ideology (Hagstrom, 1965). This ideology justifies the claims that such a discipline makes on the scientific world and, per consequence, the larger society. An ideology then embodies the cognitive "facts" of a discipline whilst

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of turf…" (Abbot, 2001:124). The English system, originally, was anti-professional, and arguably anti-research. There was little emphasis on disciplinary structures with more importance being placed on the content of examinations, "… these were an unlikely foundation for disciplinary specialisation, for most of them were pedagogical unities unconnected with a specific research community" (Abbot, 2001:125). The American system borrowed from the German system the Doctorate of Philosophy and it evolved into doing a doctorate in "something" (such as D.Litt. or D.Comm.). This enabled the organisation of universities internally while providing career mobility for practitioners. The South African higher education system is founded on the British system (Cloete, Mouton & Sheppard, 2015).

determining that which should be studied (Hagstrom, 1965:212). Whitley (1980) calls these "domain assumptions" (1980). Similarly, Pantin in his classification of sciences as either restricted or unrestricted, attributes the "… richness and complexity of [their] phenomena…" as the distinguishing factor of sciences (Pantin, 1968:18). Pantin's classification is based on the essence of phenomena which are studied. Both Pantin and Hagstrom, therefore, place the "object" of the science as the defining dimension of an academic discipline (Pantin, 1959:26).

For Hagstrom, the ideology[7] (or commonly accepted truths) has various functions. First, the ideology of a discipline defines the jurisdiction of the discipline: that which it includes and excludes (Hagstrom, 1965:212). This jurisdiction then establishes the disciplinary delineations between sciences. The second function of the disciplinary ideology is to withstand claims made on the discipline by those "… for whom it has instrumental value…" (Hagstom, 1965). In other words, many newly established fields draw on the well-established fields (for Hagstrom alludes here to pure disciplines) in their application. The established ideology then compels these fields to adhere to and respect the laws and tenets of the "pure" discipline.

The third function of the ideology is to "… regulate relations among specialties within the discipline, and by contributing to the self-conceptions and self-esteem of specialists they help maintain its solidarity…" (Hagstrom, 1965:212). The ideology, therefore, unifies the discipline and those working within it through ideological consensus. In cases where a researcher might be working on non-traditional (or unusual) problems, such a researcher may be perceived as "deviant". Hagstrom posits that "… differences between specialties may be viewed as deviance by members of specialties that are traditional or central to the discipline, and attempts may be made to sanction such deviance…" (Hagstrom, 1965:223).

For Hagstrom, disciplines have similar structures, but varying goals (Hagstrom, 1965:244). This renders disciplines socially autonomous (Hagstrom, 1965). Areas within a discipline can also differentiate functionally. For example, where theoretical and experimental physics have differentiated from physics (Hagstrom, 1965:245). For Whitley, the goals of disciplines do not only differ but can vary across time (Whitley, 1980). For him, some topics of enquiry may be a result of scientific "fashion" which may cause the delineations of fields to shift.

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[7] Geertz also considers disciplines to have a share ideology. But he considers an ideology a cultural system (Geertz, 1973).

Kuhn, in his widely influential book *The structure of scientific revolutions* (1970) postulates that scientific fields are founded on a shared paradigm. He introduced the idea of a "paradigm shift" to distinguish between established and emerging disciplines (I discuss this in a later section). The term "paradigm shift" has since become synonymous with Kuhn, although his use of the term "paradigm" received heavy criticism from peers (Lodahl & Gordon, 1973). In response to this criticism, Kuhn concedes that his use of the term is somewhat inconsistent[8].

Defining disciplines along their cognitive structure allows for the conscientious grouping together of natural similarities. Kuhn states that "… men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent consensus it produces are prerequisites for normal science…" (Kuhn, 1970:11). For Kuhn then, existing paradigms group sciences together from which rules and standards evolve[9]. He, therefore, perceives a scientific paradigm to be the source of coherence. In other words, a discipline can exist before and outside rules, but not without a paradigm (Kuhn, 1970:44). In a similar fashion to Kuhn, Abbot views the cultural structures of disciplines as axes of cohesion. These axes embody the central principles within a discipline (Abbott, 2001). Abbott argues that disciplines have varying degrees of cohesion "alignment". This echoes Kuhn's view of paradigmatic and pre-paradigmatic fields. For Lodahl and Gordon, this implies that theories and findings have to be accepted as true (or proven) to create consensus within a field (Lodahl & Gordon, 1973). These "formative procedures" (Whitley, 1980:304) then pave the way (epistemologically and methodologically) for the disciplinary practitioners to approach new problems.

However, Kuhn also states that "… a paradigm is what the members of a scientific community share, and conversely, a scientific community consists of men who share a paradigm …" (Kuhn, 1970:176). Here we are faced with a causality dilemma: Does the paradigm precede a scientific field?

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[8] His first adoption of a "paradigm" refers to "…the entire constellation of beliefs, values, techniques and so on shared by the members of a given community…". Secondly, a paradigm denotes "…one sort of element in that constellation, the concrete puzzle-solutions which, employed as models or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal science…" (Kuhn, 1970:175).

[9] Critics of Kuhn comment on his disregard for the institutional, as well as social structures and processes that influence disciplinary development. For Kuhn a disciplinary paradigm evolves almost independently (Mendelsohn, 1977). Critics of Kuhn comment on his disregard for the institutional, as well as social structures and processes that influence disciplinary development. For Kuhn a disciplinary paradigm evolves almost independently (Mendelsohn, 1977).

Or does the academic field (in its conception) produce and communicate a shared consensus? Bridges poses the question.

> There is, perhaps, the risk of either a certain circularity in this position or of an internal contradiction. If we can know the value of beliefs (generated by the disciplines) 'empirically and pragmatically' then presumably we do not need the disciplines as means of discriminating the wheat from the chaff of belief. Alternatively, if it is through the disciplines (alone) that we can distinguish the wheat from the chaff of belief, then we cannot determine their value 'empirically and pragmatically'. (Bridges, 2006:267)

The answer, Phenix argues, lies in the generative power of a discipline (Phenix, 1964:48). Despite the characteristics assigned to a discipline through its construction, the essence of a discipline lies in its reproduction through its practitioners.

2.1.4 Disciplines as discursive communities

The fourth, and final, definition of academic disciplines views disciplinary fields as **cultural practices** which embody a set of shared language, vocabularies and meanings. Through this approach, scholars such as Becher view academic disciplines as "tribes" which shares a set of accepted values (Becher, 1981; 1987; 1989; 1994). Abbot terms these academic settlements, comprising of a cultural and a social structure, which are guided by their axis of cohesion and argues that at "… the heart of the disciplinary system is a stable social structure between disciplines and mutable cultural structures within them" (Abbot, 2006). I do not contest Abbot's idea of the stable intra-disciplinary structures here but rather focus on the "mutable cultural structures". The cultural structure within academic disciplines is the central theme in Becher's work on academic tribes and territories. Abbot drew from Becher's argument that groupings of disciplines and organisational systems are cognitive communities which fundamentally underline our understanding of the "contrasting identities and characteristics" of disciplinary fields. Although Becher makes a strong argument for the understanding of academic disciplines as a cultural community, he, like Abbot, argues that one cannot consider the cultural aspects of a discipline as separate from its cognitive structures (Becher, 1994). Such an approach would be too simplistic in capturing the multiplicity of processes responsible for the ordering of disciplines.

The categorisations of disciplines, along this argument, are a direct result of the divergent tribes and cultures that manifest in different disciplines. This view places an immense importance on the actors (academics and students) and their roles in producing and maintaining the disciplinary culture. Academics and faculty members, therefore, belong to a disciplinary "tribe" in which they inhabit "knowledge territories" through self-created cultural practices. These practices and norms, therefore, directly influence how knowledge is produced. From this perspective one can consider the cultural boundaries that exist between disciplines, particularly with reference to the notion of belonging. Belonging to a culture inadvertently creates the notion of "them" and "us". This idea is particularly important when one considers the challenges associated with interdisciplinary or transdisciplinary collaboration.

Trowler and Becher view disciplines as having "… recognisable identities and particular cultural attributes …" (Trowler & Becher, 2001). Academic disciplines, they argue, have idols, artefacts and a shared language.

> Each tribe has a name and a territory, settles its own affairs, goes to war with others, has a distinct language or at least a distinct dialect and a variety of symbolic ways of demonstrating its apartness from others. Nevertheless the whole set of tribes possess a common culture: their ways of construing the world and the people who live in it are sufficiently similar for them to be able to understand, more or less, each other's culture and even, when necessary, to communicate with members of other tribes. (Becher, 1994)

Not only does every discipline have a cultural grouping, but academic disciplines are also part of larger institutional groupings (universities, nations, civilisations, etc.). Kuhn echoes this argument in that scientific disciplines are communities ("at a lower level") and that academic disciplines are positioned in a global community of (natural) scientists (Kuhn, 1970:177). Here, Kuhn argues that "… a paradigm governs, in the first instance, not a subject matter, but rather a group of practitioners" (Kuhn, 1970:180). Although Kuhn's understanding of a scientific discipline is founded on cognitive structures, he recognises that the paradigm of a discipline cannot be disembodied from its practitioners.

Geertz, in a similar fashion, places practitioners of a discipline as the focal point in studying academic disciplines (Geertz, 1973). He argues that if one wants to understand scientific enquiry, one should not concentrate only on its cognitive structures (theories and its findings), but rather on "… what the practitioners of it do…" (Geertz, 2000:5). For Geertz, however, the disciplinary culture should not be interpreted as a power that regulates behaviour, but rather as the context that describes it.

Koutsantoni views an academic discipline as a discourse (discursive) community (Koutsantoni, 2007). She claims that the language used within a discipline, both orally and textually, defines the discipline. The language used, in turn, is shaped and constructed by the cultural repertoire of a discipline. Bridges similarly considers a discipline in the sense of a shared language, as a "… rule-governed structure of enquiry" (Bridges, 2006). For Bridges, disciplines establish rules[10] "… that shape the shared meaning and understanding that underpins research enquiry and its claims…" (Bridges, 2006:266). The creation of disciplinary languages also serves a protecting purpose. The specialised, disciplinary language serves to protect and claim the authority and influence of its members as experts (Krishnan, 2009:23). Academic disciplines then strive to maintain their cultural distinctiveness and autonomy through disciplinary discourses. This does not, however, mean that the academic disciplines remain static as new disciplines can be formed on the fringes of existing disciplines where "interlanguages" emerge (Krishnan, 2009).

> Highly specialist disciplinary languages are thus simplified and partially integrated or mixed in the process of the trading and borrowing of ideas and concepts. New hybrid cultures and communities can form and exist at these fringe areas, culturally enriching their respective larger disciplinary communities. In particular the Internet offers great opportunities for virtual communities where specialists from various disciplinary backgrounds can establish new interdisciplinary communities and intellectual networks. (Krishnan, 2009:24)

Bridges, however, claims that disciplines or disciplinary discourses can be an obstacle to enquiry. He draws from the work of Foucault who positions academic disciplines/discourses as a "… stumbling block, a point of resistance and a starting point for an opposing strategy …" (Bridges, 2006:269). Bridges argues that "…discourses constrain the possibilities of thought … they order and combine words in particular ways and exclude or displace other combinations …" (Bridges, 2006:269). This notion is reiterated by the cultural approach as tribes' cultural conceptions lead to disciplinary "othering". Bridges' understanding of a disciplinary discourse includes an "ideology" of theories and concepts which constructs practitioners' ideological, theoretical and methodological endeavours (Bridges, 2006:269).

Bridges takes a Foucauldian approach in his argument that one cannot detach the epistemological from the political. As stated previously, the historical, political and social context have sculpted how knowledge is pursued. This pursuit of scientific knowledge, however, is not only influenced by power structures outside the academic world, but also by the power-relations within.

[10] Bridges maintains that the rules underlie our understanding of academic disciplines. These include (1) rules that link the methods appropriate to the research task or conclusion to particular ontologies and epistemologies and hence shape the character of the truth claims, (2) rules that shape the way in which appropriate inferences can be drawn from the evidence or indicate the impossibility of such inferences, and (3) rules that indicate what are the analytic and explanatory concepts appropriate to the research task and evidence (Bridges, 2006:266).

For Bridges, disciplinary research is a rule-governed activity. The constellation of questions, methods and procedures and standards of enquiry (Bridges, 2006:265) guides practitioners' empirical efforts. For the authors, these rules are often inexplicit and uncodified. The idea that the rulebook becomes definitive when transgressions occur, is central to the cultural approach of a disciplinary definition, as argued by Bridges and Foucault. The defining of the "deviant" is then, as Hagstrom argues, one of the functions of the ideological consensus.

The organisational and cultural characteristics simulate boundaries between disciplines which intend to create a coherent body of theory, concepts and methods. These delineations enable testing and validation of hypotheses according to a pre-agreed set of rules specific to each discipline (Krishnan, 2009:19). Bridges argues that these delineations construct a "community of arguers" whilst enhancing the credibility of the scientific research conducted (Bridges, 2006). These boundaries, therefore, enable members to maintain a discipline-specific rigour of enquiry. An important question within the cultural argument is how these boundaries are reproduced. This, I argue, is done through academic socialisation.

2.2 The academic discipline as socialisation agent

When we accept that academic disciplines have particular sets of norms, practices and values, we have to examine how these cultural systems are conveyed. The cultural idiosyncrasies of scientific fields are thus learnt. This is done through what scholars call disciplinary or academic socialisation (Austin, 2002; Creswell & Bean, 1981; Gardner, 2007; 2010; Holley, 2011; Parry, 2007; Reybold, 2003). It is important to emphasise, however, that academic socialisation is not limited to the communication of disciplines' cultural schemes, but also of the institutions in which these disciplines function. Kolb was fascinated by the cultural differences encapsulated within a single university.

> The diversity that lies below is staggering – not one university but many, each with its own language, norms, and values, its own ideas about the nature of truth and how it is to be sought. By crossing the street, or in some cases even the hallway, I can visit cultures that differ on nearly every dimension associated with the term. There are different languages (or at least dialects). There are strong boundaries defining membership and corresponding initiation rites. There are different norms and values about the nature of truth and how it is to be sought. There are different patterns of power and authority and differing criteria for attaining status … Most important, these patterns of variation are not random but have a meaning and integrity for the members. There is in each department or profession a sense of historical continuity and in the most cases historical mission. (Kolb, 1981:233)

Here Kolb refers to the *habitus* of each discipline or academic department. Bourdieu's *habitus* refers to a set of cultural practices that are enforced by the social power of "belonging" to an institution or group (Bourdieu, 1988). These cultural practices are formed through societal and historical processes. Another useful theoretical concept is that of an academic identity and how it is shaped and appropriated through disciplinary membership (Wozniak, 2013). Austin maintains that the "… culture of the discipline is the central source for a faculty member's identity …" (Austin, 1990:64). It is important to note, however, that the ordering of disciplines not only dictates inter-disciplinary communication and interaction but also interaction with the outside world (society) in terms of how it is perceived (Becher, 1994).

Austin views the graduate school as the point of socialisation for an academic career. It is during this point that the student becomes part of the discipline, institution and academic community. Austin argues that the graduate student experiences many socialisation processes simultaneously which include socialisation to the role of a graduate student, socialisation to the academic life and the profession, and the socialisation to a specific discipline or field (Austin, 2002; Gardner, 2007). Given the differences between disciplines introduced above, each discipline will have a distinct socialisation process. Graduate students in the social sciences are more likely to learn how to work as independent researchers, whereas their counterparts in the natural sciences need to learn how to work in close collaboration with other students. The socialisation process, however, is a constant process as boundaries between disciplines are constantly shifting. The academic profession and its relationship with external factors (society at large, the labour market, and political institutions) is also a non-constant which requires continual negotiations with all parties involved.

Barbara Lovitts argues that departmental, or disciplinary, cultures are passed on to new faculty members and students through enforcing written and unwritten rules (Lovitts, 2001). These rules are manifested in formal and informal practices as well as in cultural forms such as traditions and rituals. Hunt terms this the "discipline of a discipline" (Hunt, 1991). For Bridges, these rules are the foundation of the community of arguers (Bridges, 2006). Socialisation typically takes place through observation, listening and interaction with faculty members and peers. These interactions can take place during both structured and non-structured opportunities (Austin, 2002). Krishnan terms knowledge production, as a social process, social epistemology (Krishnan, 2009). He takes a Foucauldian view in that the knowledge production process is subjugated to an external reality which requires adherence to. This refers to the external reality of an individual within a faculty, the faculty within an institution, as well as the institution within the broader societal and political context. The importance of successful socialisation for the graduate student should be underscored as this may be crucial to the successful completion of the doctoral degree (Gardner, 2010).

Disciplinary membership is not only concerned with a "… sufficient level of technical proficiency in one's intellectual trade…", but is also a measure of loyalty, both to one's professional peers and also to the constellation of norms and practices (Trowler & Becher, 2001:47). Becher argues that disciplinary cultures are universal and often transcends the boundaries of departments and universities. Identifying with an academic department, as the basic organisational element of the university, however, signals the start of the socialisation process into the specific culture of a discipline (Becher, 1994). Austin claims that the discipline, as the primary unit of membership and identification within the academic profession, is often the elucidator of difference rather than similarity among academic professionals (Austin, 2002).

> For students, education in an academic field is a continuing process of selection and socialisation to the pivotal norms of the field governing criteria for truth and how it is to be achieved, communicated, and used, and secondarily, to peripheral norms governing personal styles, attitudes and social relationships … over time these selection and socialisation pressures combine to produce an increasingly impermeable and homogenous disciplinary cultural and correspondingly specialised student orientations to learning. (Kolb, 1981:233–234)

Krishnan argues that within more coherent disciplines (such as the natural sciences/hard sciences) there exists a stronger identity. This is due to the well-structured and well-defined nature of these sciences. The author further argues that a strong disciplinary identity is crucial for the survival of the discipline in its pure form (Krishnan, 2009:24).

> As a result, academic tribes, especially those with less tradition, strife (sic.) for developing a strong cultural identity that allows them to prosper. It is definitely in the self-interest of a disciplinary group to keep its members in line and to uphold disciplinary purity. Academic tribes will therefore eagerly protect their knowledge and their methods by adding cultural features that are difficult to understand or to copy for outsiders.

In the sections above, I have discussed the theoretical scholarship through which scholars have deliberated the formation, ostensible nature and *raison d'être* of academic disciplines. I have contemplated a definition of an academic discipline by drawing on four lines of reasoning. Each of the four arguments identifies a dimension which together constitute the academic discipline. Many of the authors cited above do not consider the discipline along one single dimension but rather as parallel and complementary aspects. In my conceptualisation of an academic discipline, I do not consider one hypothesis to be more pertinent than another. Each of these approaches has emphasised a dimension which could, and have, influenced the way in which academic disciplines have been institutionalised.

This institutionalisation, however, differs over time and context and one should take cognizance of the historical, organisational, epistemological and cultural forces that underlie the formation of scientific fields. In the next section, I continue the discussion on academic disciplines and consider how knowledge, and specifically scientific knowledge, is classified.

2.3 The classification of disciplines

The classification of things, Foucault argues, is an intrinsic human trait (Foucault, 1970).

> There is nothing more tentative, nothing more empirical (superficially, at least) than the process of establishing an order among things; nothing that demands a sharper eye or a surer, better-articulated language; nothing that more insistently requires that one allows oneself to be carried along by the proliferation of qualities and forms … (Foucault, 1970:xxi)

Pantin similarly claims that classification ("the determination of the class to which a phenomenon belongs") lies at the heart of scientific research (Pantin, 1968:16). He, however, simultaneously concedes that the act of classification is a subjective endeavour which does not always yield (deductively) accurate results (Pantin, 1968:78). For Pantin, such a division of the sciences is arbitrary and its value lies only in its practicability. "The division … is such a division of practical convenience and no more …" (Pantin, 1968:24). For Weingart, the practical use of classification lies in the creation of relatively stable delineations. In creating taxonomies of knowledge then, we are able to mediate and direct social change (Weingart, 2010:4).

In the next section, I give a brief overview of some of the classifications of scientific knowledge and academic disciplines. I begin the discussion by exploring some of the earlier ideas regarding the ordering of knowledge. Here I consider Plato and Aristotle's notions of *technê* and *epistêmê* as differentiating between types of knowledge (Barnes, 1986; Plato, 1850). Subsequently, I discuss August Comte's *law of the classification of sciences* (Comte, 2000) and more contemporary works which include Kuhn's differentiation between paradigmatic and pre-paradigmatic sciences (Kuhn, 1970) and Pantin's distinction between restricted and unrestricted fields (Pantin, 1968). The most prominent classification includes Biglan and Kolb's multidimensional framework between hard/soft, pure/applied and life/non-life systems (Biglan, 1973b; 1973a; Kolb, 1981; 1984). Biglan drew from Storer's (1967) original hard/soft dichotomy while also using the pure/applied distinction termed by Bush (1945). I conclude the section with a short discussion on the limitations of the reviewed classifications.

1.1.1. Early classifications of scientific knowledge

The foundations for the classification of knowledge belong to the Greek philosophers. For the purpose of this chapter, I do not comprehensively engage with the early origins of the ordering of knowledge, but rather focus on the modern extensions of these frameworks. It is, however, useful to highlight briefly some of the key ideas that founded the philosophy of (scientific) knowledge. These ideas anteceded our modern concept of institutionalised academic disciplines.

Plato and Aristotle were among the first to think about a differentiation of knowledge. Plato distinguished between *epistêmê* and *technê.* The former relates to knowledge while the latter to craft or skill (Plato). In short, *technê* encompasses the practical knowledge or knowing how to do, whereas *epistêmê* refers to the theoretical knowledge underlying the practical knowhow. In *The Republic* (380 BC), Plato claims *epistêmê* to be logical and deductive. Plato then continues to distinguish between theoretical and practical *technai*, whereas the former exists as an entity *within* itself while practical *technê* results in products *separate* from itself.

Aristotle expanded on Plato's distinction by including three new branches of thought which include *phronêsis* (wisdom), *sophia* and *nous*. In the *Nicomachean Ethics* (Aristotle, 2000), Aristotle views *epistêmê* as scientific knowledge. Scientific knowledge is universally valid and is theoretical in its foundation which accentuates its certainty (Weingart, 2010:3). *Epistêmê* is the result of observation and contemplation and it is perceived to be more stable and independent of context. However, Aristotle later concedes that *epistêmê* cannot always observe what *is*, but rather what *is for the most part* (Aristotle, 2000:1027a; Barnes, 1986). Aristotle saw mathematics, physics[11] and philosophy as the three areas which constitute the *epistêmê.* The objects that exist in *epistêmê*, therefore, exist out of necessity and demonstration.

> Thus scientific knowledge is a demonstrative state, (i.e., a state of mind capable of demonstrating what it known) … i.e., a person has scientific knowledge when his belief is conditioned in a certain way, and the first principles are known to him; because if they are not better known to him than the conclusion drawn from them, he will have knowledge only incidentally. (Aristotle, 2000:1139b)

[11] For Aristotle, physics included the knowledge of the material world and all forms of life –similar to the field of biology as understood today. Mathematics comprised of geometry arithmetic optics and harmonics whereas philosophy was concerned with the cosmos and theology (Weingart 2010:3).

Technê, however, is practical knowledge which is context-dependent and less stable than *epistêmê*. Craftsmanship (*technê)* is primarily concerned with bringing something into being. *Phronêsis* signifies practical wisdom which is pragmatic, variable, and similar to *technê,* dependent on context. Included in this branch of knowledge is that of ethics. "What remains, then is that it is a true state, reasoned and capable of action with regard to things that are good or bad for man" (Aristotle, 2000:1140a). *Phronêsis* and *technê* differ in the sense that the former is concerned with action while the latter with production (aiming at an "end other than itself"). In his writing of *Metaphysics*, however, the distinction between *epistêmê* and *technê* becomes less clear. Aristotle positions the doer of both *epistêmê* and *technê* as someone making a universal judgement from "knowing the cause". *Technê,* therefore, includes more than merely the act of doing, but also the theoretical reasoning behind the doing (perhaps the theoretical *technê* to which Plato was referring) (Aristotle, 2000:981b). Perhaps we can see this as a precursor to the modern classification of pure and applied sciences.

August Comte made a significant contribution towards the ordering of the sciences in that he positioned academic disciplines in a hierarchical fashion (Comte, 2000). Comte mapped the sciences in relation to each other and identified which fields influenced which, and in what ways. His classificatory framework is founded on the basis of observation. Comte perceived scientific disciplines as hierarchical in importance and historicity. Comte positions astronomy as the most general and simple of the sciences as the "first" discipline. Astronomy as a discipline, however, emerged as a result of the principal laws of mathematics. Mathematics, for Comte, is the most independent field. From astronomy, in turn, disciplines such as physics, chemistry, biology and sociology emerged. For Comte, scientific disciplines emerged in a linear fashion building on the foundations of the disciplines which precede them. Comte maintained that "… every science receives the laws which render its existence possible from the sciences which have preceded it in the series …" (Cogswell, 1899; Comte, 2000). Therefore, the formation of new disciplines is built on former or existing disciplines.

Comte positions mathematics, as the foundational science, as studying the simplest phenomena, on the lowest rung of the hierarchy and is followed by astronomy, physics, chemistry, biology and at the top, sociology. For Comte, sociology, as a scientific field, is the most complex. Comte draws the hierarchy of disciplines in terms of *decreasing* generalisability and *increasing* complexity. Therefore, in his law of the classification of sciences, Comte distinguishes between sciences that are simple to complex, general to specific and independent to dependent. It is important to note, however, that Comte's disciplinary hierarchy should not be interpreted to be a value judgement or a normative framework, but rather that sociology as a discipline at the top of the hierarchy, brings together all the other sciences into a relationship with each other in that it is the most complex. In other words, sociology is the most dependent on all the other preceding sciences for its formation or existence (Comte, 2000).

Comte's view of disciplinary fields also speaks to the methodologies associated with each discipline. For Comte, in his *law of the three stages*, sciences move through three stages. All sciences begin (begun) at the theological stage, after which it moves to the metaphysical stage, and finally, the positivist stage. In the final phase, the discipline is able to draw measurable (observable) conclusions through reasoning and observation (Comte, 2000). For Comte, disciplines such as physics have moved to the positivist phase and, therefore, differ in scientific rigour from fields such as sociology, which is (has) yet to move through the final stage. For Comte, simpler fields moved through the three phases quicker than complex fields. Comte, therefore, implies that the development of certain disciplines, such as sociology, lag behind those such as physics. This idea has influenced modern scholars such as Thomas Kuhn as is discussed in the following section.

2.3.1 Prominent (modern) classificatory models of academic disciplines

Even though Comte's *Law of the Classification of Sciences* does not imply a value-driven ordering of the sciences, the stratification of academic disciplines as "lower or higher", resulting from their institutionalisation at universities, guided the thinking around academic disciplines leading up to the eighteenth century (Weingart, 2010:4). Towards the end of the eighteenth century, this idea seemed less pervasive, but is still echoed in some of the modern classificatory frameworks. Kuhn's distinction between pre-paradigmatic fields and mature fields arguably claims that some fields are less likely to become mature. Writing as a physicist interested in the history of the sciences, Kuhn's thesis draws evidence mostly from the physical sciences. His classification, therefore, is partial to the physical sciences. In the quote below, one detects Kuhn's assumption that only when challenging puzzles can be solved, a discipline has matured. Kuhn neglects to attribute status to the problem-seeking nature of the social sciences which fall outside that of "normal science". What is unclear, however, is whether Kuhn views the natural sciences as superior to the social sciences and whether he merely acknowledges the distinctive nature of these fields.

> Only after the change is normal puzzle-solving research possible. Many of the attributes of a developed science which I have above associated with the acquisition of a paradigm I would therefore now discuss as consequences of the acquisition of the sort of paradigm that identifies challenging puzzles, supplies clues to their solution, and guarantees that the truly clever practitioner will succeed. (Kuhn, 1970:179)

Similarly, the distinctions between disciplines offered by Carl Pantin observe the linear and hierarchical ideas introduced by Comte (Pantin, 1968). Pantin's starting point towards identifying scientific fields places mathematics and physics at the top of the hierarchy while more descriptive sciences find themselves towards the lower end. Similar to Comte, Pantin's positioning of fields is dependent on their "exactness".

> In our everyday consideration of them, the sciences are apt to be taken as though they could be placed in a linear series. Mathematics and physics at the top and the others are arranged down the rungs of the ladders up which they are proceeding as they become more exact – as in a dice game. So-called descriptive sciences, such as taxonomy, stand at the bottom, still waiting for a lucky throw. (Pantin, 1968:24)

Pantin, primarily concerned with the natural sciences, classified sciences as either "restricted" or "unrestricted". He viewed the physical sciences as restricted sciences and the biological sciences as unrestricted. His observations of the sciences were based on the knowledge (cognitive) structures of each field. According to Pantin, researchers of the unrestricted sciences (biological sciences) must be prepared to follow their problems into any science whatsoever, whereas the restricted sciences (physical sciences) have delimited phenomena which can be more easily investigated. Pantin claims that the more restricted the observable phenomena are, the more far-reaching the concluding deductions can be. A necessary exclusion of a variety of observable phenomena is an inevitable result (Pantin, 1968).

Kuhn presented a simple two-fold classification which classifies the sciences as either mature or pre-paradigmatic. Kuhn's dichotomy is based on the revolutionary phases of the development of physics and other natural science. Kuhn identifies a mature science as one which has acquired a paradigm (Kuhn, 1970). This acquisition is a direct result of a scientific revolution which replaces the existing paradigm with a new one. He terms this a paradigm shift. Immature sciences (pre-paradigmatic sciences), which include the social sciences and humanities, therefore, exist without clear rules and structures. These sciences need scientific revolutions (paradigm shift) which question the previously accepted foundations of the science in order to evolve into a mature science. What Kuhn argues, however, is that in scientific schools outside that of the physical sciences, such scientific revolutions are unlikely as one discovery cannot revolutionise the many conceptual and theoretical approaches that face social scientists as is typically the case in the physical sciences.

> … (T)he transition from the pre- to the post-paradigm period in the development of a scientific field … Before it occurs, a number of schools compete for the domination of a given field. Afterward, in the wake of some notable scientific achievement, the number of schools is greatly reduced, ordinarily to one, and a more efficient mode of scientific

> practice begins. The latter is generally esoteric and oriented to puzzle-solving, as the work of a group can be only when its members take the foundations of their field for granted. (Kuhn, 1970:178)

Kuhn identifies the pre-paradigmatic state of a discipline as one marked by "… frequent and deep debates of legitimate methods, problems, and standards of solution" (Kuhn, 1970:47). The aim of these debates, however, is not to reach a methodological or conceptual agreement, but rather to define a school (i.e. discipline). During this stage, Kuhn describes scientific efforts, as it characteristically takes place in competing schools, as not contributing to science as we know it (Kuhn, 1970). Only when a science has reached the mature stage can the results of scientific enquiry be regarded as cumulative. The status as a pre-paradigmatic science does not, however, preclude the possession of a paradigm. Rather the nature of the existing paradigm[12] is altered during the maturation process.

Whitley's approach is similar to that of Kuhn (Whitley, 1980). For Whitley, certain disciplines have a high degree of formalisation of intellectual norms and procedures. He compares these fields to those where the methods of enquiry are less formalised and there exist a number of valid alternatives to methods. In other words, the intellectual procedures are more definite (albeit tacit in some cases). Examples of this posit physics and chemistry as disciplines where the domain assumptions are strongly formulated. In other words, researchers in these fields have less variety in (correctly) studying phenomena.

There are a number of scholars who have grappled with the idea of disciplinary differences and how to classify them. For the purpose of this chapter, I limit the discussion to those frameworks I deem relevant to answer the research question of the study. It is, however, important to take notice of some of the various models in the literature. The variation of models are based on the different dimensions of academic disciplines. Lodahl and Gordon are concerned about the level of paradigm development, or consensus, within different fields (Lodahl & Gordon, 1972; 1973). They make a distinction between low- and high-paradigm fields. This idea is also prominent among scholars such as Braxton and Hargens (1996) and Kuhn (1970). Similarly, Hargens studies the idea of consensus within disciplines (Hargens, 1975).

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[12] It is, however, important to state that Kuhn's usage of the term paradigm is not clear. In his post-script Kuhn clarifies his confounding use of the term and clarifies that "a paradigm is what the members of a scientific community share, and, conversely, a scientific community consists of men who share a paradigm" (Kuhn, 1970:176).

One prominent typology adopted by many studies is the *Holland theory of occupational classification* (Jones, 2011). This classification creates a personality-based career development framework by surveying individuals' skills and abilities within their occupational contexts. Instead of then focusing on the characteristics of the disciplines, applications of this framework are interested in how different types of people would fit within which types of disciplines. This framework identifies six types of disciplines which refer to disciplines as (1) *investigative* (included those such as biology and life sciences, geography, physical sciences, engineering and sociology), (2) *artistic* (these include architecture, fine arts, foreign languages and theatre), (3) *social* (including ethnic studies, humanities, education, psychology and social sciences), (4) *realistic*, (5) *conventional,* and (6) *enterprising* (business, communications, computer information, law and journalism). I found this classification to be confounding with little consistency across fields. Subfields, in engineering, for example, fall under *investigative* and *enterprise.* While this classification takes into account the nuances within fields, I found the application of this model limited.

Below, I discuss the three classifications I found to be the most relevant in the theoretical underpinning of the research problem of the present study. I discuss the hard/soft typology by Storer (1976), the basic/applied distinction by Bush (1945) and the Biglan-Kolb taxonomy which draws on the two former classifications (Biglan, 1973a; 1973b; Kolb, 1981; 1984).

2.3.1.1 The hard and soft sciences

The hard/soft dichotomy of academic fields is one that has been at the forefront of many scholars' empirical efforts and necessitates an in-depth discussion. One of the first examples of the terms "hard" and "soft" disciplines is found in Storer's work (1967). Storer's categorisation of disciplines is rooted in their methodologies. The author sets out to understand what implications the informal[13] distinction between "hard sciences" and "soft sciences" have on the organisation of knowledge. In Storer's milieu, the hard sciences were characterised by the use of rigorous mathematical methods which made the professional recognition of scientists the order of the day (Storer, 1967). He perceives the rationale for research (above that of teaching and earning a salary) as professional recognition from peers.

[13] He later refers to this as folk-wisdom.

The use of the term "hard sciences" was based on the level of mathematical rigour used in each field. Disciplines such as physics, chemistry and zoology were considered hard sciences whereas political science and sociology were viewed as softer. The terms "hard" and "soft" were also used to describe the level of difficulty in mastering the discipline where "… physics presumably requires more concentration, more hours of homework and laboratory exercises, than does sociology if one is to earn an 'A' for the semester …" (Storer, 1967:76). Storer, however, is critical of the over-simplistic use of these "classifications".

The author is interested in the social dynamics of the science system and it organises knowledge. His thesis is an effort to describe how this organisation of knowledge relates to the hard/soft classification. He argues that in order for novel contributions in science to be evaluated and accepted, members must be able to relate it to the established set of symbols representing what they know about the phenomena. In sciences such as physics and mathematics, this is a more precise exercise. In sciences such as sociology, the rules of organisation are less precise (Storer, 1976:78). Storer, therefore, acknowledges that there are differences in the rigour of producing and evaluating knowledge in different disciplines. He warns that no body of knowledge is watertight, but that among the hard sciences there is a relative difficulty in mastering a subject.

> It suggests also the degree of difficulty involved in making a contribution to the subject and, thus, the degree of risk a scientist takes when he offers a contribution. If a hard science is one in which error, irrelevance, or sloppy thinking is relatively easy to detect, then the scientist must take greater pains in his research if he does not wish to be exposed as incompetent. (Storer, 1976:79)

In the softer sciences, conversely, "… it is likely that such non-scientific criteria as relevance to common values or to practical problems, elegance of style, or even the unexpectedness of one's findings *vis-a-vis* common sense, will play a larger part in determining the acceptance and success of a contribution…" (Storer, 1976:79). The fact that scientists arguably take greater risks in making scientific contributions in the hard sciences than the social sciences, renders the label appropriate. He attributes this greater risk to the fact that new research is evaluated along a stricter set of rules (rigour) than found in the softer sciences.

Storer, although acknowledging the different dynamics and characteristics that make up different disciplinary fields, states that there is a trend among the softer sciences to emulate the rigour and precision displayed by sciences such as mathematics. He claims this not to be an emulation, but rather a need from within the softer sciences to gain more effective grounds on which to organise the collective efforts of its scientific members (Storer, 1976:83).

2.3.1.2 The basic and applied sciences

The separation of basic (pure) and applied science was first made by Bush in 1945 (Bush, 1945; Stokes, 1997). As director of the Office of Scientific Research and Development, Bush used this distinction in his plans for scientific progress in the USA. Bush's categorisation is founded on the goals of research, rather than their characteristics. For Bush then, the basic sciences aim to contribute to the understanding of the phenomena within the relevant field as "… basic research is performed without thought of practical ends …" (Bush, 1945). Applied research, therefore, is a response to a societal or individual need. In other words, applied research aims to produce research for a specific use. Following the Bush report, the assumption was generally that basic research was done out of intellectual curiosity or "… to discover new knowledge for its own sake …" (Stokes, 1997:11). Similarly, in the post-war period, it was believed that basic and applied research were two different undertakings by different researchers "… with different gifts and different interests …" (Stokes, 1997:11). This tension was at the forefront of Bush's thinking about the functions of research and argued that the two cannot be conflated as "… applied research [will] invariably drive out the pure …" (Bush, 1945).

The Organisation for Economic Co-operation and Development (OECD) defines basic research as "… experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts …" (OECD Glossary of Statistical Terms - Basic research Definition, n.d.; Stokes, 1997). Some of the ostensible differences between basic research and applied research include originality, that those working in basic research have more freedom compared to their applied counterparts, and that the length of time between discovery and application differs between the two "types" of fields (Stokes, 1997:7). For Bush, basic advances in research are the primary source for technological innovation. This opposing positioning of the two "types" of research lies at the core of their distinction. Stokes argues that there exists an inherent tension between the two types of research where the one exists only in opposition to the other (Stokes, 1997). He claims that "understanding" and "use" are perceived as conflicting goals. For him, this renders this paradigm a static one.

Bush, however, extended his original classification towards a more dynamic, linear model (Bush, 1945). The author claims that (basic) scientific advances could move towards, or be converted, to application, or practical use. Basic research could then, in a technological sequence, be converted to applied research, from where it converts to development, and finally production and operations (Stokes, 1997:10).

> Together with its equally linear static corollary, the basic applied spectrum, this dynamic linear image provided a general paradigm for interpreting the nature of research, one that is remarkably widespread in the scientific and policy communities and in popular understanding even today. (Stokes, 1997:11)

Reagan suggests that given the difficulties in demarcating basic versus applied sciences, one should perhaps move past such a classification. He, like Bush, places the two types of research on a continuum (Reagan, 1967). He argues that "… the distinction between basic and applied may also be but a matter of time …" (Reagan, 1967:1384). Reagan suggests that this (arguably arbitrary) dichotomy may be less appropriate in demarcating basic sciences from the applied, and rather speak to "… considerations of status, prestige, and social ideology …" (Reagan, 1967:1384).

Towards the latter half of the twentieth century, the rationale for doing research has traversed Bush's narrow classification. Despite its limitations, the basic and applied dichotomy has been greatly influential in discerning between scientific disciplines. Gibbons et al. in their presentation of new modes of knowledge production, reconfigured Bush's dichotomy (Gibbons et al., 1994). For the authors, doing basic research can be thought of as generating knowledge in Mode one, whereas Mode two includes applied knowledge or research. I do not elaborate on the new modes of knowledge production here, as the authors do not offer a classificatory framework through which to consider specific academic disciplines. Although they do claim that knowledge produced in Mode two is generally interdisciplinary, their framework is not directly relevant to the discussion here.

The theoretical framework that guided the classification of disciplines in the study drew on both the distinctions offered by Storer and Bush (Bush, 1945; Storer, 1967). In the following section, I introduce the taxonomy of Biglan and Kolb as the theoretical framework I argue to be the most useful in thinking about disciplinary differences (Biglan, 1973a; 1973b, Kolb, 1981; 1984).

2.3.1.3 The Biglan-Kolb taxonomy of disciplinary fields

Biglan was interested in how the subject matter of disciplinary fields influence their departmental organisation. (Biglan, 1973b). For Biglan, academic fields are built on a shared paradigm or cognitive structure. The author claims that the organisation of academic disciplines has been taken as the norm, with little attention given to the role that the characteristics of subject matter play in the conception of academic disciplines. Biglan claims that there existed no systematic study that identified the nature of subject matter differences between physics and psychology, for example. In his classification, he sought to identify disciplinary differences along several dimensions. The author undertook to study the judgments of practitioners across disciplines on the characteristics of their subject matter in 36 academic fields in terms of the perceived similarities or differences. His aim was to identify a multidimensional framework of the characteristics of the subject matter of disciplines (Biglan, 1973b).

Biglan anticipated that his respondents would think about differences between disciplines in terms of Kuhn's paradigmatic and nonparadigmatic dichotomy. Similarly, he foresaw that scholars would judge disciplinary differences along the lines of their practical application. In his data analysis, Biglan identified three dimensions along which to classify differences in subject matter[14] (Biglan, 1973b). He identified the first dimension as the hard/soft dimension. He plotted science-oriented areas such as the physical sciences and engineering on the hard side of the dimension, while the social sciences are positioned in the middle, with the humanities on the soft side of the dichotomy. Biglan identified the hard/soft dimension as the most prominent and supportive of Kuhn's typology.

> The paradigm serves an important organising function; it provides a consistent account of most of the phenomena of interest in the area and, at the same time, serves to define those problems which require further research. Thus, fields that have a single paradigm will be characterised by greater consensus about content and method than will fields lacking a paradigm. (Biglan, 1973b:202)

For Biglan then, paradigmatic fields such as physical and biological sciences are synonymous with Storer' conception of the hard sciences. He accepted Kuhn's idea that pre-paradigmatic fields, such as the humanities and education, have yet to achieve a clear paradigm replacing their arguably idiosyncratic content and method. A criticism of Kuhn's classification, however, is his predilection towards the physical sciences with little or no regard for the social sciences. Biglan also makes no explicit mention of the hard/soft dichotomy presented by Storer (1969). Storer's classification makes the distinction between fields based on the rigorousness of their methods rather the presence of a clear paradigm. The reader of is then left uncertain of where Biglan's terminology in terms of hard/soft fields, originates.

The second dimension identified by Biglan is the pure/applied dimension. Biglan places disciplines such as education, accountancy, finance and engineering on the applied end of the scale, while fields such physical sciences, mathematics, social sciences, languages, history and philosophy are considered as pure (basic) fields. Biglan argues that fields classified as applied, are intrinsically concerned with the "… practical application of their subject matter…" (Biglan, 1973b:198). Once again,

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[14] Biglan used Kruskal's (1964) technique for nonmetric multidimensional scaling to analyse his results.

Biglan does not explain his use of the terms pure and applied any more than this and he does not elaborate whether he drew this dimension from Bush's original differentiation.

Biglan identified a third dimension of academic disciplines as distinguishing between disciplinary areas which are concerned with studying living or organic phenomena. He identified fields such as agricultural, biological, the social sciences and education as those involving the study of living things (including humans, or systems). On the other side of this dimension lie fields whose subject matter does not include living things (inanimate objects). In other words, what they have in common is the "… absence of biological objects of study…" (Biglan, 1973b:198).

In his identification of a framework, Biglan is primarily concerned with the cognitive processes which construct an academic field. In summary, Biglan's framework identifies the cognitive styles of academic fields in three dimensions which include first, hard/soft as the cognitive paradigm of a discipline, in other words, "the degree to which a paradigm exists", second, pure/applied in its focus on practical application, and third, life/non-life as the study of life (or non-life) systems (Biglan, 1973b).

David Kolb focused on the learning styles of students and studied, particularly how it relates to the cognitive styles of disciplines (Kolb, 1981; 1984; Kolb & Plovnick, 1974). He identified an experiential learning model which is a dialectical conceptualisation of the learning process. This four-stage process takes into account the different learning styles and learning environments of students. A student can draw from a set of learning abilities depending on what is required for a specific learning task (Kolb, 1981). Kolb set out to examine the differences in "… inquiry norms of academic disciplines …" through his *experiential learning theory* by studying the learning styles of a combination of graduate students and practicing managers[15]. Kolb built on Biglan's framework by adding the learning-style dimensions of abstract-concrete[16] and reflective-active. Kolb found that there exist strong similarities between his and Biglan's classificatory framework (Kolb, 1981).

Kolb indexed disciplines in four quadrants which include the (1) concrete-reflective, (2) abstract-reflective, (3) abstract-active, and (4) concrete-active. Fields in the natural sciences and mathematics are considered as abstract-reflective, while other science-based professions (such as engineering) fall in the abstract-active quadrant. The concrete-active fields include the social professions such as education, social work and law, while the concrete-reflective sciences include the

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[15] Kolb originally studied graduate students and practitioners in management studies. He later replicated his study with 32 936 graduates in 158 institutions and 60 028 faculty members across 303 institutions, in mathematics.

[16] Kolb drew from the writings of Snow (1998) in his use of the terms concrete and abstract.

humanities and social sciences. In the figure below, I illustrated Kolb's dimension in relation to its conceptual counterparts as constructed by Biglan.

Abstract-reflective/ hard-pure *Natural Sciences and Mathematical Sciences*	**Abstract-active/ hard-applied** *Science-based professions such as Engineering Sciences*
Concrete-reflective/ soft-pure *Humanities and Social Sciences*	**Concrete-active/ soft-applied** *Social professions such as Education, Social Work and Law*

Figure 2-1 The Biglan-Kolb classification of academic disciplines

The use of this hybrid taxonomy is applied by Becher in his work on academic tribes and territories (Becher, 1987; 1989; 1994). Becher extends Biglan's classification and replaces the life/non-life systems with convergent-divergent sciences while adding urban-rural sciences. As mentioned earlier in the chapter, the work of Becher has been influential in thinking about differences between disciplines as cultural communities. This framework has also been used by Neumann, Becher and Parry in their study of teaching and learning within disciplinary contexts (Neumann, Becher & Parry, 2002).

Although the extension of Biglan's model by Kolb appears to provide a comprehensive classificatory framework, the Biglan-Kolb simple two-dimensional taxonomy (hard/soft and pure/applied) has been the most widely used as a theoretical framework to underpin empirical research which focus on disciplinary differences[17]. A number of studies found that Biglan's taxonomy proved consistent and valid when tested as a theoretical framework[18].

Given its widespread acceptance as a valid framework, I employed Biglan-Kolb's two-fold dimension of hard-soft (abstract-concrete) and pure-applied (reflective-active) sciences as the classificatory scheme of disciplines in this study.

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[17] See Barnes & Randall (2012); Barnes, Williams & Stassen (2012); Creswell & Bean (1981); Fanelli (2010); Gardner (2009a; 2010b); Jones (2011); Karimi (2014); Kreber & Castleden (2009); Krishnan (2009); Lee (2007); Mastekaasa (2005); Neumann, Becher & Parry (2002); Richardson (2013); Schommer-Aikins, Duell & Barker (2003); Simpson (2017); Smeby (2000); Stoecker (1993).

[18] See Barnes, Agago & Coombs (1998); Creswell & Bean (1981); Del Favero (2006); Malaney (1986); Muffo & Langston IV (1981); Paulsen & Wells (1998); Smart & Elton (1975); Smart & McLaughlin (1978); Stoecker (1993).

It is, however, important to consider the limitations associated with this model. Biglan collected his data by surveying faculty members at two institutions in the USA. It can be argued, therefore, that his framework is Amerocentric in its conception (Simpson, 2017) and its validity to the structures of disciplines, especially in the African context, can be questioned. A study by Mastekaasa applied Biglan's framework to the study of gender differences in recruitment to Norwegian doctoral programmes and found the framework to retain its validity (Mastekaasa, 2005).

I previously mentioned that Biglan's theoretical reliance on Kuhn makes for a narrow conception of a definition of a paradigm, and subsequently an academic discipline. In addition, Kuhn's distinction of paradigmatic and pre-paradigmatic fields neglects to engage with the "idiosyncrasies" of the social sciences. Biglan also omits to state explicitly whether his hard/soft dimension is compatible with that presented by Storer. Biglan rather equates his hard/soft dichotomy with the paradigmatic and pre-paradigmatic distinctions of Kuhn. The classification of disciplines, as I argue in the section below, is problematic at best, but given the extensive application of Biglan-Kolb's multidimensional framework in the literature, I believe it to be a sufficient schema for the empirical analysis of the study.

2.3.2 Limitations of the classification of disciplines

I have previously discussed Foucault's argument that the construction of knowledge should be situated within a social and historical context. He extends this argument to include the manner in which we classify or order things. Foucault warns us that there is a great danger is grouping together some, and distinguishing between others, as categorisations are not unbiased or detached from a system of elements (Foucault, 1970). Becher also warns us against the unquestioning use of disciplinary taxonomies as disciplines are ever changing (Becher, 1989). One should, therefore, use caution when "ordering" phenomena without a thorough reflection of its influencing factors. Pantin is also wary of knowledge taxonomies in his emphasis on the arbitrary nature of classification. Kuhn also contemplates this question.

> Research as a strenuous and devoted attempt to force nature into the conceptual boxes supplied by professional education. Simultaneously, we shall wonder whether research could proceed without such boxes, whatever the element of arbitrariness in their historic origins and, occasionally, in their subsequent development. (Kuhn, 1970:5)

Although Kuhn does not explicitly refer to academic disciplines, he raises the question of whether science as we know it can exist without the fabricated delineations. I have previously discussed this "causality conundrum".

In the previous sections, I presented an overview of some of the most prominent models which explain differences between disciplines. Almost all of the classifications discussed have their origins in either Europe or the USA. One can, therefore, argue that these models are limited to Western models of knowledge and science systems. Many of the authors discussed also share a focus on disciplines in the natural sciences with little explicit claims about those in other fields. Many of the characteristics attributed to disciplines in the social sciences, particularly in the works of Kuhn, Pantin and Hagstrom, are constructed *in opposition to* the natural sciences.

The bulk of the modern classifications discussed here were prominent in the latter half of the twentieth century and I have found no significant novel classifications following the 1980s (with the exception of Gibbons et al.) that could contribute to the classificatory framework of the study. Instead, there has been a shift in focus toward interdisciplinarity (Bradbeer, 1999; Krishnan, 2009; Morillo, Bourdons & Gomez, 2003; Neuhauser, Richardson, Mackenzie & Minkler, 2007; Thompson Klein, 2006; Turner, 2000; Weingart & Stehr, 2000).

I have argued, throughout the chapter, that the definitions and delineations of academic disciplines are well deliberated and I have presented those which I consider as the most prevailing. In my application of these classifications, I do not necessarily agree with the assumptions underlying their construction and given the extensive debates on what constitutes an academic discipline and how we should go about comparing them, I argue that we should move beyond these particularities. Instead, we should aim our attention at *how* disciplinary cultures or knowledge structures are internalised and communicated. This lies at the core of graduate education and how to go about comparing it across disciplinary fields. Phenix offers a poignant summary of this argument.

> How … can we be sure that the concept of a discipline is definite and significant enough to serve as a basis for the organisation of knowledge? [The answer] is empirical and pragmatic: disciplines prove themselves by their productiveness. They are the visible evidence of ways of thinking that have proven fruitful. They have arisen by the use of concepts and methods that have generative power. (Phenix, 1964:48)

In the following section, I explore how these differences are manifested and produced across the five selected disciplines and I briefly discuss some of the core ideas as argued by the authors discussed above.

2.4 A profile of five selected disciplines

In this section, I focus on the theoretical frameworks discussed above with reference to the five selected disciplines that I have selected for the empirical analysis. I focus specifically on the *implications* that these ideas have on the way that doctoral education is performed. It is important to note, however, that the ideas presented below are the starting assumptions of the authors on which they founded their classifications. In some cases, empirical evidence underlies the characteristics ascribed to disciplines (Becher, 1994; Biglan, 1973b; Kolb, 1981; Smeby, 2000), but it should be noted that these characteristics are constructed on observations and should be interpreted as such. Kolb acknowledges that his efforts to highlight differences between disciplines are somewhat reductionist in that he cannot capture all the complexities and variation within disciplinary knowledge structures (Kolb, 1981). He emphasises that there exists significant variation within disciplines and that his findings should merely serve as dimensions through which to describe these variations.

It should also be noted that in the empirical components, I studied time-to-degree within disciplines as a whole. In other words, I compared physics with sociology and with education and so forth. I did, therefore, not distinguish between, for example, theoretical physics or experimental physics and I did not explicitly study differences among disciplinary subfields. In addition, I have previously argued that disciplines are institutionalised differently across universities, and for the most part, I treated the five selected disciplines homogenously in the empirical analysis.

The first discipline I discuss is physics. There is a general consensus that physics is one of the foundational or "mother" disciplines (Hagstrom, 1965; Kuhn, 1970; Pantin, 1968) and there is thus a comprehensive body of scholarship on physics as a scientific discipline. There is a similar fascination with sociology, and its relevance, as an academic discipline. I do not elaborate on these ideas here, but rather focus on how the cognitive, methodological and cultural structures of sociology differ with that of physics. Finally, I discuss engineering, education and the clinical health sciences under the banner of applied fields. I contrast the theoretical conceptions of these disciplines with that of the pure/reflective sciences such as physics and sociology. For each of the disciplines discussed below, I provide, where available, an overview of the discipline in South Africa.

2.4.1 Physics

The larger part of the classifications of disciplines discussed in this chapter took physics as a starting point. Many of the differences between disciplines observed were done so in relation to physics. As discussed earlier in the chapter, physics was one of the founding academic disciplines. Kuhn, however, attributes the establishment of the first cohesive physics community to the middle of the nineteenth century merging from mathematics and natural philosophy (Kuhn, 1970). He saw physics as mature science with a clear paradigm given the existence of clear paradigm shifts in its evolution. Pantin holds physics as a discipline in high esteem and argues that given its restricted nature, physics has been able to mature into an exact science (Pantin, 1968:18). Biglan and Kolb classify physics as a hard-pure/abstract-reflective science given its clear paradigm and the ostensible rigour associated with its enquiry methods.

Kolb in his analysis of the learning styles of disciplines, argues that knowledge structures differ between disciplines, i.e. that which is considered to be valid knowledge, how knowledge is reported, enquiry methods, and criteria for evaluation (Kolb, 1981). For Kolb then, the science-based disciplines (such as physics) are "… predominantly analytical, seeking to understand wholes by identifying their component parts …" (Kolb, 1981:244). He contrasts this with the synthetic nature of the social-humanistic fields, in that within these fields (where human behaviour often constitutes the subject matter), the whole should be analysed in its totality or as a sum of its component parts. Kolb also associates science-based fields with empiricism and quantitative model building based on structuralism[19].

> … (T)he analysis, measurement, and categorisation of observable experience and the establishment of empirical uniformities defining relationships between observed categories (natural laws) with a minimum of reliance on inferred structures of processes that are not directly accessible to public experience. (Kolb, 1981:244)

Kuhn claims that unique to the hard-pure sciences (or the mature sciences) is the fact that demands for solutions to problems are the starting point for new knowledge. There is also a great amount of value placed on innovation "for innovation's sake" (Becher, 1989:13). At any given time, scholars in the hard-pure sciences, are able to identify the pressing questions needing further investigation (Becher, 1989). Along this argument disciplinary boundaries are clearly defined and circumscribed.

The hard-pure sciences (such as chemistry) are typified by relatively steady growth. New findings are often generated in a linear fashion starting from an existing state of awareness. Becher and Kuhn refer to a process of accretion (Becher, 1989; Kuhn, 1970). For Kuhn, past knowledge is

[19] He refers here to Piaget's structuralist philosophy as one which "…seeks to distinguish the primary, essential elements and relationships in a phenomenon from the secondary, accidental relationships" (Piaget, 1970; Kolb, 1981:244).

superseded among the hard-pure sciences. Metaphorically new knowledge "… grows like a crystal or branches out like a tree …" (Becher, 1989; Kuhn, 1970). This argument supports the notion that in the hard-pure sciences previous findings are assimilated (Becher, 1989). Kolb and Storer argue that the hard sciences typically break down complex ideas into simpler components whereas in the soft sciences, complexity is valued and holistic approaches esteemed (Becher, 1989; Kolb, 1981; Storer, 1967). Austin views knowledge in the hard-pure sciences to be cumulative where "… goals are discovery, explanation, identification of universals and simplification …" (Austin, 1990:64).

Methodologically, the hard-pure sciences typically follow a quantitative route which values precision of measurement (Becher, 1989:14). Although methods in the social sciences evolved over past decades, the soft/concrete sciences typically employ qualitative research methods which allow researchers to engage with minute conceptual delineations (Becher, 1989:14). Smeby refers to hard (abstract) fields as "codified" fields which typically use a stringent symbol system and the extensive use of mathematics (Smeby, 2000). Kolb and Pantin similarly argue that the hard sciences gather knowledge by "… seeking regularities and framing mathematical models …" (Becher, 1989:14; Kolb, 1981; Pantin, 1968).

2.4.2 Sociology

August Comte, often termed the "father of sociology" argued the case for sociology as an academic discipline in the nineteenth century. As already mentioned, Comte views sociology as the most complex of the sciences (at that time) in that it was the least specific in terms of its methods, but also subject matter. Pantin takes a similar approach in his notion that sociology, as an unrestricted field, is faced with a multitude of variables and phenomena to be studied (Pantin, 1968:123). It is thus more difficult to identify clearly the relationships between phenomena through hypotheses. Kuhn[20] argues that among the social sciences

> … the student … is constantly made aware of the immense variety of problems that the members of his future group have, in the course of time, attempted to solve. Even more important, he has constantly before him a number of competing and incommensurable

[20] It should be emphasised here again that both Pantin and Kuhn were only concerned with the physical sciences and that their opinions of the social sciences, in this case sociology, are only implied.

> solutions to these problems, solutions that he must ultimately evaluate for himself. (Kuhn, 1970:164)

Within these disciplines then, practitioners are confronted with, more often than not, competing paradigms. Authors such as Biglan (1973a; 1973b), Kolb (1981) and Becher (1989) consider sociology a soft-pure/concrete-reflective science. As stated earlier, their studies include empirical research on which they based their understanding of the differences between disciplines. One should, however, be wary to take these characteristics as definitive as they are bound within the limitations of their respective studies. It is, however, useful to highlight some of their key ideas.

Becher views sociology as a discipline as one where well-defined boundaries are arguably lacking (Becher, 1989). Research questions are also selected in a *laissez-faire* manner. He argues that there is a "… greater apparent permeability of the loosely defined border zones which exist between neighbouring territories …" (Becher, 1989). The soft-pure sciences (i.e. sociology) are predominantly recursive, or have a reiterative pattern of development. Academic work seldom explores foreign ground and Becher and Kuhn visualise knowledge to evolve like an organism or a meandering river (Becher, 1989; Kuhn, 1970). The soft-pure sciences typically lack consensus about that which constitutes an authentic contribution. Criteria for evaluating research contributions are, therefore, diverse and contested. Academic contributions are often new interpretations or enhanced insight into existing and familiar questions. This lack of consensus is what Kuhn views as pre-paradigmatic. This stands in direct opposition to the hard-pure sciences where there is an "… apparent clarity of the criteria for establishing or refuting claims to new knowledge ..." (Becher, 1989:13).

Kolb argues the social sciences' approach towards knowledge as organicist. For him, the search for truth lies in its coherence as "… a meaningful gestalt that integrates phenomena …" (Kolb, 1981:244). The author, however, concedes that within disciplinary fields, there is a great variety of norms of enquiry and knowledge structures. Functionalist sociology, for Kolb, is abstract and theoretical in nature, whereas phenomenology is often more concrete and active (Kolb, 1981:244). For Abbot, this variation lies at the heart of sociology. Abbot views the nature of sociology as interstitial in that it cumulates subject matter and styles of thought (Abbott, 2001).

> … (T)he discipline is not very good at excluding things from itself… once such an area makes a claim for sociological attention, the discipline doesn't have any *intellectually* effective way of denying that claim. So sociology has become a discipline of many topics – always acquiring them, seldom losing them. (Abbot, 2001:5)

Abbot thus echoes Pantin's notion of the unrestrictedness of the phenomena studied in, for example, sociology. Abbot also reprises Comte's argument about sociology's generality in that "… sociology's claim as the most general social science rests on its implicit and fuddled claim that no form of knowledge (about society) is alien to it…" (Abbot, 2001:6). Sociology's (social science) interstitial nature is in its positioning between the natural sciences and humanities. The author argues that this positioning leaves the social scientist in the gaps of modes of knowledge, modes of facts and modes of values.

It is important to note that sociology has a history of being a fragmented and often politicised discipline, both in South Africa (Jubber, 2007; Mapadimeng, 2009) and internationally (Becher, 1981). Although there are various schools of thought that subscribe to Kuhn's idea of opposing paradigms, I do not elaborate on these here, but rather emphasise that the nature of sociology as a general and complex discipline with a plethora of subject matter, paradigms or methods shine light on the challenges faced by doctoral students in this disciplines. I discuss this in further detail in the next chapter where I also explore the state of sociology in South Africa, as an academic discipline.

2.4.3 Engineering, the health sciences and education

In the final section of the chapter, I discuss the remainder of the selected disciplines (the clinical health sciences, electrical engineering and education) under the banner of applied/active fields. These disciplines have also been referred to as vocational or professional fields. Toulmin's notion of an applied science, in relation to a pure science, echoes Bush's original distinction.

> A mechanical engineer, for instance is trained to apply techniques of representation devised by the physicists of earlier generations. What differentiates the engineering from the physicist is, precisely, the physicist's obligation to apply his explanatory techniques critically exploring the limits of their scope rather than taking them on trust, improving them rather than putting them to practical use. (Toulmin, 1972:165)

Creswell and Bean argue that the applied sciences are typically more service-oriented (Creswell & Bean, 1981). Biglan, similarly, emphasises the practitioner's preoccupation (or responsibility) towards service-oriented activities (Biglan, 1973b).

Biglan and Kolb make a distinction between what they term hard-applied/abstract-active and soft-applied/concrete-active sciences (Becher, 1989; Biglan, 1973a; 1973b; Kolb, 1981). Kolb classifies education as a soft-applied science. He also considers soft-applied fields (including social work and law) as social professions. Soft-applied disciplines, for Kolb typically deal with complex phenomena (Kolb, 1981). These areas, therefore, draw on soft-pure knowledge in attempting to understand human behaviour. The aim, however, is to enhance the quality of subjects' personal and social life.

The academic fields are often less stable than hard-applied fields and show less evident levels of progression. Given the nature of soft-applied areas' object of research, its intellectual roots are often found reformulated interpretations of the social sciences and humanities (Becher, 1989). The primary outcomes of soft-applied research are procedures and protocols that are judged for its pragmatic and utilitarian use.

Hard-applied disciplines, such as engineering, are "… amenable to heuristic trial and error approaches …" (Becher, 1989:15). Its knowledge is not necessarily cumulative, but from time to time, and depending on the area of research, it may draw on the techniques and findings of cumulative knowledge. The main purpose of hard-applied science is to find ways of mastering the physical world, judged by purposive criteria, which typically results in products and techniques. Kolb, however, views professional fields, such as the clinical health sciences (and to an extent, education) as multidisciplinary in its foundation which comprises of a variety of learning styles. Disciplines such as the clinical health sciences are both concerned with human service and scientific knowledge (Kolb, 1981:244).

I have referred here to a number of studies which have described the ostensible differences between academic disciplines in their application. Many of these findings, however, contribute to a popular notion of the hard (natural sciences) as superior to its counterparts given the rigour of its methods in comparison to, for example, the social sciences and humanities. As I have mentioned earlier, the ideas highlighted above are assumptions contained within particular studies and it should be noted that many of these studies investigated the perceptions of practitioners within selected fields. Regardless then of the accuracy of these claims, they are founded on how those working within the fields perceive the knowledge structures of their disciplines.

2.5 Conclusion

In this chapter, I set out to discuss the theoretical frameworks through which to approach the primary research question of this study. I started this chapter with a four-fold definition of a scientific discipline. The first approach considered scientific knowledge as a culmination of historical and social processes. Central to this argument was Foucault's notion that scientific knowledge is positioned within an epochal episteme. A second definition viewed disciplines as organisational forms. From this perspective, academic disciplines are viewed as a response to market demands and reflects a division of labour. The institutionalisation and professionalisation of academic disciplines are central to this idea. The third approach saw the development of academic disciplines around cognitive structures. Here, the body of knowledge, which include commonly shared theories and concepts, constitute the paradigm of a discipline, or axis of cohesion. The final definition introduced scientific fields as discursive communities and as aggregates of cultural practices. Academic disciplines were subsequently thought of as tribes which inhabit territories and shared customs. Each academic tribe shares a disciplinary discourse which members have to internalise. This internalisation process is done through academic socialisation. The disciplinary *habitus* is communicated from faculty members to graduate students through which the students become members of a discipline. In defining an academic discipline, the theoretical approaches identified four dimensions of academic disciplines and how historical, organisational, epistemological and cultural forces have influenced the institutionalisation of scientific fields. Throughout the chapter, I argued that the definition of a discipline is secondary to the *performance* of the discipline.

In the second half of the chapter, I discussed some of the classification systems used in thinking about scientific disciplines. I recognised the constraints of classification in that such an exercise is often a subjective and inaccurate one. Notwithstanding these limitations, I explored Plato and Aristotle's notions of *technê* and *epistêmê* as differentiating between types of knowledge. Subsequently, I discussed Comte's *law of the classification of sciences*. Comte classified sciences in a linear hierarchy from simple to complex; specific to general and independent to dependent. Thereafter, I reviewed some of the modern classifications where Kuhn differentiated between paradigmatic and pre-paradigmatic sciences in that he saw disciplines such as physics or chemistry as mature sciences that are guided by clear paradigms. Pantin separated scientific fields on the basis of their subject matter and postulated that fields with a restricted number of observable phenomena (such as the physical sciences) are more exact than those with unlimited variables. The discussion continued towards a theoretical framework underpinning this empirical research. I presented Biglan and Kolb's multidimensional framework as a suitable taxonomy in the distinction between hard/soft, basic/applied and life/non-life systems. While aware of the taxonomy's shortcomings, I argued that the widespread application of the Biglan-Kolb model renders it a useful approach.

I concluded the chapter with a brief discussion of the characteristics assigned to disciplines. In Table 2-1 below, I summarise the dimensions of academic disciplines along firstly, their classification along the Biglan-Kolb taxonomy, secondly their paradigm development or cognitive structures and processes, thirdly the characteristics of subject matter, and finally, the methodological assumptions and methods which use are prominent within the selected fields

Table 2-1 Biglan-Kolb classification of selected disciplines

	Biglan-Kolb taxonomy	Paradigm development/Cognitive styles	Characteristics of subject matter	Methodological implications
Physics	abstract-reflective/ hard-pure	• Mature science with a clear paradigm • Clear paradigm shifts in its evolution • New findings are typically generated in a linear fashion through accretion • Past knowledge is superseded or assimilated	• Restricted and exact science • Codified field • Complex ideas are broken down into simple components • Knowledge is cumulative • Goals of discovery, explanation, identification of universals and simplification	• Rigorous methods used • Empiricist • Predominantly quantitative methods • Based in structuralism • Predominantly analytical • Seek to understand the whole as a sum of its component parts
Sociology	concrete-reflective/ soft-pure	• Pre-paradigmatic • Competing paradigms • Boundaries of disciplines are less defined • Recursive field with a reiterative pattern of development • Great variety in norms of enquiry and knowledge structures	• Subject matter is unrestricted • Complexity is valued • Often includes human behaviour as subject matter • Interstitial	• The whole is analysed in its totality • Holistic approaches where often qualitative methods are favoured • Least specific field in terms of methods (generalist) • Organicist
Clinical health sciences and Electrical engineering	abstract-active/ hard-applied	• Knowledge not purely cumulative • Multidisciplinary in foundation	• Vocational or professional fields • Service-oriented • Goals include human service and scientific knowledge	• Heuristic trial and error approaches • Outcomes judged by purposive criteria which include products and techniques
Education	concrete-active/	• Pragmatic and utilitarian • Less stable than hard-applied fields	• Social profession • Complex phenomena which	• Outcomes include procedures and protocols

	Biglan-Kolb taxonomy	Paradigm development/Cognitive styles	Characteristics of subject matter	Methodological implications
	soft-applied	• Intellectual roots in reformulated interpretations of social sciences and humanities	include human behaviour • Goals include the human service and scientific knowledge	

In this chapter, I discussed the nature of physics, as a hard-pure science, with regard to its cognitive structures and methods of enquiry. Scientific enquiry in physics is often perceived to be analytical, empirical and cumulative and guided by a codified and clear consensus. Sociology, by contrast, is observed as complex, organicist and unrestricted in its subject matter and methods of enquiry. Finally, engineering, education and the clinical health sciences, as applied disciplines, were considered as pragmatic and service-oriented disciplines. In the forthcoming empirical components, the analysis of determinants of doctoral completion times is conceptualised within these theoretical schemes.

In the next chapter, I discuss the findings of existing literature on the conceptualisation and measurement of doctoral success and analyse existing studies on doctoral education in South Africa.

Chapter 3 | Conceptualising and measuring doctoral success

In this chapter, I give a discussion of existing studies on the conceptualisation and measurement of doctoral success. I start the discussion with a review of existing studies on doctoral education in South Africa. There has been a recent emphasis, on the part of the South African government, to expand doctoral education and this has led to a number of empirical studies on the topic. Similarly, the study of student retention and drop-out rates has gained prominence in recent years and I review the findings of the most prominent literature. I discuss some of the shortcomings of existing studies on doctoral education in South Africa and discuss how the present study aims to address them. Drawing on existing research done in the South African context, I present an overview of doctoral education in South Africa which I do along five themes. First, I identify trends in enrolment and graduates. Second, I describe the demographic profile of doctoral students in South Africa. I then explore the doctoral pipeline. Fourth, I discuss doctoral supervisory capacity, and last, I identify the prominent models of doctoral education in South Africa. This subsection concludes with a discussion of the use of performance in research on doctoral education.

Subsequently, I briefly review the state of doctoral education in the five selected disciplines in South Africa. The chapter concludes with a synthesis of the main findings concerning success in doctoral education in South Africa and that found elsewhere.

3.1 Research on doctoral education in South Africa

There exists a substantive body of scholarship on measuring student success across all degree levels. From a scholarly and institutional perspective, there has been a global and widespread effort to understand and address matters pertaining to student success[21].

[21] See Abiddin & Ismail (2011), Adams et al. (2010), Allen (1999) Ampaw & Jaeger (2012), Bamforth, Robinson, Croft & Crawford (2007), Bourke et al. (2004a, 2004b), Brooks (2012), Brunsden, Davies, Shevlin & Bracken (2000), Cabrera, Nora & Castañeda (1993), Cardona (2013), Carter (2007), Chyung (2001), Crede & Borrego, (2013), Crosling, Heagney & Thomas (2009), De Valero (2001), Elgar (2003), Fontaine (2014), Fox & Palmer

The bulk of the literature, however, studies undergraduate retention/attrition and identify the various dimensions associated with student success. Of studies that are concerned with doctoral students, the majority primarily investigate measures of and factors that attribute to completion or success. Studies which explicitly examine time-to-degree of doctoral students are less frequent. In this section, I review the most recent studies that explore doctoral education and student success in South Africa. Recently, identifying indicators along which to measure the efficiency of higher education in South Africa, has gained prominence. This has been a response to the benchmarks set out by the NDP to expand doctoral education in South Africa (2011). However, the majority of studies over the last 15 years have focused primarily on identifying barriers towards the desired expansion of higher education (including doctoral education). Studies by the CHE (2009), ASSAf (2010), Mouton et al. (2015) and Cloete, Mouton and Sheppard (2015) have raised concerns about the efficiency of, particularly postgraduate training. I discuss these studies, among others, chronologically below.

A Human Sciences Research Council (HSRC) policy brief in 2008 examined undergraduate drop-out rates and factors that contribute to student attrition (Letseka & Maile, 2008:5). The brief highlights disparities in South African students' graduation rates and considered the benchmarks of NPHE towards expanding higher education. The authors looked at the full-time equivalent enrolment data (2001 to 2004) of undergraduate students and concluded that black African and coloured students have lower success rates than white students. The brief outlined the drop-out rates of undergraduate students and the subsequent high cost to the National Treasury (Letseka & Maile, 2008).

In 2009, the CHE released a statistical profile of postgraduate students in South Africa (CHE, 2009). The aim of the study was to give a quantitative account of master's and doctoral studies in South Africa. The study was conducted through an analysis of the HEMIS data of postgraduate students between 2000 and 2005. In the report, the analysis of postgraduate students is compared across five disciplinary groupings which in include the natural and agricultural sciences, engineering and applied technology, health sciences, humanities and the social sciences.

(2012), Golde (1998, 2005), Hagedorn (2006), Hanover Research Council [HRC] (2010), Jacobs & Berkowitz King (2002), Jiranek (2010), Jones (2008), Knight (2008), Kurantowicz & Nizinska (2013), Lashari, Bhutto, Muhammad & Abro (2013), Lassibille & Navarro Gómez (2008), Longden (2002), Mastekaasa (2005), Mcmillan (2008), O'Keefe (2008), Olsen (2007), Park (2005a), Pearson (2012), Robinson (2004), Rochford (2003), Scott (2005), Simpson (2013), Soria & Stebleton (2012), Sowell, Allum & Okahana (2015), Thomas (2002), Tinto (2010), Van der Haert, Ortiz, Emplit, Halloin & Dehon (2013), Van de Schoot et al. (2013) Van Stolk, Tiessen, Clift, Levitt (2007), Visser & Van Zyl (2013), Whitehead & Hooley (2005), Wood (2012), Zhao, Golde & Mccormick (2005).

The report aimed to provide a comprehensive overview of postgraduate education in South Africa and focused on enrolment and graduation trends, participation rates, the transformation and internationalisation of higher education, as well as the supervisory capacity of postgraduate students. I discuss the findings of the report in more detail in the thematic discussions throughout this chapter. It might, however, be worthwhile to highlight some of the key findings of the report. The study found that doctoral time-to-degree is comparable with that of Europe and the USA. South African doctoral students, however, are much older compared with those in Europe and the USA.

Another important finding of the CHE report refers to the increasing burden on supervisors and found that the supervisory capacity at South African HEIs is decreasing due to an aging academic workforce. The CHE report found that in the five disciplinary fields studied, doctoral time-to-degree in 2005 was the longest for students in the humanities (5 years), while the health sciences and engineering and applied technologies recorded the shortest time-to-degree of 4.5 years. There are, however, only small differences in time-to-degree among the five fields (a range of 0.5 years) (CHE, 2009).

One of the most significant findings of this report is the "pile-up" effect at South African HEIs (CHE, 2009). The report defines a pile-up effect as the result of students who continue to enrol for a degree without dropping out. The pile-up effect of doctoral students was analysed across the broad disciplinary fields. With regard to the percentage ongoing (historical) enrolments of total enrolments (between 2000 and 2005), all fields, except in the natural and agricultural sciences, showed an increase (therefore an increased pile-up effect). In the natural and agricultural sciences, the percentage decreased by 6% which is commensurate with the percentage of graduates to total enrolments which also increased by 6%. With regard to the latter indicator, the social sciences saw the largest decrease of the percentage of graduates to total enrolments (32% in 2000 to 19% in 2005) showing that the social sciences are the most vulnerable with regard to students stagnating in the system (CHE, 2009).

In 2009, Watson conducted a study in which she looked at the throughput rates of master's and doctoral students at one South African university (Watson, 2009). She used a cohort analysis of data obtained by the university in question. She did not set out to calculate the average time to graduation (time-to-degree), but rather determined the time period for which completion rates should be calculated. Watson found that there exist significant differences in completion rates across disciplinary degree programmes and asks whether this could be attributed to the nature of subject matter, differences in teaching methods or the impact of extra-curricular factors in determining time-to-degree. Watson warns against using combined throughput rates (without regard for differences between programmes) as an indicator. Similarly, Watson found vast differences between completion rates of full-time and part-time students. Her results yielded an approximate 20% lower completion rate for part-time students compared to their full-time counterparts (compared within programmes). Surprisingly, in her comparison of completion rates across a broad grouping of disciplines, the author found that completion rates in the humanities (this includes law and education) were higher compared with fields in engineering and technology (SET), and business, commerce and management (BCM)(Watson, 2009).

An important study conducted in the South African context is the doctoral thesis by Backhouse (2009). Backhouse investigated doctoral education, although from a pedagogical approach, of four departments. She used a case-study design and included the departments of mathematics and applied mathematics at the University of Cape Town (UCT) (representing the hard-pure disciplines), the School of Civil and Environmental Engineering at the University of the Witwatersrand (WITS), representing the hard-applied disciplines), the Department of English Studies at the University of Kwazulu-Natal (UKZN) (representing the soft-pure disciplines) and the Graduate School of Public and Development Management at WITS (representing the soft-applied disciplines) (Backhouse, 2009). The author used a variety of data collection methods, one of which was observation and her intention was to "… gain an understanding of the processes of doctoral education, the experiences of the PhD people and the culture of the discipline and academic unit …" (Backhouse, 2009). One of Backhouse's research questions aimed to understand why students enrol for a doctorate. I discuss her findings in the thematic discussion in the next chapter.

A study by Portnoi looked at the experiences of South African graduate students in their pursuit of graduate degrees. Her primary aim was to study, qualitatively, the vocational choices of graduate students, particularly from underrepresented groups in South Africa (Portnoi, 2009:6). Portnoi interviewed both master's and doctoral students at three departments (arts/humanities, science, and social science) across two institutions. Her sample consisted mainly of black African and coloured (male and female) respondents. Portnoi explored the experiences of postgraduates throughout their master's or doctoral studies and she identified four primary challenges encountered by students which include funding of graduate studies, the feeling of not being supported or ''going at it alone", the psychological legacy of apartheid, and issues of institutional culture and race. In addition, the author set out to identify the factors that contribute to students' choices underlying enrolment in their respective degree programmes. I discuss her findings in the thematic discussions in the next chapter.

A study by Lubben, Davidowitz, Buffler, Allie and Scott (2010) identify factors which influence student persistence. Their study, however, was limited to undergraduate students, albeit final year students and the authors used qualitative methods in investigating if (and how) students' career aspirations affect their persistence. The study included students from one university (UCT) and was limited to students studying B.Sc. degrees. The study found that approximately half of the respondents indicated that they had considered dropping out of their course at some point or another. Reasons for this include academic challenges, financial difficulties, family concerns and taking courses which are not in line with their career choices (Lubben et al., 2010).

One of the more comprehensive studies in doctoral education in South Africa is a Consensus report commissioned by ASSAf in 2010 (ASSAf, 2010). The primary aim of the report was to provide evidence-based advice on the status of the doctoral education in South Africa. The report looked at general trends among demographic groups and faculties in the production of doctoral graduates. As a result, the study lists problems that affect the pipeline to the PhD as well as significant factors which contribute to the attrition of doctoral candidates. These include, among others, institutional, financial and administrative constraints. The study identified four barriers to the expansion of doctoral education in South Africa which include, first, financial constraints of doctoral students. Second, the authors argue that the quality of incoming students is not up to standard, which leads to a blockage, or pile-up effect of students in the system. A third barrier is low supervisory capacity and finally, the study found that some existing government rules and procedures hamper the expansion of doctoral education in South Africa (ASSAf, 2010). The report was produced by two research teams, one largely quantitative, and the other qualitative in their methods. Given the scope of the report, I present its findings throughout this chapter and the next in the various thematic discussions. The report disaggregates the findings by five main disciplinary groupings including the health sciences, social sciences, natural and agricultural sciences, humanities, and engineering science, materials and technologies.

From the Consensus report, a number of articles surfaced. In 2011, a volume of the South African Journal, *Perspectives in Education,* was dedicated to research on doctoral education in South Africa. Among these is an article by Mouton (2011). With regard to doctoral drop-out, the author found that almost half of doctoral students (46%) who enrolled in 2001 never graduated. He found significant differences between disciplines in that students enrolled in the humanities are the most likely to drop out (53%) compared to those in the natural, health and engineering sciences (36%). Almost a third of students dropped out within their first two years of study (Mouton, 2011).

One of the few studies on doctoral attrition in South Africa was conducted by Herman (Herman, 2011b). Through a qualitative study of PhD programme leaders, she identifies six determinants of attrition among doctoral students. These include (1) personal reasons, (2) students' lack of ability, skills or motivation to do a PhD, (3) students' lack of financial support, (4) poor supervision, (5) inflexible policies, and (6) faulty equipment. The author similarly highlighted barriers towards the expansion and diversification of higher education in South Africa which include, (1) insufficient funding, (2) restricting policies, (3) scarcity of students, (4) limited supervisory capacity, (5) lack of recognition of the value of the doctorate and furthering graduate education, and (6) limited and inadequate partnerships (Herman, 2011a).

Herman's findings are echoed by a report that was commissioned by the DST, that studied the retention, completion and progression rates of postgraduate students in South Africa (Mouton et al., 2015). One of the primary findings of the report is that financial challenges constitute the biggest obstacle to the expansion of postgraduate education in South Africa. Doctoral students indicated that the availability of funding was one of the deciding factors in their considerations of further study. The study attributed low progression and completion rates of postgraduate students in South Africa to the largely part-time nature of postgraduate studies.

The study by Mouton et al. (2015) is among a few which identify factors contributing to postgraduate student drop-out. The authors found that at least 40% of respondents indicated that they had considered dropping out of their postgraduate studies. The top three reasons given by doctoral respondents for considering dropping out are financial challenges, challenges in balancing work and studies, and challenges in personal and social life. The study includes a focus on specific disciplines in its analyses, albeit within broad groupings such as the natural sciences, engineering, health sciences, social sciences and humanities (Mouton et al., 2015). Although the study identifies various factors influencing students' choices regarding their postgraduate study, the study is limited in its ability to measure the relationships between these factors with either successful completion, or not.

In the same year, Cloete, Mouton and Sheppard published a book on doctoral education in South Africa (Cloete, Mouton & Sheppard, 2015). The book draws on past studies[22] to provide

[22] These include studies done by the Centre for Higher Education Trust (CHET) and the Centre for Research on Evaluation, Science and Technology (CREST) between 2005 and 2015.

accumulative findings on the doctoral student in South Africa. Where relevant, I present the findings of the book in the forthcoming thematic discussions.

3.2 Trends in doctoral education in South Africa

The aforementioned research on the state of postgraduate education in South Africa has highlighted some key obstacles in the pipeline to the doctorate. Nevertheless, there has been a noteworthy growth in doctoral enrolments and graduates across most fields, specifically during the last ten years. In the section below, I discuss this growth along with some of the most pertinent challenges facing the expansion of doctoral education in South Africa. I do this under five headings which include, first, the state of doctoral enrolments and graduates in South Africa, second, the profile of doctoral students, third, the doctoral pipeline, fourth, the supervisory capacity of doctoral students, and lastly, prominent models of doctoral education. I conclude this section with a discussion of proposed strategies and initiatives to address the leaky pipeline in conjunction with an overview of the indictors used in describing it.

3.2.1 Doctoral enrolments and graduates at South African institutions

In 2012, there were 49 561 doctoral enrolments registered in South Africa. Between 1996 and 2012 doctoral enrolments grew with 6.4%. Between 2008 and 2012, the number of doctoral graduates grew with 12.3% which was the highest growth rate[23] for the period since the 1920s (Cloete, Mouton & Sheppard, 2015). In 2012, doctoral enrolments constituted 1.5% of all students registered at South African universities (Cloete, Mouton & Sheppard, 2015). In 2012, doctoral enrolments in the natural sciences constituted 31% of all enrolments, engineering and technology 9%, the health sciences 11%, education 10%, and the humanities and social sciences 30%. The proportion of enrolments in the social sciences and humanities decreased to 30% from 41% between 1996 and 2012. In a breakdown of doctoral graduates by academic institution, 76% of doctoral enrolments, in 2012, were registered at (traditional) universities, while 19% were enrolled at comprehensive universities, and only 5% were

[23] Reasons for this increased growth rate may be due to the revised DHET research subsidy framework (2008) which created financial incentives through subsidies for postgraduates students.

enrolled at universities of technology. The University of Pretoria (UP) enrolled the most doctorates, 1 860, in 2012 (Cloete, Mouton & Sheppard, 2015). The largest share of doctoral enrolments in 2012, at universities of technology, was in engineering and technology (12%) followed by education (8%) and business, economic and management sciences (8%). At universities, the largest share of enrolments was in the health sciences (84%) followed by the natural sciences (83%). At comprehensive universities, the largest share of enrolments was in education (30%).

In 2012, 1 879 doctorates graduated from South African universities. The top seven universities produced 68% of doctoral graduates in 2010. The top producer of doctoral graduates was Stellenbosch University (SU)(13%) followed by UP (10%). Between 1996 and 2012, the share of graduates in the natural sciences increased from 26% to 35% while that of the social sciences and humanities decreased from 38% to 28%. Graduates in engineering and technology constituted 8% of all graduates, health sciences 10%, and education 11% (Cloete, Mouton & Sheppard, 2015). Traditional universities produced the most graduates in 2012 (75%) notably in engineering and technology (85%) and the health sciences (84%). Comprehensive universities produced 20% of all doctoral graduates and were the biggest contributor of graduates in business, economic and management sciences (38%). The share of graduates at universities of technology increased from 1% in 1996 to 4% in 2012 and produced 13% of graduates in engineering and technology (Cloete, Mouton & Sheppard, 2015).

Herman, in her analysis of doctoral education from 1971 to 2004, suggests that historically, there has been a knowledge divide between universities (Herman, 2017). She argues that previously advantaged universities produce more PhDs in the hard-pure or hard-applied sciences, whereas the newly merged universities (comprehensive universities and universities of technology) or previously black universities are more likely to focus on producing doctorates in the soft-applied disciplines (Herman, 2017). The author suggests that the twenty-first century in South Africa saw a decline in graduates in “traditional and fundamental” humanities disciplines (i.e. economics, history, philosophy, politics and sociology) and a growth in professional fields, such as education, religion and psychology. Herman claims that in recent years, there has been a trend to produce graduates for the labour market rather than strengthening research and scholarship (Herman, 2017).

Examining the trends of doctoral graduates between 1996 and 2012 there has been growth at a rate of 6.5% (compared to 6.4% of enrolments for the same period). Doctoral enrolments and graduates grew at higher rates than any other degree level between 1996 and 2012 which indicates that there has been a favourable response to policy initiatives, among others, to expand doctoral education in South Africa (Cloete, Mouton and Sheppard, 2015).

> The resultant growth in doctoral enrolments and graduations is clearly the result of a variety of demand-side factors (new demands from the labour market; the demand created by the increase in students from other African countries who choose South Africa as a destination for postgraduate students), as well as supply-side factors (new master's and PhD programme offerings, increased supervisory capacity at most universities, increased funding for doctoral studies, as well as the effect of the new incentive and reward strategies of universities. (Cloete, Mouton & Sheppard, 2015:55)

There has been a concurrent increase in doctoral graduates in science, engineering and technology, and business, economic and management sciences. This has most likely been the result of targets set out by the Ten-year Innovation Plan to increase doctorates in STEM sciences facilitated by a funding framework favouring students in these fields. Doctoral enrolments in science, engineering and technology constituted just over half of all doctorates in 2012. Notwithstanding these advancements, doctoral production in South Africa is below average when compared internationally with countries of similar population size and GDP ranking (Cloete, Mouton & Sheppard, 2015).

3.2.2 A demographic profile of doctoral students in South Africa

The ASSAf report determined that in 2007, a doctoral graduate enrolled at a South African university was male, white, South African and in their thirties (ASSAf, 2010). The majority of doctoral graduates are older than 30 years. When looking at the gender profile of doctoral graduates between 2000 and 2007, there has been little fluctuation with males outnumbering females three to two. In 2012, the gender distribution of doctoral enrolments was almost equal with male enrolments constituting 55% of the share of total enrolments. This share increased slightly among graduates, where male graduates had 58% of the share of total graduates in 2012 (Cloete, Mouton & Sheppard, 2015). Upon the disaggregation into the five disciplinary groupings, the ASSAf report found that female graduates are well represented in the health sciences (62% in 2007) and the social sciences (51% in 2007). In the engineering sciences, materials and technologies female graduates constituted only 15% of graduates in 2007 (ASSAf, 2010).

In 2012, only 65.5% of doctoral enrolments and graduates in South Africa were domestic students (Cloete, Mouton & Sheppard, 2015). With regard to the composition of graduates by race, black African graduates increased from 19% of all graduates in 2000 to 32% in 2007. The share of Indian/Asian and coloured graduates remained virtually unchanged, with the share of white graduates having decreased from 70% to 54% in 2007 (ASSAf, 2010). In 2012, 48% of doctoral enrolments were black African, while only 38% were white (Cloete, Mouton & Sheppard, 2015). For the same year, African graduates constituted 44% of total graduates, while white students had 43% of the share. The field in which the share of black African students has increased the most was that of the social sciences. In 2007, just more than half of the doctoral graduates in the social sciences were black African with an increase of 20% from 2000 to 2007. Black African students in the health sciences only constituted 39% of total graduates in this field for 2007 (ASSAf*,* 2010).

In the eight-year period studied in the ASSAf Consensus report, there was a steady increase in non-South African doctoral graduates. The overall proportion of South African graduates (of total graduates) decreased from 84% in 2000 to 71% in 2007 (ASSAf*,* 2010). In recent years, there has been a significant increase in the inward-bound mobility of doctoral students to South Africa, especially from the African continent. This is primarily a result of South African policy frameworks that advocate for this internationalisation, but also that South African universities are affordable and quality alternatives for African students pursuing doctoral education (Cloete, Mouton & Sheppard, 2015; Sehoole, 2011). Considering the demographic profile of doctoral graduates in South Africa, one can observe a shift from a historically completely white student body, to one that is increasingly representing black students (Herman, 2017). This is primarily due to the influx of international students from Africa.

Given the focus on the transformation and diversification of doctoral education in South Africa, it appears as if there have been notable successes. However, the proportion of black African, South African doctoral students is less impressive. In 2000, of the 160 black African doctoral graduates, 86 were non-South African and this proportion grew significantly to 2007, where of the 405 black African graduates, 338 were not South African (ASSAf, 2010). In 2012, of South African graduates, only 26% were black African. Cloete, Mouton and Sheppard (2015) determined that between 2000 and 2012, doctoral enrolments from the rest of Africa recorded an average annual growth rate of 17.7%, while African enrolments from South Africa, only grew with 9.6%. Among graduates, those from the African continent grew with 21.3% compared to 9.8% of South African black students (Cloete, Mouton & Sheppard, 2015).

With regard to age, in 2007, only 12% of doctoral graduates were younger than 30 years while the average age at graduation was 40 years. Since 2000, the ASSAf report found the average age at graduation increased with 20% of graduates being older than 50 years. The average age at graduation in 2007 was also higher among students graduating from universities of technology (45 years) compared to their counterparts at traditional universities (39.5 years). Graduates in the natural and agricultural sciences were the youngest (35.7 years) compared to the eldest in the humanities (44.5 years) in 2005 (ASSAf, 2010). In terms of age at enrolment, the average age of students in the social sciences and humanities was significantly higher (41 years) compared to their counterparts in the natural and agricultural sciences (33 years) in 2007. The average age at enrolment of students in the engineering sciences, materials and technologies was 34 years and the health sciences 38 years (ASSAf, 2010).

The Consensus report found that in 2007, more than half of doctoral graduates in South Africa were employed in the higher education sector (ASSAf, 2010). A survey conducted found that 20% of doctoral graduates sought employment in industry while nearly 10% in government. PhD graduates in the engineering sciences, materials and technologies and the natural and agricultural sciences were more likely to be employed in industry. The majority of graduates in the social sciences were employed in the higher education sector, while more than 10% were employed in a government position. More than 25% of graduates in the humanities work in the non-profit sector. The ASSAf Consensus report found that 58% of respondents enrolled for their doctorates at the same institution at which they completed their master's degree (ASSAf, 2010).

In recent years, there has been a shift in the demographic profile of doctoral students in South Africa with a substantial increase in the absolute number of black and female students at South African universities. However, when looking at participation rates, it appears as if black African students are still significantly lagging behind their white counterparts. Cloete, Mouton and Sheppard determined the participation rates of South African black Africans as 3.61 students per 100 000 of the age-relevant race in 2012. This compares to 63.16 per 100 000 of white students in 2012 (Cloete, Mouton & Sheppard, 2015). These figures reported above, therefore, show that significant changes in the demographic profile of doctoral students in South Africa have been made, but that substantive transformation of higher education in South Africa is still a work in progress.

3.2.3 The doctoral pipeline

As mentioned in Chapter 1, one of the discourses in doctoral education today is that of efficiency. However, measuring the efficiency of doctoral education is less clear. Cloete, Mouton and Sheppard introduce four definitions, or indicators, towards understanding efficiency (Cloete, Mouton & Sheppard, 2015). The first is progression rates which consider the system as efficient when optimal numbers of students progress from lower degree levels to doctoral studies. The second, retention rates, is when optimal numbers of students are retained in the system. Third, completion rates is an indication of when optimal numbers of students enrolled for a degree complete within acceptable time-frames. And last, when academic staff holding doctorates produce, on average, increasing numbers of doctoral candidates, we can measure positive productivity rates (Cloete, Mouton & Sheppard, 2015).

An ineffective system, however, is one where there is a pile-up of students in the education system. The CHE study defines the "pile-up" effect as "… the state of affairs where students remain enrolled for their degree for much longer than expected (or desirable)…" (CHE, 2009:xvi). The authors determine the pile-up effect using two indicators which include (1) ongoing (historical) enrolments as a percentage of total enrolments, and (2) graduates as a percentage of ongoing enrolments. An increase in the first indicator and a decrease in the second indicator show that fewer students are leaving the system, therefore, contributing to the pile-up effect. With regard to doctoral students, the study found that the percentage ongoing enrolments to total enrolments increased from 55% to 59% between 2003 and 2005, while the percentage graduates (of ongoing enrolments) declined from 25% in 2000 to 21% in 2005, thus showing that the pile-up effect of doctoral students worsened.

The PhD Consensus report determined that from 2000 to 2006, the average conversion rate from master's to doctoral degrees was approximately 37% (ASSAf, 2010). The authors define the conversion rate as the percentage of master's graduates who enrol for a doctorate directly after completing a master's degree[24]. It is important to note, however, that this calculation is an estimate, as it does not track a specific cohort. This rate then does not include those students who left the system between degrees, albeit for employment reasons or other. The conversion rate, as calculated for each year of the period analysed, fluctuated slightly from year to year. The report also determined that for seven master's students (6.9) only one would enrol in a doctorate. A disaggregation of disciplines showed that students in the natural and agricultural sciences are more likely to enrol for a doctorate upon completion of a master's degree when compared to other fields. The conversion rates of students in the natural and agricultural sciences were between 61 to 75% from 2000 to 2006. This is almost double the average of 37% across all fields. Conversion rates in the social sciences are much lower, varying between 29 to 30% for the period analysed. This means that students in these fields are more likely to "take a break" after completing a master's degree.

The CHE report determined that the average doctoral time-to-degree in South Africa, between 2000 and 2006, is approximately 4.5 years. They found that this statistic did not change over the six-

[24] This is calculated as $\frac{first\ doctoral\ enrolments\ in\ year\ x+1}{masters\ graduates\ in\ year\ x}$

year period studied (CHE, 2009). The ASSAf report states that in 2007, doctoral time-to-degree increased slightly to 4.8 years (ASSAf, 2010).

Mouton et al. determined the completion rates of doctoral students who enrolled in 2001 (Mouton et al., 2015). They report the four-year completion rates of this cohort at 30.3%, while only 50% completed after seven years. After seven years of enrolment, the completion rates of doctoral students plateaued with only an increase of 5% between seven-year and 13-year completion rates. Similarly, Cloete, Mouton and Sheppard (2015) calculated the completion rate of five cohorts. Five-year completion rates varied between 36% for the 2003 cohort, to 38% for the 2007 cohort. With regard to six-year completion rates, only 41% of the 2003 cohort completed their degrees in six years, while the 2007 cohort had a 45% completion rate. The authors determined that of the 2006 cohort, SU had the highest seven-year completion rate (65%) followed by the University of Western Cape (UWC)(60%). Of the 2006 intake, only 12 institutions graduated more than 50% of doctoral students after seven years, while six graduated between 30 and 50%, and three institutions graduated fewer than 30% of their 2006 doctoral intake after seven years (Cloete, Mouton & Sheppard, 2015).

With regard to disciplinary differentiation, the authors found that completion rates of the 2006 cohort in the natural sciences (53%) and the health sciences (53%) have the highest completion rates, followed the humanities and arts (49%), social sciences (46%) engineering and technology (44%) and education (44%). Business, economics and management had the lowest seven-year completion rates of 37% (Cloete, Mouton & Sheppard, 2015).

Cloete, Mouton and Sheppard also found a strong correlation between high progression and completion rates and full-time enrolment (Cloete, Mouton & Sheppard, 2015). The authors claim that more than 60% of South African doctoral candidates study part-time, therefore, studying while employed. They argue that fields such as the natural sciences yield higher completion and progression rates because students in these fields are more likely to study full-time. The authors found that students who are able to study full-time are more likely to progress faster between degree levels and more likely to have shorter time-to-degree. With regard to race, they argue that black students have fewer resources to support their studies, and are thus more likely to take longer to complete their postgraduate studies (Cloete, Mouton & Sheppard, 2015).

3.2.4 The supervisory capacity of doctoral students in South Africa

The CHE report determined that in South Africa, doctoral education is challenged by what is termed the "burden of supervision". The report argues that South African academics are "… increasingly burdened with an unrealistically high number of postgraduate students to supervise …" (CHE, 2009). This phenomenon is attributed to first, the fact that the number of postgraduate students has doubled while the number of staff has only increased by 40% for the same time period. In measuring supervisory capacity in South Africa, the report states that the number of students per supervisor has increased from 1.3 in 2000 to 2.2 in 2005 (CHE, 2009). The ASSAf report indicates that in 2007, the ratio of doctoral students to supervisors, across all South African institutions, was 2:1 (ASSAf, 2010). The CHE report disaggregated this statistic by disciplinary fields. The most notable increase in the burden of supervision is among the humanities (1.6 in 2000 to 2.9 in 2005) and the social sciences (1.7 in 2000 to 3 in 2005). In the natural and agricultural sciences the burden increased only somewhat from 1.5 in 2000 to 1.8 in 2005. In 2005, the natural and agricultural sciences also had the highest supervisory capacity of 1.8 students per supervisor compared to the other fields who all had between 2.7 and 3 students per supervisor (CHE, 2009).

The ASSAf Consensus report determined that in 2007, at least 30% of permanent academic staff at South African institutions held a doctoral degree (ASSAf, 2010). This percentage increased to 39% in 2012 (Cloete, Mouton & Sheppard, 2015). With regard to the supervisory capacity across disciplinary groupings, the social sciences had the highest share of permanent academic staff with a PhD (24%), followed by the natural and agricultural sciences. Engineering sciences, materials and technologies had the lowest share of 6% in 2007. The humanities reported a supervisory capacity of 13% while health sciences reported 8% of permanent academic staff with a PhD in 2007 (ASSAf, 2010). The report found that in 2007, SU had the highest share of permanent academic staff with a PhD at 61%, followed by UCT (58%) and RU (50%).

The ASSAf report found that the supervisory capacity is higher among universities compared to universities of technology (ASSAf, 2010). The five strongest research-oriented universities (UCT [1.9], UKZN [2.4], UP [2.4], WITS [2.2] and SU [1.9]) did not necessarily have the lowest student-to-supervisor ratios. The supervisory capacity (ratio of doctoral students per potential supervisor) in 2007, was the lowest for the University of Johannesburg (UJ) at 3.4 students per supervisor, followed by the University of Fort Hare (UFH) of 2.8 students per supervisor. The highest capacity, for research-oriented universities (excluding comprehensive universities and universities of technology) is recorded for the University of Limpopo (UL) (1.3) and RU (1.5). The report found that at the time of the study, the majority of doctoral candidates had more than one supervisor. A doctoral candidate in the natural sciences is more likely to have more than one supervisor (70%) compared to a student in the humanities, where only 33% have more than one supervisor. Fifty-five per cent of doctoral candidates in the social sciences only had one supervisor, compared with 35% in engineering science, materials and technologies, and 32% in the natural and agricultural sciences (ASSAf, 2010).

On the topic of doctoral supervision, the ASSAf Consensus report found that 80% of doctoral candidates in the social sciences and humanities reported that they spend less than two hours per month with their supervisor(s) (ASSAf, 2010). This compares to 66% of students in the health sciences, natural and agricultural sciences, and engineering science, materials and technologies. Across all fields, 26% of respondents indicated that they spend more than two hours a month with their supervisor(s). Full-time candidates also received more supervision time than those enrolled part-time (ASSAf 2010). In a survey of doctoral supervisors, Cloete, Mouton and Sheppard (2015) found that 45% of respondents indicated that they supervised students outside their main areas of expertise. This was typically the case among supervisors in the social sciences, humanities and arts and in the engineering and mathematical sciences. Nearly 60% of supervisors included in the study, felt that they did not provide sufficient attention to their doctoral students (Cloete, Mouton & Sheppard, 2015).

In 2011, Mouton (2011) found that the majority of supervisors (46.3%) supervised between two to five doctorates. Just over 30% graduated one student per year. Almost 10% of supervisors had more than ten students a year while 13.3% supervised between six and nine students. Mouton suggests that the top 22% of productive supervisors have, on average, given students' average time-to-degree and drop-out rates, between four and six doctoral candidates per year which translates into a heavy supervisory load (Mouton, 2011). Cloete, Mouton and Sheppard suggest that the ratio of doctoral graduates to staff holding doctorates at South African universities increased between 2011 and 2013. The ratio of graduates to staff increased from 0.25 in 2011 to 0.28 in 2013. In 2013 then, every staff member (with a PhD) produced a doctoral graduate every three and half years. In 2013, the authors found that SU, UP and UWC were the most efficient with a graduate-to-staff ratio of 0.37 (Cloete, Mouton & Sheppard, 2015).

3.2.5 Prominent models of doctoral training

Five models of doctoral training are offered at South African academic institutions. These include the traditional research-based PhD, the PhD by publication, the taught PhD, professional or work-based PhDs and practice-based PhDs (Cloete, Mouton & Sheppard, 2015). Historically, the South African doctorate has typically been offered by research dissertation only. The traditional research-based PhD (also referred to as the British model) typically follows on the completion of a master's degree by dissertation. The traditional PhD is often defined in terms of its original contribution to knowledge and the PhD candidate typically works alone on the dissertation under the supervision of one or two supervisors. Many have argued that the lack of coursework at a graduate level has resulted in students lacking the specialised knowledge needed to qualify for an academic career (Du Toit, 2012). Following the 1980s, the master's degree in South Africa started to include greater components of coursework, which aimed towards providing the technical and specialised building blocks for the doctorate.

The PhD by publication is based on a supervised research project, but the thesis is constructed around a volume of academic peer-reviewed publications. Typically, this is accompanied by an introduction and reflection or an over-arching paper that presents an introduction and conclusion. There is an active debate on the suitability of this model of doctorate training. Many departments across South African universities have embraced this model while some have rejected it outright. Despite the disagreement, an increasing number of students in the natural sciences and health sciences, in South Africa are choosing to do their doctorate by publication (Cloete, Mouton & Sheppard, 2015).

The South African higher education system also allows for the provision of the professional doctoral degree. The function of the professional doctorate, as defined by the CHE, is to provide "… education and training for a career in the professions and/or industry and is designed around the development of high level performance and innovation and a professional context" (CHE, 2009). The professional doctorate typically includes a combination of coursework and the submission of an original thesis or "… another form of research that is commensurate with the nature of the discipline or field and the specific area of inquiry …" (CHE, 2009). For the professional doctorate, the research component should comprise at least 60% of the degree and may include appropriate forms of work-integrated learning.

> The supervised research project is often smaller than the traditional PhD, is more applied, and is work-based or work-focused. The research problems investigated often emerge from professional practice and the students are typically experienced professionals. (Cloete, Mouton & Sheppard, 2015:135)

The CHE states the professional doctorate's defining characteristic as the following: "… in addition to the demonstration of high level research capability it requires the ability to integrate theory with practice through the application of theoretical knowledge to highly complex problems in a wide range of professional contexts …" (CHE, 2009). In addition to the PhD, a Higher Doctorate may be awarded on the "… basis of a distinguished record of research of published works, creative works and/or other scholarly contributions that are judged by leading international experts to make an exceptional and independent contribution to one or more disciplines or fields of study …" (CHE, 2009). The Higher Doctorate is typically awarded to faculty members at a later stage in their careers.

Despite the expansion of doctoral qualifications in South Africa the doctorate is still primarily based on the model where students compose a substantial research project, in the form of a thesis, under the guidance of a supervisor (master-apprentice model) (Backhouse, 2009). The function of the doctoral graduate as the "preserver of the culture of his/her discipline" has greatly attributed to the prominence of the traditional PhD in South Africa (Backhouse, 2009). The PhD thesis then typically constitutes either a traditional dissertation (monograph), a coherent collection of peer-reviewed academic articles and papers, or in certain fields, creative work such as artefacts, compositions, public performances and public exhibitions in partial fulfilment of the research requirements (CHE, 2009). In programmes where coursework is offered, it serves only as preparation for research and does not contribute to the credit value of the doctorate.

Mouton (2011) observed a shift from a "thin" model of doctoral training, which was the norm in the 1980s and 1990s, towards a "thicker" approach. He defines the approach towards doctoral training at the end of the twentieth century as one characterised by *laissez-faire* supervision with little structure from the supervisor (Mouton, 2011). He argues that there is now a trend towards "thick" models of doctoral training where students are typically being selected through rigorous screening processes (Mouton, 2011). Departments are increasingly aware of aligning and streamlining doctoral training with the skills and expertise of potential supervisors. The process of developing the research proposal has also gained more structure with departments including admission committees and proposal "examinations". These models also include compulsory coursework in theory and research methods. There has also been a shift in the supervisory model towards more transactional and structured interactions. Another feature of "thicker" training models includes the expectation for publications on the part of the student (Mouton, 2011).

3.2.6 Towards an efficient system of doctoral education

Cloete, Mouton and Sheppard characterise doctoral education in South Africa as a long and leaky pipeline (Cloete, Mouton & Sheppard, 2015). Most doctoral students have insufficient funding to support their graduate studies, while many are compelled to interrupt their studies due to work- or employment-related demands. Doctoral students in South Africa are typically older at graduation when compared to those in Europe and North America. With regard to completion rates, South African doctoral students compare favourably to international rates. Some of the most notable barriers to doctoral education, however, are high teaching loads and an increasing burden of supervision which compromises the quality of supervision received by students. Nevertheless, the small pool of doctoral supervisors has proved to be very efficient. When considering completion and throughput rates, arguments can be made in support of effective university structures and mechanisms for doctoral education in South Africa (Cloete, Mouton & Sheppard, 2015). The most notable enabler towards increasing the efficiency of doctoral training, many have argued, is to ensure that a greater number of students pursue their doctorates full-time.

Cloete, Mouton and Sheppard highlight strategies at a national, institutional and departmental/supervisory level that may improve the efficacy of the higher education system *vis-à-vis* doctoral education. On a national level, the authors call for a continuation of government funding incentives and an expansion of scholarship support by bodies such as the NRF, for doctoral students. Current funding of NRF scholarships are insufficient in wholly supporting doctoral candidates for the duration of their studies and there is a need for additional financial support. Many universities and Centres of Excellence have responded to this call, but there remains a need for additional instruments, particularly aimed at students nearing the completion of their studies. On an institutional level, there have been concerted efforts to improve supervisory efforts through offerings of supervisory training. Similarly, students need support, through writing centres, graduate schools and so forth, to improve their skills in writing, research methods and proposal development (Cloete, Mouton & Sheppard, 2015).

Cloete, Mouton and Sheppard (2015) make an argument for a new model of supporting doctorates. They argue for a model of establishing cohorts of full-time doctoral students which are to be employed, by universities, as junior staff members. Such an approach would "… enable experimentation with different models of doctorate management, such as graduate schools, and with possibly more coursework, more integration and group/laboratory approaches …" (Cloete, Mouton & Sheppard, 2015:192). Evidence shows that at one graduate school in the social sciences and humanities at SU, time-to-degree of full-time, funded, students in 2014 was significantly shorter (2.84 years) compared to the university average of 5.73 years. Such models have gained prominence internationally (USA, Europe and particularly Scandinavia) and are proposed to increase progression rates, increase the quality of dissertations, improve the preparedness of students through reducing opportunities for the interruption of studies, create opportunities for peer-group learning, and improve students' technical skills through training efforts.

In the Netherlands, such a model is the standard. PhD candidates are employed on a contract basis by the university during which time they can work on their PhD full-time. The contract can vary between three and five years. This method has proved successful in that the average doctoral completion rate in the Netherlands is around 75% (Van de Schoot et al., 2013). The biggest concern for this model, however, is the cost associated with supporting candidates (at a junior lecturer level) for three to four years. Cloete, Mouton and Sheppard, however, argue that if effective doctoral training is to be the outcome, the benefits of this model outweigh the costs (Cloete, Mouton & Sheppard, 2015).

3.3 Performance indicators in higher education

The appraisal of higher education in South Africa requires an investigation of the methods and measures used. The literature is inundated with terms used to study student pathways. Although there is a general understanding of the terms "time-to-degree", "throughput", "retention rates", "drop-out", "completion rates", "progression rates" and so forth, these terms are used inconsistently (Scott, 2005; Watson, 2009). In addition to a lack of consensus on some of the core concepts there is a lack of standardised methods in calculating the above (Watson, 2009). Adding to the problematic nature of defining and measuring the concepts in question, one has to concede that cross-country comparisons are precarious at best given the differences in degree structures and programme characteristics. Within the South African context, Watson argues that higher education institutions are grappling to make sense of their student throughput and graduate data with regard to performance measurements and terminology, while also struggling with the reliability of the definitions of the NPHE (Watson, 2009).

In 2004, a report by Bunting and Cloete was among the first to think about developing indicators for higher education within the South African context (Bunting & Cloete, 2004). The authors define an indicator as "… a means of referring to higher education properties, either at a specific moment in time or as these change over time …" (Bunting & Cloete, 2004:54).

> ... A measure – usually in a quantitative form – of an aspect of an activity of a higher education institution. The measure may be either ordinal or cardinal, absolute or comparative. It thus includes the mechanical applications of formulae and can inform, and

> be derived from, such informal and subjective procedures as peer evaluations or reputational rankings. (Bunting and & Cloete, 2004:20)

The authors distinguish between two types of indicators which include descriptive indicators and performance indicators. The former refers to the existing properties of institutions or higher education systems and so forth. Performance indicators, however, refer to the resulting properties of directed policy or national goals, or, in other words, intentional actions.

The NPHE refers to a number of indicators in their approach towards measuring the efficiency of the South African higher education system (DoE, 2001). The NPHE identifies four terms for measurement of student retention and throughput. The first is the "graduation rate". This measurement is positioned as a benchmark and is measured as the proportion of enrolled students in a given year, for a certain degree, and who graduate within the required length of the degree. There are two problems associated with this measurement. First, this indicator groups together occasional students (those who enrol in single courses here and there) with those students enrolled for full degrees. This inclusion then negatively affects the graduation rate of the institution. A second problem associated with this measurement is that it presupposes that the intake of students is constant over a degree of more than one year (Watson, 2009:728).

The NPHE also refers to retention rates. Retention rates are calculated as the proportion of students registered in one year who return the following year. This measurement of retention rates include students who have graduated and return to enrol for a different programme (Watson, 2009). Drop-out rates, conversely, are defined by the NPHE as the number of students who have neither graduated nor returned to enrol in the following year. There is a brief mention of success rates in the policy document and success rates are calculated as the proportion of full-time equivalent credits earned by the number of students enrolled. This measurement is used to indicate students' pass rates at the course level (NPHE, 2001). Watson considers this calculation as limited in its scope as it does not consider degree registrations or retention (Watson, 2009).

The NDP of 2011 included many targets for higher education, as discussed in Chapter 1 (NDP, 2011). The document called for improved efficiency in higher education through an increase in throughput, graduation and participation rates (among others) and a decrease in drop-out rates. However, the NDP neglects to define these indicators as well as explain how these indicators are calculated. This leaves the reader to assume that the NDP refers to the efficiency indicators presented in the NPHE.

The studies on doctoral education in South Africa which are cited throughout the chapter, use these terms mentioned above differently. Cloete, Mouton and Sheppard (2015) use throughput, graduation and completion rates interchangeably. The authors also introduce "progression rates" as an indicator which measure the numbers of students progressing from lower degree levels to doctoral studies (Cloete, Mouton & Sheppard, 2015). The CHE report refers to this indicator as "conversion rates" (CHE, 2009).

Completion rates are also referred to as "success rates" by some (Letseka & Maile, 2008). Cloete, Mouton and Sheppard (2015) define completion rates as an indication of when optimal numbers of students enrolled for a degree complete within acceptable time-frames. Time-to-degree has been the least complicated to calculate and has been extensively studied in Australia (Bourke et al., 2004a; 2004b). In the South African literature, however, this indicator has generally been neglected and often mentioned in passing. Exceptions include the report by the CHE (2009), Mouton et al. (2015) and Mouton, Valentine & Van Lill (2017). The use of time-to-degree as an indicator is consistent across these studies and is defined as the time (in years) successful (i.e. graduating) students take to complete their studies (CHE, 2009). The CGS in the USA computed time-to-degree as the number of months from the time a student started a doctoral programme until the student earned the doctorate (Sowell, Allum & Okahana, 2015). An important point made by Watson is that in calculating doctoral time-to-degree by using the date of graduation, might, in some cases, add a year to a student's actual time-to-degree. In some cases, the graduation dates of a student might be only be the following year (therefore, the year after submission), thus adding an extra year to their time-to-degree (Watson, 2009). Additionally, institutions and departments have varying policies where students may or may not register for the PhD without a research proposal.

Paterson and Arends consider throughput rates synonymous with time-to-degree as they define the former as the number of years a student or a cohort of students take to complete their respective qualifications (Paterson & Arends, 2008). The authors consider graduation rates as the number of graduates divided by the total number of enrolments within a programme in the selected year. In other words, the rate at which students graduate from their respective programmes. The CGS in the USA define completion rates as the percentage of students who started their doctoral study during a selected time period (Sowell, Allum & Okahana, 2015). Watson suggests that in calculating doctoral completion rates, it might be useful to use more than one time period (such as five-year and seven-year completion rates).

Attrition or drop-out rates are considered the antithesis of retention rates. Scott, in his study of student attrition in New Zealand, defines retention as how long students persist in their studies and "… specifically records what percentage of students stay in the study programme until they have successfully completed" (Scott, 2005:4). Jones defines retention as "… keeping students on the programme until its natural conclusion …" (Jones, 2008). Robert Reason (2009) differentiates between the terms "retention" and "persistence". He defines retention as an organisational phenomenon where "… colleges and universities retain students …" while persistence is an individual phenomenon when "… students persist to a goal …" (Reason, 2009:660). Reason, however, argues that student persistence is inadequate as an indicator as it does not delineate an outcome, but is rather "… part of the student environment… " (Reason, 2009). Pascarella and Terenzini use the term "educational attainment" to refer to students' varying goals regarding their degrees (Pascarella & Terenzini, 1991, 2005). Other terms used include non-completer and stop-out (Reason, 2009). Girves and Wemmerus suggest that the use of the term "student success" is clear when used in relation to undergraduate studies (Girves & Wemmerus, 1988), but success in the context of doctoral studies encompasses more than degree attainment. However, throughout this study, I use the terms student success, completion and degree attainment interchangeably.

The literature on student success offers an abundance of indicators and measurements which include terms such persistence, throughput, completion rates, graduation rates, progression, retention, attrition, drop out, non-completion, non-continuation, conversion, withdrawal and so forth. Gardner suggests that the conceptualisation of student success has been constructed and measured along the lines of several outcomes which include retention, academic achievement, completion (graduation) and professional socialisation (Gardner, 2009a). While the former terms have been widely studied in a quantitative fashion, Gardner emphasises the role of more qualitative measures in thinking about performance indicators. The use of a single indicator (such as time-to-degree) in exploring and understanding doctoral education discounts the complexity of the education process. It is, therefore, important to consider the interaction of indicators (both quantitative and qualitative) in the investigation of doctoral education in South Africa. In Chapter 5, I define the indicators used in the empirical analyses of this study and discuss their operationalisation.

3.4 The state of five selected disciplines in South Africa

In the preceding sections, I outlined the state of doctoral education in the South African higher education system as a whole. In this section, I focus on the state of the five selected disciplines in South Africa with regard to doctoral education. I include discussions on physics, sociology, education, the clinical health sciences and electrical engineering.

3.4.1 Physics

Physics, as a unified, academic discipline was institutionalised in South Africa around 1945 with the founding of the Council for Scientific and Industrial Research (CSIR). With the establishment of the National Physical Research Laboratory (NPRL), a market for physicists was created while universities started to strengthen their postgraduate and research programmes (Chetty, Petruccione & Lindebaum, 2005; Diab & Gevers, 2009). The early initiatives of the physics community in South Africa were aligned with the strategies of the then segregationist government, particularly in the area of nuclear energy and nuclear weapons. Due to a constant stream of funding, physics in South Africa flourished.

> While it is ironic that physics in South Africa should have been strengthened by the country's isolation, the downside is that much of this work was confidential and even secret, hence many scientists who wished to develop their careers submitted 'classified' MSc dissertations and PhD theses at accrediting universities, and most publications were not in the public domain. (Chetty, Petruccione & Lindebaum, 2005)

With the formation of the NRF, physics once again benefited from initiatives to support "blue skies" research. In recent years, there has been increased efforts on the part of government to support the physics community with the necessary infrastructure through investment in equipment (particularly telescopes), analytical equipment, research chairs, centres of excellence and new national institutions of interdisciplinary sciences and technology facilities (Chetty, Petruccione & Lindebaum, 2005).

In 2004, the DST, NRF and the South African Institute of Physics (SAIP) produced a report *Shaping the Future of Physics in South Africa* (2004). The report states that in South Africa, the physics community is small but reputational. There are, however, a number of problems that plague education in physics. Although the physics community is "vibrant, active, talented and enthusiastic", physics only produce a small number of graduates every year (Grayson & Moraal, 2005). There is a notion among those working in the higher education sector that students entering physics programmes are of poor quality and struggle to master the technical skills required (CHE & SAIP, 2013). The quality of undergraduate students in physics is a concern for sourcing students for postgraduate studies. Grayson and Moraal argue that a balance must be found between doing small science and big science and that university departments need to position themselves to serve communities through "… strongly integrated programmes[s] of knowledge production and dissemination, and of the application of this knowledge …" (Grayson & Moraal, 2005).

As a response to this report, the SAIP undertook to support of a number of initiatives. One of this is a South African physics graduate database. The aim of this database is to develop a support system for graduates in physics. Another project by the SAIP was the *Physics 500* project. The aim of this project is to promote physics in industry by publishing the careers of approximately 500 physicists who work in industry, as role models. This project aims to "… help students find role models and opportunities in industry, and to help industry inspire students to pursue careers in physics …" (Moraal, 2011). The project also aims to create research collaboration between industry and academia.

The 2004 report on *Shaping the future of Physics in South Africa* reports that between 2000 and 2002, there were between 10 and 25 new doctorates per year, while approximately 150 PhDs were registered during the three-year period studied. At the time of the report, there were an estimated 220 to 250 academics in physics at universities (excluding those at technikons) who were primarily white, male and older than 50 years. The report concluded that students in physics have a "… disastrously small part of the science market …" (*Shaping the Future of Physics in South Africa*, 2004).

In 2005, the Women in Physics in South Africa Project (WiPiSA) was launched by the DST in an attempt to "… stimulate an increased interest in physics among girls and women, and assist in removing or overcoming obstacles to the study of physics and to work in physics-related careers …" (Diale et al., 2009). In 2006, approximately 16% of the 500 members of the SAIP were female. At all levels of study in physics, male students outnumber female students, two to one (Diale et al., 2009). In 2017, Mouton, Valentine and Van Lill (2017) reported that doctoral enrolments in the physical sciences increased with 47% between 2000 and 2015 while the number of graduates only grew with 12%. The report found that in the physical sciences, the growth rate for doctoral enrolments is near twice the growth rate for master's students. In 2014, the conversion rate of master's to doctoral qualifications in the physical sciences was approximately 70% (Mouton, Valentine & Van Lill, 2017).

3.4.2 Sociology

Sociology, as a discipline, was introduced to South Africa at the start of the twentieth century (Jubber, 2007). Before that, sociology was offered as a sub-discipline within philosophy, anthropology or social work (Uys, 2004). The South African Association for the Advancement of Science (SAAAS) was fundamental to the institutionalisation of sociology in South African higher education (Groenewald, 1989). Accompanying the call for sociology as an academic discipline, was a need for more social research to be done within the South African landscape. The first sociology course offered in South Africa was at the University of South Africa (Unisa) in 1919 after which departments at universities such as Pretoria, Stellenbosch, Cape Town, Witwatersrand, Potchefstroom, Natal and the Free State were established throughout the 1930s. The focus of sociology in the founding years was social welfare with a particular focus on poverty and unemployment. The most prominent scholars in sociology in the early years came from fields such as psychology and economics (Jubber, 2007). During the 1950s and 1960s, there was a focus to professionalise sociology and to distinguish itself from social work (Mapadimeng, 2009). During the apartheid regime, sociology, specifically at Afrikaans-speaking universities, became politicised in its support for racial segregation.

> What was promising to become an independent vibrant discipline however came to be bedevilled by racial and ethnic divisions under the apartheid regime, very much in line with the racially based separate development government policies that sought to promote and uphold white racial supremacy. This saw sociology growing as a divided discipline in different universities taking different directions in terms of its role and interventions in the society. (Mapadimeng, 2009)

The result was thus an "oppositional sociology" at English-speaking universities and an "Afrikaner sociology" at Afrikaans-speaking universities (Mapadimeng, 2009). The former was explicitly combating apartheid, with the latter in support thereof.

In 1994, there were approximately 350 academic sociologists over 30 departments of sociology in South Africa (Uys, 2004). Uys suggests that in South Africa, sociology as a discipline is widely unknown to students upon entering university. She adds that the majority of students in sociology are recruited "accidentally" at an undergraduate level when students familiarise themselves with the discipline. Following 2005, Uys argues, there has been a decrease in student numbers in sociology as some institutions have ceased to provide courses in sociology at an undergraduate level. This was the result of the restructuring of higher education by the South African government[25]. "Restructuring has fragmented disciplines into smaller units or programs [sic] on the one side and absorbed departments into schools of social science on the other" (Burawoy, 2004:23). Uys and

[25] This restructuring included the establishment of the South African Qualifications Authority which sought to create a common curriculum and set of standards across HEIs and to develop a vocationally oriented educational system. Secondly, there was a merger of higher education institutions across South Africa. Thirdly, the previous Foundation for Research Development (FRD) for the natural sciences and the Centre for Science Development (CSD) for the social sciences and humanities were merged into the National Research Foundation (NRF)

Burawoy argue that sociology as a discipline has suffered following the centralisation of higher education, which sought to create common standards through the merging of universities and the withdrawal of resources. Faculty members in the social sciences were arguably faced with high administrative workloads and subject to external criteria for evaluation which led to a fragmentation of the discipline (Burawoy, 2004). At the same time, sociology has had to respond to international pressures of becoming market-related through the discipline's instrumentalisation.

A survey of 15 sociology departments across South Africa in 2003 found that the average staff-to-undergraduate-student ratio in sociology was 67.9:1 while the average staff to student (including postgraduate students) ratio was 71.7:1. This shows a heavy teaching load in sociology. In 2003, 76% of staff in sociology was white, 37.6% were older than 50 years and 36% had a doctorate. Another survey in 2007 found, however, that there was an improvement in the number of enrolments in sociology between 2003 and 2007. This increase resulted in a similar increase in staff-to-student ratios and an increased teaching and supervisory burden which, Mapadimeng argues, inadvertently lead to a compromise on quality and faculty members have less time to do research (Mapadimeng, 2009). In 2009, Mapadimeng claimed that there were only 170 full-time staff members in sociology (Mapadimeng, 2009). This means that the number of faculty members in sociology nearly more than halved in 15 years, while enrolments increased in recent years.

> While the increased number of students could be seen as a sign of optimist, it is however off-set by the current scenario of low number of academic staff/sociologists implying heavy teaching and supervision loads, with the subsequent negative impact on the quality of teaching and training. (Mapadimeng, 2009:7)

The ASSAf report claims, for the period studied, that the social sciences recorded the highest growth rate (11.9%) when compared with the other four broad fields (ASSAf, 2010). In the social sciences in 2007, of black African, Indian/Asian and coloured (AIC) students, 41% were female, none were younger than 30 years and 64% were South African. Sixty-three per cent of white graduates in the social sciences were female, with only 7% younger than 30 and 94% were South African. This shows that in the social sciences, graduates are relatively old when compared to other fields. The ASSAf study reports that in the social sciences, UP produced the most graduates in 2007, followed by North-West University (11.7%) (ASSAf, 2010).

3.4.3 Education

Education as a discipline, in South Africa, is mainly a professional one and its primary aim has been the training of teachers. During the 1960s the training of teachers was located at teacher education institutions (Chisholm, 2009). These institutions were mainly provincially-controlled and racially segregated and were responsible for the training of primary school teachers. Students studying to become secondary school teachers did so at universities. During the apartheid era, these colleges proliferated as many (black African) South African students were excluded from higher education institutions and positions in the formal economy.

> The provision of vocational training under Apartheid was characterised by unequal access to learning opportunities based on race; the division between theory and practice; and an unequal allocation of funding between historically white institutions … and historically black colleges … (Bisschoff & Nkoe, 2005)

During the 1990s, the National Commission on Higher Education (NCHE) proposed that these institutions be incorporated into the public universities. The primary reason for these mergers was financial. It was argued that teacher education institutions were small, expensive and heavily subsidised by the state. Many of these institutions, given their size, had low student-to-lecturer ratios and were regarded as an inefficient use of resources (Chisholm, 2009). The mergers were thus seen as an effort to reduce unit costs and increase productivity through their restructuring. The incorporation of teacher training colleges into universities was also an effort to integrate teacher education racially, while also aiming to control for the quality of training since, given the number of small colleges, it was difficult to standardise the quality of education offered.

During the restructuring, these colleges were given the option to become autonomous higher education institutions, permitting that they had a minimum of 2000 full-time equivalent students, or they were to be merged with existing universities or universities of technology. Lecturers at these colleges were subsequently absorbed into provincial departments of education. In 2001, all former colleges of education were formally incorporated into universities or universities of technology. This resulted in a significant decrease in institutions offering teacher education qualifications. The restructuring also had other implications. First, many are of the opinion that teacher education, specifically at the primary school level, is regarded as third or second class and is thus neglected by higher education institutions. Second, universities have strict entrance criteria for primary school teachers, which many feel are inappropriate as it excludes aspiring teachers. This includes high university fees which exclude disadvantaged students, such as black women from rural areas. Third, since universities have historically only trained secondary school teachers, many consider them to be unequipped to train primary school teachers (Chisholm, 2009).

> University education is too theoretical and abstract. As many former college students and lecturers attest, colleges provided hands-on training, a practical education that today's universities and universities of technology do not provide. Higher education institutions are often considered to be inadequately capacitated to address the needs at primary school level. They do not use or provide opportunities for experienced principals and teachers to participate in training future teachers. (Chisholm, 2009)

In recent years, there has been a rising debate for the re-opening of education colleges in an attempt to address the decreasing supply of school teachers. In South Africa, there is a critical shortage of teachers in the foundation phase, mother tongue education, and mathematics and science. The teacher-pupil ratios are high and one of the reasons underlying the perceived shortage of teachers is that teaching is not viewed as an attractive profession (Chisholm, 2009).

Little has been written on the state of education[26] as an academic discipline in South Africa. The majority of literature focuses on teacher training. In 2009, the HSRC conducted a study on teacher graduate production in South Africa (Paterson & Arends, 2009) but the report focused almost exclusively on trends in undergraduate programmes with little reference to doctoral production. The authors argue that doctoral candidates in education are most likely practising teachers who pursue a postgraduate qualification to further their professional training or research skills (Paterson & Arends, 2009).

The authors found that the closure of teacher training colleges had a significant impact on the enrolments of students in teacher training. The number of enrolments of black African females under the age of 30, declined noticeably. However, the enrolment of undergraduate teaching degrees at universities grew steadily between 1995 and 2005. According to Paterson and Arends (2009), doctoral enrolments in education at South African universities and technikons almost doubled for the period 1995 to 2004 (532 in 1995 to 1016 in 2004). However, the proportion of enrolments in education to all postgraduate degrees (including honours, master's and doctorates across both universities and technikons) decreased slightly from 0.5% in 1995 to 0.4% in 2004. With regard to doctoral graduates, there was a slight increase from 92 graduates in 1994 to 127 in 2004.

[26] In my empirical analysis, I study education in general. I present the subfields within education in Appendix A.

Despite the limited evidence for and perhaps differing methods in its calculation, doctoral production in education has increased significantly over the last decade. In 2012, doctoral enrolments in education constituted 10% of all doctoral enrolments (Cloete, Mouton & Sheppard, 2015). In 2007, doctoral graduates in education constituted 32% of all graduates in the social sciences and 11% of total graduates. The PhD Consensus report found that in 2007, education was the field which produced the most doctoral graduates of all the fields analysed (ASSAf, 2010).

3.4.4 The clinical health sciences

The clinical health sciences or medical clinical sciences[27] are treated as one discipline throughout this study although it is composed of a clustering of sub-disciplines. Fields included in this category include anaesthesiology, cardiology, psychiatry, neurology, ophthalmology and more[28]. Little has been written on the state of these fields in South Africa. The education model used in the clinical health sciences is unique to the clinical fields as nearly all doctoral candidates are professional medical doctors who are employed full-time for the duration of their studies.

In 2010, fewer than 10% of PhDs in South Africa were in clinical or public health (Grossman & Cleaton-Jones, 2011). Grossman and Cleaton-Jones ascribe the low numbers of doctorates in the health sciences to events in the 1970s when the Department of Health (DoH) "… rationalised all health care facilities to its control and prioritised health care and service delivery to the detriment of research activity …" (Grossman & Cleaton-Jones, 2011:111). In other words, training in the health sciences is solely oriented towards service delivery and the training of academics or researchers is neglected. This is exacerbated by a disconnect between the then Colleges of Medicine of South Africa (CMSA) and the university qualification requirements for clinical training. Students in the clinical sciences could obtain a master's degree through the CMSA through coursework without completing a research component, as was the case at most universities. Many students opted to go this route. These factors led to a "… 30-year haemorrhage in the PhD pipeline at the master's level in the clinical sciences" (Grossman & Cleaton-Jones, 2011). Following 2011, in an effort to address the dearth of research capacity in the clinical sciences, the Health Professions Council of South Africa (HPCSA) introduced the requirement

[27] Following the reclassification of CESM fields the clinical health sciences were referred to as the medical clinical sciences.

[28] For the complete list of fields refer to Appendix A.

of a research component in order to register as a clinical specialist in South Africa. In addition, the HPCSA has called for protected study time (20%) for master's students. In many undergraduate medical programmes today, such as UCT, UP, WITS, students are introduced to doing research in their third or fourth years of study (ASSAf, 2009).

There exist little data on postgraduate studies or publication output in the clinical sciences (Grossman & Cleaton-Jones, 2011). An article by Grossman and Cleaton-Jones (2011) used the Dental Research Database to extract records on dental postgraduate output to use as a proxy for other clinical sciences. The study included records from 1954 to 2006 and found that PhD students in dentistry are mainly enrolled part-time, are self-funded and are non-clinicians. In 2012, 11% of doctoral enrolments were enrolled in the health sciences (Cloete, Mouton & Sheppard, 2015). The ASSAf Consensus report found that in 2007, 65% of all black[29] doctoral graduates were female, while only 10% were younger than 30 years. Sixty-three per cent of black students were South African. This compares to white graduates in the health sciences, where 60% were female, 25% were younger than 30 years, and 89% were South African (ASSAf, 2010). In 2007, UCT produced the highest share of doctoral graduates in the health sciences (24.2%), followed by WITS with 18.9%. A study of master's students in pharmacy (Summers & Mpanda, 2014) reports that the average completion time for master's graduates in the health sciences is approximately three years.

Grossman and Cleaton-Jones determined that PhD conversion rates in the Dental Research Institute (DRI) were below average (Grossman & Cleaton-Jones, 2011). As with the majority of professional fields, the rationale for a PhD in the health sciences is a well-debated one. The authors cite the ASSAf Consensus report on revitalising clinical research in South Africa in claiming that there exists no employment market for the clinician PhD as one does not need a doctorate for a career in clinical research (Grossman & Cleaton-Jones, 2011). For the most part, the PhD in the clinical sciences is then reserved for aspiring academics or "life-long learners" as many postgraduates in these fields consider the PhD superfluous.

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[29] African Black, Indian/Asian and coloured students

3.4.5 Electrical engineering

Little has been written about the state of engineering in South Africa, particularly with reference to electrical engineering. In 2016, an article on the status and challenges of industrial engineering in South Africa was published (Schutte, Kennon & Bam, 2016). One of the main findings of the report is that the transformation of the sub-discipline, specifically pertaining to black students, is lacking. An article on the role of an academic department of metallurgical engineering in 2003 positioned the role of the academic department as a necessary partner for industry (Pistorius, 2003). Pistorius argues that the majority of students in metallurgical engineering hold bursaries from industry. The author also suggests that university departments should seek to offer relevant degree programmes and conduct poignant research which must be constructed in partnership with and in response to trends in industry. For the author, the role of the academic department should act as "… a technical resource for industry, a source of information and expertise …" (Pistorius, 2003:605). Between 1992 and 2002, there has been a steady increase in postgraduate enrolment in metallurgical engineering. The author attributes this to the establishment of longer-term research programmes.

The PhD Consensus report found that in 2007, doctoral graduates in electrical engineering constituted 30% of graduates in the engineering sciences, materials and technologies, while only contributing 2% to the total output of doctorates (ASSAf, 2010). In 2017, a study on the status of postgraduate students in engineering in South Africa looked at trends in master's and doctoral enrolments and graduates across all engineering fields (Mouton, Valentine & Van Lill, 2017). The report is purely statistical and reports on growth trends, demographic profiles of students and time-to-degree. Between 2000 and 2014, the number of doctoral enrolments in engineering increased nearly 300% while the number of graduates more than doubled. Electrical, electronics and communications engineering had the highest share of doctoral enrolments while enrolments increased from 134 in 2000 to 366 in 2014. In 2000, almost all doctoral enrolments in electrical engineering were male (96%), but this decreased to 86% in 2014 (Mouton, Valentine & Van Lill, 2017).

In 2014, the average age of doctoral enrolments in engineering was 34.2 years. Although growing from a low base, the growth of enrolments by black African students grew significantly between 2000 and 2014. There has been a noticeable increase in students from outside of Africa. The share of doctoral enrolments in engineering from Africa (all African countries, excluding South Africa) grew from 59% in 2000 to 71% in 2014. In 2014, slightly fewer than 50% of doctoral enrolments in electrical engineering were not South African. WITS, SU and UCT graduated the most doctoral students over the 15-year period. In 2014, graduates in electrical engineering constituted the largest share of total graduates in engineering. The average age of doctoral graduates in 2014 was 36 years old, while the majority were male, while 37.5% were from outside of Africa (non-South African). In 2014, the conversion rate from master's to doctoral degrees was about 30% (Mouton, Valentine & Van Lill, 2017).

In 2015, an article on BusinessTech.co.za ("Shocking number of engineering dropouts at SA universities", 2015) reports that the drop-out rate of engineering students, particularly at undergraduate level, are on the increase ("Shocking number of engineering dropouts at SA universities", 2015). Reasons for this include, first, students' rationale for enrolling in engineering as being misguided. Second, a degree in engineering requires the mastering of a multitude of technical and theoretical skills, particularly in the area of physics and mathematics and lastly, engineering as a discipline is facing pressures to produce graduates who can meet the demands of potential employers. Often these skills are multidisciplinary in nature where employers expect graduates to have a grasp of "… solid technical experience combined with a track record in project management, team work, a grasp of financial management and more …" ("Shocking number of engineering dropouts at SA universities", 2015). I discuss the relevance of the doctorate in more applied fields such as electrical engineering in the next chapter.

3.5 Conclusion

In this chapter, I reviewed studies on doctoral education in South Africa. The most pertinent research in higher education has been in response to the demand to increase the production and efficiency of doctoral education while transforming the demographic profile of doctoral students. There is limited empirical research on doctoral time-to-degree within the South African context, but I discussed the most prominent studies with reference to the trends and demographic profile of doctoral students in South Africa. Findings by the CHE (2009), ASSAf (2010) and Cloete, Mouton and Sheppard (2015) among other, on the doctoral pipeline, supervisory capacity and the use of performance indicators in South Africa were presented. In the second half of the chapter, I briefly discussed the status of the five selected disciplines in South Africa with special reference to doctoral education within each discipline.

In the next chapter, I include the findings of some of the studies reviewed here in the thematic discussions on the determinants of timely degree attainment.

Chapter 4 | Determinants of student success

This chapter is assigned to a discussion of the factors that influence timely doctoral completion. Studies of this topic are plentiful. The chapter starts with a brief discussion of theoretical models which aim to explain student withdrawal and degree attainment from scholars such as Tinto, Astin, Bean and Spady (Astin, 1977; 1984; Bean, 1980; Spady, 1970; Tinto, 1975; 1988; 1993). I continue the discussion of existing empirical studies that identify some of the pertinent factors associated with doctoral time-to-degree and completion. Using a revised classification of barriers as constructed by Cross' in her *chain of response model*, I distinguish between the nature of a discipline, student demographics, and contextual institutional, situational, and dispositional factors which scholars argue, underpin doctoral success (Cross, 1982). Within each set of barriers, I review the pertinent literature.

As argued in Chapter 2, one of the hypotheses of this study is that epistemological factors, i.e. the nature of a discipline and the organisation of doctoral training within the discipline, impact on time-to-degree. Here I review studies in support of and against, this argument. A second set of hypotheses would postulate that various student characteristics are correlated with timely degree attainment. I deliberate on the effect of gender, age, race, and nationality on time-to-degree. The third set of factors, institutional or environmental, considers the role and efficiency of the institution and its capacity for doctoral supervision in degree attainment. A fourth argument relates to situational factors which include among others, the relationship of financial support, mode of enrolment, and family commitments with timely completion. Finally, I discuss dispositional factors which include a review of literature on student satisfaction (this includes institutional, programme and supervisor satisfaction), motivation and intentions of the student. I conclude the chapter with an overview of the perceived shortcomings of existing studies after which I discuss how the current study addresses these.

4.1 Theoretical approaches explaining student success

Theoretical frameworks for understanding the timely completion of, specifically, the doctorate are lacking. The bulk of the theoretical endeavours focusses on student success, and its converse, attrition.

Within psychology, scholars have investigated how the learning experiences and styles of adults differ to that of younger students, but few have a specific focus on how learning at the doctoral level is achieved. In the following section, I briefly discuss some of the most prominent theories that explain how and why students succeed or fail to persist. Although these theories do not have a direct application on my investigation of time-to-degree, I consider them useful in conceptualising degree attainment.

There has been a long and widespread effort to explain student attrition theoretically (Aljohani, 2016; Bean, 1980; Reason, 2009; Tinto, 1975). The emphasis on student attrition has its roots in the early twentieth century with 35 studies of student attrition conducted between 1913 and 1962 (Bean, 1980). Earlier models, before the 1970s, largely explained student attrition in terms of students' characteristics and personal attributes (Aljohani, 2016). Among the first studies on student attrition was McNeely's study of undergraduate student attrition across 60 institutions in the USA. McNeely referred to student drop-out as student "mortality" or "… the failure of students to remain in college until graduation …" (McNeely, 1938). This study was the first, and considered a precursor, for the fascination with student success to follow in the next eighty years (Demetriou & Schmitz-Sciborski, 2011). After the 1970s, research endeavours of student success started to include theoretical models and frameworks which based their explanations on the students' positioning within and relationships with the broader institutions. Scholars of student retention turned away from psychological perspectives towards more sociological theories. Towards, the 1980s, theoretical models underpinning student success were extensive. Many of these theories were based on the ideas of Durkheim who studied social and academic integration (Aljohani, 2016). Here, I discuss some of the most influential theories.

Spady was among the first to study the interaction between the student and the institution with his *undergraduate dropout process model of William* (Spady, 1970). Spady proposes that a student's perception of social integration, or "social fit", is associated with persistence. Students who drop out are more likely to perceive themselves as having less interaction with the institution than those who persist in their studies (Spady, 1970). Newcomb and Flacks refer to students who drop out or consider terminating their studies, as social deviants (Flacks & Newcomb, 1963). Summerskill argues that the degree to which the intellectual development is consistent with the prevailing intellectual climate of the institution contributes to a student's success or withdrawal (Summerskill, 1962). Tinto is one of the most prolific scholars in the field of student attrition and draws on the ideas of Spady in his *student integration model*. Tinto and Spady equate student drop-out with Durkheim's notion of suicide. For Durkheim, suicide is the result of an individual's failed or insufficient integration with society (Durkheim, 2002). This includes a non-alignment of the individual's values with that of society "… as a result of insufficient personal interaction with other members of the collectivity …" (Tinto, 1975).

Tinto considers the college (HEI) a social system with its own values and social structures. Drop-out would then be the result of "… insufficient interactions with others in the college and insufficient congruency with the prevailing value patterns of the college collectivity …" (Tinto, 1975). Schertzer and Schertzer refer to student-institution congruency and student-faculty congruency in determining "academic fit" (Schertzer & Schertzer, 2004). The authors argue that a lack of academic fit leads to dissatisfaction and a lack of institutional commitment, which most likely results in attrition.

Tinto (1975) distinguishes between the social and academic domain of the institution and argues that withdrawal from the university can be voluntary (like suicide) or from dismissal due to academic non-performance or related matters. Student success, therefore, requires sufficient integrations in both the social and academic realms of the university. Although Tinto makes arguments for a structural model of student attrition, he recognises the role of individual characteristics, including psychological attributes, in explaining the intra-societal variations in degree attainment. These include background characteristics of students and expectational and motivational attributes (including individual educational goal commitment). For Tinto, student drop-out is a longitudinal process through which the student must constantly modify his/her goals. In the case of low-goal commitment, a student is more likely to withdraw from the institution (Tinto, 1975). Included in Tinto's model is the *theory of cost-benefit analysis* which claims that the individual bases his/her decision to persist on the perceived costs and benefits related to his/her activities.

> With regard to staying in college, this perspective argues that a person will tend to withdraw from college when he perceives that an alternative form of investment of time, energies, and resources will yield greater benefits, relative to costs, over time than will staying in college. (Tinto, 1975:97)

An analysis of the perceived costs and benefits of study, forms part of the student's goal modification. Student persistence, or drop-out, is then the "… outcome of a longitudinal process of interactions between the individual and the institution (peers, faculty, administration, etc.) …" (Tinto, 1975). Tinto's *student integration model* remains one of the most prominent theories to date.

> Tinto's student integration model has changed over the course of the 35 years from when it was originally introduced. Most notably, its more recent versions have included motivational variables including goal commitment. Over the last decade, motivational theories from multiple fields of study, including educational psychology and social psychology, have been applied to practice, theoretical developments and the study of

> undergraduate retention. In particular, attribution theory of motivation has been notable in practice and in the retention literature. Additionally, expectancy theory, goal setting theory, self-efficacy beliefs, academic self-concept, motivational orientations and optimism have been used to gain understanding into college student persistence and retention. (Demetriou & Schmitz-Sciborski, 2011)

Another of Tinto's influential models is his *institutional departure model* (Aljohani, 2016; Tinto, 1993). Tinto's model was based on the anthropological work of Van Gennep in his study of rites of passage or membership of tribal societies (Tinto, 1988; Van Gennep, 1960). In this model, Tinto argues that student attrition is a process of three stages. The first stage (*separation*) embodies the disassociation of the student from the community (social, academic or institutional). This is followed by a transition stage leading into the final stage (*incorporation*) where the student starts to integrate him/herself into their new community (institution) through an assimilation with its norms and values. Each of these stages marks changes in the interaction patterns between the individual (students) and member of society (university) (Tinto, 1988; 1993).

Bean criticised the sociological models in their methodologies and considers them lacking in that they are unable to use path analytic techniques to test causal linkages between dimensions of attrition (Bean, 1980). Bean likens student attrition to employee turnover in work organisations in his *student attrition model*. From this organisational perspective, student satisfaction is a predictor of persistence. Students who are dissatisfied with their institutions, faculties, departments, and so forth will withdraw just as an employee might leave his/her organisation (Bean, 1980). Alexander Astin introduced his *theory of student involvement* as a pedagogical theory based on the idea that a higher degree of involvement would result in student success in that "… the greater the student's involvement in college, the greater will be the amount of student learning and personal development …" (Astin, 1984:529). Astin defines involvement as the "… amount of physical and psychological energy that the student devotes to the academic experience …" (Astin, 1977; 1984). For Astin, involvement is manifested on a continuum where a student can display different levels of involvement over different periods of time and across a range of objects. Student involvement can also be considered as a quantitative and qualitative construct.

Bean and Metzner considered the frameworks based on social integration inadequate to explore the experiences of non-traditional undergraduate students (Bean & Metzner, 1985). Non-traditional students include older, part-time and distance (commuter) students. The authors argue that for non-traditional students, social integration has minimal effect on their academic experiences. Rather, external environmental factors, such as family responsibilities have a significant bearing on student success. Similarly, Cabrera, Nora and Castañeda in their *student retention integrated model*, built on the models of Bean and Tinto and found the effects of environmental factors as more significant than stated by Tinto and Bean (Cabrera, Nora & Castañeda, 1993).

The literature identifies a legion of factors that determine successful completion. The most prominent theoretical models, however, have their origin in the study of undergraduate students and one might argue that social interaction as an influencer of student persistence is less apt for doctoral students compared to undergraduate students. Given that the theoretical models are limited to the experiences of undergraduate students, the experiences of doctoral students can most likely be assimilated with Bean and Metzner's non-traditional students. The authors suggest that for non-traditional students, external environmental factors are more pertinent in predicting student success than the student's social interactions. In Tinto's *institutional departure model*, he suggests that his model is not only applicable to explaining student departure, but can also be used to think about student development. Perhaps it is thus a worthwhile exercise to consider doctoral candidacy along these three stages, where the doctoral student has to separate him/herself from its previous (undergraduate) community towards socialising and integrating with the expectations associated with a doctoral candidate.

The aforementioned theoretical models are limited in their generalisability, as much of the evidence from which these models were constructed are limited to the USA, are limited to traditional academic institutions and to traditional types of students. In addition, these studies are primarily quantitative in nature. With the exception of models founded on the writings of Durkheim, the theoretical foundations of the reviewed models are relatively thin. However, the majority of empirical studies exploring student success draws heavily on the theoretical models of, particularly Tinto (Brunsden et al., 2000; Cabrera, Nora & Castañeda, 1993; Pascarella & Terenzini, 1979; 1983). In the next section, I present the conceptual framework for investigating the enablers of and barriers to timely completion.

4.2 Toward a classification of barriers to and enablers of timely completion

Many authors have generated models explaining the intersection of barriers and how these impact on students' experiences. The factors that affect student retention, progression and completion are numerous and complex and, amongst others, include age, gender, socio-economic status, student satisfaction, doctoral supervision, funding, academic preparedness, motivation, personal characteristics, institutional factors and so forth (Allen, 1999; Bean, 1980; 1983; Brunsden et al., 2000;

Callender & Jackson, 2005; Cochran, Campbell, Baker & Leeds, 2014; Elliott & Healy, 2001; Jancey & Burns, 2013; Le & Tam, 2008; Letseka & Breier, 2005; Seagram, Gould & Pyke, 1998; Sheard, 2009; Van den Berg & Hofman, 2005; Van de Schoot et al., 2013; Woloschuk, McLaughlin & Wright, 2010; Wright & Cochrane, 2000). Silva, Cahalan and Lacireno-Paquet undertook a comprehensive review of the theoretical and conceptual frameworks which explain adult education participation, specifically with reference to decision-making and the barriers most often encountered (Silva, Cahalan & Lacireno-Pacquet, 1998). Similarly, Sverdlik, Hall, McAlpine and Hubbard (2018) reviewed the empirical literature on the factors that affect doctoral student completion, achievement and well-being.

4.2.1 A conceptual framework

Cross studied adults as learners and investigated how adult learning differs from more "traditional" learning. (Cross, 1982). The author suggested that adult students differ from younger learners by means of physical characteristics (aging), sociocultural characteristics (life phases) and psychological characteristics (development stages) and, therefore, encounter a distinct set of barriers to learning. Although one can argue that the doctorate as a research-oriented degree demands skills beyond that of a mere assimilation with subject matter, I find Cross' classification of barriers and enablers to participation a useful framework in classifying factors that are associated with timely completion. In her *chain of response model*, Cross explores barriers to "mature-aged" students' participation in education by classifying barriers into three categories. Barriers to and enablers of participation are classified as situational, institutional or dispositional. I describe each set of barriers below.

i. Institutional factors include "… procedures, policies and structures of the educational institution that exclude or discourage participation in educational activities …" (Carroll, Ng & Birch, 2009).

The first set of factors, Cross defines as institutional factors which include "… all those practices and procedures that exclude or discourage working adults from participating in educational activities" (Cross, 1982:98). Some of these practices and procedures include inconvenient class schedules or locations, irrelevant courses, procedural or administrative problems of study and so forth. Institutional barriers are often experienced by students when they perceive university programmes as inaccessible, particularly to adult (working) students. Latona and Browne (2001) also refer to these barriers as environmental factors which may lead to a students' dissatisfaction with the institution or programme. These include (1) staff responsiveness, (2) programme design, (3) relevance of the programme to students' career goals and objectives, (4) student support systems, and (5) student orientation programmes (Latona & Browne, 2001).

ii. Situational factors refer to a student's particular life circumstances at the time of their studies.

The second set of factors, Cross identifies as situational barriers which refer to "… those arising from one's situation in life at a given time" (Cross, 1982:98). These include employment and home/family responsibilities, a lack of time for study commitments and financial challenges (Cross, 1982). Carroll, Ng and Birch identify five key situational factors as (1) employment pressures, (2) financial pressures, (3) family commitments, (4) the independent study context, and (5) the health of the student (Carroll, Ng & Birch, 2009; Cross, 1982; Gibson & Graff, 1992). Studying doctoral students who have discontinued their studies, Lovitts found that 70% of students cited personal reasons underlying their decisions to drop-out, while 42% mentioned academic reasons and 29% attributed their withdrawal to financial reasons (Lovitts, 2001). Similarly, Cross found that in her survey research, situational barriers were more often cited as obstacles to learning than institutional or dispositional barriers. "The cost of education and lack of time lead all other barriers of any sort by substantial margins" (Cross, 1982:100). However, Cross suggests that citing external reasons (such as the high cost associated with funding) rather than internal barriers (such as more attitudinal factors) is often considered a more socially acceptable reason for experiencing challenges to learning and do not always accurately reflect the attitudes and experiences of students (Cross, 1982; Mertesdorf, 1990).

iii. Dispositional factors include the individual's or collective's beliefs, values, attitudes and perceptions.

Cross defines the third set of barriers, dispositional factors, as "… those related to attitudes and self-perceptions about oneself as a learner" (Cross, 1982). Dispositional factors are personal or attitudinal and consist of the individual's beliefs, values or perceptions that influence their academic participation. These include (1) student motivation, (2) having realistic goals, (3) students' self-confidence as learners, and (4) student satisfaction (Carroll, Ng & Birch, 2009). Key factors included here are student satisfaction and the motivations or intentions of the student. Cross suggests that dispositional factors are the most difficult to identify or study and are often underestimated given the methodological challenges (such social desirability) in its measurement (Cross, 1982).

iv. Epistemological factors refer to the (potential) difficulties that students experience with the content and context of a discipline (Manathunga, 2002; Morgan & Tam, 1999).

Garland, in her doctoral thesis, extended Cross' model to include epistemological factors as barriers to learning (Garland, 1992). Morgan and Tam similarly added the content and context of an academic discipline as an epistemological factor in their analysis of degree attainment of online students (Morgan & Tam, 1999) and numerous authors have since included course-specificities in their analyses (Bernard & Amundsen, 2008). In the preceding chapters, I have clearly stated the research problem of the study by positioning the nature of a discipline as central to the discussion on doctoral time-to-degree. In Chapter 3, I have thoroughly reviewed arguments in support of how the nature of a discipline influences students' learning experiences. By the inclusion of epistemological factors in the conceptual framework, I not only examine the role of the discipline in and by itself, but I also investigate the role of the selected institutional, situational, dispositional, and student characteristics within and across the five selected disciplines.

v. Student characteristics or demographics

In my conceptual framework, I include a final set of factors which consists of the demographic characteristics of doctoral students. Earlier models of student retention consider student characteristics or demographic factors as pivotal to the understanding of student success (Aljohani, 2016) and studying student success at the hand of students' characteristics has been a prevalent approach (Morgan & Tam, 1999). In their study of Australian doctoral candidacy, Bourke et al. found that the characteristics of the doctoral student account for the most variance in their measurement of time-to-degree when compared with other types of factors (Bourke et al., 2004a).

Carroll, Ng and Birch argue for the usefulness of Cross' theoretical model given its non-prescriptive nature of factors associated with student success (Carroll, Ng & Birch, 2009). Several studies have used a version of Cross' model in studying student success (Boeren, 2009; Bowles & Brindle, 2017; Mertesdorf, 1990; Morgan & Tam, 1999; Roosmaa & Saar, 2017) and have added additional factors such as informational barriers (Darkenwald & Merriam, 1982), technology barriers (McClelland, 2014; Roberts, 2004) and broader structural barriers (Rubenson & Desjardins, 2009) to the framework. Although Cross' original model is non-directional in that it does not consider certain factors to have a greater influence on the student's learning experience, in the present study, I investigated if the academic discipline is paramount to our understanding of timely completion of doctoral studies. For this reason, in my empirical analysis, I studied the selected contextual factors both within and across the selected disciplines. In Figure 4-1 below, I illustrate the conceptual framework.

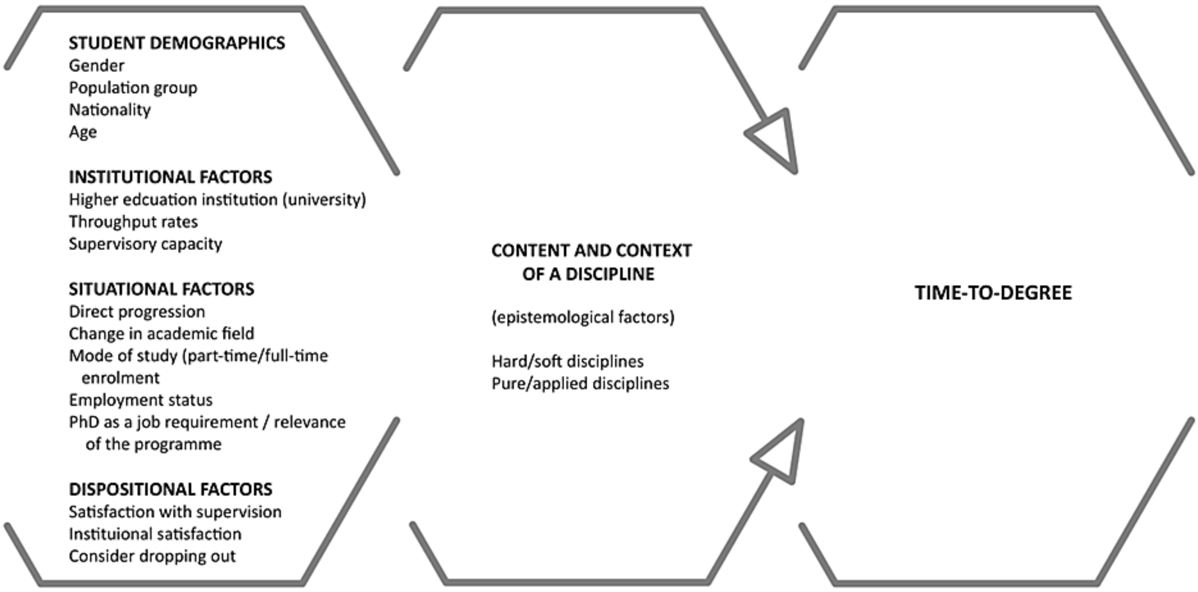

Figure 4-1 Conceptual framework factors influencing doctoral time-to-degree

The use of the term "factors" includes both enablers of and obstacles to degree attainment. In my conceptual framework, I included the measurable factors in the study in the five categories as discussed above. I included the nature of a discipline, both the content and context, as an epistemological factor. The role of doctoral students' gender, race, nationality and age in time-to-degree are investigated as student characteristics. Institutional factors include an analysis across academic institutions and I investigated if a correlation between the average throughput rates and the supervisory capacity of universities with timely completion, exists. I turn to the survey data to study situational factors which include degree progression, changes in the academic field in this progression, mode of enrolment, employment status and the relevance of the PhD. Finally, I include student satisfaction and students' perceptions of the doctoral experience as dispositional factors. In the remainder of the chapter, I discuss the findings of existing empirical research which identify the role of selected contextual factors on timely degree completion.

In the table below, I align the conceptual framework with the factors included in the empirical components of this study.

Table 4-1 Alignment of empirical analyses with the conceptual framework

	Factors		Included in the study	Chapter
Epistemological	**Nature of a discipline**	Hard/soft (abstract/concrete)	Disciplines are grouped as hard/soft (abstract-concrete)	Chapter 7
		Basic/Applied (reflective/active)	Disciplines are grouped as pure-applied (reflective-active)	
Student characteristics	**Gender**	Male	Gender is included in the descriptive analyses and as a variable in the regression model	Chapter 8 and 11
		Female		
	Race	Black (minority)	Race groups (in four categories: African black, Indian/Asian and white) are included in the descriptive analyses and regression model	
		White		
	Nationality	Domestic	Nationality (in three categories: South Africa, rest of Africa and rest of world) is included in the descriptive analyses and regression model	
		Foreign/International		
	Age	Younger	Age (in two categories: younger than 40 years and 40 years and older) are included in the descriptive analyses and regression model	
		Older		
Institutional	**HEI**	Research intensive universities	Differences in average time-to-degree of institutions are included	Chapter 9
		Comprehensive universities	HEI (in three categories: universities, comprehensive universities and universities of technology) are included in the regression model	Chapter 11
		Universities of Technology		
			Administrative challenges related to the HEI as per the survey data	Chapter 10
	Throughput rate		Relationship between throughput rate and e time-to-degree	Chapter 9
	Supervisory capacity		Relationship between supervisory capacity and time-to-degree	
Situational	**Financial support**	Funded	Included in qualitative analysis of survey data	Chapter 10
	Mode of enrolment/study	Full-time	Mode of enrolment included in regression model	Chapter 11
		Part-time	Survey data are used for full-time employment	Chapter 10
	Balancing work/life/study commitments		Survey data are used	
	Degree progression		Survey data are used	
Dispositional	**Student satisfaction**	Satisfaction with supervisor	Survey data are used	
		Satisfaction with institution	Survey data are used	
	Relevance of PhD		Survey data are used	
	Student motivation		Survey data are used	
	Drop-out	Consider voluntary withdrawal	Survey data are used	

4.2.2 The nature of a discipline as an epistemological factor

In Chapter 2, I discussed how scholars perceive epistemological differences across disciplines and what the implications of these differences are for its practitioners. For Gardner, the acknowledgement of disciplinary differences is imperative to the study of doctoral education (Gardner, 2009b). A number of studies have found evidence for differences between disciplines in degree attainment (Bourke et al., 2004a; Bowen & Rudenstine, 1992; Gardner, 2009b; Golde, 2005; Herman, 2011b; Lovitts, 2001; Smeby, 2000). I discuss the findings here.

The PhD Consensus report compares doctoral time-to-degree over five broad groups of disciplines at South African universities (ASSAf, 2010). Over the eight-year period studied, the natural and agricultural sciences and humanities recorded the longest time-to-degree of 4.8 years, engineering sciences, materials and technologies 4.7 years, health sciences 4.5 years, and the social sciences the shortest with 4.3 years. Herman reports on the obstacles to on-time completion of the doctorate and found that in disciplines in the humanities, social sciences and health sciences, students considered academic challenges as an obstacle significantly more than students in other fields (Herman, 2011b). She explains this result as being due to the typically isolated nature of the doctorate in the social sciences. The study by Mouton et al. reports that postgraduate students in the natural sciences have significantly higher completion and progression rates when compared to their counterparts in other disciplines (Mouton et al., 2015). The researchers attribute this to the fact that students in the natural sciences are more likely to study full-time and are, therefore, more likely to complete their studies successfully.

One of the first empirical studies looking at the differences between disciplines with regard to doctoral education was done by Leonard Baird who looked at variances in the average duration of doctoral study in the USA per discipline (Baird, 1990). Baird found that students in the biological, mathematical, physical sciences and engineering doctoral programmes have the shortest time-to-degree whereas those in the humanities have the longest. Baird used secondary data analysis to examine whether programme characteristics contribute to the duration of a doctoral study and whether these characteristics are different across disciplines. Baird's results show that the "fastest" fields included chemistry (5.9 years' duration), chemical engineering (5.9 years) and biochemistry (6.0 years). The disciplines in which students took the longest to complete their doctoral degrees were music (10 years), art history (9.3 years), French (9.2 years) and history (9.2 years) (Baird, 1990).

Bowen and Rudenstine, in their study of doctoral students in the USA, found that time-to-degree varies greatly across the fields studied (Bowen & Rudenstine, 1992). Doctoral students in history showed to have the longest estimated time-to-degree whereas students enrolled in mathematics completed their doctorates faster. The authors attribute this to the generally more theoretical nature of mathematics versus the experimental nature of sciences such as physics. Their study shows that chemists had the lowest completion times (Bowen & Rudenstine, 1992:134).

The National Science Foundation (NSF) reported on doctoral time-to-degree in 2003 by discipline in the USA as determined from the Survey of Earned Doctorates (SED) (Hoffer & Welch Jr., 2006). They calculated time-to-degree as the total elapsed time from graduation from an undergraduate degree (baccalaureate) to the completion of the doctorate. In 2003, the median time-to-degree of doctoral recipients in physics and astronomy was 7.6 years, engineering 8.6 years, sociology 11.2 years, health sciences 13.0 years and education 18.2 years. Generally, graduates in the fields of science and engineering (physical sciences, engineering, life sciences and social sciences) recorded shorter time-to-degree than fields such as health, humanities, education and other professional fields.

A similar study of underrepresented minority doctoral students in the USA between 1992 and 2004, estimated doctoral students' median time-to-degree at 66 months (5.5 years) (Sowell, Allum & Okahana, 2015). Time-to-degree was calculated as the total time enrolled for the doctorate. The study found that among their selected fields, students in the social and behavioural sciences recorded the longest median time-to-degree of six years. This compares to 5.4 years in the life sciences, 5.3 years in the physical and mathematical sciences and five years in engineering (Sowell, Allum & Okahana, 2015). In the Canadian context graduates in mathematics (6.8 years), physics (7.1 years) and chemistry (7.2 years) had the shortest time-to degree while the longest disciplines included sociology (8.2 years), political science (8.2 years) and psychology (8.1 years) (Elgar, 2003).

A study of doctoral completion times in the UK recorded an average of 5.94 years that doctoral students take to complete their studies (Seagram, Gould & Pyke, 1998). The authors found that students in the natural sciences completed their studies significantly faster than their counterparts in the humanities and social sciences. A study completed by Wright and Cochrane found that students who were most likely to complete within four years were enrolled in a science-based subject, were funded by a research council, studied part-time and were international students (Wright & Cochrane, 2000).

Bourke et al. studied completion times and candidacy times (time-to-degree) of doctoral candidates in Australia (Bourke et al., 2004a). The authors report the average time to degree at approximately four years (7.4 semesters) while the elapsed time (the total time that the student was registered), on average, was 4.4 years. With regard to time-to-degree across disciplinary fields, education had the shortest candidacy time (6.5 semesters), followed by business (6.6 semesters), health (7.5 semesters), engineering (7.5 semesters), arts, humanities and social sciences (7.5 semesters), and science (7.8 semesters). Similar results were found by another Australian study of doctoral students in the faculty of science at one university, where the average time-to-degree was calculated as five years (Jiranek, 2010). In his study of doctoral graduates in Australia, Heath reports the median time-to-degree as 3.2 years for full-time students (Heath, 2002). A study of doctoral graduates in the Netherlands reports the average time-to-degree for doctorates as approximately 60 months (five years) (Van de Schoot et al., 2013). In New Zealand, Scott suggests the average length of study required for full-time doctorates is four years.

Golde studied doctoral students who dropped out in the first year of their doctoral programmes in geology, biology, history and English (Golde, 2005). He examined the reasons for their attrition per discipline. He concludes that disciplinary norms and departmental structures play a vital role in shaping doctoral students' academic experiences. He deems the academic department the "locus of control" in doctoral education (Golde, 2005). Golde argues that the solitary nature of scholarship within the humanities contributes to students' feelings of isolation. Doctoral programmes within the humanities are also often more flexible which puts a lot of responsibility on the individual to maintain his/her motivation. The structure of, for example, doctoral education in English (at his institution) is demanding in terms of coursework and results in many students failing to reach the dissertation phase (Golde, 2005).

Lovitts found that doctoral attrition was the highest among the humanities and the lowest among the (natural) sciences (Lovitts, 2001). She attributes the lower attrition rates in the sciences to the ostensible well-structured intellectual nature of the natural sciences. Bowen and Rudenstine found similar results in their study. They found that completion rates are consistently lower (between 22 to 28%) for students in the humanities and the social sciences than the natural sciences (Bowen & Rudenstine 1992:124). The authors found the probability for students completing a dissertation in mathematics or physics at 90% whereas the probability of completing for their counterparts in English, history and political science was only 79%. The authors ascribe the differences in completion rates to funding being more readily available for students in the natural sciences (Bowen & Rudenstine 1992:129).

HEFCE conducted a comprehensive study on doctoral[30] students in the UK. Among doctoral students in the UK, at least 10% interrupted their studies for at least one academic year (HEFCE, 2005). The analysis of students is split between full-time and part-time students. Among full-time students, 57% graduated after five years, compared to only 9% of part-time students. Seven-year completion rates for full-time students were 71% compared to 34% of part-time students. Between disciplinary fields, full-time students in the biological and physical sciences had seven-year completion rates of 81%. Full-time candidates in health fields recorded completion rates of 76%, engineering 70%, education 66% and students in the social sciences 61%. These findings are congruent with that found for part-time students (HEFCE, 2005).

There is a general consensus that in the USA only half of enrolled doctorates would complete their degrees (Crede & Borrego, 2013). Between 41 and 46% of students enrolled for a doctorate in the USA successfully complete their degree within seven years, while 57% do so within ten years (Ampaw & Jaeger, 2012; Sowell, 2008). In 2008, the CGS reported on the completion rates of doctoral students in the USA for the period 1992 to 2004. Students in engineering recorded ten-year completion rates of 64%, of which students in electrical engineering recorded the highest completion rates (56%) among the engineering subfields. Graduates in the physical and mathematical sciences had, on average, the lowest ten-year completion rates (55%) while 59% of students in physics graduated within ten years. Students in the social sciences fared only slightly better than their counterparts in the physical sciences with 56% completing within ten years. However, sociology was amongst the fields with the lowest ten-year completion rates (45%). The report also found that students in mathematics and physical sciences were more likely to drop out compared to students in other fields. In 2015, a similar study was done on underrepresented minority students[31] in the USA for the period 1992 to 2012. Disaggregation by disciplinary field shows that ten-year completion rates were the highest among minority graduates in the life sciences (including health sciences) (63%), followed by engineering (56%), social and behavioural sciences (52%) and the physical and mathematical sciences (45%) (Sowell, 2008).

One of the most comprehensive studies looking at the differences between disciplines is that of Gardner (2009a). The author studied, qualitatively, how faculty members of seven departments at

[30] The study followed a cohort of students who enrolled for a PhD (or MPhil leading to a PhD) in the academic year 1996/97.

[31] These include students from the following groups: Black/African American; American Indian/Alaska Native and Hispanic/Latino students.

an American university define and conceptualise success in doctoral education. She found that the notion of success differs vastly across disciplines as each department tends to prioritise one skill above another. The disciplines which had the highest completion rates (communication at 76.5%, oceanography at 72.7%, and psychology at 70.7%) shared certain attributes. The author found that departments with the lowest completion rates (in her sample of departments) were mathematics, engineering, and computer science (Gardner, 2009a). Unlike Gardner, Elgar found disciplines with lower completion rates among fields in the social sciences and humanities (Elgar, 2003). Elgar in his investigation of Canadian universities found that disciplines with the lowest PhD completion rates were English (39.6%), history (58.9%) and philosophy (45.5%). The highest completion rates were recorded by students in the life sciences including biology at 78.9%, biochemistry at 82.8% and epidemiology at 63.2% (Elgar, 2003).

A number of studies have been conducted on student success within the Australian context (Abiddin & Ismail, 2011; Adams et al., 2010; Bourke et al., 2004b). Jiranek (2010) found, in his study of Australian doctorates in the faculty of science at one university, that approximately 67% of students completed their studies within five years. Bourke et al. (2004a; 2004b) conducted a number of studies focusing on the relationships between candidature, completion times and the quality of doctoral education as well as attrition rates and reasons for failure. Bourke et al. (2004b) found that five-year completion rates of PhD candidates in Australia were the highest among engineering (83%) and health disciplines (73%) and the lowest for students in business (39%), arts, humanities and the social sciences (47%). Students in education had a five-year completion rate of 56% compared to those in the sciences (70%) while the average five-year completion rate across all fields was 66%. Students who withdrew completely were the highest among those enrolled in business and lowest for those enrolled in engineering (Bourke et al., 2004b).

HEFCE found that seven-year completion rates of doctoral students in the UK are significantly affected by the subject area of the PhD (HEFCE, 2005; Park, 2005). They attribute this finding to the extent to which disciplines have well-established research fields and agreed methodologies.

> Natural sciences and related subjects all have well established research fields with largely agreed methodologies … Typically, results from research in these fields are reported in learned journals. Most of the research fields in these subject areas are well established, and basic methodological disputes are rare. In these subjects, identifying topics and questions for PhD students is usually relatively straightforward. Fields of research in social sciences and humanities, are not always as well established as in the natural sciences, and methodologies may still be disputed. Sometimes it may be difficult to identify topics which can yield substantial results through a PhD research programme. (HEFCE, 2005)

A study of doctoral completion times in the UK supports this argument in finding that students in the social sciences report greater difficulty in selecting topics for their doctoral dissertation which result in them starting their research later than students in other fields. These students are also more likely to change their dissertation topic than students in the natural sciences (Seagram, Gould & Pyke, 1998). According to Wright and Cochrane, students in the sciences are more likely to complete than students in the arts and humanities. Explanations for their findings include the argument that students in science and engineering are more likely to work in groups while students in the arts and languages arguably receive less support from faculty and peers (Wright & Cochrane, 2000).

Lovitts, in her comprehensive study on doctoral attrition, explains how the structure (intellectual organisation) and epistemology of each discipline contribute to the success rate of doctoral students (Lovitts, 2001). She argues that the intellectual organisation of a discipline shapes the academic and social interactions of a faculty, which in turn influences the success rates of students. She, therefore, uses the theory of community membership, or socialisation, in explaining doctoral drop-out. She attributes lower rates of attrition to a stronger community within a discipline (Lovitts, 2001:47). Kolb explains graduate drop-out when there is a mismatch between a student's own epistemology and that of the specific discipline (Kolb, 1981: 233). In other words, when a student's learning style differs from the learning demands of a particular discipline and the subsequent disconnect often leads to drop-out.

Lovitts suggests that the subject matter of the natural sciences' is vertically integrated and graduate students typically focus only on one or two theories. It is arguably easier for students in the natural sciences to master theoretical frameworks as the body of scholarship is coherent. The fact that students also work in teams and in a close relationship with their supervisor adds to these students' success. Smeby follows this line of reasoning by suggesting that fields where "directed" supervision is the norm, levels of student success is higher than for other fields (Smeby, 2000). The frequent exposure (both academically and socially) to faculty members and other graduate students, therefore, contributes to a strong sense of community, which, in Lovitss' opinion, contributes to lower rates of drop-out. Girves and Wemmerus emphasise the role of faculty members in the socialisation of postgraduate students.

> The norms and expectations of the faculty vary by department. The nature of the department, including the attitudes of the faculty and the activities they value and engage in determine, in part, the kind of experience the graduate student has. Department environments appear to influence differentially the extent of both master's and doctoral degree progress. (Girves & Wemmerus, 1988)

For the authors, the perceived lack of structure among the social sciences and humanities presents many challenges for graduate students. Subject matter is horizontally structured and graduate students are challenged with grasping a vast range of classical and theoretical theories. The fact that students often work in isolation with little interaction with faculty members and other graduate students neglects the socialisation process which leads to intellectual and professional development.

> Departments that are collegial and that provide structures and opportunities for interaction and intellectual and professional development, should and do have lower attrition rates than departments that are less collegial and that offer few opportunities for integration. (Lovitts, 2001: 48)

Lovitts, therefore, argues that the relationships between and among the members of a department, faculty or discipline inadvertently influence the persistence outcomes of its doctoral students. Smeby, argues that sciences classified as hard/abstract sciences (natural sciences) typically show a closer relationship between students' and supervisors' research (i.e. collaboration) whereas the soft sciences (social sciences and humanities) purportedly lack "… team organisation of research … and professional authority and judgements are more subject to discussion …" (Smeby, 2000). The latter fields are also characterised by an individualistic research tradition. Smeby claims that in the soft sciences, where interpretation and synthesis are key skills, it is more difficult to teach graduate students. These skills are "… less transmissible in a straightforward didactic way …" (Smeby, 2000). The nature of knowledge in the soft sciences (conflicting paradigms, methods and so forth) makes it more difficult to implement a "directed supervision" model (Smeby, 2000). Despite the assumptive nature of some of the aforementioned explanations of differences between disciplines with regard to student performance, the studies reviewed above argue in support of the nature of academic fields as an influencer of degree attainment. In the following section, the discussion turns to the role of student demographics in time-to-degree.

4.2.3 Student demographics as predictors of timely completion

Earlier models of student retention consider student characteristics as pivotal to the understanding of student success (Aljohani, 2016). Bourke et al. found that the characteristics of the doctoral student account for the most variance in the understanding of time-to-degree when compared with other types of factors (Bourke at al., 2004a). In this section, I review the relationship between age, race, gender and nationality on the timely completion as identified in the literature.

4.2.3.1 Gender[32]

Several studies examined whether the likelihood of student success differs between male and female students (Carbonaro, Ellison & Covay, 2011; Ku & Chang, 2011; Leslie, Cimpian, Meyer & Freeland, 2015; Mastekaasa, 2005; Seagram, Gould & Pyke, 1998; Sheard, 2009). With regard to doctoral time-to-degree in the South African context, there is limited evidence in support of gender differences. The CHE report determined that female students recorded slightly shorter time-to-degree (4.4 years) compared to their male counterparts (4.7 years), whereas in 2005, both genders reported similar time-to-degree (4.7 years) (CHE, 2009). The PhD Consensus report found that female doctoral graduates recorded slightly *longer* time-to-degree (4.9 years) when compared to male students (4.7 years). In 2007, the average time-to-degree of females for the entire period was 4.5 years compared to 4.6 years for males (ASSAf, 2010). A report on the status of postgraduate students in engineering in South Africa also found no significant differences in time-to-degree between male and female doctorates (Mouton, Valentine & Van Lill, 2017).

The CHE report, however, in measuring the pile-up effect of doctoral students at South African universities, found that the pile-up effect is lower for male students than female students. Between 2000 and 2005, the percentage of ongoing enrolments of total enrolments of women increased with 7%, while the same indicator showed an increase of 3% among male students (CHE, 2009). Similarly, the percentage of graduates of total enrolments, for the same period, decreased with 7% for women compared to 4% for men. These results show that female students tend to spend more time enrolled for the doctorate than do their male counterparts.

In 2014, Snyder conducted a qualitative study of the doctoral experiences of black (African, Indian/Asian and coloured) women in South Africa (Snyder, 2014). The author argues that the intersection of race and gender is an important one within the South African context. Although based on a small sample[33], the author identifies key challenges experienced by female doctorates of colour

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[32] Throughout this study, gender is used to refer to students' sex as either male or female. The HEMIS data used for my analyses included gender categories which were submitted by the institutional offices the respective academic institutions. Each student's gender was therefore captured as that which the student submitted on enrolment and one can therefore assume that, although only three gender categories are reported (male, female, unknown), students' autonomous gender identification was captured. The use of gender categories in my analyses is non-normative purely for analytical reasons.

[33] The sample was limited to regionally to respondents in the Western Cape. All interviewees were enrolled for their doctorates in education and at either historically white, or coloured universities.

at South African academic institutions. Interviewees encountered covert, and overt racism and sexism both at individual and institutional levels. The study argues that these women had to learn how to navigate and challenge expected norms and often felt that they have two work twice as hard as their white counterparts (Snyder, 2014). One of the key findings of the study is that women (of colour) struggle to balance their often competing responsibilities from work, family and their studies.

> These women's struggle to find their place as a professional, scholar, wife, mother, and daughter, roles which often pulled them in various directions, presented challenges to their progression through their programme, as well as pushed them to reflect on their own personally held notions of the role of women in the workplace and their families. (Snyder, 2014:28)

The author argues that women of colour emphasise the need for role models and peer networks in offering support in their academic endeavours. In their analysis of doctoral completion rates of doctoral students in the USA, the CGS found that there are some differences in gender within fields. Overall, male students (58%) have higher ten-year completion rates than female students (55%). In engineering, male students record ten-year completion rates of 65% compared to 56% for female students. Fifty-nine per cent of male students in mathematics and physical sciences complete within ten years compared to 52% of female students. In the social sciences and humanities, however, female graduates record higher completion rates compared to their male counterparts (57% compared to 53% in social sciences, and 52% and 47% in the humanities). In studying the completion rates of underrepresented minority students, Sowell, Allum and Okahana found higher ten-year completion rates among female students (56%) than males (52%) (Sowell, Allum & Okahana, 2015). With regard to time-to-degree, the authors found that females (5.8 years) record longer time-to-degree than male students (5.3 years).

Scott found that in New Zealand, the five-year completion rates for male doctoral students are lower (54%), albeit slightly, than for their female counterparts (55%) (Scott, 2005). Bourke et al. found that females have longer candidacy times than male students in Australia (Bourke et al., 2004a). This finding is similar to another study of Australian doctorates in the sciences where female students report an average time-to-degree of 4.5 years compared to an average of 4.1 years among male graduates (Jiranek, 2010). HEFCE reports that among full-time students, male students have slightly higher completion rates than female students (HEFCE, 2005). A study of doctoral graduates in the Netherlands reports the average time-to-degree of doctorates as approximately 59.8 months for females and 59.7 for males (Van de Schoot et al., 2013). In New Zealand, Scott suggests the average length of study required for full-time doctorates is four years. A study of doctorates in the UK found no significant differences in completion times between male and female graduates (Park, 2005a; Seagram, Gould & Pyke, 1998). Similarly, Wright and Cochrane (2000) and Ampaw and Jaeger (2012) found no gender differences in student persistence in their respective studies.

4.2.3.2 Race[34]

The CHE report found that white graduates in South Africa record slightly longer time-to-degree (4.8 years) when compared to the 4.7 years recorded by black African students, 4.6 years for coloured students and 4.5 years for Indian/Asian students (CHE, 2009). The PhD Consensus report found similar results in that white graduates, in 2007, completed their degrees, on average, in five years, compared to 4.5 years for black African and coloured graduates (ASSAf, 2010). When computing the average time-to-degree over the total period analysed, black African and coloured graduates record the lowest time-to-degree of 4.4 years; Indian/Asian graduates record 4.6 years and white students 4.7 years. However, the differences in time-to-degree across racial group are small and not statistically significant. A report on the status of postgraduate students in engineering in South Africa, found no significant differences in time-to-degree between doctorates in engineering by race (Mouton, Valentine & Van Lill, 2017). Examining the pile-up effect at South African universities (as reported by the CHE), the report states that there are no significant differences between racial groups. Across all racial groups, the pile-up effect (ongoing enrolments as a percentage of total enrolments) increased with 5 to 6% (for the six-year period studied). With regard to time-to-degree in South Africa, the CHE report indicates no significant differences by race (CHE, 2009).

Although there is little quantitative support for differences in doctoral time-to-degree among racial groups, some studies highlight some of the challenges unique to non-white students in South Africa. Portnoi argues that the legacy of apartheid has a negative psychological effect on postgraduate students' experiences of their postgraduate studies (Portnoi, 2009:411). She found that black and

[34] The use of race in the study is in no way definitive or normative, but purely descriptive. I refer to students as black African, white, coloured and Indian/Asian. Black African, coloured and Indian/Asian students have been regarded as non-white and often considered under the umbrella term "black". The race categories used in the HEMIS database were replicated, and in the case of the survey, students were asked to indicate their association with their racial group (although many students refused to do so). The use of these racial denotations in this study is purely for analytical reasons. The classification of students within racial groups is a social construct, and one which can be debated thoroughly. However, given the emphasis on transformation within the higher education sector, it is important to include an analysis of students by race.

coloured participants, particularly women, experienced feelings of inferiority. "Based on the South African context, and recent history of institutionalised discrimination, it is not surprising that some students have internalised the negative notions that have historically been (and continue to be) attached to their personal characteristics" (Portnoi, 2009:411). The author concedes that such feelings permeates racial classifications and are not unique to previously disadvantaged groups, but that the intersection between race and gender (and perhaps class) is important to consider in postgraduate education. For participants in Portnoi's study, the university is often considered as a space from which they have previously been excluded and subsequently struggle to conform to the (perceived) expected norms.

Portnoi's findings are echoed by Herman in that she claims black African South Africans do not view an academic career as an attractive one (Herman, 2011c). She argues that for many black students, they are the first of their families to pursue doctoral studies and that there are few role models. Many young doctoral students are offered employment opportunities outside of the academic world which causes them to withdraw from their studies. Herman, like Portnoi, comments on the reported racism experienced by some black doctoral students at historically white universities, which acts as a barrier to the successful completion of their studies. Mouton et al. maintain that there exist racial inequalities with regard to access to doctoral education in South Africa (Mouton et al., 2015).

4.2.3.3 Nationality

The PhD Consensus report found that South African graduates typically take longer to complete their studies (an average of 4.9 years in 2007) compared to 4.5 years and 4.6 years for students from the SADC and from the rest of the world respectively (ASSAf, 2010). Upon calculating the average time-to-degree over the total period analysed, South African nationals record longer average time-to-degree of 4.7 years compared to those from SADC of 4.5 years, and those from outside of Africa of 4.3 years. Mouton, Valentine and Van Lill found no significant differences in time-to-degree between doctorates in engineering based on their nationality (Mouton, Valentine & Van Lill, 2017).

Jiranek, in his study of Australian doctorates in the faculty of sciences, found that international students record shorter time-to-degree (4.2 years) than domestic (Australian) students (4.6 years) (Jiranek, 2010). Reasons for this, the author argues, may be that admission into doctoral programmes is often more competitive for international students than for local students which may lead to higher academic standards among those accepted. Furthermore, international students are subjected to visa requirements which may compel students to complete their degrees within a certain timeframe (Jiranek, 2010).

Evidence from the USA shows that across all fields, international students record higher completion (67%) rates compared to their domestic counterparts (54%). This finding is especially salient in the engineering (70% compared to 59%) and mathematics and physical sciences (68% compared to 51%) (Sowell, 2008). However, of those students who completed their degrees, a higher percentage of domestic students (a difference of 12%) completed within seven years. Park found that among doctoral students in the UK, non-completion is higher among domestic students (UK students) when compared to international students (Park, 2005a). HEFCE (2005) and Wright and Cochrane (2009) found similar results. Although evidence in support of nationality as a factor to timely completion is limited, there is a consensus in the literature that international students are more likely to complete their studies in less time when compared to their domestic counterparts.

4.2.3.4 Age

Several of the studies completed on doctoral degree attainment in South Africa found a noticeable relationship between age and time-to-degree. The CHE report found that there is a strong correlation between age and time-to-degree among doctoral graduates in South Africa. Their results show, that in both 2000 and 2005, doctoral students aged 50 years or older recorded longer time-to-degree while candidates younger than 30 years had shorter completion times (CHE, 2009).

The ASSAf Consensus report identified a doctoral student's age as a risk factor for non-completion. The report found that older students take longer to finish their degrees compared to their younger counterparts. In 2007, graduates who were younger than 30 years took on average, 3.6 years to complete their doctorates, while those aged 50 years and older, on average, took 5.7 years to completion (ASSAf, 2010). Upon calculating the average time-to-degree over the eight-year period, respondents younger than 30 years typically took 3.5 years to complete, students aged 30 to 39 years took 4.6 years, students between 40 and 49 years took 4.9 years, and students aged 50 years and older took on average 5.3 years to complete. Mouton similarly reported a positive correlation between age and doctoral time-to-degree when he found that students younger than 30 years took on average 3.6 years to complete their degrees while those aged between 30 and 39 took 4.7 years, those aged 40 and 49 took 4.9 years and those aged 50 years and recorded a time-to-degree of 5.7 years (Mouton, 2011). The report by Mouton et al. (2015) identified reasons for doctoral students' considerations for dropping out.

From the literature one can clearly discern the positive correlation between age and time-to-degree. As a doctoral student's age increases, so does their completion time. Mouton et al. (2015) show that respondents aged 30 years and older have more challenges in finding sufficient time for their studies compared to their younger counterparts. The report on the status of postgraduate students in engineering found that doctoral graduates in engineering aged 36 to 40 take the longest to complete their degrees (4.8 years) when compared to other age groups (Mouton, Valentine & Van Lill, 2017).

Park found that among doctoral students in the UK, students aged 40 and older are less likely to complete their degrees when compared with students aged 20 to 29 years (Park, 2005). HEFCE similarly found higher completion rates among younger students (HEFCE, 2005). The study reports that among full-time students and part-time students, students younger than 25 years (upon entering their PhD studies) had higher completion rates (78% and 48%) compared with their older counterparts. Scott (2005) found that in the New Zealand context, students aged between 18 and 24 years have higher five-year completion rates (34%) and students aged 40 years and older have the lowest completion rates (Scott, 2005). Although Bourke et al. found that older candidates recorded shorter time-to-degree compared with their younger counterparts (Bourke et al., 2004a), the majority of the literature indicates that younger students are more likely to complete their degrees on time than older students.

4.2.4 Institutional factors associated with timely completion

The third set of factors that I include in the conceptual framework of the study, identifies barriers and enablers to timely completion associated with a student's academic institution. Kamens (1971; 1974) argues that institutional characteristics directly affect student retention, while Spady (1971) and Summerskill (1962) suggest that the interactions between student characteristics, campus environment and the personality attributes of students influence student drop-out respectively. Astin, in his *theory of involvement,* argues that a student's active involvement with college/university will decrease the likelihood of drop-out (Astin, 1984). In this section, I discuss the academic institution, the supervisory capacity and the relevance of doctoral programme as institutional factors influencing time-to-degree.

4.2.4.1 The higher education institution

In the CHE report, doctoral time-to-degree across South African academic institutions are compared (CHE, 2009). The University of Free State (UFS) and UCT recorded the longest average doctoral time-to-degree in 2005 with 5.3 and 5.2 years respectively. The shortest time-to-degree was recorded for graduates at North-West University (NWU) (3.9 years), followed by Nelson Mandela University (NMU) and RU (4.1 years) (CHE, 2009). The PhD Consensus report (ASSAf, 2010) determines the average doctoral time-to-degree, in 2007, of universities of technology as 4 years, compared to (research-intensive) universities (4.8 years), while comprehensive universities recorded 4.9 years. When comparing the average time-to-degree of graduates over the eight-year period studied, traditional universities have the longest average time-to-degree at 4.7 years, comprehensive universities of 4.3 years and universities of technology the shortest with 3.9 years (ASSAf, 2010).

The PhD Consensus report suggests that doctoral students are often challenged with a lack of facilities and resources for completing their studies. This includes substandard or faulty equipment, limited access to library or publication sources, internet of computer access, and working spaces. These are often the challenges faced by students who do not live on campus. The report found that these challenges are often exacerbated by a lack of funding at an institutional level (ASSAf, 2010). A report on the status of postgraduate students in engineering found that doctoral graduates at SU (3.6 years) and NMU (3.7 years) take significantly shorter to complete their studies when compared with other universities (Mouton, Valentine & Van Lill, 2017). The longest average time-to-degree, between 2000 and 2014, are recorded for UP (5.1 years) and WITS (5.6 years). Among universities of technology, DUT (3.3 years) and VUT (3.5 years) record the lowest time-to-degree. A possible reason for this might be that universities of technology enrol a large number of students in disciplines such as physics and engineering which generally record shorter time-to-degree.

In studying doctoral students in the UK, HEFCE found that there are significant differences in completion rates among institutions.

> For example, an institution may have a particularly high rate of PhD completion in comparison to the sector-wide average because that institution has a higher than normal proportion of Research Council students. Some variation is due to the expected random variation that will occur from year to year. However, the modelling shows that not all the variation in institutional rates can be explained through student characteristics or random variations: it shows that there are significant differences both between institutions, and between subject areas within institutions. (HEFCE, 2005)

One of the aims of the ASSAf report was to identify reasons for students selecting a particular PhD programme or institution. The report highlights some of the reasons underlying doctoral survey respondents' decisions in choosing a programme. Approximately half of the respondents indicated, as their primary reason, that they chose their programme based on the research focus of the department or programme (ASSAf, 2010). Just fewer than 50% of respondents indicated that they chose their programme or institution by wanting to work under a specific supervisor, followed by the quality of the programme. A fourth reason is whether funding was offered, while other reasons include the prestige of the institution, the location of the institution while the latter two reasons include recommendations from either friends or family or other faculty members (ASSAf, 2010). These findings suggest that the institution or related institutional factors are noteworthy pull-factors underlying doctoral students' decision-making processes.

Higher education institutions not only offer the student access to funding, support, infrastructure and services but also the academic department. One of the aims of this study is to identify whether disciplinary membership has an effect on doctoral success. Kamens highlights the importance of the institution as a socialisation agent in that it provides the linkages to the wider social order (Kamens, 1971). While both the institution and discipline are sources of student acculturation, Lee argues that institutions play a greater role in transferring values to the student "… as it relates to departmental perceptions of students, research, and professional workload and responsibilities, the institution determines a greater degree of such values" (Lee, 2007:52). For the author, differences between disciplines have less influence on departmental cultures than do institutional differences. Institutions also have varying policies on, for example, the minimum and maximum candidacy times, enrolment requirements and so forth.

As discussed in Chapter 2, disciplines have varying goals and priorities, with some more oriented to doing research (pure or reflective disciplines) while others are more concerned with finding solutions to problems (applied/active fields). However, institutions also display ranging interests towards doing research. This will ultimately affect the institutional culture and correspondingly that of the department. At the same time, different disciplines may assimilate institutional cultures more than others. Notwithstanding this argument, Lee concedes that it is difficult to delineate clearly where the disciplinary culture ends and the departmental culture begins (Lee, 2007).

4.2.4.2 Doctoral supervision

The PhD Consensus report identified four models of doctoral supervision in South Africa (ASSAf, 2010). This includes the (1) traditional apprenticeship model, (2) the cohort-based model, (3) the course-based model, and (4) the PhD by publication. These four models are not mutually exclusive as we can observe some shared characteristics between them. The first model, the traditional apprenticeship model typically embodies a personal relationship between the supervisor and student.

> The main feature of the traditional apprenticeship model is the development of an informal, unstructured, *ad hoc* and individualised, one-on-one mentoring relationship between student and supervisor. It generally does not include coursework and is defined as a delivery model whereby PhD students are expected to learn the necessary skills and competencies from their supervisors. (ASSAf, 2010:66)

This model has been the most widely used at South African institutions. In cases where a student only has one supervisor, it renders the doctoral candidate most vulnerable. There have been efforts to address this concern by supplementing the model with joint supervision, student groups and creating formal opportunities for student engagement, such as through doctoral colloquia (ASSAf, 2010). Notwithstanding these efforts, the success of the doctoral student is still largely reliant on the efforts of the individual supervisor.

There has, however, been a shift away from this model towards more structured approaches including research education and training through, for example, graduate schools (ASSAf, 2010). One of the drives away from this traditional model is towards reducing time-to-degree and attrition of doctoral candidates. There is also a need towards supervision that includes targeted research training. Examples of this include the cohort-based model and course-based model. The cohort-based model typically includes coursework where a cohort[35] of PhD students, as a group, embark on their doctorates within a specific timeframe. An advantage of this model is that it gives students access to more than one supervisor, it offers opportunities for networking, it creates structure through setting benchmarks and students develop within a community of like-minded scholars. Conversely, weaker students may "disappear" within the group. This model also typically requires more funding and infrastructure. The course-based model of supervision includes a structured curriculum of coursework

[35] "… a year-group of self-minded doctoral candidates who study together in workshops, progress through doctoral studies together, are identified by others as a group and identify themselves as a group" (ASSAf, 2010).

while the student is still supervised by an individual supervisor(s). The advantages of coursework lie in its variety in exposing students to differing epistemologies and research methodologies. Coursework also allows for the development of critical thinking while transferring discipline-specific theories and assumptions (ASSAf, 2010). The final model of supervision, the PhD by publication, was discussed in an earlier section and I do not elaborate on this model here.

It is important to note that there are disciplinary differences in pedagogy and that different models of supervision may be more applicable to some disciplines than others (ASSAf, 2010). This also applies to different institutions and countries. An important point to consider is that in the analysis, I made no distinction between models of supervision. I could, therefore, not test whether certain models of supervision result in shorter time-to-degree. I did, however, explore the relationship between students' satisfaction with their academic supervision and estimated completion times.

Regardless of the supervisory models employed, the supervisory capacity in South Africa is insufficient in providing doctoral students with the proper adequate support. Poor relationships between doctoral students and their supervisors underlie many doctoral candidates' considerations to discontinue their studies (ASSAf, 2010). The PhD Consensus report identifies four pertinent obstacles regarding doctoral supervision as identified by study participants. Many respondents indicated that they feel dissatisfied with the contact times with their supervisors as well as experiencing poor communication. Students felt that supervisors are overloaded and are, therefore, slow to give feedback, which ultimately extends their completion. Second, students felt that their supervisors make little effort to develop their (the student's) academic skills and research skills (such as writing and publishing). Participants also feel that supervisors often show little interest in the students at all and this leads to a sense of isolation and lack of motivation on the part on the student. Some students attribute this lack of interest to cultural differences between themselves and their supervisor(s). Another challenge experienced by students is the allocation of supervisors. Some candidates experience a mismatch between their research topic and the expertise of their supervisor. According to the Consensus report, supervisory obstacles are often the primary reason underlying students' rationale for withdrawing from their studies (ASSAf, 2010).

The PhD Consensus study reported on the experiences of doctoral students throughout their candidacies (ASSAf, 2010). Participants were asked to elaborate on the factors that contribute to either their positive or negative experiences of their doctoral studies. Those who deemed their overall experience as positive, highlighted the role of their supervisor(s) in supporting them. These students felt that a good supervisor shows interest and understanding in their work while offering encouragement. Supporting supervisors assist students in gaining access to funding, conferences and networking and publication opportunities. Respondents also highlighted that structured support (workshops, seminars, courses, coaching programmes, etc.) and a conducive research environment contribute to a positive experience of the doctorate (ASSAf, 2010).

A study of doctoral completion rates in the UK found that students who report shorter time-to-degree are more involved with their supervisors than students who take longer to complete. Fast-completers meet more frequently with their supervisors and they are more likely to collaborate with them on research presentations and journal articles. Students in the social sciences report more difficulty with supervision in terms of getting feedback, while those in the natural sciences report higher frequencies of contact with their supervisors (Seagram, Gould & Pyke, 1998). Heath found similar results in his study of Australian PhD graduates (Heath, 2002) in that students in the sciences are more likely have frequent formal meetings with their supervisors than those in the humanities and social sciences. The author suggests that the frequency of formal supervisory meetings contributes to candidates' satisfaction.

> In practice, science candidates working in laboratories often have incidental meetings with supervisors, and can solve many problems informally without having to wait for a formal meeting. Science candidates may also have more questions, especially on matters of detail. This is because many of them must learn to use and apply complex laboratory techniques and equipment. Although many technical questions can be answered by postdoctoral fellows other candidates or research staff, informal laboratory discussions do provide excellent opportunities for the supervisor to solve problems that arise. (Heath, 2002)

Lovitts (2001) and Smeby (2000) suggest that there are differences between disciplines with regard to the relationship between students and advisors. Lovitts argues that graduate students in the natural sciences are often chosen by, or choose, their academic advisor by the end of their first year and typically start working on research projects with their advisor. These research projects often form the basis of the students' doctoral dissertation. Lovitts suggests that this symbiotic relationship often assures the graduate student of stable funding and the promise of publication with their supervisor (Lovitts, 2001:47). The fact that most of the work in the natural sciences is conducted in teams exposes the graduate student to frequent social and academic contact with faculty members. This is in sharp contrast to doctoral students' experiences in the social sciences and humanities. Given the complexity of theoretical and methodological paradigms, students typically choose their supervisors with difficulty and often at a later stage. Doctoral graduates in these fields are seldom selected by advisors and often build on the topics of their master's theses for their doctoral dissertations. Identifying and formulating a topic for the doctoral thesis is often difficult and time-consuming for students in the humanities and social sciences. Students also typically work in isolation without the close support of faculty members and peers (Lovitts, 2001; Smeby 2000).

Over and above the guidance offered by a supervisor, authors such as Pascarella and Terenzini argue that informal interaction with faculty members leads to stronger institutional and personal commitment which is more likely to result in successful completion (Pascarella & Terenzini, 1980; Schertzer & Schertzer, 2004). Although these arguments are founded on studies limited to undergraduate students, postgraduate students are more likely to be in positions of increased interaction with faculty members.

4.2.5 Contextual student situational factors

In this section, I discuss the role of situational barriers on time-to-degree as identified in the literature. Herman, in her study of doctoral attrition in South Africa, suggests that doctoral students consider personal challenges in completing their studies, as more challenging than institutional factors (Herman, 2011b). Participants in her study listed academic challenges and financial problems as the most significant obstacles towards timely completion. This is followed by work commitments and family obligations. Institutional challenges, such as problems with supervision, administration and access to facilities are considered less challenging. One of the main findings of her study is that in South Africa, doctorate attrition is more likely to be the result of personal, or situational factors. She concludes that apart from funding and issues with supervision, practical obstacles, such as the struggle to balance studies, work and family commitments, are among the most significant struggles for doctoral students. She found little reference to institutional obstacles, such as the department, discipline, or institution, as significant barriers to completion. The author suggests that the South African discourse on doctoral education places (perhaps too much) emphasis on external factors, such as historical factors, inadequate school systems, socio-economic factors, and insufficient funding of institutions in explaining doctoral non-completion (Herman, 2011b).

Lanier conceptualises student attrition with the help of his *drop-out theory* (Lanier, 1986). Lanier argues that the causes of dropping out are multiple and interrelated, but can mainly be categorised as experiences, family circumstances, economic factors and individual behaviour (Mdyogolo, 2012). Similarly, Bean and Metzner's non-traditional undergraduate *student attrition model* argues that environmental factors have a greater impact on students' decisions to drop out than academic variables (Bean & Metzner, 1985). Although they base their model on the experiences of non-traditional students, they argue for the centrality of environmental factors, including family commitments and other responsibilities, in influencing students' experiences.

The relationships between financial support, mode of study and challenges associated with family responsibilities and timely completion, as identified in the literature, are discussed below.

4.2.5.1 Financial assistance as an enabler of doctoral success

The preponderance of studies of postgraduate education in South Africa identifies financial support as a major factor in ensuring student success. Many doctoral candidates, particularly in South Africa, are personally responsible for financing their studies (Herman, 2011a). Almost all of the studies on doctoral training in South Africa identify insufficient funding as one of the most significant barriers towards the expansion of doctoral education (ASSAf, 2010; CHE, 2009; Herman, 2011a; Mouton, 2011). Self-financing students are under immense pressure to complete their doctoral degrees in the shortest possible time (Abbidin & Ismail, 2011).

Portnoi found that her participants identified funding for further studies a primary concern (Portnoi, 2009). Almost 80% of respondents indicated that they consider the lack of funding a barrier to postgraduate studies. Participants in her study indicated that a lack of funding often results in having to pursue studies on a part-time basis. The preoccupation with finding financial support often detracts from students' focus.

> Though some students held positions unrelated to their academic pursuits, several of the students who participated are working part-time, or even full-time, as lecturers or tutors at their universities. In cases where graduate students are also employees, the work role often becomes primary while the role of graduate student becomes secondary. (Portnoi, 2009:411)

The ASSAf Consensus report also highlights the crucial role of funding in doctoral success. Respondents indicated that many struggle to buy the necessary equipment, such as laptops, and other materials. Insufficient access to libraries and the internet are also of great concern to doctoral students (ASSAf, 2010). These challenges are often more pertinent among students in the natural sciences, where experimental study materials and equipment are central. Many participants attributes delayed completion of their doctorates to either insufficient funds for fieldwork or data analysis or that they are compelled to work full-time to support their studies. The report identified five themes regarding challenges in financial support as indicated by respondents. First, doctoral students feel that there are insufficient levels of funding for doctoral students. Second, students perceive funding criteria to be unfair. Third, funding instruments and its availability differ between institutions. Fourth, students feel that there are administrative barriers in accessing funds and last, doctoral studies often include hidden costs that are not covered by funding instruments. For many students, these obstacles may lead to the discontinuation of their studies (ASSAf, 2010).

The PhD Consensus report identifies some of the most salient funding instruments of doctoral students in South Africa. Students who receive funding, particularly in the natural sciences, typically receive government funding (i.e. DST) or from statutory bodies such as the NRF. Other sources of funding include international foundations, industry, local organisations and non-governmental organisations. There have been increased efforts in South Africa to assist doctoral students with funding and some of these initiatives include efforts by the NRF to increase freestanding bursaries and fellowships as part of strategies to empower doctoral students. The NRF has also attempted to increase the value of its postgraduate bursaries and fellowships while offering additional instruments through initiatives such as the Technology and Human Resources for Industry Programme (THRiP), the South African Research Chairs Initiatives (SARChi) and Centres of Excellence (CoE) (Herman, 2011a).

Although there has been considerable effort to increase funding for doctoral students, the funding instruments of the NRF typically support students for three years. Given that the average doctoral candidate takes approximately five years to complete their studies, this often renders the time-frame of financial support too short. Students are then forced to seek employment to support themselves which often leads to a discontinuation of the degree (Herman, 2011a).

Herman found a relationship between race and perceived financial challenges an obstacle to doctoral completion. In her study, more black African students, compared to white students, report financial challenges as a significant obstacle (Herman, 2011b). This finding is similar to that reported by Mouton et al. (2015) who found that financial challenges are more prevalent among black African postgraduate students compared to other racial groups. Students aged between 30 and 40 years report more difficulty with financial challenges than those in other age groups (Herman, 2011b). Mouton et al. found that doctoral students in the natural sciences, engineering and health sciences, deem the role of available scholarships/funding/bursaries, in choosing their doctoral programmes, as significantly more important that respondents in the social sciences and humanities (Mouton et al., 2015). Akay and Pistorius suggest that the majority of doctoral candidates in engineering are fully funded by industry or local companies (Akay, 2008; Pistorius, 2003). Many doctoral students are still forced to seek employment during their studies due to limited funding. Few doctoral candidates have the opportunity to pursue doctoral studies full-time.

Ampaw and Jaeger claim that in the USA, one of the most significant predictors of doctoral success is the availability of financial aid (Ampaw & Jaeger, 2012). Their results show that although financial aid as a whole is important in affecting doctoral success "… the type of financial aid received is even more significant and has differential impacts on doctoral students' retention at each stage …" (Ampaw & Jaeger, 2012). The authors claim that research assistantships have proven the most successful in ensuring successful completion. Abedi and Benkin similarly suggest that the source of financial support is the most important variable in predicting doctoral time-to-degree (Abedi & Benkin, 1987). A study of time-to-degree of American graduates found that time-to-degree, across all disciplinary fields, is shorter for students who receive some form of institutional financial support (teaching assistantships, fellowships or grants) compared to those students who rely on their own resources (Hoffer & Welch Jr., 2006). In the USA, 80% of respondents identified financial support as an enabler of success (Sowell, Allum & Okahana, 2015).

Bourke et al. found that students who hold scholarships record shorter time-to-degree than those who do not (Bourke et al., 2004a). The authors argue that the increased provision of scholarships would improve completion rates. Their findings are congruent with that of Jiranek (2010) who found that students who received scholarships, recorded an average time-to-degree of 4.7 years compared to an average of 6.1 years of students who are not funded by scholarships (Jiranek, 2010).

A study by HEFCE, however, found that students who received financial backing have higher completion rates (HEFCE, 2005). Among full-time students who received financial assistance, those who received funding from a research council have the highest completion rates (80%). Of full-time students who received no funding, only 59% are likely to complete their degrees. However, the authors argue that full-time students who received funding from a research council, possess other characteristics which improve their chances to complete their degrees. By controlling for these factors, however, full-time students with financial support are still more likely (11%) to complete their degrees within seven years. For part-time students, this finding is repeated (HEFCE, 2005). Similarly, Litalien and Guay found that students who are supported by a scholarship are more likely to complete their studies (Litalien & Guay, 2015). This is not only for the financial benefit, but that it allows students to study full-time. Students who receive scholarships may also be perceived as having higher levels of competence.

A study on doctorates in the UK, however, found that teaching assistantships have a negative effect on doctoral time-to-degree. In their study, Seagram, Gould and Pyke determined that students who take the longest to complete, reported having received more years of teaching assistantship funding. Respondents from the natural sciences received the most years of teaching assistantships, followed by students in the humanities and social sciences (Seagram, Gould & Pyke, 1998).

Gardner suggests that although funding is an important factor in influencing completion rates, it is the confluence of many factors that affect student success (Gardner, 2009b). Given the evidence cited above, financial support is one of the most consequential predictors of timely completion of doctoral studies, as it enables students to pursue their degrees on a full-time basis, which, as I discuss below, is arguably the most significant determinant of doctoral success.

4.2.5.2 The pertinence of mode of enrolment in degree attainment

One of the most significant factors that influence student success is mode of enrolment. Across the board, studies in the South African context associate higher levels of degree success (shorter time-to-degree and higher completion rates) with full-time enrolment. Wingfield in her study of postgraduate students in the faculty of natural and agricultural sciences at one university in South Africa, found that students who record shorter time-to-degree are enrolled full-time (Wingfield, 2011). Of doctoral students in the UK, full-time students recorded significantly shorter time-to-degree than part-time students (HEFCE, 2005) which was also the case for doctoral students in Australia (Bourke et al., 2004b). HEFCE found that full-time students in the UK have significantly higher five- and seven-year completion rates than part-time students (HEFCE, 2005). Full-time students' five-year completion rates were 38% higher than part-time students, while five-year completion rates saw a difference of 37% between full-time and part-time students. Park's study echoed these findings (Park, 2005).

In Mexico, the majority of students in the humanities and social sciences are enrolled part-time (Alcantara, Malo & Fortes, 2008). Seagram, Gould and Pyke (1998) found that students in the natural sciences are more likely to be enrolled full-time while those in the humanities and social sciences are the most likely to be enrolled part-time. The ASSAf study found that in the natural and agricultural sciences, almost two-thirds of survey respondents indicated that they study full-time and, therefore, held no employment positions during enrolment (ASSAf, 2010). The study also found that black African South African students are more likely to work full-time during their studies.

The substantial number of part-time students in South Africa is mostly the result of a lack of funding to support full-time enrolment. The study conducted by Mouton et al. (2015) found that among the primary reasons cited for dropping out, at a doctoral level, is a difficulty to balance work and study obligations. The study found that among doctoral students, those who study full-time are more likely to complete their studies in half the time that it takes part-time students (Mouton et al., 2015). The study also found that doctoral students in the social sciences and humanities have significantly more challenges in finding sufficient time for studies compared to their counterparts in the natural sciences, engineering and health sciences. Ampaw and Jaeger explain the consequences of part-time enrolment.

> … (P)art-time study is more than limited time commitments of part-time students. I extends to the degree to which a student is able to become involved in the intellectual and social life of the student and faculty communities … Part-time students are more likely to be working full-time and thus have reduced opportunity costs of education. Thus, increases in the other costs of the education or reductions in the benefits from education do not affect them as much as full time students for whom a loss in financial aid may be detrimental to the continuation of their study. (Ampaw & Jaeger, 2012:655)

The PhD Consensus report found that full-time candidates receive more supervision time than those who study part-time. The study also reports that doctoral students found their work commitments (outside of the PhD) to impact on their timely completion negatively. Full-time and part-time students, however, clearly differ regarding this view. Both full-time and part-time students, however, considered time conflicts, or constraints, an obstacle to timely completion (ASSAf, 2010). Many respondents identified the interruption of studies as a big obstacle. Respondents cited that they experience great difficulty in focusing on their studies after having spent time completing other tasks. Candidates who work full-time felt that if the PhD topic is related to their full-time work, it relieves some of the conflicts. Students who tutored throughout their candidacy gained valuable experience but felt that this was at the cost of their studies (ASSAf, 2010).

Doctoral candidates who are enrolled part-time faces many challenges in completing their studies. These include, among others, (1) heavy simultaneous academic and professional workloads, (2) a lack of supervision and understanding from supervisors, (3) inflexible programme organisation and structures, and (4) feelings of isolation. These factors often lead to feelings of uncertainty and anxiety amongst part-time students (Abiddin & Ismail, 2011). In addition to these challenges, mature part-time doctoral students have to manage their academic, professional and personal lives. These include family commitments as well as financial ones, which make the successful completion of the doctorate a trying task.

4.2.5.3 Balancing study, work and family commitments

Herman found a relationship between age and considering work commitments an obstacle to completing a doctoral degree (Herman, 2011b). She found that older students, married students, and students with children deem work commitments a significant challenge, more so than younger students. She also found that students in professional fields (such as education, psychology, economic and management studies, religion and chemical sciences) regard work commitments as a significant challenge. This is likely due to the fact that students in the professional fields are typically older students who are working while studying (Herman, 2011b).

Family, commitments, in conjunction with a student's age and professional commitments, were identified as a risk factor to degree completion by the ASSAf Consensus report (ASSAf, 2010). The report found that many respondents identified the balance of work, study and family a challenge. Some of the students mentioned that too often their studies would need to stand back for other priorities. Herman reports that doctoral students often discontinue their studies due to personal reasons (Herman, 2011b). These typically include reasons pertaining to family and child-bearing. Herman found that a relationship between age and marital status and balancing family commitments exists. In addition, she found a significant difference between South African students and international students in considering family commitments an obstacle. In fields such as education, psychology, economic and management students, religion and health sciences, students are more likely to consider family commitments a barrier. This can likely be attributed to the fact that students in these fields are typically mature, working students (Herman, 2011b). Similar findings are reported in studies by Carroll, Ng and Birch (2009), Bean and Metzner (1985), Snyder (2014), and ASSAf (2010) which all identify family commitments and responsibilities a significant obstacle towards timely degree attainment.

4.2.6 The role of dispositional factors in time-to-degree

The final set of barriers in the conceptual framework includes dispositional factors. This includes student satisfaction, motivation and intentions underlying the pursuit of the doctorate and contemplating voluntary withdrawal (drop-out). Lovitts, in her study of doctoral attrition, found that dispositional factors accounted for 60% of student drop-out compared to only a third of students citing situational factors. In other words, the author assigns agency to students in that they themselves are responsible for attaining success or not (Gardner, 2009b; Lovitts, 2001).

4.2.6.1 Student satisfaction

A number of studies explore the relationship between student satisfaction and student success or retention (Barnes & Randall, 2012; Elliott & Healy, 2001; Gaskell, 2009; Juniper, Walsh, Richardson & Morley, 2012; Schertzer & Schertzer, 2004). Astin's *theory of involvement* (1984) and Bean's *student attrition model* (1980) emphasise the role that student satisfaction plays in retaining students within the higher education system. Student satisfaction, from these perspectives, is a result of student-institution, student-faculty, or student-programme "fit".

> For each individual there are environments (interpersonal and non-interpersonal) which more or less match the characteristics of his (or her) personality. A "match" or "best-fit" of individual to environment is viewed as expressing itself in high performance, satisfaction, and little stress in the system whereas a "lack of fit" is viewed as resulting in decreased performance, dissatisfaction, and stress in the system. (Pervin, 1968)

Bean conceptualises student attrition as a model of employee turnover that compares student attrition to that of resigning from a job. Background variables (e.g. past achievement, socio-economic status) and organisation determinants (e.g. perceptions of relationships, the relevance of one's course and integration) lead to either satisfaction or dissatisfaction on behalf of the student together with institutional commitment experienced by the student (Bean, 1980; McQueen, 2009).

Barnes and Randall found that amongst students studied, those enrolled in education generally report higher levels of overall satisfaction when compared with other disciplines. Education students, however, are less satisfied with their financial resources, and support and information received. Students enrolled in the humanities also indicate lower levels of satisfaction with the aforementioned factors, while those in engineering and the physical sciences are generally more satisfied with available resources and financial support (Barnes & Randall, 2012).

In the PhD Consensus report, students were asked about their satisfaction with various elements of their studies. Generally, students appeared to be satisfied with institutional matters[36], but indicated that they were the least satisfied with available funding, but generally satisfied with the interaction between themselves and faculty members within their respective departments. Participants were similarly asked about their satisfaction with their supervisor(s). Generally, students responded favourably.

> Most students report that their supervisors displayed interest in their personal welfare (64%) and professional development (76%), provided them with as much supervision as they wanted (68%), had general discussions with them about their subject area (76%), were available for consultation (78%), provided constructive criticism of their research (80%) and allowed them to work as independently as they wanted to (96%). (ASSAf, 2010)

Respondents were largely satisfied with their supervisor(s), while approximately 60% of respondents felt that their supervisor neglected to assist them with future and career planning. A few participants indicated that their student-supervisor relationship made them uncomfortable (12%) while 10% of respondents indicated that they have considered or attempted to switch supervisors (ASSAf, 2010).

As discussed under the thematic section on gender, there are conflicting findings on the effect of gender on doctoral time-to-degree. A study of doctoral completion times in the UK found no significant differences in time-to-degree between men and women but found that women are generally more unsatisfied with their academic supervision.

> Women doctoral graduates as compared with their male counterparts reported significantly less supervisor interest in their research topic and significantly more conflict among their supervisory committee members. Significantly more women than men reported lengthy delays in obtaining feed- back; significantly more women than men believed that these delays had slowed them down; significantly more women than men believed that their gender affected their progress; significantly fewer women than men collaborated with their supervisors on papers. Women, as compared with the men respondents, reported significantly lower levels of satisfaction with their super- visors and supervisory committees and significantly less satisfaction with their graduate school experience overall. In addition, there is some suggestion in the data that women may have

[36] Percentages of respondents who indicated "yes" to the following statements: satisfaction with availability of department/faculty members to meet with students (79%), satisfaction with the quality of academic advice/feedback by department/faculty (78%), satisfaction with quality of overall department/faculty member-student relationship (77%), satisfaction with the collegial atmosphere between the department/faculty members and students (74%), satisfaction with communication between department/faculty members and students (71%), satisfaction with the department/faculty interest in my personal development/future plan (61%), and satisfaction with financial support (61%) (ASSAf, 2010).

> been experiencing significant life stress (e.g., changes in marital status). (Seagram, Gould & Pyke, 1998)

Barnes and Randall found that students who dropped out of their candidacies reported lower levels of satisfaction with their doctoral experience, particularly with their supervisors (Barnes & Randall, 2012). This finding is supported by research that suggests that degree completion is related to students' overall programme satisfaction (Girves & Wemmerus, 1988) and research that suggests problems or dissatisfaction with one's advisor can contribute to reasons for withdrawal (Latona & Browne, 2001; Lovitts, 2001; Seagram, Gould & Pyke, 1998).

4.2.6.2 The perceived relevance of the doctoral programme

The PhD Consensus report found that more than 50% of doctoral graduates in South Africa are employed in higher education. More and more students, however, are leaving the academic world for employment in other sectors. There is a perception among employers, outside of academia, that the doctorate has few benefits in the workplace. This has led to those working in higher education to review the relevance of doctoral programmes (ASSAf, 2010). Notwithstanding this shift, a study conducted on employers' perceptions of the doctorate shows that many employers are still in support of hiring doctoral graduates. These employers feel that the doctoral graduate can work independently while possessing advanced research skills. However, they have certain expectations of employees who hold a doctorate. These include responsibility, going about their work rigorously, have excellent conceptual thinking and technical research skills and being able to work in diverse work environments. Often the "independent" nature of the doctorate teaches doctorates to work in isolation. Recently, there is also a perception that graduates lack the necessary technical skills, with particular reference to statistical skills (ASSAf, 2010).

In sectors related to the natural sciences, employers demand an integration of theory and practice. In these fields, many employers feel that the doctorate should be better aligned towards industry. The PhD Consensus report found that for graduates and employers alike, there is an emphasis on being able to design and manage a research project in its entirety. Both camps feel that there is a need to provide doctoral students with skills of project and business management, financial management and skills training (ASSAf, 2010). This idea is echoed by authors writing on the doctorate in engineering (Akay, 2008; Pistorius, 2003). There is an increasing need for doctoral graduates in engineering to have a grasp of more than merely technical skills. Those who train engineers feel that through this expansion of skills, it would compromise the technical depth of training. Akay describes the need for innovative graduates as a “new kind of engineer” where the graduates’ skills must have breadth and depth (Akay, 2008:404).

> Such an education model would be of interest to a broader pool of potential candidates, accommodate engineering PhDs on all points of the specialisation spectrum, and conceivably enrich and expand research areas. Further, by recognising the broader context within which the specialisation fits as well as the value of non-technical attributes, this model would help to ensure that engineering PhDs have the full complement of professional skills necessary for success in academe, business or government. (Akay, 2008:404)

The need for well-rounded graduates is the result of employers in industry considering PhD students’ education and training as too narrow. Akay suggests that employers outside of academia often feel that engineering doctorates lack skills in effective collaboration, working in teams, organisational and managerial skills and the appreciation of applied problems (Akay, 2008). Potential employers within the academia often feel that doctoral graduates do not possess adequate teaching and mentoring skills. The PhD in engineering primarily constitutes technical training which prepares the student for doing research, and often leaves graduates ill-equipped as educators, advisors or technology leaders (Akay, 2008).

The PhD Consensus report recounted doctoral students’ expectations of the doctorate (ASSAf, 2010). Forty per cent of respondents felt that their doctorate was crucial to obtaining their current employment position. Those who graduated in the natural and agricultural sciences ascribed more influence to their degrees, with almost 50% indicating that their degrees proved crucial in finding employment. This compares to only 27% of graduates in engineering science, materials and technology. Twenty-one per cent of respondents in the social sciences felt that their doctorates “did not help at all” in obtaining their current employment position which was comparable to only 7% in the natural and agricultural sciences. When asked whether graduates used the skills learnt through their doctorates 51% of graduates in the humanities reported “very frequently” compared to 34% in the engineering science, materials and technologies (ASSAf, 2010).

A study of engineering graduates in the USA found that upon graduation, engineers’ with a doctoral qualification, median salary is approximately $5000 *less* than graduates with a M.Sc. degree (Akay, 2008). The study claims that for engineering doctorates in the USA, the expected return on investment for the doctorate is only met for a number of students and is often not the norm. The exception, however, is for foreign students who obtained their PhDs in the USA.

A qualitative study of doctorates in South Africa by Backhouse identified two types of people who enrol for a PhD. First, people established in non-academic careers who seek to improve their skills or "upgrade their knowledge" (Backhouse, 2009). These candidates often work in applied or professional fields such as engineering or education and enrol for a PhD to "… deepen or broaden their knowledge base, to bring their knowledge up to date, to gain new insights or to develop their understanding of aspects of their work. However, they are focused on knowledge that is relevant to their work" (Backhouse, 2009:134). Alternatively, a second type of PhD candidate is one who pursues an academic career. Backhouse makes a distinction between established academics and early-career researchers starting out on an academic career. The former are typically older students who enrol for a PhD as a job requirement or to improve their skills. In South Africa, there has been a drive to increase the proportion of full-time staff with PhDs, even in applied and professional fields. In the pursuit of tenure at a South African institution then, a PhD is a requirement. Early-career academics are often young with a clear and direct trajectory from undergraduate studies to the doctorate. In some cases, these students enrol for a doctorate out of having no other viable employment options, whereas other pursue academic careers with an emphasis on knowledge production.

> … (I)t is common for those pursuing academic careers to identify knowledge generation as their major goal in doing the PhD. They are interested in knowledge and knowing, often with a focus in knowledge itself, rather than knowledge for some other end. They also study in order to enhance their careers or to enable them to pursue academic careers. (Backhouse, 2009:144)

Despite the reasons underlying the pursuit of the doctorate, it is important that doctoral candidates perceive the endeavour as relevant to their personal or career goals. Likewise, the perceived benefits of a PhD should outweigh the costs. If student-degree congruence is lacking it is most likely to lead to the termination of studies.

4.2.6.3 Student motivation and intentions as psychosocial factors

Motivation as a dispositional factor can be interpreted in two ways. First, it refers to students' motivations underlying the enrolment for the doctorate. And second, it indicates students' motivation (desire) to complete. Portnoi studied postgraduate students' motivations for enrolling for doctoral studies (Portnoi, 2009). Portnoi found no singular reason underlying students' rationale for enrolment in the doctorate. Many respondents indicated that the doctorate (or master's) is a way in which they could improve their qualifications. Other stated that they enrolled for further studies due to not having clear employment options at the time. A selected number of respondents indicated that they were pursuing a career in academia. The exceptions were respondents who were already employed as faculty members at the time of enrolment. Portnoi found that the career decisions of her respondents are influenced by social or personal factors, rather than institutional ones (Portnoi, 2009).

Similarly, a study conducted on the motivations underlying the pursuit of doctoral studies in Australia, identified four motivations for doctoral enrolments which include (1) encouragement of friends and family, including peers engaged in doctoral studies, (2) intrinsic motivation and desire to contribute to the body of knowledge, (3) lecturer influence, and (4) career progression (Guerin, Jayatilaka & Ranasinghe, 2015).

An important finding by Portnoi refers to the social status or prestige associated with postgraduate studies. A number of participants, particularly from disadvantaged backgrounds, indicated that they do not consider an academic career as a prestigious one. Portnoi attributes this finding as one resulting from South Africa's political history as many career options were inaccessible to the majority of South Africans (Portnoi, 2009). For graduates from disadvantaged backgrounds, a career in the private sector, for example, holds more prestige than a teaching position. Similarly, these respondents feel that an academic career would not enable them to take care of their families sufficiently as it would invariably postpone the time when they will be able to become financially stable. For some respondents, particularly from rural backgrounds, they find academic careers at odds with their community or family's points of reference (Portnoi, 2009).

The PhD Consensus report studied the doctoral pipeline and determined when doctoral candidates chose to pursue doctoral studies (ASSAf, 2010). The study found that just under 30% of respondents decided that they wanted to pursue a doctorate, during or after their undergraduate studies. The majority of students, however, only decided on a doctorate after their enrolment or completion of their master's degrees. Students in the natural and agricultural sciences (35%), and engineering sciences, materials and technology (37%) are more likely to decide on a doctorate *during* their master's degrees, while those in the social sciences decide upon the completion of their master's (51%). The study highlighted some of the most prevalent reasons why students pursue doctoral studies. Three different studies asked respondents to identify why they enrolled for a doctorate. Prevailing reasons include, (1) students enjoy academic work, (2) personal fulfilment, achievement and satisfaction, (3) a doctorate is a natural progression of studies or a career, (4) interest in a particular subject area, and (5) a doctorate is required by an employer and so forth (ASSAf, 2010).

A second interpretation of motivation refers to a student's desire (ambition) to complete their studies. Allen defines motivation as "… a stimulus within a person that incites him or her to action and is based on such factors as initial subjective probability of success, success or failure feedback, the nature of the task at hand, and the person's level of intelligence" (Allen, 1999:463). Allen argues that this motivation is one of the key driving factors behind student persistence (Allen, 1999). He posits student aspirations or motivations as a non-cognitive dimension of the persistence phenomenon. Allen claims that very little work has been done on investigating motivation as a predictor of student success and that existing studies are limited to students' self-reported experience of undergraduate education. In a survey of underrepresented minority doctoral students in the USA, 94% of respondents identify motivation and determination as a personal factor that affects their degree success (Sowell, Allum & Okahana, 2015). This finding is replicated by De Valero (2001).

Apart from the motivation for enrolment and completion, Litalien and Guay (2015) identify feelings of competence as a driver of success. The authors found that in Canada, students who perceive themselves as more competent often have higher rates of success (Litalien & Guay, 2015).

4.2.6.4 Discontinuing doctoral studies

The factors discussed throughout this chapter have been identified as having an effect on student degree attainment or its converse, non-continuation. Voluntary withdrawal, or dropping out, is, therefore, the consequence of an interplay of factors. Students who consider discontinuing their studies do so as a result of obstacles to their successful completion. It is, therefore, worthwhile to ask if considering to drop out negatively affects time-to-degree. In other words, do students who have considered withdrawing from their doctoral programmes take longer to complete their degrees than students who have never considered dropping out? The answer might be obvious as students who consider dropping out arguably experience more challenges than those who do not. Mouton found that almost half (46%) of doctoral enrolments in 2001 never completed their studies (Mouton, 2011). The study found that almost a third of students dropped out within the first two years of their studies. Among doctoral students surveyed, approximately 40% indicated that they had considered dropping out of their degree programmes. The top three reasons given included financial challenges, challenges in personal lives and a lack of sufficient academic supervision (Mouton et al., 2015). The PhD Consensus report identified four risk factors that may lead to doctoral attrition. As previously mentioned, these include (1) age of the student at the commencement of their studies along with professional and family commitments, (2) inadequate academic socialisation, (3) poor relationships with supervisors, and (4) and insufficient funding (ASSAf, 2010).

> Other notable explanations for attrition include personal reasons (such as family responsibilities and health issues); students not being academically prepared to or capable of accomplishing a PhD; students being unable to sustain the required financial, emotional and intellectual commitment; conflicting agendas (e.g. students enrol in a PhD programme in order to further their careers and are not prepared for the academic and theoretical requirements); students realising that academia is 'not for them'; lack of an appropriate supervisory and support system at institutional level; and black students' experiences of racism at South African public higher education institutions. (ASSAf, 2010)

Human capital theory has been used to explain how and why individuals decide to invest in higher education. "The theory postulates that individuals choose to pursue higher education when the benefits they expect from the investment exceed the expected costs" (Ampaw & Jaeger, 2012). The attrition of students, therefore, occurs when there is a change in either the benefits or costs of completing an academic programme. This is often the case when there is a lack of funding, particularly for doctoral students.

4.3 Conclusion

In this chapter, I reviewed the empirical research on the topic of degree attainment. I briefly discussed some of the theoretical schemes of doctoral persistence and withdrawal as identified by prominent scholars. Drawing on the work of Cross, I delineated the conceptual framework of the study in including five sets of factors through which I study time-to-degree. Subsequently, I reviewed existing empirical studies which studied differences between disciplines with regard to student success, with particular reference to time-to-degree and completion. Next, I highlighted the student characteristics that scholars associate with (timely) degree attainment. In a similar fashion, I discussed the role of selected situational, institutional and dispositional factors on time-to-degree as determined by empirical studies. I have argued throughout this chapter that the dimensions behind doctoral (timely) completion or non-continuation are multifarious and the interaction between them difficult to assess. However, a review of the literature identifies financial support, mode of study, motivation, and supervision as the most influential factors in doctoral completion. The following chapter is devoted to a discussion of the methodology and methods underlying the empirical analysis of the study.

Chapter 5 | Methodology

In this chapter, I discuss the methodology underlying the empirical components of the study. As a starting point, I list the central research problem as well as the primary and sub- research questions. I move to a discussion on the research design underlying the empirical components of the study. A brief review of the rationale for a mixed-methods approach is discussed. Subsequently, I discuss the data sources used. Here I describe how the HEMIS data were cleaned and transformed as well as the limitations associated with doing a secondary analysis. I report on the strategies used in the survey of doctoral students which include a discussion on the sample, the questionnaire as instrument, response rates and the profile of respondents. Subsequently, I define and operationalise the primary indicators used throughout the data analysis. I then discuss the thematic analysis of the qualitative survey as well as the statistical analyses used. I include a discussion on the limitations associated with doing secondary analysis and the use of quantitative indicators. Finally, I discuss the ethical considerations of this study.

5.1 Problem statement and research questions

The aim of the study was to learn about doctoral time-to-degree in five disciplines at South African universities and to explore the relationships between various identified factors and the timely completion of doctoral studies. This is embedded in three research questions as discussed below.

1. First, what is the profile of doctoral graduates in the selected disciplines? What are the disciplinary differences specifically with regard to student demographics, pile-up effect, completion rates and time-to-degree (Chapter 6)?
2. Second, how do different contextual factors relate to doctoral time-to-degree in the selected disciplines? What is the influence of the discipline (Chapter 7), student demographics (Chapter 8), institutional factors (Chapter 9) and student situational and dispositional factors (Chapter 10)?
3. Third, is it possible to predict which factors explain differences in time-to-degree in the selected disciplines (Chapter 11)?

The research questions stated here are addressed both as they pertain to the selected disciplines as well as comparatively across the five disciplines. In other words, what are the factors that affect time-to-degree within physics, sociology, education, electrical engineering and the medical clinical sciences, and are there differences in the role of these factors in doctoral time-to-degree across the five disciplines?

5.2 Research design

I considered a mixed-methods research design an appropriate design to address the aforementioned research questions. In calculating doctoral time-to-degree of doctoral students in South Africa, I undertook a secondary analysis of the HEMIS student data of all doctoral enrolments and graduates. However, the number of factors included in the database is limited and I, therefore, also undertook a secondary analysis of a survey which added primarily situational and dispositional factors to the analysis. Although the two data sources are both considered quantitative, I approached and analysed the open-ended questions of the survey qualitatively. The survey responses, therefore, provided much needed qualitative context in understanding the results of the statistical analyses.

The synthesis of the quantitative and qualitative data rendered the design a convergent mixed methods design (Bergman, 2008, Cresswell, 2014) as I integrated the analysis of the two data sources. By combining qualitative and quantitative methodologies, the mixed-methods approach enables a more complete understanding of the research problem. The integration of both qualitative and quantitative data transcends the purely positivist and constructivist approaches of data collection towards a more pragmatist one (Cresswell, 2014; Crotty, 1998). I argue the assimilation of methodological approaches to be a strength in investigating the research problem. Critics of a mixed-method design often argue for the incompatibility of methodologies in that the epistemological foundations of qualitative and quantitative methods are ontologically different (Bryman, 2012). It is my view that the assimilation of autonomous methods, approaches the research question from two complementary, rather than opposing, perspectives. Advocates of a mixed-methods approach suggest that in drawing on both qualitative and quantitative methods the strength of one method can compensate for the weakness of the other. Additionally, the triangulation of data offers context, completeness and includes more variables to the analysis. Given that the determinants of timely completion are multifarious and intersectional, it was important to include as many interrelated variables in my analysis as practically possible.

I investigated doctoral time-to-degree with the aid of selected indicators. However, I argue in the following section that by reducing the complexities of doctoral education to a number of indicators, it often compromises an accurate and contextualised interpretation of the experiences of students. The aim of the qualitative survey, therefore, was to provide context to and enable a narrative understanding of the analysis of the HEMIS data (Hesse-Biber, 2010). In doing so, it enabled me to explore the perceptions of doctoral students' experiences of the doctorate with regard to potential enablers and barriers towards timely completion. Even though I used two data sources, the population of my sources is similar. In other words, both the HEMIS data and survey include doctoral students enrolled at or graduated from South African universities. A meaningful integration of the two methods was, therefore, possible.

The theoretical approaches discussed in Chapters 2, 3 and 4, provided the necessary conceptual framework for the analysis of the different data sets. I highlighted theories, particularly on the relationship of the nature of a discipline with doctoral completion that guided the quantitative analysis of the study. In some cases, the theoretical arguments were used to identify and test selected hypotheses, but also served as frameworks for interpreting descriptive indicators.

5.3 Data sets

Two data sets were used for the empirical analysis. The first was the micro records of all students and staff at South African universities as collected by the DHET through HEMIS. Universities are required to submit audited data to the DHET from which a database is constructed. The researcher had access to these records although all fields, as collected by the DHET, were not made available. Information in the data set includes demographic information such as age, gender, race, nationality, discipline, institution and mode of study. Below I discuss how the data were cleaned and transformed for analysis.

The second data set was generated through an online survey which was conducted as part of a larger project on student retention in South Africa. This survey provided additional quantitative and qualitative data that were used to investigate factors associated with timely completion.

5.3.1 The selection of disciplines

The selection of disciplines for the analysis was done in two stages. First, the number of doctoral graduates per discipline between 2000 and 2015 was used as a selection criterion (see Table A-1 in Appendix A). The top 15 most productive disciplines (in terms of doctoral graduates) were listed. I selected fields in which higher numbers of students graduated as it was important to have a big enough sample first, in terms of the relevance of the field for doctoral education, and second, for statistical purposes. From here, in reference to the Biglan-Kolb classification model, I selected five disciplines across the four classifications. The disciplines include education as soft-applied (concrete-active), electrical engineering as hard-applied (abstract-active), physics as hard-pure (abstract-reflective), clinical health sciences as hard-applied (abstract-active) and sociology as soft-pure (concrete-reflective). It was important to select fields that were heterogeneous to enable a comprehensive analysis. I argued that the value of the study would be enhanced through a selection of disciplines that are maximally disparate in terms of research cultures, epistemology and methodological practices.

It should be noted, however, that there were some difficulties with the classification of disciplines in the data set. For each student and staff member a second-order Classification of Education Subject Matter (CESM) code, which depicts the field of study of a student's first or sole area of specialisation, was used for the selection of students in the delineated disciplines. An important methodological note is that the CESM fields were changed in 2007, as well as in 2010. In 2015, the CESM codes changed for some fields which included education. In 2010, the 22 subject areas (CESM level one classifications) were reclassified into 20 areas. This resulted in the reclassification of certain CESM level two categories. This had implications for the cleaning and transformation of the data. The disciplines selected for the analysis was done on CESM level two. However, given the fact that there is no clear record of the reclassification of subfields, education (CESM level one) was selected rather than "general education" (CESM level two) as originally planned. It was impossible to reconcile which "general education fields" codes from before 2010 were included in the CESM fields of 2010 and the subsequent changes in codes in 2015. The remaining four discipline fields were selected on CESM level two. The descriptions of the CESM fields are listed in Appendix A. It is also worth noting that although the clinical health sciences were selected and analysed at CESM level two, it contains a range of sub-fields. However, all these fields are surgical fields, which I consider similar in terms of its epistemological and methodological structures, as well as the way in which doctoral programmes are organised.

5.3.2 The HEMIS data set

In the section below, I discuss how student and staff data were cleaned and transformed. Supporting tables are listed in Appendix A.

5.3.2.1 Data cleaning: student and staff data

Selected fields of the HEMIS database, for students, between 2000 and 2016, were received from the DHET. Among these fields were included the year of commencement (registration for the doctoral programme) as well as demographic variables. This included a student's date of birth, which was used to calculate the students' age at enrolment, as well as age at graduation. Each student's gender and race was indicated as well as their nationality. Students' nationalities were recoded into three regional fields: South African, countries on the African continent (RoA) and countries from the rest of the world (RoW). In 2005, higher education institutions merged to form new institutions. All records for the years 2000 to 2004 were mapped to the post-2005 merged institutions.

The microdata of full-time equivalent (FTE) *staff* at South African universities were received from the DHET. Demographic information included gender, race, nationality and age. Staff was classified as either permanent or temporary and full-time or part-time. Staff was also classified in personnel categories (instruction/research professional and so forth[37]) and staff programmes (instruction; research, etc.[38]). Staff members' highest level of qualification was also included. The data set included each staff member's full-time equivalent on a particular programme within a particular CESM field. The fields included in the HEMIS database are indicated in Appendix A (Table A-9).

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[37] Staff categories include (1) instructional/research professional, (2) specialised/support professional, (3) technical, (4) non-professional administration, (5) executive/administration/management professional, (6) crafts and trades, and (7) service.

[38] Staff programmes include (1) instruction, (2) institutional support, (3) academic support, (4) research, (5) auxiliary enterprises, (6) student services, (7) public service, (8) hospital services, and (9) independent operations.

5.3.2.2 Challenges and limitations of the HEMIS data set

Some challenges were encountered in the secondary analysis of the HEMIS student and staff data. Due to the changes made in the CESM classifications, some discipline subfields might be included in the periods 2000 to 2007 and 2008 to 2009 which were not necessarily included in the analysis of the data of 2010 onwards. I tried as far as possible to reconcile the subfields across the three periods.

The use of the HEMIS staff data also posed some challenges. The headcount data of personnel, as collected by the DHET, do not include disciplinary disaggregation. Therefore, the FTE data were used to determine the total amount of FTE of permanent, research/instruction personnel across the five selected disciplines. With regard to the HEMIS personnel data, there was great variation in numbers between the years. This led me to question the reliability of the data in some cases. I assumed that there existed problems in the recording of staff on the part of the universities while I also found errors with regard to the definitions of staff categories (i.e. instruction/research, etc.). Similarly, a challenge encountered in the use of both the student and staff databases was missing data, or inconsistencies in reporting from universities. Missing data were noted for students at UWC for 2010 and 2011, WITS for 2005, 2010 and 2011 and UFS for 2013 and 2014. As far as possible, in my analysis, I sought to triangulate missing data from the aggregated student tables as constructed by the DHET. In many cases, the missing cases were consistent across the microdata and HEMIS tables[39].

A limitation of using secondary data is that a familiarisation with data is time-consuming. The researcher also had limited control over the quality of the data (Bryman, 2014). Similarly, there was an absence of key variables, including students' mode of study from 2000 to 2009, which posed challenges to the analysis of the data. I did, however, as far as possible, attempt to control for these limitations.

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[39] It should be noted, however, that the microdata (as used in the data analysis) are constructed using the headcount of students, while the DHET uses fractional counting (FTE) in their aggregate tables. The results then differ given the different methods used.

5.3.3 A survey of the perceptions and experiences of doctoral students

A secondary data analysis was conducted of a survey on students' experiences and perceptions of the doctorate. The survey formed part of a study conducted by Mouton et al., (2015) where I formed part of the research team[40]. The web-based survey targeted a large sample of postgraduate students at the main universities in South Africa. Students from the most productive universities ("productive" in terms of masters and doctoral output) at the time, were targeted in the survey. The aim of the survey was twofold. First, to identify factors that underlie doctoral students' choices regarding enrolling for the doctorate, and second, to identify challenges that threaten successful completion. In the current study, the analysis of the survey data provided the qualitative component towards exploring the experiences of doctoral students in South Africa. Below, I discuss the sample, the questionnaire, response rates, profile of respondents and the limitations associated with the survey as a data source.

5.3.3.1 Sample and survey instrument

The 14 most productive universities in South Africa were selected to participate in the study. Within universities, no sampling frame or sampling method was used as all doctoral students enrolled within each institution at the time were asked to participate. In total, 1 313 questionnaires were received, cleaned and analysed. The questionnaire aimed to identify factors that contribute to a student's consideration to withdraw from his/her doctoral programme and highlighted the challenges often encountered in doctoral studies. The qualitative survey also aimed to ascertain the primary reasons for students' attitudes towards either interrupting or considering the termination of their studies. Some questions also aimed to identify factors which affect students' choices towards selecting institutions and degree programmes. A number of questions asked students to rate statements on a continuous Likert scale while open-ended questions were also included. The questionnaire is attached in Appendix A.

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[40] See the study by Mouton et al. (2015) for information about the data collection.

5.3.3.2 Response rates

An approximate response rate was calculated. The actual response rates of some universities could not be calculated given that the number of emails sent to students was unknown. In cases where the number of questionnaires sent was known, such as SU, UJ, UFS and NWU, the response rates were calculated accordingly. For all other universities, the response rate was calculated as the number of questionnaires received as a percentage of the number of doctoral enrolments in each university in 2014. The aggregated tables as constructed by the DHET for 2014 were used as this was the year in which the survey was conducted. The average response rate for the total sample was 11%. The best response rates were recorded for SU of and UJ. UKZN had the poorest response rate of only 3%. In Table 5-1 below, the response rates are presented.

Table 5-1 Survey response rates by university

University	Sent	HEMIS (2014)	Received	Response rates
SU	1419	*1435*	364	25%
Unisa	n/a	2100	152	7%
UJ	532	*765*	148	27%
WITS	n/a	1646	125	8%
UCT	n/a	1604	115	7%
RU	n/a	513	87	17%
UKZN	n/a	2453	70	3%
UFS	659	*668*	66	10%
UWC	n/a	714	57	8%
TUT	n/a	321	51	16%
NMU	n/a	527	29	6%
UNIZULU	n/a	209	19	9%
UFH	n/a	477	17	4%
NWU	174	*1341*	13	7%
TOTAL	n/a	14773	1313	11%

5.3.3.3 Profile of survey respondents

A total of 1 313 responses were received. The discipline of respondents was grouped into five fields which included the natural sciences, humanities, social sciences, engineering and health sciences. In Table 5-2 below, I indicate the CESM fields which were included in the groupings of disciplines. The majority of respondents were enrolled in the natural sciences (38.9%), followed by the social sciences (32.4%), health sciences (11.7%), engineering (9.3%), and the humanities (7.6%). In the table below, I indicate the number of enrolments in 2014 as per the DHET data. I calculated the percentage of enrolments in the five broad disciplinary groupings. Survey respondents in the natural sciences (38.9%) and engineering (30.1%) were slightly overrepresented, while respondents from the other fields were slightly underrepresented. Overall, the disciplinary fields of the survey sample compared favourably with that of the population. In the analysis of the survey results, I reported the findings along disciplinary membership and did not anticipate any disciplinary bias in my analysis.

Table 5-2 Profile of survey respondents' disciplines compared to the population

Broad field	Survey profile	HEMIS profile	CESM level one categories					
Natural sciences	38.9%	30.1%	Agriculture, agricultural operations and related sciences	Computer and information sciences	Life sciences	Physical sciences	Mathematics and statistics	Architecture and the built environment
Humanities	7.6%	13.1%	Languages, linguistics and literature	Law		Philosophy, religion and theology		Visual and performing arts
Social sciences	32.4%	38.1%	Business, economics and management studies	Education	Social sciences	Psycholo-gy	Public management and services	Communicat ion, journalism and related studies
Engineering	9.3%	7.8%	Engineering					
Health sciences	11.7%	10.8%	Health professions and related clinical sciences			Family ecology and consumer sciences		

In Table 5-3 below, I show the demographic profile of survey respondents compared to that of the doctoral student population in 2014. The majority of respondents were male at 51.9% compared to female at 48.1%. The gender breakdown was similar to that observed in the population with females being overrepresented in the sample. Slightly less than 50% of survey respondents were black African, compared to 42.3% white, 5.9% coloured and 7.9% Indian/Asian. Once again the profile was similar to that of the population with black African and Indian/Asian students being slightly underrepresented and white respondents overrepresented. Respondents' nationality (by region) was representative of the overall population with 58.9% South African, 34.7% from the rest of Africa (RoA) and 6.4% from elsewhere in the world (RoW). The average age of survey respondents, however, was markedly lower at 34 years, compared with the average of 39 years in the HEMIS data.

Table 5-3 Demographic profile of survey respondents compared to the population (2014)

	Gender		Race				Age	Nationality		
	Male	Female	White	African	Coloured	Indian/ Asian		South African	RoA	RoW
Profile of respondents (%)	51.9	48.1	42.3	47.0	5.9	4.8	34.0*	58.9	34.7	6.4
Population (HEMIS 2014) (%)	55.7	44.3	32.3	54.3	5.4	7.9	39.8^	62.0	32.7	5.2

*median is 33 years
^median is 39 years

With regard to the academic institution, respondents from 14 out of the 25 institutions were included in the survey. With the exception of TUT, almost all universities of technology were excluded from the sample (see Table 5-1). However, the survey respondents were well distributed across traditional and comprehensive universities.

5.4 Data analysis

The empirical component of the study was undertaken in two parts. Selected indicators and descriptive statistics were used to explore doctoral timely completion, specifically identifying correlations between the nature of a discipline, student demographics, and selected institutional, situational and dispositional factors on time-to-degree. By doing a secondary analysis of the longitudinal HEMIS student data (2000 to 2014), I aimed to identify if and how the role of these factors differ *within* the five selected disciplines. Here I excluded data from 2015 and 2016 since, at the time of the analysis, the 2015 and 2016 data were not yet available. With the exception of the calculation of completion rates, I mainly used aggregate data (pooled data from 2000 to 2014) in the analyses of the HEMIS data. Statistical analyses of the *survey* data were limited to descriptive statistics while I undertook a qualitative thematic analysis of the open-ended questions.

The second component included hypothesis testing which aimed to predict factors associated with shorter time-to-degree and to add a robustness check to the descriptive statistics. I ran a pooled linear regression model of doctoral graduates in the five selected fields. Here I selected the HEMIS student data between 2010 and 2016. Although the HEMIS data are longitudinal, I did not conduct cohort analyses. This was due to the fact that I could not identify and track students in the HEMIS database from one year to the other. Below I discuss the key indicators and statistical methods used in the analyses.

5.4.1 Descriptive indicators

In the analysis of doctoral time-to-degree, I reported on a number of standard and non-standard indicators which include growth rates, pile-up effect, completion rates, time-to-degree, throughput rates and the supervisory capacity.

5.4.1.1 Growth rates

Average annual growth rates were used to report on enrolment and graduate trends of doctoral students in South Africa. The annual average growth rates (AAG) used throughout the report were continuously compounded and calculated as a least squares growth rate[41]. This measure was used to indicate if, and how, the number enrolments or graduates have increased during the 15-year period studied. Similarly, the growth rate of demographic variables was determined and compared across disciplines. I report on the growth rates in Chapter 6.

5.4.1.2 The pile-up effect

The second indicator used was the pile-up effect. In Chapter 3, I discussed the pile-up effect as used in the literature on efficiency indicators in South Africa (Bunting & Cloete, 2004; CHE, 2009; Cloete, Mouton & Sheppard, 2015). In my definition of the pile-up effect, I used a simple indicator of first (new) enrolments as a proportion of total enrolments.

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[41] The least squares growth rate is calculated as $r_{OLS} = \exp(\hat{\beta}) - 1$
Which is obtained by estimating the parameters of the time trend equation in $X_n = a + \beta n + \varepsilon$ where the time trend equation is obtained through a logarithmic transformation of the compound growth equation.
Where $a = \ln X_0$; $\beta = \ln(1 + r)$

$$Pile\ up\ effect = \frac{First\ enrolments\ (year\ x)}{Total\ enrolments\ (year\ x)}$$

An increase in the ratio indicates that the stock of enrolments (in other words the number of historical enrolments) is decreasing and the pile-up effect is improving. I report on the pile-up effect in Chapter 6.

5.4.1.3 Completion rates

A more accurate measure of doctoral completion was determined as four-, five-, six, and seven-year completion rates. Completion rates refer to the number of doctoral students who graduated within a specified number of years as a percentage of the number of enrolments in a selected year cohort. In the section below, I suggest that the average time-to-degree of doctoral students in South Africa ranges between four and five years. For this reason, I selected four-year completion rates as the minimum completion time in the analysis of completion rates.

Existing studies, both in South Africa and internationally, often report on five-, seven- and ten-year completion rates (Ampaw & Jaeger, 2012; Bourke et al., 2004a; HEFCE, 2005; Scott, 2005; Sowell, 2008). Watson found that in calculating completion rates after seven years, the differences were negligible (Watson, 2009). Mouton (2007), however, found that ten-year completion rates for doctoral students are more indicative of doctoral students' completion. However, given that the time-frame of my data is only 15 years, it was decided that seven-year completion rates would be an appropriate indicator of maximum completion times.

Completion rates were calculated as follows. Doctoral graduates were selected and the reporting year and the student's first year of enrolment were cross-tabulated. The cohort of students who enrolled in year x was tracked to see when they graduated, i.e. what percentage of students who enrolled in year x graduated in year $x+1, x+2, x+3$, etc. The number of graduates (of cohort x) was then divided by the number of first enrolments (new) entrants[42] of year x. The accumulative four-, five-, six- and seven-year completion rates were then calculated as a percentage of the number of graduates [year x +1; x +2; …] divided by the number of first enrolments [year x]. For doctoral

[42] First (new) enrolments are students who registered for the doctorate for the first time in a reporting year. In other words, in 2014, students whose commencement year is indicated as 2014, is considered a first enrolment.

completion rates, an adjusted completion rate was used. The minimum residency for a PhD in South Africa at the majority of institutions, is two years. The microdata show instances where a student graduated within the same year. The adjusted completion rates then excluded cases where students were indicated as graduating within the same year.

$$Adjusted\ 7\ year\ completion\ rate = \frac{Graduates\ (year\ x + 1 + year\ x + 2 \ldots year\ x + 7) - Graduates\ (year\ x)}{First\ enrolments\ (year\ x)}$$

In reporting on completion rates, an average over the selected years were calculated and used in the discussion in Chapter 6.

5.4.1.4 Time-to-degree

Time-to-degree was defined as the number of years between a student's date of enrolment (commencement date) and the year in which the student graduated. Time-to-degree was only calculated for graduates and was calculated as "reporting year" minus "year commenced" plus 1 year under the condition that the qualification requirement status was coded as "F" which is the HEMIS code for successful completion (graduates).

$$Time\ to\ degree\ (years) = (Collection\ year - Year\ commenced) + 1$$

Throughout the analysis, I used an average or mean time-to-degree as calculated for the 15-year period. The reason for using an average is due to the small numbers of graduates in disciplines in years which would have made statistical analyses problematic. In Chapter 6, I calculated the average time-to-degree of graduates for each year and found that there was a slight increase in the average time-to-degree between 2000 and 2014. However, the increase was consistent over fields and I did not anticipate that the mean would disguise significant differences between years.

By examining the distributions of time-to-degree across the five disciplines, I found that the distributions are relatively similar in shape[i]. All the distributions were positively skewed tapering off towards eight and nine years. Education showed an almost normal distribution. This could be attributed to the larger number of cases, thus increasing the likelihood of a normal distribution. In the forthcoming analyses, the *mean* time-to-degree was used to compare across and within disciplines. I explain below how the data were cleaned to ensure that the mean time-to-degree used was as accurate as possible. I discuss the calculation of five means as well as the statistical assumptions underlying each one. Subsequently I discuss how the different means were used in the forthcoming analyses.

Calculation of means using HEMIS data:

1. *Mean A: Distribution of all data*

   The first mean includes an average time-to-degree calculated from plotting all the data of the disciplines.

2. *Mean B: Means of individual disciplines (excluding outliers and cases less than two years)*

   At South African universities the doctoral candidate must be enrolled for a minimum of two years before being able to graduate. I, therefore, excluded all cases less than two years in calculating the mean time-to-degree. The distribution of time-to-degree in each discipline was plotted to identify outliers using boxplots. In each case, outliers were omitted from the calculation. The numeric parameters of each discipline are presented in Table 5-4.

3. *Mean C: Means of transformed distributions*

   Normality testing was done and showed that the distributions of time-to-degree in the five disciplines were not normal, as shown in Table 5-4 below. To prevent inaccurate results, data were transformed (where appropriate) using either square-root or log transformations, as shown above. The Q-Q plots showing the transformed data were added as endnotes.

4. *Mean D: Cross-disciplinary comparisons (≤2 years; ≥11 years)*

   To compare statistics across disciplines, the parameters identifying outliers should be uniform. A boxplot was used to identify outliers. A decision was made to set the threshold at 11 years. Although some outliers were still present it did not affect the results.

5. *Mean E: Transformed comparative data*

   In comparing time-to-degree across disciplines, data were transformed using square root[ii] given that the distribution of time-to-degree (with the parameters stated above in mean D) were positively skewed.

Table 5-4 Description of the distribution of time-to-degree in five disciplines

	Education	Electrical engineering	Clinical health sciences	Physics	Sociology
Descriptives	75% of cases ≤ 5 years	75% of cases ≤ 6 years	75% of cases ≤ 6 years	75% of cases ≤ 5 years	75% of cases ≤ 6 years
Median	4	4	4	4	4
Outliers[43]	>1 year; >8 years	>1 year; >7 years	>1 year; >10 years	>1 year; >10 years	>1 year; >10 years
Distribution	Positively skewed[iii]	Positively skewed[iv]	Positively skewed[v]	Positively skewed[vi]	Positively skewed[vii]
Transformation	none	none	Square-root	Log transformation	Square-root

Normality testing showed non-normal distributions of time-to-degree across all five disciplines. In such instances, data were transformed. This was done to prevent possible errors owing to skewed distributions in the interpretation of results. However, the transformation of data made interpretation difficult as the data no longer represent original values. I statistically compared mean differences which included independent sample t-tests and one-way ANOVA and ran test comparisons, i.e. simultaneous analyses of the skewed and transformed data, since the assumption of normality was violated in most of my distributions. This was done to ensure that the lack of normality did not meaningfully affect the interpretation of results. In cases where the null hypothesis was erroneously rejected using the non-normal data, I reported on the results of the transformed data.

From the survey data, a proxy for time-to-degree was calculated. Respondents were asked to indicate when they aimed to complete their studies as well as the date when they first enrolled for the doctorate. This period was used to determine an *estimated time-to-degree.* As a proxy for time-to-degree, this measure was used to explore the relationship of primarily situational and dispositional factors on respondents' projected time-to-degree.

[43] The percentage of outliers excluded in each discipline (including cases of less than two years) was in education, 13.9%, electrical engineering, 15.2%, clinical health sciences, 9.3%, physics, 8.2%, sociology, 14.1% and across all five disciplines, 10.8%.

5.4.1.5 Throughput rates

In Chapter 3, I suggested that throughput rates are often used interchangeably with graduation rates or completion rates (Cloete, Mouton & Sheppard, 2015; DoE, 2001). As an indicator of institutional efficiency, I measured institutional graduation rates by means of throughput rates as a proxy for completion rates. This was because of the small number of graduates within the five disciplines studied, per year and per institution.

$$Throughput\ rate = \frac{Graduates\ (year\ x)}{Total\ enrolments\ (year\ x)}$$

The throughput rate, as a simple and non-precise measure, is determined as the proportion of graduates to total enrolments for a given year. In Chapter 8, I report on both disciplinary and institutional throughput rates.

5.4.1.6 Supervisory capacity

Supervisory capacity refers to the number of enrolled doctorates as a ratio of the number of potential doctoral supervisors within an academic institution. This refers to the capacity of the system to supervise doctoral candidates sufficiently. In calculating supervisory capacity, staff members who were recorded as permanent, instructional or research (both in personnel categories and staff programmes) with a PhD as a minimum qualification, were selected as a potential doctoral supervisor. Personnel could have an FTE in more than one CESM specialisation. Each staff member's total FTE time was, therefore, calculated to determine a total FTE time spent in a selected discipline. For potential supervisors, it was decided that staff should have at least 20% FTE in instruction and 20% in research (therefore, spending at least one day a week on research and instruction).

Table 5-5 Classification of personnel of HEMIS data

	Definition	Permanent	FTE in instruction	FTE in research	Qualification
Headcount FTE	All staff with a FTE in instruction in each disciplinary field	yes	0<	Not a criterion	Across all qualifications
Potential PhD supervisor	Staff with at least 20% FTE in instruction and research across subfields	yes	0.20≤	0.20≤	Doctorate or higher

In calculating the supervisory capacity as an indicator, I, therefore, included permanent staff who had an FTE in instruction *and* research of at least 0.2. In other words, academic personnel who spent at least one day per week on instructional and research activities. Permanent staff with a minimum FTE in instruction and research who had a PhD as the highest qualification were then selected as a potential doctoral supervisor.

$$Supervisory\ capacity = \frac{Doctoral\ enrolments\ (year\ x)}{Permanent\ personnel^{44}\ with\ PhD\ (year\ x)}$$

The number of doctoral (total) enrolments was then divided by the number of potential supervisors to determine a student-to-supervisor ratio. This ratio served as an indicator of the supervisory capacity at the doctoral level.

5.4.2 A qualitative analysis of survey data

A qualitative survey analysis was done to supplement the quantitative indicators and statistics discussed above. The use of qualitative data increased the explanatory power of the analyses by adding more factors to the empirical analysis. Open-ended questions were analysed through a thematic analysis and I present the codes used below. These include selected barriers and enablers to timely completion as discussed in the conceptual framework.

Table 5-6 Themes used in the quailitative analysis

Themes	
Trajectory towards the PhD	Progression
Rationale for pursuit of the PhD	Relevance of the PhD
	Expectations from PhD attainment
	Plans after graduation
Barriers/enablers to successful completion	Institutional
	Administrative challenges/enablers
	Situational
	Employment status/mode of study
	Balancing work/life/studies

[44] Personnel who have at least a 0.2 FTE value in instruction and a 0.2 FTE value in research.

Themes	
	Financial constraints/funding
	Student characteristics
	Demographic characteristics of respondent
	Dispositional
	Student satisfaction with academic supervision and the institution
	Epistemological/ Content and context of a discipline
	Characteristics of/challenges associated with study material
	Structure of graduate programme /doing the PhD

The qualitative data were used as auxiliary to the discussion of the quantitative results. The qualitative data were presented by discipline. However, survey respondents' disciplinary membership were collected and subsequently analysed by broader disciplinary groupings and were, therefore, not directly comparable to the five disciplines used in the quantitative analysis.

5.4.3 Statistical analyses

In this section, I discuss the statistical methods used first in the descriptive analyses and second, the linear regression model.

5.4.3.1 Descriptive statistics

I investigated the relationships of selected contextual factors on time-to-degree both within and across the five selected disciplines, through means testing which included independent sample t-tests and one- and two-way ANOVA.

Independent-sample t-tests were used to determine if there is a statistically significant difference between the means of two groups on a continuous dependent variable. The t-test determines whether differences in mean time-to-degree are a real occurrence in the population or whether it is a consequence of sampling. Through testing null hypotheses I was able to determine statistically significant differences in the mean time-to-degree of selected factors such as gender, race, nationality and so forth. Statistically significant results were reported on a 95% confidence level. In cases where statistically significant results were found, I reported the effect size using the effect-size correlation r[45].

A one-way ANOVA is an appropriate measure of means differences in cases where there are more than two variables. Statistical testing was not compromised by the violations of normality in the data although the distribution of time-to-degree across and within the disciplines were non-normal. The ANOVA remains a valid measure when there is an approximation of normal data and as far as possible I transformed the data to emulate a normal distribution. Similarly, the ANOVA is not sensitive to differently shaped distributions as long as they are skewed in a similar manner, as was the case with the data. In cases where means were statistically significant, I calculated the size effect (partial eta-squared[46] as reported by η^2) which indicates the strength of the associations found.

5.4.3.2 A model predicting timely completion

In Chapter 11, I undertook a pooled linear regression in an effort to predict which factors explain differences in time-to-degree in the selected disciplines. I used the HEMIS student data of doctoral graduates in the five selected disciplines between 2010 and 2016. The aim of the regression was to first test for relationships between selected variables on time-to-degree, and second, to explore the interaction of these variables. I consider the student HEMIS data as a pooled data set where a time series of cross-sections occur. The observations in each cross-section did not necessarily refer to the same unit, in this case, the student. In the HEMIS data set, within the time-frame selected (2010 to 2016), I studied students that enter and leave the system which means that the units of observation (students) varied from year to year. Pooled data differ from panel data in that the data set did not follow the same students at multiple points in time.

Using a pooled regression assumes that there are no variables that would change the result over time (or between years of observations). This method is based on the assumption that the same model applies for each time period (Hsiao, 2014). There were no significant policy changes in the

[45] The size-effect correlation was calculated as $r_{Y\lambda} = \sqrt{(t^2/(t^2 + df))}$

[46] The size-effect was calculated as partial $\eta^2 = \frac{SS_{effect}}{SS_{effect}+SS_{error}}$ where SS is “sum of squares”. For one-way ANOVA the effect size was calculated as $\eta^2 = \frac{SS_{effect}}{SS_{total}}$

period between 2010 and 2016 which could have had an impact on doctoral completion times and the factors that may influence it. In determining the average time-to-degree[47] of doctoral graduates for the time period, I found some fluctuation between years, but no noteworthy trend in terms of a steady increase or decrease was observed.

In Table 5-7 below, I list the variables included in the regression model. The time period 2010 to 2016 was selected. The reason for this selection is three-fold. First, the CESM categorisation changed in 2010 to the most recent classification used. The CESM categories of the five disciplines in this time period were then consistent. Second, since 2010, the HEMIS data have included the mode of study for doctoral students. As discussed throughout this study, there is a strong relationship between either full-time or part-time study on doctoral time-to-degree. By selecting data following 2010, I could include mode of study as a variable in the model and test for an association between full-time and part-time enrolment and average time-to-degree. Third, at the time this study was conducted, 2016 was the most recent year for which HEMIS data were available for analysis.

Table 5-7 Variables included in the linear regression of doctoral graduates in five disciplines (2010 to 2016)

Independent variables	Categories	Dependent variable
Year	2010 to 2016	Average time-to-degree (years)
Discipline (CESM)	Education	
	Electrical engineering	
	Clinical health sciences	
	Sociology	
	Physics	
Gender	Male	
	Female	
Race	Black African	
	White	
	Coloured	
	Indian/Asian	
Age at enrolment	Younger than 40 years	
	40 years and older	
Nationality (region)	South African	

[47] Mean time-to-degree of doctoral graduates in five selected disciplines for 2010 to 2016

	2010	2011	2012	2013	2014	2015	2016
Mean time-to-degree (>1 years; <12 years)	4.71	4.90	4.57	4.98	4.98	4.53	4.51

Independent variables	Categories	Dependent variable
	Rest of Africa (RoA)	
	Rest of World (RoW)	
HEI	Traditional universities	
	Comprehensive universities	
	Universities of technology	
Mode of study	Full-time	
	Part-time	

In the final section of this chapter, I conclude with the limitations in using indicators in the study and discuss ethical aspects of the study.

5.5 Limitations associated with the use of indicators

In this chapter, I discussed the methodology and methods used in the study. Some of the challenges and limitations encountered in the study was first, as mentioned in Chapter 3, that the use of indicators is not unproblematic and provides room for misinterpretation. It is challenging to compare indicators given the differences in its conceptualisation and subsequent calculation. Insofar as a comparison is concerned, I have attempted to provide similar indicators (often from international sources) merely for descriptive purposes to give context rather than serve as a benchmark or comparison. The use of indicators also often fails to capture the complexities associated with studying human behaviour. An integrated triangulation of the qualitative data aimed to offer context and increase the number of variables observed. I have, therefore, aimed to include a variety of indicators in the description of time-to-degree to enable a thicker description.

The triangulation of data sets posed both advantages and challenges. The data sets used for the empirical analysis included firstly, the HEMIS data of doctoral graduates from 2000 to 2014, the HEMIS data of graduates between 2010 and 2016 as used in the regression model, and finally, the survey data. I have previously made mention of the fact that the average time-to-degree of doctoral graduates in South Africa did not change significantly during the last 16 years. I did, therefore, not foresee that the use of two time-frames would negatively influence the results of this study. In fact, the inclusion of the 2015 and 2016 data added more cases to the analysis of particularly, mode of enrolment, which is a central determinant of student success. A challenge in the use of the survey data included the alignment of respondents' disciplinary fields with the CESM level two fields. Despite the fact that the analysis of the survey data was done within broader disciplinary groups (such as engineering, health, social and natural sciences) the epistemological foundation and organisation within these groupings are similar to that of the selected disciplines. In other words, even though sociology (as defined in the HEMIS data) was selected as a discipline, I consider the social sciences (as defined in the survey data) similar in terms of its paradigm development and cognitive structures as well as the manner in which graduate education is organised. Given this study's focus on these dimensions of a discipline, I did not consider the ostensible misalignment between the datasets as adversely affecting the outcomes of this study.

In Chapters 3 and 4, I conceded the pitfalls associated with exploring doctoral degree attainment by investigating relationships of isolated factors. It is difficult to isolate a variable conceptually, as the effects of variables are confounded. In Chapters 7 and 11, I suggest how the effects of the identified factors are interrelated and how the interaction might influence timely completion.

In most cases, I reported on statistical significance with a 95% confidence interval. However, it should be noted that the delineations of what is statistically significant are often arbitrary and may obscure substantive differences. Additionally, in some cases the reader's interpretation may differ from the ones offered in the study. It is also important to note that often, given the small numbers of observations when disaggregating by discipline, year, university and so forth, variations may appear exacerbated. In such cases, I warned against misinterpretation.

Finally, as previously mentioned, there were problems with the HEMIS student and staff data sets in that for some years and some institutions there were missing or erroneous data. As far as possible I have attempted to control for these errors and all efforts have been made to find the correct data. There is no alternative comprehensive database on student enrolments and graduates in South Africa and, therefore, I have to acknowledge the limitations associated with doing secondary analyses.

5.6 Ethical considerations

Finally, I would like to acknowledge some of the ethical considerations of this study. I did not foresee significant ethical challenges in the completion of my research. Given the Protection of Personal Information (POPI) Act of 1996, all HEMIS data were presented anonymously. For the purpose of the analysis, dummy identity numbers were generated to identify students in the system. It was, however, impossible to link these dummy indicators to any persons individually and this was not done in the analyses. Ethical clearance was received from all universities who participated in the survey of postgraduate students and students were in no way coerced to participate in the online survey. All HEMIS and survey data and results were handled confidentially and anonymously. All survey responses were anonymous and all results were presented in an aggregate form which protects the responses of individual participants. The questionnaire reiterated this anonymity and the voluntary nature of participation. Survey respondents were able to exit the online questionnaire at their discretion.

The following five chapters are dedicated to the empirical components of this study. In the next chapter, I provide a profile of doctoral enrolments and graduates within the five disciplines.

Chapter 6 | A profile of doctoral students in South Africa

This chapter marks the first of six chapters dedicated to a thematic analysis and discussion of the data. In this chapter, I address the first research question of the study by investigating the profile of doctoral students in the selected disciplines. First, I provide an overview of all doctoral enrolments in South Africa, in other words, nationally, and in the five disciplines along demographic factors which include gender, race, nationality, age and academic institution. Each disciplinary profile includes an overview of annual and periodic trends compared with the national data. I discuss and compare the average annual growth rates of doctoral enrolments and calculate the pile-up effect of doctoral students in the five disciplines. Subsequently, I present a profile of doctoral graduates which include a demographic profile graduates nationally and per discipline. I examine how the average annual growth rates of doctoral graduates differ across the five disciplines and demographic subgroups and compare the growth rates of enrolments and graduates as a second measure of the pile-up effect.

In the latter half of the chapter, I describe doctoral graduates in South Africa along two efficiency indicators. First, I determine and compared four-, five-, six- and seven-year completion rates of doctoral graduates over the five disciplines. Finally, I determine the average time-to-degree of doctoral students in the five disciplines and examine changes in the completion times of doctoral graduates over the 15-year period analysed.

6.1 A profile of doctoral enrolments in five disciplines

In this section, I present an analysis of trends in doctoral enrolments. I include a discussion on the demographic profile of doctoral enrolments in the five disciplines. Subsequently, I examine disciplinary and demographic growth rates and determine the pile-up effect as the ratio of new enrolments to total enrolments.

6.1.1 Doctoral enrolments in five disciplines

In 2014, nearly 18 000[48] doctoral students were enrolled at South African universities. The number of doctoral enrolments in South Africa grew from 6 446 in 2000 to 17 986 in 2014 with an AAG of 6.6%. The growth between 2000 and 2008 was steady with an increase of approximately 3 500 enrolments. Following 2009, however, the number of enrolments increased with nearly 8 000 students in six years. In Appendix B, supporting graphs for the data reported here are presented.

In 2014, in *education*, there were 2 038 doctoral enrolments of which 915 were *new* enrolments, a steady increase from 269 in 2000. The number of enrolments in *electrical engineering* also increased steadily from 134 in the year 2000 reaching 366 in 2014. The annual average growth rate for enrolments in electrical engineering over the 15-year period was 7% while the number of first enrolments grew at an AAG of 5%. Doctoral enrolments in the *clinical health sciences* more than doubled in the 15-year period analysed, reaching 484 enrolments in 2014 while the number of enrolments in *physics* grew with an AAG of 6.8% from 120 enrolments in 2000 to 295 in 2014. The number of first enrolments grew at a slightly faster rate (AAG) of 7.8%. Doctoral enrolments in *sociology* showed steady growth between 2000 and 2014 with an AAG of 9%, while the number of enrolments increased nearly four-fold from 136 in 2000 to 512 in 2014. The number of enrolments increased rapidly after 2010 from 209 to 349[49]. At the same time, *new* enrolments grew from 45 in 2000 to 174 in 2014.

In section 6.1.2 below, I discuss the annual average growth rates observed for doctoral enrolments nationally and within the five disciplines. In the following sections, however, I describe the profile of doctoral enrolments along the gender composition, race, nationality, average age at enrolment and academic institution. The demographic profile of doctoral enrolments per discipline is presented in **Error! Reference source not found.** below.

[48] The DHET reports the number of doctoral enrolments in 2014 as 17 943.
[49] The increase in 2010 is due to the sharp increase in enrolments reported by UFH where the number of enrolments jumped from 5 in 2009 to 78 in 2010. This increase was also observed at WITS from 17 enrolments in 2009 to 54 in 2014.

6.1.1.1 Gender

The gender disaggregation of doctoral enrolments, *nationally,* showed that male students constitute the majority of enrolments. However, over the period analysed, the proportion of female enrolments had increased by 6%. The proportional share of female enrolments increased from 38% in 2000 to 44% in 2014, nearing an equal distribution of male and female enrolments. Female students constituted 42.6% of *first* enrolments in 2014.

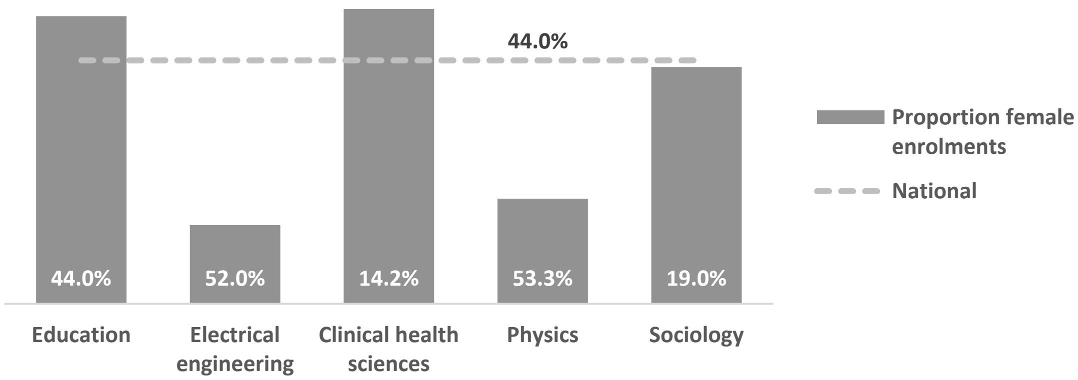

Figure 6-1 Proportion of female doctoral enrolments in 2014 by discipline

With reference to the gender distribution of doctoral enrolments in *education*, there was a gradual proportional increase in the number of female enrolments over this period. In 2000 female enrolments in *education* constituted 49% of total enrolments which increased to 52% in 2014. In 2014, of *first* enrolments, female students constituted 43.3%. In comparison with the national gender distribution, female doctoral enrolments in education constituted a higher share in 2014 (52% compared with 44%).

Engineering has traditionally been and still remains a male-dominated field. Male enrolments accounted for almost 90% of all *electrical engineering* enrolments every year between 2000 and 2014. Even though the number of female enrolments had increased over the period analysed (6 to 52), the percentage of female enrolments remain low compared to that of male enrolments (4.5% compared with 95.5% in 2000, and 14.2% compared with 85.8% in 2014). Female enrolments constituted 10.3% in 2014 of *first* enrolments. In comparison with the national data, female enrolments in electrical engineering were massively underrepresented. The share of female enrolments in 2014 of 14.2% compare poorly with the 44% of the national share, although the AAG of female enrolments was nearly double that of the national average (13% compared to 7%).

The gender composition of doctoral enrolments in the *clinical health sciences* shows that the percentage of male and female students are relatively equal. In 2000, there were 97 female enrolments which increased to 258 in 2014. The number of female enrolments grew with 6% over the period which is just slightly below that of the national average of 8%. In 2014, female enrolments constituted 60.5% of *first* enrolments. The proportional share of male and female enrolments remained relatively equal over the 15-year period. In 2000, female enrolments constituted 40.8% of all enrolments in the clinical health sciences, which increased to 53.3% in 2014 which is nearly 10% higher than the national average.

The gender distribution of doctoral enrolments in *physics* is similar to that of electrical engineering where the majority of students are male. The number of female enrolments in physics grew from 18 in 2000 to 56 in 2014 (an AAG of 7.2%). The average growth rate of female enrolments in physics was 7.2% which is lower than the national average of students across all disciplines. There has been an increase in the proportional share of female enrolments from 15% in 2000 to 19% in 2014, but the share of female enrolments remain small when compared to the national average of 44% in 2014.

The proportions of male and female enrolments of the total number of enrolments in *sociology* for the period were similar, although the proportional share of female enrolments decreased from 47.1% in 2000 to 42.8%. The proportion of male enrolments overtook female enrolments in 2010 when male enrolments' share increased with more than 10% in one year[50]. The number of male enrolments grew at an AAG of 9.3% compared to 8.6% of females over the 15-year period. Of *first* enrolments, in 2014, female enrolments only constituted 35.6% of the share of doctoral enrolments in sociology. The AAG of female enrolments was slightly higher than that of the national average. However, the proportional share of female enrolments in 2014 was slightly lower than the national share of female enrolments.

From the data above I found that the proportion of female enrolments in sociology is slightly lower than the national average while that of education and the clinical health sciences is roughly 6 to 7% higher than the national average. In both education and the clinical health sciences, in 2014, there were more female doctoral enrolments than males. In electronic engineering and physics, female enrolment was less than 20% of total enrolments. Although both fields recorded a growth in female

[50] Between 2009 and 2010 there was a significant increase of doctoral enrolments (male and from the rest of Africa) observed at UFH and Unisa.

enrolments the proportional shift of female enrolments in physics was less than the national average. The proportional shift of female enrolments in electrical engineering was just slightly higher than the national average.

6.1.1.2 Race

Over the past 15 years, there has been an increase in the representation of black doctoral students at South African universities. Nationally, the number of black African enrolments grew rapidly from 1 626 in 2000 to 9 317 in 2014 with an AAG of 12.1%. For the same period, the number of white enrolments increased steadily from 4 017 in 2000 to 5 744 in 2014 at an AAG of 1.8%. The proportional share of black African enrolments increased from 25.2% in 2000 to more than half (53.7%) of enrolments in 2014. Black African enrolments made up nearly two thirds (59.1%) of *first* enrolments in 2014. In the same year, 66.9% of all doctoral enrolments in South Africa were black (AIC).

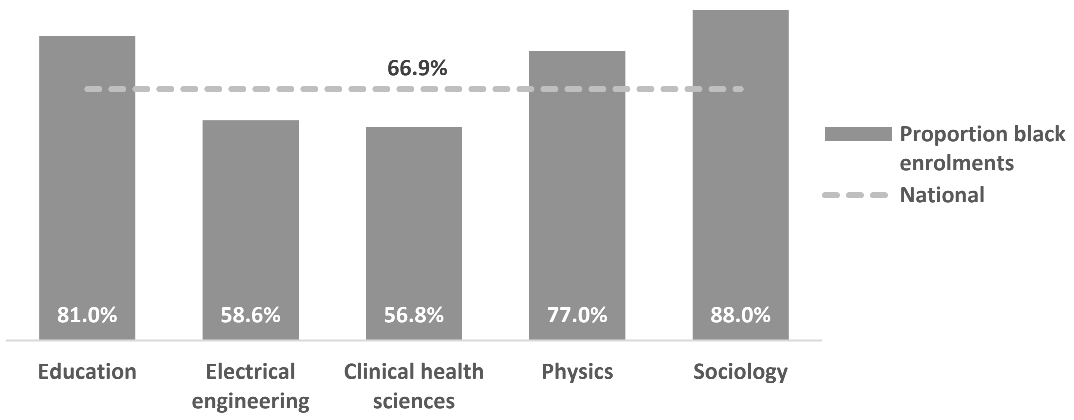

Figure 6-2 Proportion of black enrolments in 2014 by discipline

There was a similar increase in *education* where black African enrolments grew at an AAG of 10.2%, while the number of enrolments increased almost five-fold from 262 in 2000 to 1 285 in 2014. The proportion of black African students to total enrolments grew substantially from 39% in 2000 to 64% in 2014. Similarly, the number of black enrolments (including Indian/Asian and coloured) grew at an AAG of 8.7%, while the proportion to total enrolments increased with 23%. In 2014, 63% of all black African enrolments in education were South African, while 36% were from the rest of Africa. Indian/Asian and coloured students constituted approximately 17% of the total enrolments in 2014, which was much higher than the national average (13%). In 2014, black African students constituted

71.7% (a significant increase from 42.8% in 2000) of *first* enrolments. In 2014, the share of black African doctoral enrolments in education was approximately 10% higher than the national average.

As far as the composition of doctoral enrolments by race in *electrical engineering* is concerned, the majority of enrolments for the total period were white. However, this masks the significant transformation as the number of black African enrolments grew rapidly from 9 enrolments in 2000 to 139 in 2014 (AAG at 19.6%), overtaking the number of white enrolments in 2014 (136) (AAG at 1.0%). Black African students comprised 52.6% of *first* enrolments in 2014. The proportional share of African black enrolments increased from 6.7% in 2000 to 42.2% in 2014. For the same period, the proportional share of white enrolments more than halved. In 2014, black (AIC) enrolments constituted nearly 60% of all enrolments in electrical engineering. Disaggregating black African enrolments by nationality shows that 75% of all black African enrolments in electrical engineering were international students (from the rest of Africa). Compared with the national profile of students, black and black African students were slightly underrepresented in electrical engineering.

The disaggregation of doctoral enrolments in the *clinical health sciences* by race showed that the number of black African enrolments grew from 33 in 2000 to 148 in 2014, with an AAG of 11.6%. The number of white enrolments increased from 159 to 199 over the 15-year period (AAG at 1.8%). The proportional share of black African enrolments increased from 13.9% in 2000 to 32.2% in 2014, while the proportion of white students decreased with 23.6%. Of the total enrolments in the clinical health sciences for the period analysed, South African black African enrolments constituted 62% of all enrolments. The share of black (AIC) enrolments increased from 33.2% in 2000 to 50.7% in 2008 to 56.8% in 2014. Of *first* enrolments, black African students constituted 37% in 2014. The share of black African enrolments in 2014 in the health sciences was significantly lower than the national average (32.2% compared to 53.7%) while the proportion of black enrolments was nearly 10% lower than the national average. In the health sciences, therefore, there were more Indian/Asian and coloured enrolments compared to the national average.

Black African enrolments in *physics* increased from 44 in 2000 to 181 in 2014, which is a dramatic increase (an AAG of 10.6%). For the same period, the number of white enrolments remained practically unchanged from 62 in 2000 to 65 in 2014 (an AAG of 1.4%). Proportionally, the share of black African enrolments nearly doubled from 36.7% in 2000 to 64% in 2014. In 2014, the share of black enrolments in physics constituted 77% of all enrolments. In physics, black African students constituted 71.4% of *first* enrolments in 2014. The growth rates of black and black African enrolments in physics were lower than that recorded for enrolments across all disciplines, but both black and black African students had higher proportional shares in 2014 when compared to the national average.

The number of black African enrolments in *sociolog*y increased from 40 in 2000 to a massive 366 in 2014 with a recorded AAG of 16%. For the same period, the number of white enrolments only grew somewhat from 76 in 2000 to 90 in 2014 with a negative AAG of -0.2%. The proportional share of black African enrolments in sociology increased with 43.9% over the 15-year period[51]. In 2014, 88% of doctoral enrolments in sociology were black. A breakdown of race by region showed that more than 60% of black African enrolments in sociology were from outside of South Africa. In 2014, 79.9% of *first* enrolments were black African. The proportional share, however, of black and black African enrolments in sociology was significantly higher when compared to the national average, with the share of black enrolments and black African enrolments in sociology at almost 20% higher than the national average.

Examining the profile of doctoral students by race in the five selected disciplines showed that among doctoral enrolments, sociology has a much higher proportion of black and black African enrolments compared with the national data, electrical engineering and the clinical health sciences. Education and physics also have a high proportion of black enrolments compared to the national data. Both education and the clinical health sciences have higher proportions of Indian/Asian and coloured enrolments. In electrical engineering and the clinical health sciences, the share of black enrolments is smaller than the national average. Scholars have suggested that the low participation of black students in the STEM sciences is a result of the systematic exclusion of black students in primary and secondary education, particularly in these fields (Schutte, Kennon & Bam. 2016). With the apartheid segregationist policies, particularly regarding discriminatory education, *Bantu* education focused primarily on vocational training in fields such as education (Chisholm, 2009). Black students are then more likely to be better represented in fields in the social sciences and humanities (ASSAf, 2011).

6.1.1.3 Nationality

There has been a noticeable increase in the number of international doctoral students at South African universities, specifically from the rest of Africa. Nationally, the number of South African enrolments grew from 5 197 in 2014 to 11 007 in 2014 with an AAG of 4.5%. At the same time, enrolments from

[51] From 2009 to 2010 the proportion of black African enrolments increased with 16.2%. This was due to the increased number of enrolments, particularly from the rest of Africa, as observed by UFS and Unisa.

the rest of Africa increased ten-fold from 584 in 2000 to 5 874 in 2014 at an AAG of 16.6%. The proportional share of South African enrolments decreased with 22.4% while that of enrolments from Africa increased from 9.4% in 2000 to 32.9% in 2014. In 2014, students from the rest of Africa constituted 39.4% of *first* doctoral enrolments.

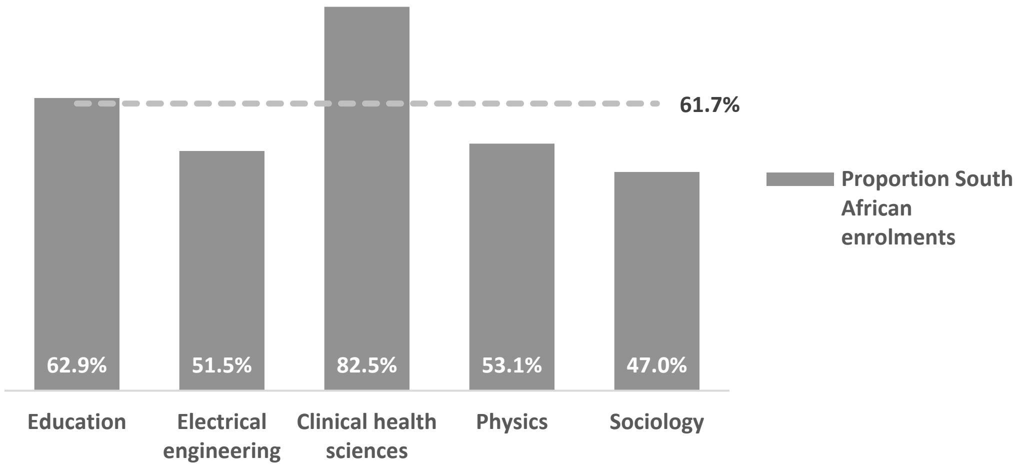

Figure 6-3 Proportion of South African enrolments in 2014 by discipline

The majority of doctoral enrolments in *education* in 2014 was South African (62.9%) with an increase from 592 in 2000 to 1 275 in 2014 (an AAG of 4.2%). However, the enrolments from the rest of Africa increased substantially over the 15-year period, with an AAG of 18% while the proportion of South African enrolments decreased with 26.5%. Of *first* enrolments in education, 44.4% were from the rest of Africa in 2014. In *electrical engineering*, the majority of enrolments over the period analysed were South African. However, enrolments from the rest of Africa increased hugely from only 5 in 2000 to 142 in 2014 with an AAG of 23.2%. In 2014, international students constituted more than half (51.8%) of *first* enrolments. The share of foreign doctoral enrolments in electrical engineering was 10% higher than the national average.

Although the number of enrolments from the rest of Africa has grown steadily in the *clinical health sciences*, from 11 to 63 (an AAG of 4.4%), proportionally the numbers remain low when compared to that of South African enrolments with 4.9% in 2000 to 13.1% in 2014. Of *first* enrolments, the share of students from the rest of Africa in 2014 was 17.8%. In the same year, only 17.5% of enrolments in the clinical health sciences were international students compared to 28.3% nationally.

Looking at enrolments in *physic*s across the 15-year period, enrolments from the rest of Africa have increased from 21 in 2000 to 123 in 2014 with an AAG at 13.4%, although in absolute numbers, it trails behind that of South African enrolments. South African enrolments increased from 90 in 2000 to 155 in 2014 with an AAG of 4.1%. Proportionally, enrolments from the rest of Africa increased from 18.1% in 2000 to 42.1% in 2014, while that of South African enrolments decreased with 24.5% over the 15-year period. Of *first* enrolments, enrolments from the rest of Africa constituted 43.6% in 2014. The share of non-South African enrolments in 2014 was nearly 10% higher among doctoral enrolments in physics than the national average.

Unsurprisingly, in *sociology*, the number of enrolments from the rest of Africa increased significantly from 10 in 2000 to 234 in 2014, with an AAG of 24.2%. At the same time, the number of South African enrolments increased with an AAG of 4.6% from 112 in 2000 to 237 in 2014. As expected, the proportional share of enrolments from the rest of Africa increased from 7.8% in 2000 to 46.4% in 2014. Of *first* enrolments, students from the rest of Africa constituted 57.4% of all first doctoral enrolments in sociology in 2014. Once again the proportional share of non-South African students was much higher than the national average with nearly 53% international enrolments in 2014. In all fields, except the clinical health sciences, there has been a substantial internationalisation of doctoral education. In the clinical health sciences, foreign enrolments in 2014 only constituted 17.5% of total enrolments. This suggests that doctoral education in the clinical health sciences in South Africa is a less attractive option to foreign students compared to other fields. Studying abroad is arguably less feasible in professional fields such as the clinical health sciences and education, as seen by the larger proportion of domestic students, due to the fact that training in these in fields are often context-specific and overseen by regulatory bodies. In sociology, students from the rest of Africa constituted 57.4% of all *first* doctoral enrolments in 2014. The proportional share of international students in sociology, electrical engineering and physics were much higher than the national average which suggests that these disciplines are attracting large numbers of international doctoral students. It is, however, difficult to ascertain whether the inflow of students from the African continent is a result of increased efforts to internationalise doctoral education in South Africa (i.e. pull factors), or whether African students pursue doctoral studies abroad due to domestic challenges in their home countries (i.e. push factors).

6.1.1.4 Age at enrolment of doctoral students

The average age at enrolment of doctoral students in South Africa increased slightly from 36.6 years in 2000 to 38.1 years in 2014. In 2014, the median age at enrolment was slightly lower than the mean at 37 years, while the mode was 26 years[52].

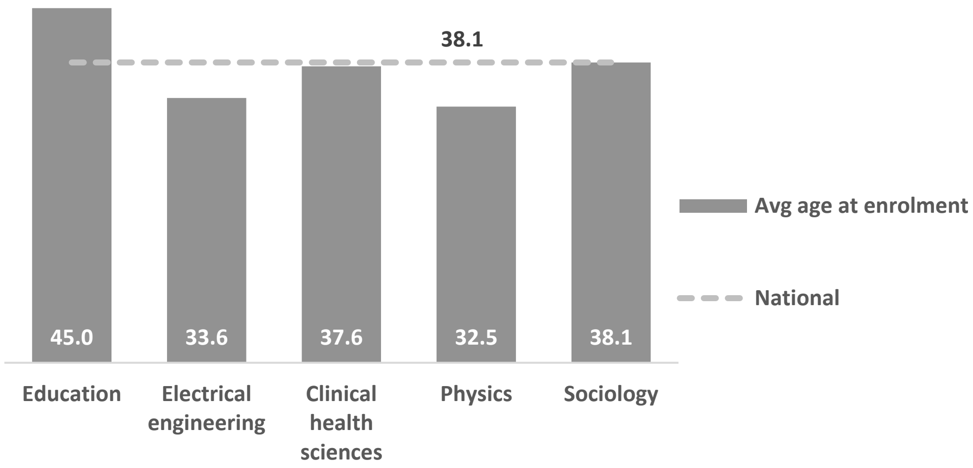

Figure 6-4 Average age at enrolment of doctoral enrolments in 2014 by discipline

The average age at enrolment of doctoral enrolments in *education* increased somewhat from 42.1 years in 2000 to 45 years in 2014. Compared with all students in 2014, doctoral enrolments in education were much older than the national average by at least six years. The average age at enrolment for doctoral students in *electrical engineering* also increased slightly from 31.8 years in 2000 to 33.6 years in 2014. In 2014, the median age was slightly lower at 31 years. The average age of *first* enrolments in 2014 was 35 years. Compared with the national data, doctoral enrolments in electrical engineering were on average five years younger.

The mean age at enrolment of doctoral students in the *clinical health sciences* decreased somewhat from 38.4 years in 2000 to 37.6 years in 2014. However, there was some fluctuation between years. In 2014, the median age was 37 years while the average age of enrolments in the clinical health sciences is comparable to the national average. The average age of doctoral enrolments

[52] Upon demographic disaggregation, the mean age at enrolment of female students was consistently similar to the national average. However, the mean age at commencement of doctoral enrolments from the rest of Africa was higher than the national average at 38 years in 2000, while in 2014 it reached a similar average age of 38.05 years compared with all enrolments.

in *physics* remained similar over the 15-year period with a slight increase of 31.4 years to 32.5 years in 2014. In 2014, the median age was 30 years. The average age of doctoral enrolments in physics was nearly six years younger than the national average age. The age of doctoral enrolments in *sociology* increased minimally over the 15-year period analysed. In 2014, the average age at enrolment was 38.1 years and the median 37 years, which are commensurate with the national average.

Doctoral enrolments in education are on average six years older than the national average. A possible reason for finding older enrolments in education is that doctoral candidates in education are often professionals who enter their doctoral studies as a means for career advancement after having been in the workforce for a period of time. I continue this argument throughout this study. Conversely, doctoral students in physics and electrical engineering are on average five to six years *younger* than the national average. I discuss in Chapter 10, that students in physics (or the natural sciences) often progress through degree qualifications leading up to the doctorate quickly and this may explain why they are younger than doctoral students in the social sciences or humanities. In the basic sciences, such as physics, the doctorate is often a minimum requirement for a research career and students are compelled to pursue their doctoral studies at the beginning of their careers.

6.1.1.5 Institutional profile of doctoral enrolments

With regard to the institutional affiliations of doctoral enrolments, UP and UKZN enrolled the most doctoral students nationally. The latter university enrolled the most doctoral students in 2014. Looking at the proportional share of doctoral enrolments, UP enrolled the biggest share of students in 2000 (17.7%) which decreased to 12.3% in 2014. Generally, UP, UKZN, UCT, Unisa, WITS, SU and NWU together enrol more than 75% of doctoral students in South Africa. The institutional breakdown of doctoral enrolments is presented in Appendix B.

Disaggregating doctoral enrolments by academic institution[53] in *education*, showed that Unisa and UP enrolled the most doctoral students. With regard to the institutional profile of doctoral

[53] With regard to new entrants (first enrolments) in education, Unisa showed the fastest AAG of 17%. UFH also showed noticeable growth in new entrants in education (16% AAG) between 2005 and 2014. UP recorded negative growth of -7% (AAG). Looking the proportional share of first enrolments at universities Unisa's share grew from 4.5% in 2000 to 39% in 2014. Similarly, the proportional share of new entrants at UKZN increased

enrolments in *electrical engineering*, UCT recorded the highest number of total enrolments for the entire period 2000 to 2014[54]. In the *clinical health sciences*, in 2000, almost 30% of enrolments were enrolled at UCT. The proportional share of doctoral enrolments at UCT, however, decreased to 22% in 2014. In 2014, almost 30% of the total enrolments in the clinical health sciences were enrolled at WITS[55]. WITS and UKZN enrolled the most doctoral students in *physics* for the total period analysed as well as in 2014[56] while WITS and SU enrolled the most doctoral students in *sociology* for the total period analysed. In 2014, however, UFH enrolled the most students in sociology, but this finding is most likely due to an erroneous data entry[57].

with 8.3%. UP's share of first enrolments decreased with 12.3% between 2000 and 2014 while that of UNIZULU decreased from 10.4% in 2000 to 1.7% in 2014. The proportional share of enrolments at Unisa increased from 13.5% in 2000 to 21.1% in 2014. For the same period, the proportional share of UP decreased from 18.2% in 2000 to 7.5% in 2014. In 2014, UKZN also enrolled a higher share of doctoral students in education (19%) compared to 2000 (7.8%). TUT in 2014, enrolled nearly 2.5% of doctoral enrolments in education, while that of CPUT remained low at 0.9%.

[54] Looking at the proportional share of enrolments across institutions, the share of UCT increased from 14.2% in 2000 to 21% in 2013. The share of TUT increased with 9.4% between 2000 and 2014, while the rest of the proportional share of the universities of technology decreased. In 2000, SU had the largest proportion of total enrolments (20.1%) which decreased to 13.7% in 2014. Similarly, the share of enrolments in electrical engineering at WITS, UKZN and NMU decreased between 2000 and 2014. The university with the highest growth rate, among total enrolments, is TUT, with an AAG of 29% although this started from a very low base. Among traditional universities, UCT showed an AAG of 10% while UJ grew with 13% (AAG). CPUT also showed significant growth (AAG 21%) in doctoral enrolments for the 15-year period. The only institution with a negative AAG is VUT (-9%)

[55] The DHET tables give no alternative record for enrolments in 2012. The share of enrolments at SU remained steady over the 15-year period. After 2009, UWC recorded no doctoral enrolments in the clinical health sciences. In 2008, however, 7% of all doctoral enrolments in the clinical health sciences were at UWC. Corroborating this with the staff data (as discussed in Chapter 8) one could assume that UWC ceased to offer doctoral programmes in the clinical health sciences (as defined by HEMIS).

[56] UP showed the highest annual average growth rate of 16% for the 15-year period analysed. NWU and Unisa both recorded negative growth rates for this period. WITS had the highest number of total enrolments for the 15-year period of 471 enrolments. For 2005, 2010, 2011 and 2012 no enrolments were recorded for WITS, which, as mentioned in Chapter 5, is a recording error in the HEMIS database. In 2010, UWC shows a sharp decline in doctoral enrolments in physics. This decline in enrolments is continued for the next four years. A plausible explanation might be that UWC restructured their doctoral programmes in physics. UKZN also showed significant growth among doctoral enrolments in physics. The proportional share of doctoral enrolments of UKZN grew from 10% in 2000 to 16.7% in 2014. The share of enrolments of WITS decreased from 35.8% in 2000 to 17.3% in 2014, while that of UCT and SU remained steady. UP showed an increase of 6.6% in proportional share between 2000 and 2014

[57] Looking at the proportional share of doctoral graduates per university we see that the share of enrolments at SU decreased from 35% in 2000 to 6.8% in 2014. The share of total enrolments at UP and UFS also declined with approximately 5%. UFH only started enrolling doctoral students in sociology in 2008. Their share of enrolments thus increased with 15% between 2008 and 2014. The proportional share of graduates at UCT remained relatively steady. UWC showed the highest AAG of 12% for the period, while enrolments at UCT grew with 11% (AAG). UP showed a negative growth rate (AAG) of -9% between for the 15-year period. At WITS, we saw a

Examining the institutional differences in doctoral enrolments between the five disciplines shows that the traditional top universities, such as UCT, SU and WITS enrol the most doctoral students in fields such as electrical engineering, the clinical health sciences, physics and sociology. However, Unisa enrolled and graduated the most students in education and graduated the most doctorates in sociology. Unisa only offers part-time enrolment through distance learning which suggests that the majority of doctoral students in education are enrolled part-time. This is an important finding on which I elaborate throughout the study.

6.1.2 Growth rates of doctoral enrolments in five disciplines

In this section, I compare the annual average growth rates as calculated for doctoral enrolments in the five selected fields. The annual average growth rates are presented in Table 6-1 below. Examining the annual average growth rates of the five disciplines, of both total and first enrolments showed that sociology grew at the fastest rate for the period analysed (an AAG of 9%). Enrolments in sociology grew at nearly 3% faster than the national average. The growth rates of total enrolments in electrical engineering, physics and education compared favourably to the national AAG. Enrolments in the clinical health sciences[58] grew with an AAG of 5% between 2000 and 2014 and grew at the slowest rate of the five disciplines studied. With regard to first enrolments, the clinical health sciences once again recorded the lowest growth rate of more than 3% lower than the national average. Both education and electrical engineering recorded lower growth rates of first enrolments compared to the national average, while the AAG of first enrolments in physics and sociology grew at a faster rate than the national average.

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significant increase in enrolments between 2009 and 2010. Similarly, there was a dramatic rise in total enrolments at UFH between 2009 and 2010 (5 in 2009 to 78 in 2010). This growth in enrolments was sustained until 2014. As seen in Chapter 6, this is due to an influx of students from the RoA. At the same time, Unisa also experienced a threefold increase in enrolments (from 11 in 2009 to 31 in 2010).

[58] With regard to the subfields attracting the most doctoral enrolments, clinical health sciences lead (2 970; n = 4 900; clinical health sciences other; 408) followed by psychiatry (289 enrolments) and paediatrics (196).

Table 6-1 Growth rates of doctoral enrolments in five disciplines per demographic subgroup (2000 to 2014)

	Indicator	National	Education	Electrical engineering	Clinical health sciences	Physics	Sociology
				AAG			
Enrolments	Total enrolments	6.6%	6.5%	7.0%	5.0%	6.8%	**9.0%**
	New enrolments	6.4%	5.0%	5.0%	3.0%	7.6%	**9.5%**
	Female	7.7%	7.0%	**13.0%**	6.0%	7.2%	8.6%
	Black (AIC)	10.6%	8.7%	**15.9%**	9.0%	9.7%	5.3%
	Black African	12.1%	10.2%	**19.6%**	12.3%	10.6%	16%
	RSA	4.5%	4.2%	3.0%	4.4%	4.1%	**4.6%**
	RoA	16.6%	18.0%	23.2%	4.4%	13.4%	**24.2%**

Uys (2004) suggests that we have witnessed a "waning of sociology" at the beginning of the twenty-first century. Examining the higher growth rate of new enrolments in sociology, however, supports claims by Mapadimeng that there has been a revitalisation of sociology in South Africa in recent years (Mapadimeng, 2009). Ken Jubber suggests that the centrality of HIV/AIDS in South African and sub-Saharan society has opened new opportunities for research thus attracting sociologists and postgraduates students to sociology (Jubber, 2007). It is necessary, however, to emphasise that this observed growth in sociology is not necessarily driven by South African enrolments, but by students from the African continent where enrolments from the rest of Africa grew at the fastest rate (24.2% compared with 16.6% nationally) of all disciplines analysed. From the growth rates above, one can also see that the higher growth rates of black African enrolments in sociology and electrical engineering were driven by the inflow of international students.

6.1.3 The pile-up effect

A pile-up effect of students refers to an inefficient system where existing students remain in the system for long periods of time without graduating. The stock of historical enrolments thus increases at a faster rate than at which graduates exit. I discuss the pile-up effect of doctoral students at the hand of two measures. The first which is reported here and the second in section 6.2.3.

The CHE report measures the pile-up effect as the percentage of *ongoing* (historical) enrolments compared to *total* enrolments for a given period (CHE, 2009). An increase in this percentage indicates that the number of existing students, in other words those who remain within the system, is increasing which points to an ineffective system. The CHE reported the pile-up effect of all doctoral students (ongoing enrolments as a percentage of total enrolments) as 55% in 2000 which improved to 59% in 2005 (CHE, 2009). My estimation of the pile-up effect, however, using the HEMIS microdata, shows that the proportion of *first* enrolments to *total* enrolments in 2000, nationally, was 33% after which it improved to 36% in 2014[59]. I similarly calculated the pile-up effect of the doctoral students in five disciplines which are presented in the table below.

Table 6-2 First enrolments as a proportion of total enrolments (pile-up effect) for five disciplines (2000 to 2014)

Indicator	**National**	**Education**	**Electrical engineering**	**Clinical health sciences**	**Physics**	**Sociology**
Ratio of first enrolments to total enrolments (2000)	33.0%	**40.2%**	31.3%	28.2%	25.0%	36.9%
Ratio of first enrolments to total enrolments (2014)	36.0%	**44.9%**	23.8%	24.6%	26.8%	38.5%

Examining the pile-up effect within the five discipline, I found that the pile-up effect increased for electrical engineering and the clinical health sciences. A decrease in the ratio of first enrolments to total enrolments in these fields suggests that the number of students who remain in the system is increasing. In education, physics and sociology, I found a decrease in the pile-up effect over the 15-year period studied. However, the pile-up effect of students in electrical engineering, the clinical health sciences and physics were greater (lower ratio) than the national average which suggests that a large number of historical students stay in the system without graduating. In section 6.2.3, I discuss a second measure of the pile-up effect which compares the annual average growth rates of doctoral enrolments with graduates.

6.2 A profile of doctoral graduates in five disciplines

In the aforementioned sections, I presented a profile of doctoral enrolments in five selected disciplines. In this section, I explore the profile of doctoral graduates in a similar fashion. First, I

[59] I calculated the pile-up effect for 2005 at 29%. However it is important to note that the measurement of the pile-up effect in the current study differs from that used in the CHE report.

compare the profile of doctoral students within the five disciplines after which I compare the demographic profile of graduates with regard to gender, race, nationality, age and academic institution. Subsequently, I comparatively discuss the annual average growth rates measured for doctoral graduates in the five disciplines, per demographic subgroup. As mentioned in the previous section, I determine a second measure of the pile-up effect and compare this measure across the five disciplines. This section concludes with a discussion on doctoral completion rates and average time-to-degree as determined for graduates in each of the selected disciplines.

6.2.1 Doctoral graduates in five disciplines

In 2014, 2 256[60] doctoral students graduated from South African universities. The number increased from 972 in 2000 at a growth rate of 6.2% for the 15-year period. In *education*, the number of doctoral graduates increased from 143 in 2000 to 235 in 2014 while the number of graduates in *electrical engineering* increased from 15 in 2000 to 38 in 2014. The number of graduates in the *clinical health sciences* grew at an AAG of 5.8% over the 15-year period from 34 in 2000 to 56 in 2014. Similarly, the number of doctoral graduates in *physics* increased steadily from 14 in 2000 to 50 in 2014 with an AAG of 8.3%. Doctoral graduates in *sociology* grew at an AAG of 9.8% for the period studied from 14 in 2000 to 60 in 2014, which is higher than the national average.

6.2.1.1 Gender

In 2000, 41% of doctoral graduates in South Africa were female and the share of female graduates remained identical over the 15-year period.

[60] The DHET reports the number of doctoral graduates in 2014 as 2 258.

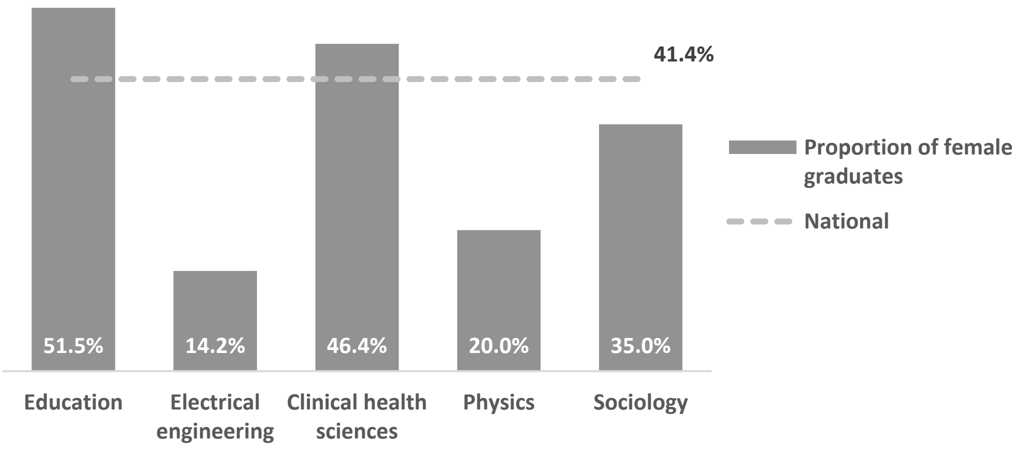

Figure 6-5 Proportion of female graduates in 2014 by discipline

Examining the gender distribution of female graduates in *education* shows that the proportion of female graduates is similar to that found in enrolments, while the AAG of female graduates was lower than that of enrolments (5.8% compared with 7.0%). The growth rate of female graduates was also one percentage point lower than the national average. Once again, *electrical engineering* remained male-dominated with male graduates constituting more than 85.8% of graduates in electrical engineering in 2014. Even though female graduates grew with an AAG of 8% for the period analysed, the numbers are low (0 in 2000 to 6 in 2014). The proportional share of female graduates in the clinical health sciences decreased slightly from 50% in 2000 to 46.4% in 2014. Although the number of female graduates in *physics* increased with an AAG of 5.7% between 2001 and 2014 (from 0 in 2000 to 10 in 2014), the proportional share of female graduates remained low with 20% in 2014. The number of female graduates in *sociology* increased from 5 in 2000 to 21 in 2014, with an AAG of 9.4%. The proportional share of female graduates decreased slightly from 35.7% in 2000 to 35.0% in 2014.

Why then, is female membership in physics and engineering low? A study by Eccles identified selected theories to explain low female participation, particularly in STEM fields (Eccles, 2007). She attributes gender socialisation as a leading cause of low enrolments in fields such as engineering and the physical sciences. She suggests that women or girls are less likely to be encouraged by parents, friends, peers, teachers, etc. to pursue careers in the physical or engineering sciences. In her *subjective task value* model, Eccles (2007) suggests that there are ostensible gender differences in the interest, utility and attainment values associated with different careers.

> Females should be more likely than males to want to work at occupations that help others and fit well into their family role plans. Males should be more likely than females to want future occupations that pay very well and provide opportunities to become famous. There is also evidence that males are somewhat more interested in females in activities and jobs related to manipulating physical objects and abstract concepts, whereas females are more interested in activities and jobs related to people and social interactions. (Eccles, 2007:203)

Eccles (2007) suggests that there are gender differences in the values placed on different occupations. The author argues that gender socialisation leads to conscious and unconscious achievement-related choices. In other words, aspiring students' vocational or career choices are based on their expectations for success or personal efficacy. Along the *expectancy value model,* students will choose a disciplinary field if they believe that they would succeed in that field. Eccles suggests that female students are arguably less likely to pursue careers in which they feel they will not be successful. Gender socialisation is also based within a broader and complex social reality which, often through inaccurate stereotypes, makes some fields seem more "masculine" than others (Eccles, 2007). England et al. suggest that the more a field is perceived as a feminised field, the less likely male students would be to pursue studies in that field (England et al., 2007). The authors use the *devaluation theory* to explain how male students would avoid "feminine" fields in that they associate lower salaries with predominantly female fields. I have briefly mentioned some of the theories explaining low female participation in certain disciplines, but these arguments are by no means a comprehensive account of the complexities surrounding gendered participation in higher education. In Chapter 8, I continue the discussion of female students' experiences of the doctorate, but I am limited in the scope of this study in providing a thorough account of female students' experiences.

6.2.1.2 Race

Nationally, the proportional share of black African graduates increased from 21% in 2000 to 48.3% in 2014. In 2014, more than 60% of doctoral graduat
es in South Africa were black (AIC) students.

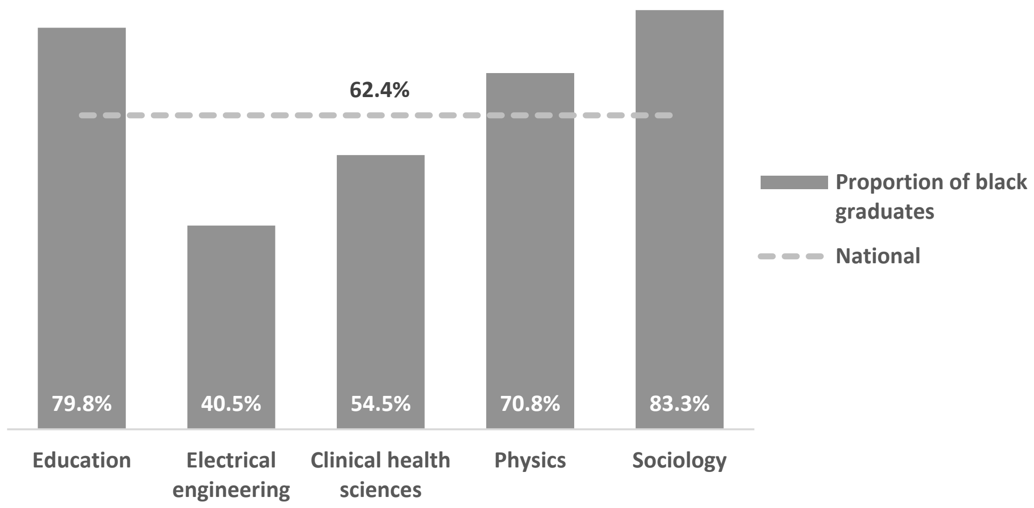

Figure 6-6 Proportion of black graduates in 2014 by discipline

Similarly, the number of black African graduates in *education* increased from 46 to 146 between 2000 and 2014, while the proportional share increased from 32.2% to 62.7%, almost doubling in 15 years (an AAG of 9.8%). At the same time, the number of white graduates decreased from 74 in 2000 to 47 in 2014 (an AAG of 0.3%) while the proportional share decreased from 51.7% in 2000 to 20.2% in 2014. The proportional share of black African doctoral graduates in *electrical engineering* increased with 33.8% between 2000 and 2014. However, in 2000 there were no black African graduates. The growth rate of black[61] African graduates was slightly higher compared to black African enrolments.

The number of black African graduates in the *clinical health sciences* increased from 4 in 2000 to 19 in 2014 and grew with an AAG of 13.7%. For the same period, white graduates decreased somewhat from 27 in 2000 to 25 (an AAG of 2.4%). Proportionally, black African graduates constituted 34.5% of graduates in the clinical health sciences in 2014, while black graduates constituted more than half of graduates in the clinical health sciences (54.5%) for the same year. The number of black African graduates in *physics* increased steadily at an AAG of 13.6% from 4 graduates in 2000 to 28 in 2014. For the same period white graduates increased from 9 in 2000 to 14 in 2014. Proportionally, the share of black African graduates increased with 28.7% over the period analysed. In 2014, the share of black graduates constituted 70.8% of all graduates in physics. With regard to doctoral graduates in *sociology*, the number of black African graduates increased with an AAG of 20.8% from only 2

[61] Most black graduates in electrical engineering, however, are from the RoA (78%) compared to 17% of black African South African graduates.

graduates in 2000 to 45 in 2014. At the same time white graduates recorded a negative growth rate of -1.4%. The proportional share of black African graduates increased from 14.3% in 2000 to 75% in 2014. Black graduates constituted 83.3% of all doctoral graduates in sociology in 2014.

6.2.1.3 Nationality

Similar to what was observed for doctoral enrolments, the number of South African graduates nationally, increased steadily at an AAG of 3.8% compared to graduates from the rest of Africa at an AAG of 18.2% where the number of graduates increased more than ten-fold. The proportional share of graduates from the rest of Africa increased from 7.2% in 2000 to 33.8% in 2014, while the share of South African graduates decreased by 22.7%.

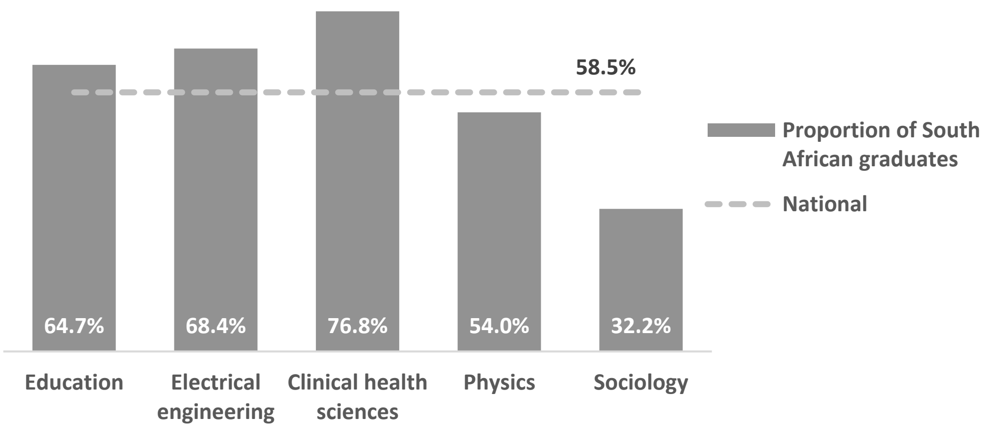

Figure 6-7 Proportion of South African graduates in 2014 by discipline

In the same fashion, the number of South African doctoral graduates in *education* increased from 129 in 2000 to 152 in 2014 at an AAG of 2.9%, while the number of graduates from the rest of Africa increased ten-fold from 8 in 2000 to 81 in 2014 with an AAG of 17%. Proportionally, the share of South African graduates in education decreased by nearly 26% over the 15-year period while the share of graduates from the rest of Africa increased by nearly 30% in the same period. In 2014, less than 1% of graduates in education were from the rest of the world.

In 2000, there were no graduates in *electrical engineering* from the rest of Africa but have since grown with an AAG of 20% (from 2003 onwards) to 11 in 2014. In 2014, approximately a third of graduates in electrical engineering were international students with South African graduates constituting 68.4% of graduates in 2014. The disaggregation of doctoral graduates in the *clinical health sciences* by nationality showed that South African graduates remained in the majority although having shown a steady decline in proportional share from 96.7% in 2000 to 76.8% in 2014. When disaggregating doctoral graduates in *physics* by nationality, the number of graduates from the rest of Africa increased from 2 in 2000 to 19 in 2014 with an AAG of 18.3% while graduates from South Africa only increased with an AAG of 5.6%. Proportionally, the share of South African graduates decreased by 24.6%. The number of graduates from the rest of Africa in *sociology* increased from 1 in 2000 to 35 in 2014. Proportionally, the share of doctoral enrolments from Africa increased from 7.1% in 2000 to 59.3% in 2014. For the same period, the share of South African graduates decreased by 53.5% (from 2000 to 2014).

6.2.1.4 Average age at completion of doctoral studies

Nationally, the average age of doctoral graduates at completion in 2014 was 40.5 years.

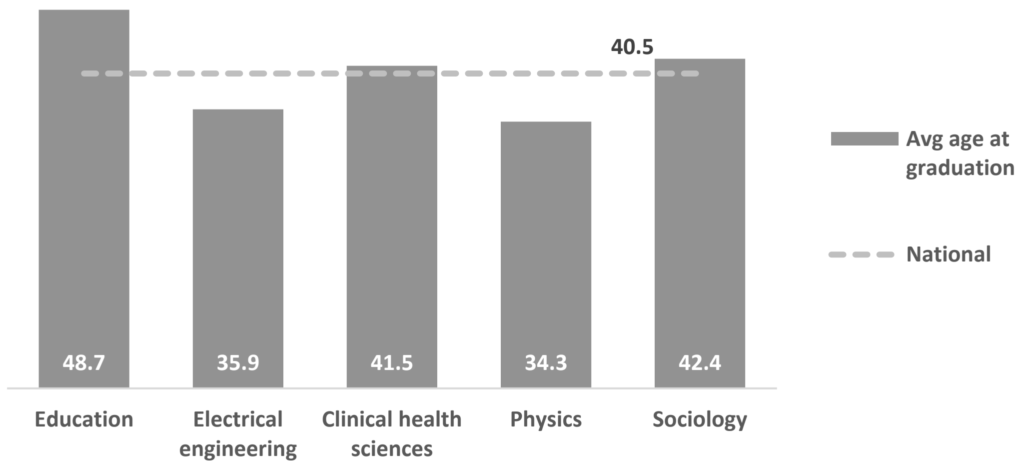

Figure 6-8 Average age at completion of doctoral graduates in 2014 by discipline

For graduates in *education*, the average age of graduation increased from 44.6 years in 2000 to 48.7 years in 2014 which is nearly eight years older than the national average. In *electrical engineering*, in 2014 the average age was 35.9 years which is nearly five years younger than the national average. The average age at completion of graduates in the *clinical health sciences* increased slightly from 39.7 years in 2000 to 41.5 years in 2014. Similarly, the average age at graduation of students in *physics* increased somewhat between 2000 and 2014 to 34.3 years. The average of graduates in *physics* in

2014 was nearly six years younger than the national average. The average age of at graduation of students in *sociology* decreased slightly from 42.8 in 2000 to 42.4 in 2008, which is slightly older than the national average.

Comparing the average age of doctoral students across the five disciplines, I found that the age at completion of graduates in education is as expected, much older by at least seven to eight years than the national average and other disciplines, and that students in education were on average the oldest across the five disciplines. Conversely, graduates in electrical engineering and physics were five to six years younger than the national average. ASSAf (2010) similarly found that graduates in the natural sciences were the youngest at 35.7 years and graduates in the humanities the oldest at 44.5 years. A study of graduates in the USA found that doctoral graduates in physics and engineering fields were typically younger (30.3 years and 31.4 years respectively) compared to those in sociology (34.7 years), health (37.2 years) and education (43.5 years) (Hoffer & Welch Jr., 2006) which is commensurate with the age profile of doctoral graduates in the five selected disciplines.

6.2.1.5 The institutional profile of doctoral graduates

The top seven universities consistently produced more than 75% of graduates with UKZN and UP graduating the most doctoral students between 2000 and 2014. Unisa graduated the highest number of doctoral students in *education* for the 15-year period (320) while its proportional share of graduates decreased from 2000 to 2014. Approximately 40% of all doctoral graduates in education in 2000 were enrolled at Unisa (38%) but its share decreased to 20% in 2014[62]. In *electrical engineering*, in 2000, 20% of doctoral students graduated from SU which increased to 21.1% in 2014. In the *clinical health sciences*, UCT graduated the most students for the total period (2000 to 2014) at a total of 178 graduates. Looking at the proportional share of graduates by academic institution I found that the

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[62] I found that between 2006 and 2011 the proportional share of graduates at Unisa decreased noticeably from the previous years. Similarly, the share of graduates at UJ also decreased from 17% to 5.5% in 2014 and the University of Western Cape (UWC) from 4.9 in 2000 to 4.7 in 2014. The university whose proportional share of graduates increased the most was that of UKZN with 3.5% in 2000 to 10.6% in 2014. WITS recorded the highest annual average growth rate of 18% while UJ and the University of Zululand (UNIZULU) recorded negative growth rates (AAG).

proportional share of graduates at UCT decreased from 35.3% in 2000 to 16.1% in 2014[63]. In *physics*, WITS graduated the most doctoral students over the 15-year period with 74 graduates, followed by SU with 49 graduates[64]. Unisa graduated the most doctoral students in *sociology* for the entire 15-year period (60), with WITS and SU following closely behind with 55 and 51 students respectively[65]. Given that WITS and SU enrolled the most students in sociology for the total period studied, and Unisa graduated the most, it suggests that Unisa has been more efficient in producing doctorates in sociology than WITS and SU.

6.2.2 Growth rates of doctoral graduates

In Table 6-3 below, I present the growth rates of doctoral graduates by demographic subgroup in the five disciplines. Nationally, the number of doctoral graduates increased with an AAG of 6.2% between 2000 and 2014. The annual growth rate of graduates in electrical engineering, education and clinical health sciences were below that of the national average of 6.2%. For the same period, the number of graduates in sociology grew with an AAG of 9.8%. In 2014, however, the number of doctoral graduates in sociology composed only 2.7% of total doctoral graduates in South Africa. Of the five disciplines,

[63] Since many institutions did not graduate any doctoral students in some years, the annual average growth rate could only be calculated for WITS and UKZN. Both these institutions recorded an AAG of 5% which is one percentage point lower than the average for graduates in the clinical health sciences. Similarly, the share of graduates at UP decreased from 20.6% in 2000 to 5.4% in 2014. It appears as if the proportional share of WITS increased noticeably (30.4%), but this is only because no graduates were recorded for 2000. It should be noted, however, that the number of graduates in each year was small and that any variation could appear as a significant proportional shift. It is, therefore, useful to look at the absolute numbers

[64] UCT recorded the highest AAG of 10% (among those that could be calculated). In 2000, 50% of doctoral graduates in physics graduated from WITS. This share decreased to 20% in 2014. The share of graduates from SU increased for 7.1% in 2000 to 12.9% in 2014. The proportional share of graduates at UCT also increased with 10% between 2000 and 2014.

[65] However, in 2014, just fewer than 22% of all graduates in sociology graduated from UFH. The proportional share of doctoral graduates of UFH grew by 21.7% from 2000 to 2014. The share of Unisa decreased by 8.6% between 2000 and 2014, while the shares of UJ also decreased by almost 20%. Once again the absolute numbers in each year are very small and, therefore, a decrease of 3 graduates to 1 student (as was the case with UJ) reflects a decrease in proportional share of 20%. In the year 2000, there were only 14 graduates in sociology, and the shares of the participating universities, therefore, look convincing. Seeing as the number of doctoral graduates increased by 10% for the 15-year period, it is, therefore, expected that the shares of universities who graduated students in 2000, would decline. It might then be more useful to look at the 2008 data, but once again, only 14 students graduated in 2008.

graduates in education constituted the highest share of all doctoral graduates in South Africa at 10.4% in 2014 but recorded the lowest average growth rate over the 15-year period.

Table 6-3 Growth rates of doctoral graduates in five disciplines per demographic subgroup (2000 to 2014)

Indicator	**National**	**Education**	**Electrical engineering**	**Clinical health sciences**	**Physics**	**Sociology**
			Share			
Share of all doctoral graduates (2000)	-	14.7%	1.5%	3.5%	1.4%	1.4%
Share of all doctoral graduates (2014)	-	10.4%	1.7%	2.5%	2.2%	**2.7**%
			AAG			
Graduates	6.2%	5.0%	6.0%	5.8%	8.3%	**9.8%**
Female	6.9%	5.8%	8%	6.1%	5.7%	**9.4%**
Black (AIC)	11.2%	7.9%	n/a	11.0%	12.5%	**18.6%**
Black African	12.8%	9.8%	20.5%	13.7%	13.6%	**20.8%**
RSA	4.0%	2.9%	3.0%	4.9%	**5.6%**	3.6%
RoA	18.2%	17.0%	**20.0%**	13.0%	18.3%	n/a

Similar trends are observed in the growth rates of doctoral graduates as were found for doctoral enrolments. The number of black and black African graduates in sociology and electrical engineering grew rapidly between 2000 and 2014. Unfortunately, an AAG of graduates from the rest of Africa in sociology could not be calculated due to some years where no doctoral students from the rest of Africa graduated.

6.2.3 The pile-up effect of doctoral students in five disciplines

A second indicator of the pile-up effect includes a comparison of growth rates of *enrolments* with that of *graduates*. If graduates record a faster AAG than that of *first* enrolments, it suggests that the flow of students is increasing. In other words, students are leaving the system at a faster rate than at which they are entering.

Nationally, the growth rate of *first* enrolments was marginally lower (an AAG of 6.4%) when compared to that of total enrolments (an AAG of 6.6%). For the same period, the number of doctoral graduates increased with an AAG of 6.2%. Although the AAG of graduates is slightly lower than that of enrolments, a comparison would suggest that nationally, the rate at which doctoral students enter the system is commensurate with the rate at which they are completing and the pile-up effect, therefore, is minimal.

Table 6-4 Comparisons of growth rates per discipline in determining pile-up effect

Indicator		**National**	**Education**	**Electrical engineering**	**Clinical health sciences**	**Physics**	**Sociology**
		AAG					
Enrolments	**total** enrolments	6.6%	6.5%	7.0%	5.0%	6.8%	**9.0%**
	new enrolments	6.4%	5.0%	5.0%	3.0%	7.6%	**9.5%**
Graduates		6.2%	5.0%	6.0%	5.8%	8.3%	**9.8%**

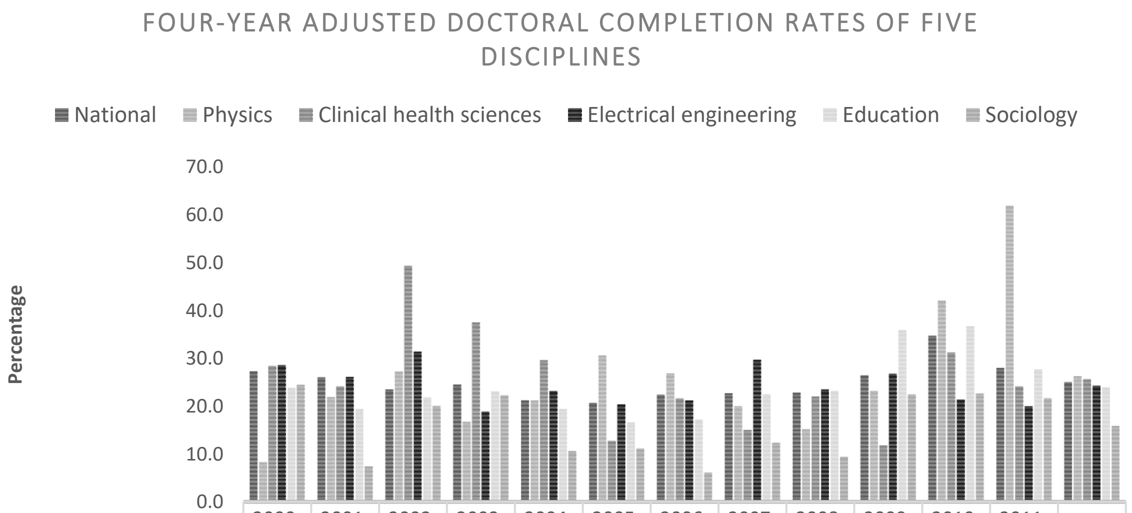
Examining the pile-up effect within the five disciplines show that in education and electrical engineering, doctoral students are graduating at a slower rate when compared to the growth rate of total enrolments. However, in education, the AAG of new enrolments and graduates are equal at 5.0%. In electrical engineering, doctoral students are graduating at a slower rate than that of total enrolments.

Examining the growth rates in the table above show that the number of graduates grew at a faster rate than enrolments, including first enrolments, in sociology, physics and the health sciences. This suggests that these fields are more efficient than the other fields, in that students are leaving the system at a faster rate than at which they enter. In electrical engineering, the AAG of graduates is higher than that of first enrolments, while that in education is similar. In both cases, however, the stock of enrolments in the system is growing at a faster rate.

Although the growth rates of graduates and new enrolments in education were slower compared to total enrolments, the proportion of first enrolments to total enrolments is the highest across the fields compared, and increased between 2000 and 2014, indicating a decrease in the stock and increase in the flow of doctoral students. Similarly, the output of students in sociology also increased between 2000 and 2014 with a pile-up effect comparable to the national average. In the next section, I use a more robust calculation of completion rates to think about the efficiency of doctoral students in the five selected disciplines.

6.2.4 Completion rates of doctoral students in five disciplines

In this section, I report on the completion rates of doctoral graduates in five disciplines compared with the national average. Supporting tables are presented in Appendix B | Chapter 6: A profile of doctoral enrolments and graduates (Table B-19 to Table B-30). The average four-year completion rate of doctoral students in South Africa was 25%. This means that on average, only 25% of doctoral students completed their doctoral studies after four years. Looking at the data across years, I found some variation, but generally, the completion rate of doctoral students remained in the 20%. Examining the completion rates per discipline, I found some variation between years, but graduates in the physics recorded the highest average four-year completion rates of 27.3%. Graduates in education and sociology recorded the lowest average four-year completion rates while the average completion rates of doctoral students in sociology were much lower than the national average. After four years, an average of only 16% of doctoral students in sociology graduated with a doctorate. This is nearly 9% lower than the national average. In Figure 6-1 below the four-year doctoral completion rates of the five selected disciplines are illustrated for the period 2000 to 2011.



	2000-2003	2001-2004	2002-2005	2003-2006	2004-2007	2005-2008	2006-2009	2007-2010	2008-2011	2009-2012	2010-2013	2011-2014	Avg.
National	27.3	26.0	23.5	24.5	21.2	20.7	22.4	22.7	22.8	26.4	34.7	28.0	25.0
Physics	8.3	21.9	27.3	16.7	21.2	30.6	26.9	20.0	15.2	23.2	42.1	61.9	26.3
Clinical health sciences	28.4	24.1	49.3	37.5	29.6	12.7	21.6	15.0	22.0	11.8	31.2	24.1	25.6
Electrical engineering	28.6	26.1	31.4	18.9	23.2	20.4	21.2	29.7	23.5	26.8	21.4	20.0	24.3
Education	23.8	19.4	21.8	23.1	19.4	16.6	17.2	22.5	23.2	35.9	36.7	27.7	23.9
Sociology	24.4	7.4	20.0	22.2	10.6	11.1	6.1	12.3	9.4	22.4	22.6	21.6	15.8

Cohort

Figure 6-9 Four-year adjusted completion rates of doctoral students in five disciplines (2000 to 2011)

Across the board, graduates in sociology and education recorded the lowest completion rates. The incremental increases in the four- to five-, five- to six-, and six- to seven-year completion rates across all disciplines are comparable with the national average, but the average completion rates of doctoral students in sociology, are well below the national average. This means that on average, 10% fewer graduates in sociology complete their degrees after seven years when compared to doctoral students across all disciplines.

Table 6-5 Average four-, five-, six- and seven-year completion rates of doctoral graduates in five disciplines

Average completion rates (%)	National	Education	Electrical engineering	Clinical health sciences	Physics	Sociology
Four-year	25.0	23.9	24.3	25.6	**27.3**	15.8
Five-year	34.3	31.9	33.8	35.4	**35.9**	22.4
Six-year	39.3	36.3	39.6	**40.9**	40.7	28.4
Seven-year	42.2	36.9	43.9	**46.2**	43.6	31.2

Looking at the average four-, five-, six- and seven-year completion rates of students in physics, the clinical health sciences and electrical engineering, we see that the differences between disciplines are small while slightly more than 46% of students in the clinical health sciences completing after seven years. In education, we see a marginal increase between six- and seven-year completion rates which is nearly 10% lower than seven-year completion rates of graduates in the clinical health sciences.

Turning to the literature, my estimation of a national average four-year (25%) and seven-year (42.2%) completion rate of 25% is slightly less than the 30.3% and 50% as reported by Mouton et al. (2015). Cloete, Mouton and Sheppard determined a five-year completion rate which varies between 36% and 38% and a six-year completion rate between 41 and 45% which are slightly higher than the completion rates reported here. In the UK, HEFCE determined five- and seven-year completion rates of full-time and part-time students where average five-year completion rates of full-time doctoral students were estimated at 57% while that of part-time students was 9% (HEFCE, 2005).

In calculating the completion rates of South African graduates, I did not disaggregate completion rates by students' mode of study. If I were to take the average UK completion rates of full-time and part-time students, I could argue that five-year completion rates of doctorates in the UK are 33%. In a rough comparison (using the average and acknowledging the different methods of calculation), the average five-year completion rates of 34.3% of all doctoral students in South Africa compares favourably with the UK statistic. Comparing the five-year completion rates of doctoral graduates in South Africa with doctoral students in Australia, I found that Australian five-year doctoral completion rates are nearly double that of students in South Africa where in the UK, nearly 66 to 67% of students completed within five years (Bourke, et al., 2004a; Jiranek, 2010). Compared to doctorates in New Zealand, five-year completion rates in South Africa are higher than the average of 26% of doctoral graduates in New Zealand (Scott, 2005). Looking at *seven-year* completion rates, HEFCE determined a 71% completion rate for full-time students and 34% for part-time students. The average of 52.5% is notably higher than the 42.2% recorded among doctorates in South Africa. In the USA, seven-year completion rates vary between 41% and 46% (Sowell, 2008). Average seven-year completion rates of South African graduates are slightly lower than those recorded for graduates in the USA, but the varying systems of doctoral education between the USA and South Africa make a comparison difficult.

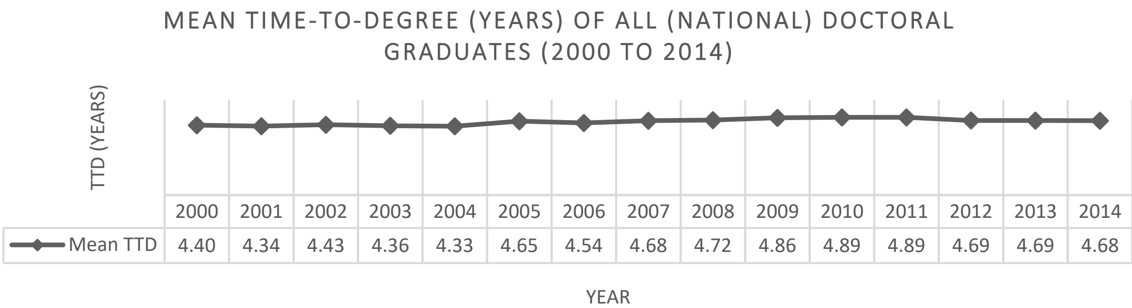
I found that disciplinary differences in average doctoral completion rates compare favourably with that found by Cloete, Mouton and Sheppard (2015) who found higher completion rates for students in the natural and health sciences and lower completion rates for students in the social sciences, engineering and technology and education. My results resemble disciplinary completion rates in Australia where Bourke et al. (2004a) found that students in engineering and the health sciences have higher completion rates compared to students in the social sciences. My results also support that of Sowell (2008) who found that in the USA, graduates in sociology had the lowest completion rates. However, in his study, students in engineering recorded higher completion rates than graduates in physics.

In the previous section, I found that the majority of doctoral graduates in sociology and education, over the 15-year period analysed, were enrolled at Unisa. Unisa, as a distance learning university, only offers part-time doctoral education. This suggests that the majority of doctoral students/graduates in sociology in South Africa are enrolled part-time. From the literature I found evidence that completion rates are lower for part-time students compared to their full-time counterparts (Cloete, Mouton and Sheppard, 2015; HEFCE, 2005). The low completion rates recorded for graduates in sociology might, therefore, be attributed to the fact that doctoral students in these disciplines are more likely to be enrolled part-time. The same explanation may be given for the lower than national average completion rates of students in education. Previously, I also suggested that doctoral students in education are more likely to be professionals who return to their studies on a part-time basis. In addition, I found that doctoral students in education are much older than those in the other selected disciplines. Studies have found that older students are more likely to record lower completion rates (HEFCE, 2005; Park, 2005).

In the next and final section of this chapter, I calculate the average time-to-degree of doctoral graduates and examine if there exist differences between the five selected disciplines.

6.2.5 Average time-to-degree of doctoral graduates in five disciplines

In Chapter 5, I discussed the methods used in calculating the average time-to-degree of doctoral students in South Africa. In the forthcoming analyses in Chapters 7 through 9, the mean time-to-degree of doctoral students over the entire period studied (2000 to 2014) was used. This is due to the small numbers of doctoral graduates within a discipline, within a year. In Figure 6-2 below, the mean[66] time-to-degree of all doctoral students (across all disciplines) is presented between 2000 and 2014. In 2014, the average time-to-degree of all doctoral graduates in South Africa was 4.68 years. Overall, I found a slight, but steady increase in time-to-degree between 2000 and 2014 where the average completion times of doctoral graduates increased from 4.4 years to a high of 4.89 years in 2008. Following 2009 the mean time-to-degree decreased slightly to 4.68 years in 2014.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mean TTD	4.40	4.34	4.43	4.36	4.33	4.65	4.54	4.68	4.72	4.86	4.89	4.89	4.69	4.69	4.68

Figure 6-10 Mean time-to-degree (years) of all (national) doctoral graduates (2000 to 2014)

The CHE and ASSAf reports determined that the average time-to-degree of doctoral students in South Africa ranges between 4.5 and 5 years (CHE, 2009; ASSAf, 2010). A study suggests that doctoral graduates in the UK take an average of six years (5.94 years) to complete their studies (Seagram, Gould & Pyke, 1998). In Australia, the average time-to-degree of full-time students was approximately 4.4 years (Bourke et al., 2004a; Jiranek, 2010). In the Netherlands, the average time-to-degree of doctoral students was estimated at five years (Van de Schoot et al., 2013) while that of doctorates in New

[66] The mean was calculating by excluding cases less than two years and more than 15 years.

Zealand was four years (Scott, 2005). Time-to-degree in the USA is significantly longer (Sowell, 2008) but it can be attributed to the fact that models of doctoral training are structurally different from those in South Africa[67].

In Figure 6-3 the average time-to-degree of doctoral graduates in the five selected disciplines is presented on a stacked line to illustrate the changes between 2000 and 2014. This figure is not an accurate representation of the actual mean time-to-degree, but as a stacked line, shows the differences over the 15-year period. I found some variation between years. With the exception of physics, the average time-to-degree of all disciplines increased over the period studied (including electrical engineering from 2001 onwards).

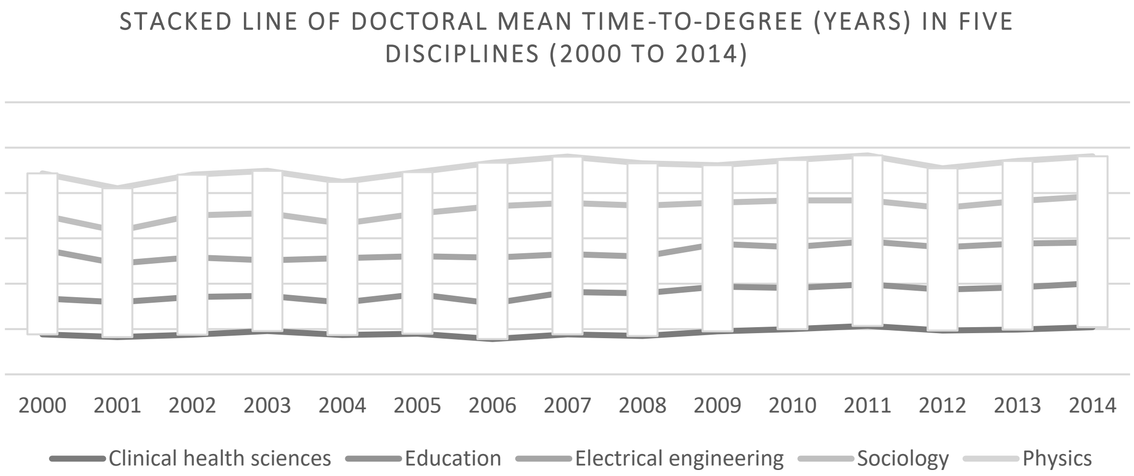


Figure 6-11 Stacked line of doctoral mean time-to-degree (years) of five disciplines (2000 to 2014)

The average time-to-degree of graduates in the clinical health sciences increased from 4.41 years in 2000 to 5.2 in 2014. Similarly, doctoral time-to-degree in education increased from just under 4 years in 2000 to 4.84 in 2014. There was some variation between years with the longest time-to-degree recorded in 2009. Similarly, I found an increase in doctoral time-to-degree in sociology from 3.79 years in 2000 to 5.07 in 2014. For both electrical engineering and physics, the average time-to-degree over the period decreased. In 2000, the average time-to-degree in electrical engineering was 5.38 years which was the highest of the period recorded after which it decreased to 4.51 years in 2014. Doctoral time-to-degree in physics decreased from 4.62 years in 2000 to 4.42 years in 2014.

[67] Typically the doctorate in the USA includes compulsory coursework which is to be completed before commencing on the research dissertation. Doctoral studies can be pursued directly upon completion of a baccalaureate as the doctoral coursework are often in lieu of a master's qualification.

Examining the average time-to-degree of doctoral graduates over the 15-year period shows that in all disciplines there was a similar increase. I argued in Chapter 5, that given this consistency over fields, the use of an average time-to-degree in the forthcoming statistical analyses would not be problematic. In Table 6-8 below, I compare the mean time-to-degree of doctoral graduates in five disciplines as recorded by the HEMIS student data. As discussed in Chapter 5, five different means were calculated.

Table 6-6 Summary of mean time-to degree of five disciplines

		Mean A	Mean B	Mean C*	Mean D	Mean E
		Include all cases	Exclude <2 years; and ≥x years (boxplot)	Transformed individual distributions*	Exclude <2 years; and ≥11 years (all disciplines)	Transformed** comparative data
Education	n	2172	1871	-	1926	1926
	Mean	**4.17**	**4.15**	-	**4.41**	**2.05**
	Std. dev.	*2.203*	*1.458*	-	*1.787*	*0.418*
Electrical engineering	n	394	334	-	355	355
	Mean	4.31	4.27	-	4.54	2.09
	Std. dev.	*2.129*	*1.418*	-	*1.768*	*0.405*
Clinical health sciences	n	625	567	567	567	567
	Mean	4.74	4.69	2.12	4.69	2.12
	Std. dev.	*2.620*	*1.831*	*0.420*	*1.831*	*0.420*
Physics	n	376	345	345	358	358
	Mean	4.53	4.56	0.633	4.56	2.10
	Std. dev.	*2.094*	*1.591*	*0.148*	*1.591*	*0.364*
Sociology	n	392	340	340	340	340
	Mean	4.59	4.74	2.13	4.74	2.13
	Std. dev.	*2.648*	*1.912*	*0.440*	*1.912*	*0.440*

*note that for mean C data for education and electrical engineering were not transformed and can therefore not be compared with the means of physics, the clinical health sciences and sociology.
**transformed data do not represent the original values.

Across the board, students in education recorded to shortest mean time-to-degree. Except in the calculation of mean A, sociology recorded the longest mean time-to-degree of a range between 4.37 years and 4.74 years. Cloete, Mouton and Shepard (2015) found that students in the natural sciences and engineering recorded shorter time-to-degree when compared with their counterparts in the humanities and social sciences (Cloete, Mouton & Sheppard, 2015). Bourke et al., (2004a; 2004) however, found that students in the natural sciences had the longest time-to-degree among their selected disciplinary fields. Studies in Australia found that graduates in education recorded some of the shortest time-to-degree (Bourke et al., 2004a; 2004b) while studies of American graduates found the opposite to be the case (Hoffer & Welch Jr., 2006). In Chapter 7, I deliberate the differences between the disciplines reported here and further explore possible reasons underlying these differences. Similarly, in Chapters 8 through 10, I identify the role of selected factors in the timely completion of doctoral graduates using the mean time-to-degree reported here.

6.3 Conclusion

In this chapter, I presented a profile of doctoral students in the five selected disciplines. First, I provided an overview of doctoral enrolments nationally and in the five disciplines along demographic factors which included gender, race, nationality, age and academic institution. I discussed the average annual growth rates of doctoral enrolments in the five disciplines and compared the growth rates of demographic subgroups. I calculated the pile-up effect as the ratio of first enrolments to total enrolments. The lowest pile-up effect was found in education, where the ratio of first enrolments to total enrolments increased to 45% in 2014. Of the five disciplines compared, enrolments and graduates in sociology recorded the highest AAG of the 15-year period analysed.

Subsequently, I presented a profile of doctoral graduates which included a demographic profile of graduates nationally and per discipline. I discussed how the average annual growth rates of doctoral graduates differ across the five disciplines and demographic subgroups and compared the growth rates of enrolments and graduates as a measure of the pile-up effect. I found that doctoral enrolments in electrical engineering and physics were predominantly male despite the increases in the proportional share of female enrolments towards 2014. In electrical engineering, physics and sociology, large proportions of enrolments were international students which suggest that these fields are attractive options to foreign students, particularly from the African continent. Doctoral students in education were noticeably older than the national average and other fields which suggests that doctoral students in education are more likely to be professionals pursuing the doctorate at a later stage in their careers who aim to improve their skills and ultimately to improve their career prospects. With regard to the institutional profile of students, UP, UKZN, UCT, Unisa, WITS, SU and NWU consistently enrolled more than 75% of doctoral students in South Africa.

Finally, I described doctoral students in South Africa along two efficiency indicators. First, I determined and compared four-, five-, six- and seven-year completion rates of doctoral graduates over the five disciplines. Between 2000 and 2014, the average seven-year completion rate of doctoral students in South Africa was 42.2%. The average completion rates differed over the five selected disciplines. The clinical health sciences recorded the highest six- and seven-year completion rates of doctoral students while graduates in physics recorded the highest four- and five year completion rates. The lowest completion rates were consistently recorded for graduates in sociology. My findings on doctoral completion rates of selected disciplines support the arguments found in the literature that completion rates in the soft (social sciences) are lower compared to fields in the hard (physical) sciences. Second, I determined the average time-to-degree of doctoral students in the five disciplines and examined how the completion times of doctoral graduates changed between 2000 and 2014. In 2014, the average time-to-degree of doctoral graduates, nationally, was 4.68 years. I found a steady increase in the average doctoral time-to-degree for all doctoral students in South Africa for the period analysed which was consistent across the five disciplines. Although differences in mean time-to-degree are small, graduates in education recorded the shortest mean time-to-degree while graduates in sociology recorded the longest completion times.

Chapter 7 | The role of the discipline in time-to-degree

This chapter marks the first of four chapters dedicated to addressing the second research question of this study which considers the role of contextual factors in time-to-degree. It is one of this study's hypotheses that epistemological factors, i.e. the nature of a discipline and the manner in which it has been institutionalised, is associated with differences in timely completion. In Chapter 4, I discussed the conceptual framework that guided the empirical components of this study which define epistemological factors as the (potential) challenges or enablers that students experience with the disciplinary content and context in their respective disciplines (Morgan and Tam, 1999). In Chapter 2, I reviewed some of the theoretical frameworks underpinning the thinking of academic disciplines and I argued that academic disciplines differ in terms of their bodies of knowledge, cultural practices and organisational forms. Subsequently, in Chapters 2 and 4, I discussed how scholars attribute the differences in (timely) degree attainment between disciplines to the ostensible differences in the content and context of academic fields.

From the literature, I posit two research questions which I address using the HEMIS data. First, I explore whether there exist significant differences in average time-to-degree between what are considered as the hard (abstract) and soft (concrete) disciplines. Similarly, I consider, the differences in time-to-degree between pure and applied disciplines. In both cases, I include a qualitative analysis of the survey data in contextualising why there may exist disciplinary differences in timely degree attainment.

7.1 The nature of the discipline

In Chapter 6, I found that there exist differences in the average time-to-degree of doctoral graduates between five disciplines in South Africa. I found that graduates in education recorded the shortest time-to-degree while students in sociology recorded the longest time-to-degree of the five disciplines selected. A one-way ANOVA was run to test if the observed differences in mean time-to-degree between the five disciplines were statistically significant. The means are summarised in Table 7-1 below. Data are reported as means ± standard deviation.

Table 7-1 Results of a one-way ANOVA means test of time-to-degree of the five selected disciplines

Discipline	n	Mean*	Std. dev.
Education	1926	4.41	1.787
Electrical engineering	355	4.54	1.768
Physics	358	4.56	1.287
Clinical health sciences	567	4.69	1.831
Sociology	340	4.74	1.912
Results		F=4.457; p=.001; partial η^2=.005	

*mean D was used for the interdisciplinary comparisons

Comparison tests were run on both the original and transformed data and the results of the original data are reported here. The assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances (p=.002) and the differences in means are statistically significant (p = .002). Games-Howell post hoc analysis revealed that the mean time-to-degree of graduates in education was significantly shorter (4.41 ± 1.787) than that of the clinical health sciences (4.69 ± 1.831; p=<.05) and sociology (4.74 ± 1.912; p<.05). However, it should be noted that although the differences are statistically significant, the observed mean differences and size effect are small. We can, however, argue, given the results here, that despite the small differences, I found evidence in support of disciplinary differences in doctoral time-to-degree. In the sections below, I investigate these differences at the hand of the theory and literature reviewed earlier. The discussion of literature in Chapter 4 suggested that using Storer's distinction of disciplines, students in soft disciplines generally record longer time-to-degree when compared to students in the hard sciences. Below I test whether this hypothesis holds true for doctoral time-to-degree in the five selected disciplines and I discuss the results of the differences between the disciplines recorded here.

7.1.1 Hard-soft (abstract-concrete) dichotomy

Kolb and Biglan's classification of academic discipline places physics, engineering and the clinical health sciences in the hard/abstract quadrants while sociology and education are considered as soft disciplines. One of the research questions addressed here is does doctoral time-to-degree differ significantly between the hard/abstract and soft/concrete sciences? What makes this first question so difficult to answer is that the nature of a discipline cannot be held constant. In other words, it is difficult to discern if observable differences can be attributed to differences between disciplines only. The grouping together of disciplines as hard or soft implies a collection of characteristics. For example, in the natural sciences, there is typically a "closer" relationship between students and supervisors (Smeby, 2000). Similarly, the soft sciences are considered problem-seeking disciplines rather than problem-solving (Baird, 1990) and identifying research questions is time-consuming and arduous. These disciplinary attributes, therefore, speak to the nature of the discipline, but also to supervisory models, teaching modes and the research process. The abstraction of disciplines as hard and soft is, therefore, an assemblage of arguably observable features. These features, as mentioned in Chapter 2, are also based on a set of assumptions which renders its measuring precarious. I, therefore, acknowledge the reductionist idea of simply positioning the soft and hard sciences on a continuum.

Conventionally, the natural sciences have become synonymous with hard sciences while the social sciences are considered soft sciences. Notwithstanding the complexity of these ideal types, as an introduction in comparing disciplinary time-to-degree, I offer a simple comparison of the mean time-to-degree of hard/natural sciences versus the soft/social sciences. As a starting place for the following analyses, I state my first null hypothesis.

H_0: There is no statistically significant difference in the mean time-to-degree of students in the natural and social sciences

$$H_0: \mu_s = \mu_h$$

Where μ_s is the mean time-to-degree of students in the soft sciences and μ_h is the mean time-to-degree of students in the hard sciences

In Figure 7-1 below, the mean time-to-degree of the five selected disciplines selected are plotted[68]. The mean time-to-degree of the five disciplines are plotted on a horizontal axis showing the mean time-to-degree in years. The literature suggests that students in the natural/hard sciences typically record shorter time-to-degree than in the social/soft sciences (Baird, 1990; Bowen & Rudenstine, 1992; Hoffer & Welch Jr., 2006; Elgar, 2003; Seagram, Gould & Pyke, 1998; Sowell, Allum & Okahana, 2015; Wright & Cochrane, 2000). Therefore, one would expect disciplines in the hard sciences/natural sciences to cluster around the left/lower end of the dimension with shorter time-to-degree and the social/soft sciences towards the right/upper end.

[68] HEMIS data, mean E was used.

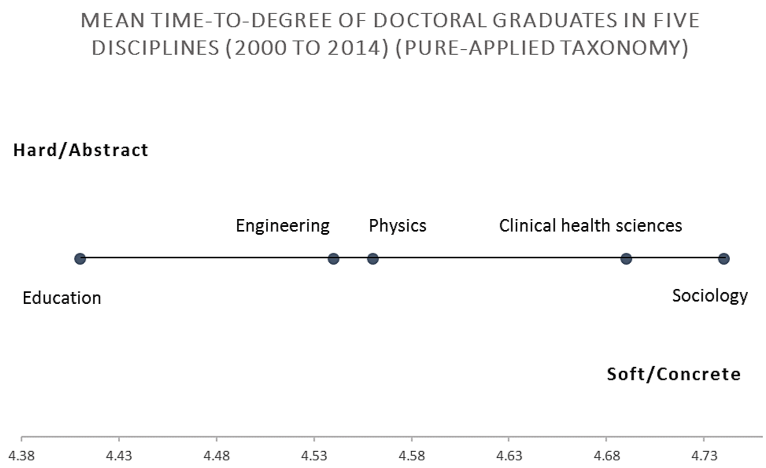


Figure 7-1 Average time-to-degree of doctoral graduates in five disciplines plotted on the hard-soft taxonomy

In Figure 7-1 above, I found that the two soft sciences are positioned on both (opposing) sides of the continuum. Sociology is located on the right side (soft side) of the dimension while education is located on the far left. Of the three disciplines in the natural sciences, electrical engineering and physics are clustered towards the middle of the dimension whereas the clinical health sciences is positioned towards the soft/abstract side.

Discussion

My findings indicate that graduates in sociology recorded the longest time-to-degree of the five selected disciplines, while electrical engineering and physics reported shorter time-to-degree compared to sociology. This result is congruent with the findings in the literature which found longer time-to-degree among doctoral students in sociology (Elgar, 2003; Seagram, Gould & Pyke, 1998). Similarly, with regard to shorter time-to-degree in physics and electrical engineering (compared to the social sciences), my results support those found in studies of doctoral students in the USA and Canada (Baird, 1990; Elgar, 2003; Hoffer & Welch Jr., 2006; Sowell, Allum & Okahana, 2015). In Australia, however, one study found doctorates in the health sciences to have shorter time-to-degree than in engineering and the social sciences, while those in the sciences (natural or life) recorded the longest time-to-degree (Jiranek, 2010). However, my results are partly congruent with that found by ASSAf (2010) in the Consensus report which found that doctoral students in South Africa, in the social sciences recorded the shortest time-to-degree when compared to students in the natural sciences, health sciences and engineering.

The results, therefore, partially support the hypothesis that fields in the social (soft) sciences report longer doctoral time-to-degree compared with the natural (hard) sciences. In Chapters 2, 3 and

4, I discussed the theoretical and empirical scholarship which suggests that competing paradigms and the abundance of theoretical frameworks in the soft sciences make identifying research problems and mastering core concepts more challenging compared to the harder sciences (Lovitts, 2001; Kuhn, 1970). Turning to the survey data, one respondent in education identifies this problem.

> It is quite different from a pure science degree so I have had to delve into a lot of philosophy in which I have not been trained. – education

The literature and theory reviewed in Chapters 2, 3 and 4 argue that academic disciplines, and the manner in which they are practiced, embody specific characteristics. A number of scholars have suggested that these characteristics affect successful degree completion (Ampaw & Jaeger, 2012; Biglan, 1973a; Bourke et al., 2004a; Gardner, 2009b; Kolb, 1981; Lovitts, 2001; Smeby, 2000). These include the epistemological structures of disciplines, levels of theoretical and methodological consensus, the methods used in empirical research, the manner in which graduate education is structured, including supervisory arrangement, the goals of scientific research and so forth (Austin, 1990; Becher, 1987; Biglan, 1973a; Bush, 1945; Kolb, 1981; Kuhn, 1970; Pantin, 1968; Storer, 1967). This has led to many scholars arguing that doctoral students in the hard (concrete) sciences generally have higher completion rates and shorter time-to-degree compared to students in the soft (abstract) disciplines (Baird, 1990; Bowen & Rudenstine, 1992; Elgar, 2003; Gardner, 2009b; Smeby, 2000).

The Biglan-Kolb classification of disciplines considers education a soft science, and in my analysis of doctoral time-to-degree, doctoral graduates in education reported significantly shorter time-to-degree when compared to physics and sociology. In his study of Australian doctorates, Jiranek found a similar result in that in his sample, graduates in education recorded the shortest candidacy times (compared to business, health, engineering, arts, humanities, social sciences and natural sciences) (Jiranek, 2010). However, among doctoral students in the USA, Hoffer and Welch Jr. found that graduates in education recorded the longest time-to-degree of fields studied (including physics, engineering, sociology and health sciences) (Hoffer & Welch Jr., 2006). Few studies cited, however, included education as a discipline in their sample of analysed disciplines. The shortest time-to-degree recorded by students in education suggests that I found evidence to both accept and reject the null hypothesis that time-to-degree in the soft sciences is longer compared to the hard sciences. However, education is considered a soft-applied discipline whereas Biglan and Kolb consider sociology a soft-pure (concrete-reflective) discipline. The results above suggest that we should consider more than the hard-soft (abstract/concrete) dichotomy in our interpretation of the observed differences in timely completion between disciplines. Consequently, I explore time-to-degree of the five disciplines along the pure (reflective) and applied (active) distinction.

7.1.2 Pure-applied (reflective-active) dichotomy

The classification of academic disciplines, as reviewed in Chapter 2, distinguishes between pure (basic) and applied sciences. This distinction is often made on the basis of the rationale for doing research and the goals associated with its outcomes. Bush saw the pure sciences as an endeavour "… to discover new knowledge for its own sake …" while the applied sciences typically formulate research questions around societal or industrial needs (Bush, 1945; Stokes, 1997). Although empirical research on this classification of disciplines is more limited, some studies suggest that students in professional disciplines record longer time-to-degree than those in the pure/basic sciences (Hoffer & Welch Jr., 2006). Below I investigate whether disciplines in the applied sciences have shorter time-to-degree compared to their pure counterparts.

H_0: There is no statistically significant difference in the mean time-to-degree of students in the applied sciences and the basic sciences.
$H_0: \mu_b = \mu_a$
Where μ_b is the mean time-to-degree of students in the basic sciences and μ_a is the mean time-to-degree of students in the applied sciences.

The mean time-to-degree of the five disciplines are plotted in Figure 7-2 below. Applied sciences, (education, electrical engineering and the clinical health sciences) are positioned above the horizontal line, while the pure/reflective sciences (physics and sociology) below.

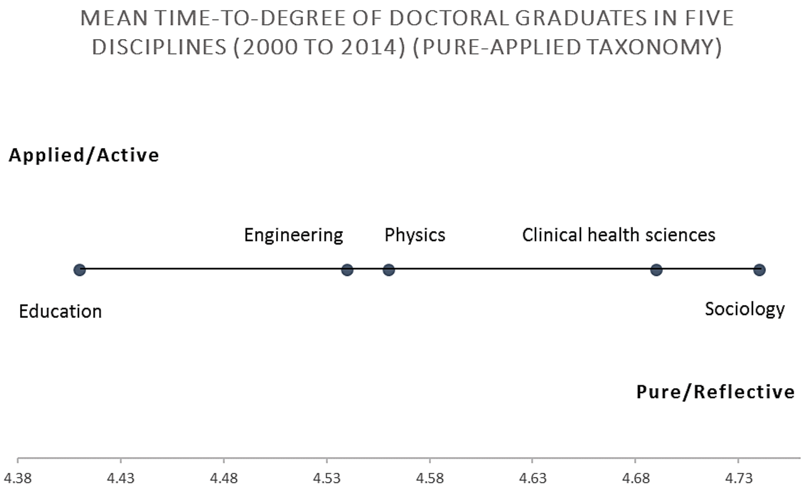


Figure 7-2 Mean time-to-degree of doctoral graduates in five disciplines on the pure-applied taxonomy

Except for students in the clinical health sciences[69], the mean time-to-degree of graduates in the applied sciences and pure sciences are located towards either end of the continuum. Graduates in education and electrical engineering recorded shorter mean time-to-degree while those in sociology and physics longer. Heath (2002), in his study of doctoral time-to-degree in Australia, found shorter candidacy times associated with disciplines such as education, health and engineering compared to the social sciences and sciences[70]. Hoffer and Welch Jr. (2006) found that among doctoral graduates in the USA, students in professional disciplines such as health, humanities and education record longer time-to-degree compared to students in disciplines such as science and engineering. The authors found shorter time-to-degree among students in physics when compared to students in engineering (Hoffer & Welch Jr., 2006).

Although graduates in engineering, as a hard-applied (abstract-active) science, recorded the near-shortest time-to-degree of the five disciplines selected, authors such as Becher (1989) argue that knowledge in more applied disciplines is not as cumulative as in the pure sciences. Becher claims that the trial and error approaches in applied fields often pose many challenges to students (Becher, 1989). Applied disciplines are often positioned in the middle of academia and industry where research efforts have to be aligned with to industry demands. Often this requires novel approaches which draw on a range of skills, often from other disciplines. Survey respondents identified some challenges in doing research in engineering.

> Inter-disciplinary study is difficult. You don't quite fit in anywhere and it really takes an open minded supervisor who has industry experience to see the value of the study. – engineering

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[69] Mean time-to-degree of five disciplines compared

		Education	Electrical engineering	Clinical health sciences	Physics	Sociology
		soft-applied / concrete-active	hard-applied / abstract-active	hard-applied / abstract-active	hard-pure / abstract-reflective	soft-pure/ concrete-reflective
HEMIS	n	1926	355	575	342	328
	Mean (B)	4.15	4.27	4.69	4.56	4.74
	Std. Dev.	1.458	1.418	1.831	1.591	1.912

[70] The study does not say which fields are included in the term "sciences", but we assume it to refer to the natural and life sciences.

> I had to start from scratch in learning the jargon, processes and methods used in the field. – engineering
>
> I knew nothing of the subject and neither did my supervisors and had to teach myself. – engineering
>
> I took a piece of unique work that was actually done in industry while working full time and used it to complete a PhD. The university systems are not geared to research of this nature it is very frustrating dealing university mentality on work which is already reviewed. – engineering
>
> Nobody at our department has worked in this specific field yet. – engineering
>
> The field I am researching on is new which is a bit of a challenge since I am required to start from scratch. I am enjoying the content of the field though but it requires a lot of time and can be frustrating if I have to read about every little term and concept of this new field from scratch. – engineering

It is not uncommon for students to find themselves at odds with their supervisor or departments' cognitive structures, regardless of discipline, which can be challenging for the doctoral candidate. Although theoretical and ontological alignment of the student and department/supervisor in the soft sciences is imperative, it does not mean that this is inconsequential in the natural sciences. Given, however, that knowledge structures in the hard sciences are arguably more codified, scholars such as Lovitts (2001) and Smeby (2000) argue that it makes such conflicts less likely.

> All my previous studies were in a career-orientated field, and now I have moved into a field which was previously only included as part of my undergraduate studies very many years ago. I find I am not in sync with the fundamental academic outlook and objectives of the present Department (actually, nor in my previous Department either, which has changed considerable (sic.) in recent years). – social sciences

Although many studies suggest that students in hard disciplines are more likely to complete their doctoral studies and do so in a timely manner, doing research in any field has its challenges. Successful and timely doctoral completion is the result of a number of interacting factors. Although there are differences in time-to-degree between disciplines, it is important to consider how the demographic profile of a discipline indirectly affects trends within disciplines.

Discussion

I found that students in more applied disciplines, such as education and electrical engineering have shorter completion times when compared to graduates in the pure disciplines such as physics and sociology. I cannot conclusively reject the null hypothesis, but there is some evidence to support the notion that doctoral time-to-degree in the applied sciences are shorter than in the pure sciences.

Reconciling my findings with that of the literature yields inconclusive results. Across the board, studies found shorter time-to-degree among physics and engineering, which supports the hypothesis that disciplines in the natural/hard sciences have shorter candidacy times. Findings on the health sciences are more varied, but generally, the health sciences have longer time-to-degree when compared to disciplines in the natural sciences and shorter completion times in comparison with the humanities and social sciences. Among existing studies, sociology graduates conclusively take longer to complete their degrees when compared to students in the natural, engineering and health sciences, which strongly supports the argument that students in the social sciences take longer to complete their degrees. However, the exception is education. Graduates in education as soft-applied discipline recorded a much shorter time-to-degree than anticipated. Looking at the profile of doctoral students in education, we see that the students in education are more likely to be older and enrolled part-time. Both these characteristics, as argued in the literature, are associated with *longer* completion times. Considering that the determinants of doctoral time-to-degree are complex and interrelated, I include these selected student demographics and situational factors in a regression model (Chapter 11).

7.2 Conclusion

In this chapter, I investigated whether the nature of a discipline has a significant influence on doctoral time-to-degree. Statistically significant differences between disciplines, although small, in time-to-degree were found while graduates in education recorded significantly shorter time-to-degree when compared to graduates in the clinical health sciences, sociology and physics. The literature on disciplinary differences in timely completion, although varied, suggests that graduates in the hard (abstract) and pure (reflective) sciences generally record shorter time-to-degree than students in the soft and applied sciences. Using the Biglan-Kolb classification of disciplines I could only partially reject the null hypothesis that students in disciplines considered as soft (abstract) fields take less time to complete their studies. Similarly, I could not conclusively reject the null hypothesis that students in more applied fields record shorter completion times. In the following chapter, I consider the influence of student demographics on doctoral time-to-degree.

Chapter 8 | The role of student demographics in time-to-degree

In this chapter, I investigate the relationship of selected student demographics with timely completion. Numerous studies have placed the emphasis on student demographics in explaining differences in time-to-degree. Early models of student success, were largely based on student characteristics and personal attributes (Aljohani, 2016). The preponderance of studies of doctoral students in South Africa, therefore, is limited to analyses of the effect of student demographics on timely completion. In Chapter 4, I reviewed these studies and more that investigated doctoral time-to-degree by means of demographic variables. In this chapter, I then examine whether there exist significant differences in the mean time-to-degree among demographic sub-groups and whether the results are congruent with the empirical findings of existing studies. Using the HEMIS data, I calculate doctoral time-to-degree of graduates by gender, race, nationality and age. Guided by the research problem of this study, these analyses are done both within and across disciplines. In other words, the descriptive statistics presented in this section explores whether there are differences in timely completion between disciplines and across demographic variables and whether these differences are replicated in the five selected disciplines.

8.1 Gender as an influencing factor on time-to-degree

In the literature, I found contrasting views on the relationship between gender and timely degree completion. There are studies that suggest male doctoral students take less time than their female counterparts to complete their studies (ASSAf, 2010; Bourke et al., 2004a; Jiranek, 2010; Sowell, Allum & Okahana, 2015), while others suggest that there are no significant gender differences in doctoral degree attainment (HEFCE, 2005; Mouton, Valentine & Van Lill, 2017; Seagram, Gould & Pyke, 1998). I state my null hypothesis below.

H_0: There is no statistically significant difference in the mean time-to-degree of male and female doctoral candidates.

$H_0: \mu_1 = \mu_2$

Where μ_1 is the mean time-to-degree of female students and μ_2 is the mean time-to-degree of male students.

First, within each of the five selected disciplines, I tested whether there are statistically significant differences in time-to-degree between male and female students and second, time-to-degree of all female and male students were compared across the five disciplines.

Intra-disciplinary comparisons

In electrical engineering and sociology, male graduates recorded shorter time-to-degree than female graduates, while in physics, education and the clinical health sciences, female graduates recorded shorter time-to-degree. An independent samples t-test revealed no statistically significant differences in male and female time-to-degree for graduates within education, electrical engineering, the clinical health sciences and physics. Among graduates in sociology, male graduates (4.48 $\pm$ 1.871) recorded a statistically significantly shorter mean time-to-degree than female graduates (5.05 ± 1.920; p=.006; r=.014). The results are displayed in Table 8-1 below.

Table 8-1 Male and female mean time-to-degree compared within five disciplines

		Male	Female	Results
Education	n	869	1002	-
	Mean*	4.29	**4.23**	
	Std. dev.	1.561	1.595	
Electrical engineering	n	299	35	-
	Mean*	**4.22**	4.63	
	Std. dev.	1.397	1.555	
Clinical health sciences	n	264	303	-
	Mean*	4.70	**4.68**	
	Std. dev.	1.935	1.738	
Physics	n	288	57	-
	Mean*	4.59	**4.42**	
	Std. dev.	1.575	1.499	
Sociology	n	185	155	t=2.767; p = .006 r = .014
	Mean*	**4.48**	5.05	
	Std. dev.	1.871	1.920	

*Means B used

Inter-disciplinary comparisons

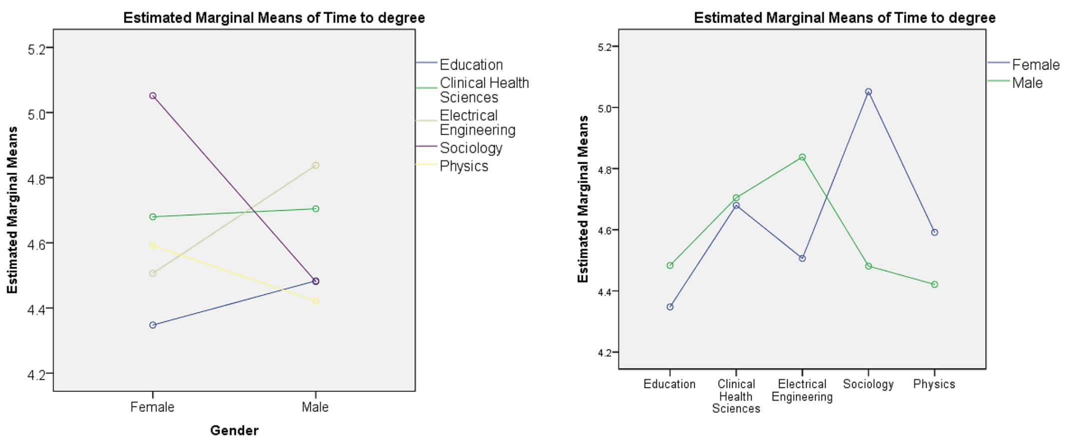
Subsequently, I found statistically significant differences in the average time-to-degree across the five disciplines using a one-way ANOVA[71] with female mean time-to-degree as statistically significantly shorter[72] in education (4.35 ± 1.755) compared to sociology (5.05 ± 1.920; p=.000) and the clinical health sciences (4.68 ± 1.738; p=.081). The test was repeated for male graduates and male graduates in physics recorded the shortest time-to-degree of the five disciplines analysed, but the differences between the disciplines are small and were not statistically significant. The results are presented in the table below.

Table 8-2 Mean time-to-degree of male and female graduates compared across five disciplines

	Discipline	n	Mean	Std. dev.	Sig.
Female	Education	1024	**4.35**	1.755	p=.081; p=.000
	Clinical health sciences	303	4.68	1.738	p=.081
	Electrical engineering	37	4.84	1.756	-
	Sociology	155	5.05	1.920	p=.000
	Physics	57	4.42	1.499	-
	Results				F=6.881; p=.000; partial η^2=.017

[71] For female graduates, the homogeneity of variances was violated (p=.002) as tested by Levene's test and between-group differences were significant as tested by Welch and Brown Forsythe (p=.000).

[72] A two-way ANOVA was conducted to see whether there exists an interaction effect between gender and discipline on mean time-to-degree. For this test, I used the transformed data (means C). Notwithstanding the efforts made to exclude outliers (by excluding cases more than ten years), outliers were still present. These are illustrated though boxplots. The assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances, p = .045. There was a statistically significant and disordinal interaction between gender and discipline for time-to-degree, F(4, 3536)=3.198, p =.012, partial η^2 =.004. These results are presented in the figures below.



	Discipline	n	Mean	Std. dev.	Sig.
Male	Education	902	4.48	1.822	-
	Clinical health sciences	264	4.70	1.935	-
	Electrical engineering	318	4.50	1.769	-
	Sociology	185	4.48	1.871	-
	Physics	57	**4.42**	1.499	-

Discussion

Testing for statistically significant differences in time-to-degree between male and female graduates *within* each of the selected disciplines yielded mixed results. In electrical engineering and sociology, male graduates recorded a shorter time-to-degree than female graduates, while in physics, education and the clinical health sciences, female graduates recorded a shorter time-to-degree. Statistically significant differences were only found for graduates in sociology. My results, therefore, echo the ambiguity which is found in the literature in that in certain cases, here referring to graduates in sociology, there is evidence for differences in timely completion among the genders, while in others there are not (Ampaw & Jaeger, 2012; Mouton, Valentine & Van Lill, 2017; Seagram, Gould & Pyke, 1998; Wright & Cochrane, 2000). When we look at differences across the five disciplines, once again (female) graduates in education recorded statistically significant shorter time-to-degree than graduates in the clinical health sciences and education. For male graduates, the differences in time-to-degree between education, physics and sociology are inconsequential, but male graduates in physics took slightly shorter in completing their degrees.

In both the literature and the findings reported above, I found mixed results on gender differences in doctoral time-to-degree. In Chapter 6, I found that female students are still vastly underrepresented in electrical engineering and physics in South Africa. Some studies have attempted to explain low female membership in some disciplines along gender socialisation (Eccles, 2007). Others have attributed the shortage of women in the STEM sciences to negative stereotypes about females in these fields while others suggest that male and female students have differing value systems which inform their choice of academic disciplines (Berg & Ferber, 1983; England et al., 2007). Some even suggest that there are innate differences between men and women which guide female students' decision-making processes *vis-à-vis* their graduate experience (Berg & Ferber, 1983; Eccles, 2007). In cases where we witness slower completion rates among female graduates, we should aim towards a more nuanced understanding. The most evident, and perhaps overplayed explanation points to child-related activities and responsibilities in the domestic sphere. The quote below illustrates a situation of a female graduate in the social sciences.

> Though I have a 2-year-old son and am pregnant again, and despite the 'disapproval' of the department and supervisor, I don't think that pregnancy or children should be considered a hindrance, but at the same time, there also needs to be recognition that being a woman who is a mother changes the ways in which a person operates. – social sciences

This quote speaks to the child-caring responsibilities of women which some posit as a possible hindrance to timely completion (Maher, Ford & Thompson, 2004). Although child-rearing activities are considered a more poignant explanation for gendered differences in degree attainment, it is important to note that one cannot extend this explanation to all female students. Authors such as Snyder and Portnoi point to more systemic challenges facing females in academia (Portnoi, 2009; Snyder, 2014). The authors argue that women often have greater difficulty entering roles from which they have historically been excluded. Although the number of female doctoral enrolments is on the rise, both internationally (Herzig, 2004) and domestically, I found, in Chapter 6, that the proportional share of female graduates in disciplines such as electrical engineering and physics has hardly increased over the past 15 years. This seems to suggest that women in these fields are still facing significant blockages in degree attainment in these disciplines.

Berg and Ferber suggest that female students often lack female mentors which may contribute to differences in degree success (Berg & Ferber, 1983). Understanding why gendered differences in degree attainment exist is a complex task. Herzig considers the works of Tinto and the like in attributing gendered differences to limited intellectual and social integration on the part of female graduates in predominantly male fields (Herzig, 2004). We can, however, extend this argument, and many have, to the experience of minority groups, or in South Africa's case, black students. A study on women in physics in South Africa reiterates this point in suggesting that "… many of the issues of women in physics in South Africa parallel those of black physicists" (Diale et al., 2009). Looking at the results presented above there is limited evidence for differences in time-to-degree between male and female graduates in the five selected disciplines. I might, therefore, infer that the barriers to timely completion as identified through this analysis, are shared by both male and female students.

8.2 Race

Investigating race as a determinant of time-to-degree, in the South African context is challenging. As discussed in Chapter 3, a number of authors argue that minority students face challenges in their candidacies related to isolation, marginalisation and integration (Herman, 2011b; Portnoi, 2009). This include covert institutionalised racism and financial challenges. For many black African students in South Africa, they are also the first of their families to pursue tertiary studies and these students often experience a dissonance in value systems. Cross-country comparisons of time-to-degree by race are difficult given the peculiarities of the South African social fabric. The history of black disenfranchisement in South Africa has created a majority group with minority characteristics. Events in the past few years have brought to light the plight of black South Africans to culturally identify with higher education syllabi[73]. Similarly, given the high proportion of international black students at South African institutions, it was difficult to isolate race as a determinant of doctoral time-to-degree without considering nationality[74]. However, below I investigated whether there exist differences in time-to-degree of doctoral graduates by race. I state my null hypothesis below.

H_0: There are no statistically significant differences in the mean time-to-degree of students by race.

$H_0: \mu_a = \mu_b = \mu_c = \mu_d$

Where μ_a is the mean time-to-degree of white students and μ_b is the mean time-to-degree of black African students and μ_c is the mean time-to-degree of coloured students and μ_d is the mean time-to-degree of Indian/Asian students.

The first comparison was done between racial groups in each individual discipline. Thereafter, the average time-to-degree of all black African students were compared across disciplines. This test was repeated for white students[75].

[73] This refers to the *Fees Must Fall* movement circa 2014 and the subsequent call for the decolonialisation of higher education in South Africa.
[74] In Chapter 11, I controlled for the interaction between race and nationality in the regression model.
[75] I did not repeat the test for coloured or Indian/Asian students due to the small number of cases in each field.

Intra-disciplinary comparisons

White students in engineering, physics and sociology recorded the shortest mean time-to-degree while coloured students in education and the clinical health sciences recorded shorter completion times. The results are summarised in Table 8-3 below.

Table 8-3 Mean time-to-degree of graduates by race within five disciplines

		Black African	White	Indian/Asian	Coloured	Results
Education	n	814	735	187	132	F=4.251 p=.005 Partial η^2=.007
	Mean	4.35	4.14	4.50	**4.08**	
	Std. dev.	*1.563*	*1.594*	*1.594*	*1.534*	
	Results	p=.080	p=.080 p=.053	p=.053	-	
Electrical engineering	n	72	216	28	15	-
	Mean	4.35	**4.19**	4.43	4.73	-
	Std. dev.	*1.189*	*1.518*	*1.289*	*1.223*	-
Clinical health sciences	n	134	323	76	29	-
	Mean	4.88	4.54	5.14	**4.52**	-
	Std. dev.	*1.599*	*1.724*	*2.146*	*1.724*	-
Physics	n	176	134	23	9	-
	Mean	4.69	**4.39**	4.57	5.00	-
	Std. dev.	*1.560*	*1.511*	*1.779*	*1.871*	-
Sociology	n	181	122	16	20	-
	Mean	4.77	**4.69**	**4.69**	4.85	-
	Std. dev.	*1.813*	*2.093*	*1.991*	*1.725*	-

*Means B used

I found that there exist statistically significant differences in time-to-degree between racial groups in education (p=.005; partial η^2 = .007). with black African graduates (4.35 ± 1.563) and Indian/Asian (4.50 ± 1.594; p=.053) graduates recording statistically significantly longer time-to-degree when compared to white graduates (4.14 ± 1.594). In all other disciplines no statistically significant differences were found in the average time-to-degree of racial groups.

Inter-disciplinary comparisons

The mean time-to-degree of black African students were compared across disciplines through a one-way ANOVA[76]. Using the transformed data, post-hoc Games-Howell tests showed that mean time-to-degree was statistically significantly shorter for black African graduates in education (2.08 ± 0.415) when compared to the clinical health sciences (2.14 ± 0.417; p=.037)[77]. The test was reproduced for white graduates, and white graduates in education (2.02 ± 0.419) recorded statistically significantly shorter time-to-degree when compared to white graduates in the clinical health sciences (2.09 ± 0.427; p=.093)[78]. In the table below I present the results of both the original and transformed data.

Table 8-4 Mean time-to-degree of white and black African graduates compared across five disciplines

Race	Discipline	n	Mean	Std. dev.	Sig.	Mean	Std. dev.	Sig.
			Original data			Transformed data		
Black African	Education	841	**4.51**	1.79	-	**2.08**	0.416	p=.037
	Clinical health sciences	134	4.88	1.60	-	2.18	0.356	p=.037
	Electrical engineering	74	4.46	1.36	-	2.09	0.318	-
	Sociology	181	4.77	1.81	-	2.14	0.417	-
	Physics	180	4.67	1.58	-	2.13	0.361	-
	Results			-		F=2.482; p=.042; partial η^2=.007		
White	Education	750	**4.25**	1.759	-	**2.02**	0.419	p=.093
	Clinical health sciences	323	4.54	1.837	-	2.09	0.427	p=.093
	Electrical engineering	233	4.54	1.928	-	2.08	0.442	-
	Sociology	122	4.69	2.093	-	2.11	0.479	-
	Physics	142	4.43	1.564	-	2.07	0.364	-
	Results			-		F=2.923; p=.020; partial η^2 =.007		

Discussion

The findings reported above show that the differences in time-to-degree within disciplines based on a student's race, with the exception of graduates in education, are not statistically significant which

[76] Homogeneity of variances was violated (p=.000) and between-group differences were significant as tested by Welch and Brown Forsythe (p<.050).

[77] A two-way ANOVA was run to test whether there exists an interaction effect between race and discipline on mean time-to-degree, but no statistically significant results were found.

[78] I did not replicate the test for coloured and Indian/Asian students given the small number of cases in each discipline.

suggest that race is not a significant determinant of timely completion. There were also no clear trends within disciplines to suggest that graduates of one race are more likely to complete in less time than others. I did, therefore, not find substantial evidence, except for graduates in education, to reject the null hypothesis that there are no statistically significant differences in doctoral time-to-degree between racial groups. My findings, however, do not correspond with that found by the CHE and the ASSAf reports which found that black African students had slightly shorter time-to-degree when compared to white students (ASSAf*,* 2010; CHE, 2009). In fact, in none of my disciplines did black African students record the shortest time-to-degree.

Testing for differences of black African graduates *across* the five disciplines, I once again found that (black African and white) graduates in education had statistically shorter completion times when compared to graduates in the clinical health sciences. I have mentioned that investigating the role of race on timely completion is difficult considering that within the (South) African context, race and nationality are associated. In testing for differences in mean time-to-degree across race, I did not make a distinction between black African graduates who are South African and those who are not, due to the statistically insignificant results found in the analyses here. In Chapter 11, however, both race and nationality were included in the regression model.

8.3 The nationality of students as a determinant of time-to-degree

In Chapter 6, I found that a high proportion of black African doctoral students at South African institutions are international students. Cultural dissimilarities, linguistic challenges, funding, etc. can prove challenging to foreign doctoral success, however, studies in the literature found that foreign students (non-nationals) often record shorter time-to-degree compared to their domestic counterparts (ASSAf*,* 2010; Jiranek, 2010; Sowell, 2008). I state my null hypothesis below.

H_0: There is no statistically significant difference in the mean time-to-degree of international and South African students.

$$H_0: \mu_e = \mu_f = \mu_g$$

Where μ_e is the mean time-to-degree of South African students and μ_f is the mean time-to-degree of students from the rest of Africa and μ_g is mean time-to-degree of students from the rest of the world.

First, an intra-disciplinary analysis was done to test for significant differences between graduates from South Africa, the rest of Africa and the rest of the world. Subsequently, a comparison of all students from the rest of Africa was done across the five disciplines. This was repeated for students from South Africa and students from the rest of the world.

Intra-disciplinary comparisons

One-way ANOVA tests between the mean time-to-degree of graduates from South Africa, the rest of Africa and rest of the world were done to test if the differences in mean time-to-degree are statistically significant. In education and sociology, graduates from the rest of Africa recorded the shortest time-to-degree while in electrical engineering, the clinical health sciences and physics, students from the rest of the world recorded the shortest completion times. However, in all five disciplines the differences in time-to-degree are small and no statistically significant between-group differences in time-to-degree was found. The results are summarised in Table 8-5 below.

Table 8-5 Mean time-to-degree of graduates from South Africa, RoA and RoW compared within five disciplines

		South Africa	Rest of Africa	Rest of world
Education	n	1453	344	61
	Mean	4.27	**4.25**	4.31
	Std. dev.	1.588	1.503	1.718
Electrical engineering	n	237	66	28
	Mean	4.23	4.42	**4.21**
	Std. dev.	1.505	1.216	1.134
Clinical health sciences	n	440	78	33
	Mean	4.74	4.71	**4.24**
	Std. dev.	1.845	1.660	1.871
Physics	n	209	110	18
	Mean	4.60	4.53	**4.44**
	Std. dev.	1.647	1.425	1.464
Sociology	n	193	111	25
	Mean	4.77	**4.73**	4.92
	Std. dev.	2.059	1.678	1.891

Inter-disciplinary comparisons

Mean differences were tested through a one-way ANOVA for statistical significance of graduates from the rest of Africa and the rest of the world and no significant results were found. The test was repeated for graduates from South Africa[79] and showed that South African graduates in the clinical health sciences recorded statistically significantly longer time-to-degree (2.12 ± 0.591) when compared to education (1.99 ± 0.541; p=.000) and electrical engineering (1.99 ± 0.545; p=.027)[80]. The results are presented in the table below.

Table 8-6 Mean time-to-degree of graduates by nationality compared across five disciplines

		n	Mean	Std. dev.	Sig.	n	Mean	Std. dev.	Sig.
		Original data				Transformed data			
SA	Education	1503	**4.45**	1.827	-	1679	**1.99**	0.541	p=.000
	Clinical health sciences	440	4.74	1.845	-	491	2.12	0.591	p=.000 p=.027
	Electrical engineering	256	4.58	1.916	-	287	1.99	0.545	p=.027
	Sociology	193	4.77	2.059	-	231	2.06	0.652	-
	Physics	219	4.59	1.679	-	240	2.06	0.507	-
	Results	F=3.077; p=.015; partial η^2 = .005				F=6.038; p=.000; partial η^2=.008			
RoA	Education	348	**4.30**	1.578	-	348	**2.04**	0.378	-
	Clinical health sciences	78	4.71	1.660	-	78	2.14	0.368	-
	Electrical engineering	67	4.48	1.283	-	67	2.09	0.304	-
	Sociology	111	4.73	1.678	-	111	2.14	0.391	-
	Physics	112	4.54	1.457	-	112	2.11	0.332	-

Discussion

Although statistically significant differences in the average time-to-degree of graduates were found in education only, international students (from the rest of Africa and the rest of the world) recorded the lowest average time-to-degree in all five disciplines. This finding supports results found in South Africa (ASSAf, 2010), Australia (Jiranek, 2010), and the UK (Park, 2005a; Wright & Cochrane, 2000) which suggest that foreign students often finish their candidacies in less time than their domestic

[79] Homogeneity of variances was violated, and group differences were significant (Welch and Brown-Forsythe p=.000; partial η^2 =0.82).

[80] A two-way ANOVA was conducted to test the effect of nationality and discipline on mean time-to-degree and showed no significant interaction effect.

counterparts. The quote below sheds light on why international students might complete their doctorates faster than domestic students.

> I am employed by another university (on another continent) and have had to take long unpaid leave in order to enrol for this degree. On completion of the degree, I will have to return to my home country and resume my employment at my home institution (Also because my current South African student permit will not allow me to find full-time employment in this country). – health sciences

International students are also not allowed to hold employment positions while studying in South Africa.

> [A]s a foreign national, I am not permitted to work outside of the university, which in my current position, is not necessary. – social sciences

> [A]vailability of employment [is] not possible for non-permanent residents. – social sciences

These restrictions, one can argue, enable foreign students to concentrate on their studies fully. One of the most likely explanations of shorter time-to-degree of international students is that that foreign students are subject to visa requirements which make timely completion crucial (Jiranek, 2010). Similarly, as can be seen in the quote above, often international students are granted study leave by their employers for a set period of time. Jiranek also suggests that the admission requirements for foreign students are competitive which often leads to high-quality international students accepted into doctoral programmes (Jiranek, 2010).

Looking at differences in time-to-degree across the five disciplines, South African students in education and electrical engineering recorded a statistically significant shorter time-to-degree when compared to the clinical health sciences. For graduates in education, I could reject the null hypothesis, while for the remaining four disciplines, no statistically significant differences in time-to-degree were found.

8.4 Age at enrolment of doctoral students in exploring time-to-degree

There is a consensus in the literature that age is an important determinant of doctoral time-to-degree. In South Africa, Mouton found a strong correlation between age and doctoral time-to-degree in that older students often take longer to complete their studies when compared to their younger counterparts (Mouton, 2011). Similarly, ASSAf identified age as a risk factor in doctoral completion

(ASSAf, 2010). In the UK, HEFCE found similar results (HEFCE, 2005; Park, 2005a). I state my null hypothesis below.

H_0: There is no significant difference in the mean time-to-degree between students in four age groups.

$H_0: \mu_m = \mu_n$

Where μ_m is the mean time-to-degree of students younger than 40 years and μ_n is the mean time-to-degree of students aged 40 years and older.

In Chapter 6, I found that the average age of doctoral students differs significantly in the five disciplines. Doctoral graduates were classified into four age categories (quartiles) guided by the distribution of their age at enrolment within each discipline and I tested for whether differences in mean time-to-degree were statistically significant[81]. I found that for graduates in education and

[81] Mean time-to-degree of doctoral graduates in four age categories of five disciplines

Discipline		Age categories				Results
Education		≤ 37 years	38-43 years	44-48 years	≥ 49 years	p=.050 partial η² = 0.42
	n	468	517	413	473	
	Mean	4.28	4.37	4.29	**4.10**	
	Std. dev.	*1.499*	*1.638*	*1.595*	*1.57*	
			p=.037	p=.037		
Electrical engineering		≤ 25 years	26-29 years	30-35 years	≥ 36 years	p=.001 partial η² = 4.87
	n	79	88	82	85	
	Mean	4.03	**4.00**	4.24	4.79	
	Std. dev.	*1.441*	*1.295*	*1.411*	*1.407*	
		p=.007	p=.003		p=.007; p=003	
Clinical health sciences		≤29 years	30-36 years	37-45 years	≥46 years	-
	n	151	142	157	117	
	Mean	4.91	4.73	4.61	**4.49**	
	Std. dev.	*1.683*	*1.759*	*1.789*	*2.124*	
Physics		≤25 years	26-28 years	29-33 years	≥34 years	-
	n	76	97	99	86	
	Mean	**4.39**	4.49	4.69	4.65	
	Std. dev.	*1.396*	*1.508*	*1.701*	*1.720*	
Sociology		≤31 years	32-37 years	38-43 years	≥44 years	-
	n	99	77	75	88	
	Mean	4.94	4.92	4.75	**4.39**	
	Std. dev.	*1.725*	*2.114*	*1.817*	*1.974*	

electrical engineering, there were statistically significant differences across age groups. In education, students aged 49 years and older recorded a shorter time-to-degree, while in electrical engineering, students aged between 26 and 29 years recorded the shortest time-to-degree. In the other three disciplines there were no statistically significant differences between the respective age groups. However, it was difficult to compare the results across the five disciplines given the different age categories. Subsequently, I classified doctoral students' age at enrolment as those younger than 40 years and those aged 40 years and older. This classification was guided by the mean and median age of all graduates in five disciplines as 39.6 years and 39 years respectively.

Intra-disciplinary comparisons

The differences in mean time-to-degree of graduates younger than 40 years and those aged 40 years and older within the five disciplines were tested for statistical significance using independent samples t-tests. The results are presented in the table below.

Table 8-7 Mean time-to-degree of graduates younger than 40 years and graduates 40 years and older in five disciplines

		Age categories		Results
		<40 years	≥40 years	
Education	n	634	1237	-
	Mean	4.31	**4.24**	
	Std. dev.	*1.511*	*1.614*	
Electrical engineering	n	280	54	t=-2.387; p=.018; r = .013
	Mean	**4.19**	4.69	
	Std. dev.	*1.404*	*1.425*	
Clinical health sciences	n	352	215	t=2.273; p=.024; r = .011
	Mean (transformed)	2.16	**2.07**	
	Std. dev.	*0.396*	*0.454*	
Physics	n	311	34	-
	Mean	**4.55**	4.68	
	Std. dev.	*1.559*	*1.609*	
Sociology	n	204	135	t=2.230; p=.026; r = .012
	Mean	4.94	**4.47**	
	Std. dev.	*1.865*	*1.946*	

For graduates in education and physics, the differences in mean time-to-degree were not statistically significant. However, graduates in education aged 40 years and older recorded slightly shorter time-to-degree than younger graduates. Similarly, older graduates in the clinical health sciences (t=2.273; p=.024; r=.011) and sociology (t=2.230; p=.026; r =.012) recorded statistically significant shorter time-to-degree when compared to graduates younger than 40 years. In all three disciplines where statistically significant results were found, the effect size as measured by r is large (Cohen, 1988) which suggests that age is an important determinant of differences in time-to-degree. In physics and electrical engineering, the overwhelming majority of graduates are younger than 40 years and also recorded shorter time-to-degree compared to older graduates, although the differences were only statistically significant for graduates in electrical engineering (t=-2.387; p=.018; r=.013).

Inter-disciplinary comparisons

A one-way ANOVA test was conducted to test whether graduates aged younger than 40 years' mean time-to-degree differed significantly between the five disciplines[82]. Statistically significant differences in time-to-degree were found between graduates in education and the clinical health sciences (p=.000) and sociology (p=.079), while differences in the mean time-to-degree of students in the clinical health sciences were statistically longer compared to students in education (p=.000), electrical engineering p=.000) and physics (p=.045). I found that graduates younger than 40 years recorded the shortest time-to-degree of the five disciplines studied with a large effect size (partial η^2>.010).

Table 8-8 Mean time-to-degree of graduates in two age categories compared across five disciplines

		n	Mean	Std. dev.	Sig.
<40 years	Education	702	4.39	2.231	p=.000 p=.079 p=.000
	Clinical health Sciences	373	5.13	2.640	p=.000 p=.045
	Electrical engineering	333	**4.29**	2.186	p=.000 p=.052
	Sociology	228	4.91	2.634	p=.079 p=.052
	Physics	346	4.58	2.060	p=.045
	Results				F=8.565; p=.000; partial η^2=.017
≥ 40 years	Education	1461	**4.07**	2.183	-
	Clinical health sciences	252	4.18	2.489	-
	Electrical engineering	61	4.38	1.800	-
	Sociology	163	4.17	2.614	-
	Physics	44	**4.07**	2.317	-

[82] Homogeneity of variances was met, and group differences were significant (Welch and Brown-Forsythe p=.000; partial η^2 =1.70). Post-hoc Scheffe tests showed three homogenous subsets.

When I tested for statistical significance in the differences in time-to-degree of graduates aged 40 years and older across the five disciplines, I found insignificant results. In the original data, graduates in education and physics recorded the shortest time-to-degree. The transformed data showed that graduates in education recorded slightly shorter time-to-degree although the differences are insubstantial.

Discussion

The null hypothesis can be rejected for graduate students in electrical engineering where students aged 40 years and older recorded significantly longer time-to-degree compared to students younger than 40 years. This supports results found by Mouton who found that in his study of doctoral time-to-degree, students younger than 30 years recorded the shortest time-to-degree which increased incrementally with an age bracket of approximately ten years (Mouton, 2011). Students aged 50 years and older took on average 2.1 years longer to complete their degrees compared to students younger than 30 years. Reasons for longer time-to-degree recorded for older students in electrical engineering might be due to the fact that older students are more likely to be employed full-time while studying. Older students are also more likely to experience challenges in balancing study, work and family commitments. However, for graduates in sociology and the clinical health sciences and education (although results are not statistically significant for graduates in the latter field), I found an unexpected result in that older students (aged 40 years and older) recorded *shorter* average time-to-degree than younger students which is incongruent with that found in the literature (ASSAf, CHE, 2009; Mouton, 2011, Mouton et al., 2015). A possible explanation for this result can only be speculated. In Chapter 6, I found that the average age of graduates in education and the clinical health sciences was older than the national average and that of graduates in physics and electrical engineering. I suggested that students in the aforementioned fields are more likely to be professionals who pursue doctorates to further their careers. Perhaps the rationale for pursuing a doctorate and the expected return on investment in more professional fields such as education and the clinical health sciences, are enablers for timely completion. In Chapter 10, the rationale for doing a PhD as a dispositional factor is investigated, but its measurability was limited.

Examining the differences in time-to-degree of graduates in two age categories between the five disciplines, I found that the results varied. The transformed data showed that for both age groups, graduates in education recorded shorter time-to-degree, but the differences in actual time-to-degree were small. The investigation of age as a determinant of time-to-degree indicates that there are significant differences between younger and older students although the significance of these differences differs across disciplinary fields.

8.5 Conclusion

In this chapter, I explored the role of demographic factors in time-to-degree in addressing the second research question of this study. Within each of the five disciplines, I investigated whether gender, race, nationality and age are associated with timely completion. Subsequently, within each demographic subgroup, I measured whether there exist differences between disciplines.

Within disciplines, I found mixed results with regard to the role of gender in time-to-degree. In electrical engineering and sociology, male graduates recorded shorter time-to-degree than female graduates, while in physics, education and the clinical health sciences, *female* graduates recorded shorter time-to-degree. Statistically significant differences were only found for graduates in sociology. The results, therefore, echo the ambiguity which is found in the literature in that in certain cases, here referring to graduates in sociology, there is evidence for differences in timely completion among male and female students, while in others there are not. In the table below I summarise the statistically significant results of the role of student characteristics on doctoral-time-to-degree.

Table 8-9 Summary of statistically significant results of the role of student characteristics on doctoral time-to-degree within disciplines

Factor	Education	Electrical engineering	Clinical Health Sciences	Physics	Sociology
Gender	-	-	-	-	Female students' time-to-degree statistically significant shorter than male time-to-degree (p=.006; r=0.14)
Race	Coloured students' time-to-degree statistically significant shorter than other race groups (p=.005; partial η2=.007)	-	-	-	-
Nationality	-	-	-	-	-

Factor	Education	Electrical engineering	Clinical Health Sciences	Physics	Sociology
Age	Younger students' (<40 years) time-to-degree statistically shorter than older students (p=.018; r=.013)	-	Older students' (≥40 years) time-to-degree statistically shorter than younger students (p=.024; r=.011)	-	Older students' (≥40 years) time-to-degree statistically shorter than younger students (p=.026; r=.012)

An investigation of race as a factor showed that in four disciplines, there was no statistical evidence to suggest that graduates of one race are more likely to complete in less time than others. Except for graduates in education where coloured students recorded significantly shorter time-to-degree, I could not reject the null hypothesis. Analyses within disciplines also yielded no statistically significant differences in time-to-degree among South African and international students (from the rest of Africa and rest of the world).

Lastly, in my analysis of age as a significant factor in time-to-degree, I found unexpected and mixed results. Contrary to what is found in the literature, younger graduates recorded shorter time-to-degree in only two of the five disciplines. In electrical engineering and physics, younger graduates took less time to complete their studies. In education, the clinical health sciences and sociology, however, younger graduates recorded (statistically significantly) *longer* time-to-degree compared to their older counterparts.

Interdisciplinary comparisons within demographic subgroups showed that among female graduates, those in education recorded the shortest time-to-degree while for male graduates, those in physics took less time to complete their studies. Looking at race shows that for both black African and white students, graduates in education recorded the shortest time-to-degree where the differences in mean time-to-degree between the clinical health sciences were statistically significant. An interdisciplinary comparison with South African and graduates from the rest of Africa yielded analogous results. Finally, younger students in electrical engineering recorded significantly shorter time-to-degree when compared to education, the clinical health sciences, and sociology while older students in education recorded slightly shorter completion times.

Table 8-10 Summary of the role of student characteristics on doctoral time-to-degree between disciplines

Factor		Results
Gender	Female	Statistically significant between group differences (p=.000; partial $\eta 2$=.017)
	Male	No significant differences.

Factor		Results
Race	Black African	Statistically significant between group differences ($p=.042$; partial $\eta 2=.007$)
	Coloured	No significant differences.
	Indian/Asian	No significant differences.
	White	Statistically significant between group differences ($p=.042$; partial $\eta 2=.007$)
Nationality	South African	Statistically significant between group differences ($p=.000$; $\eta 2=.008$)
	Rest of Africa	No significant differences.
	Rest of World	No significant differences.
Age	<40 years	Statistically significant between group differences ($p=.000$; partial $\eta 2=.017$)
	≥ 40 years	No significant differences.

In this chapter, by means of descriptive statistics, I investigated differences in time-to-degree along student demographics *within* the five selected disciplines. In Chapter 11, I conclude the empirical analyses with a linear regression model where I aim to predict factors that explain timely completion. I also investigate the relationships and interconnectedness of selected factors as a robustness check to find if the results found here are replicated when controlling for related factors such as race and nationality.

In the following chapter, I continue the analysis on exploring the relationship of institutional factors, particularly throughput rates and the supervisory capacity, on doctoral time-to-degree.

Chapter 9 | The role of institutional factors in time-to-degree

In this chapter, I consider institutional factors in investigating the relationships of selected contextual factors with doctoral time-to-degree. In the first section of the chapter, I calculate average throughput rates as an efficiency indicator. The average throughput rates of doctoral students of the five selected disciplines are compared, while also comparing the disciplinary rates to the national average. Subsequently, I determine average institutional throughput rates of South African institutions. Here the use of throughput rates acted as a proxy for completion rates, which due to methodological constraints, could not be calculated for individual institutions. Average institutional throughput rates are used to investigate whether there exists a relationship between throughput rates and average time-to-degree across South African institutions.

The latter half of the chapter is devoted to supervisory capacity. I conceptualise and determine the doctoral supervisory capacity within the five selected disciplines. I compare the supervisory capacity across the five disciplines as well as with the national data. In a similar fashion, I determine the supervisory capacity of South African universities across the five disciplines selected. In comparing the supervisory capacity between disciplines, I investigate whether there exists an association between the supervisory capacity of academic institutions and average time-to-degree.

9.1 Throughput rate as an efficiency indicator

In Chapter 3, I discussed the use of descriptive indicators in doing research on doctoral education. There is little consensus about the definition, operationalisation and application of these indicators throughout the literature. As previously mentioned the terms “throughput rates”, “completion rates” and “graduation rates” are often used interchangeably. In Chapter 5, I discussed the limitations of the HEMIS data in calculating institutional completion rates and suggested that average throughput rates are used instead. This non-specific indicator measures the proportion of students leaving the system to those remaining within the system. As explained in Chapter 5, throughput rates were calculated as the percentage of doctoral graduates to doctoral enrolments in a given year. In the next section, I report on the average throughput rate of doctoral students per discipline while also comparing disciplinary throughput rates with the national average.

9.1.1 Average throughput rates of five disciplines

The throughput rates of the five selected disciplines were calculated for three five-year periods, 2000 to 2004, 2005 to 2009, and 2010 to 2014. In Table 9-1 below I present these rates and an average disciplinary throughput rate over the total period studied. The average national throughput rate (percentage of graduates to enrolments) of students across all disciplines was 12.6%. The rate varied slightly between the three five-year periods. Looking at the average throughput rate of the five selected disciplines, physics recorded the highest average throughput rate of 13.6% for the entire period, followed by education, 13% and the clinical health sciences 12.7%. Between 2000 and 2004, I found the highest average throughput rate for students in education, where the clinical health sciences recorded the highest average throughput rate between 2005 and 2009. In the last five-year period, physics recorded a higher average throughput rate when compared to the other disciplines. Sociology consistently recorded the lowest average throughput rates across all three five-year periods.

Table 9-1 Throughput rates of three cohorts compared across five disciplines

	2000-2004	2005-2009	2010-2014	Average
Physics	13.1%	12.1%	**15.5%**	**13.6%**
Education	**13.9%**	12.8%	12.2%	13.0%
Clinical health Sciences	12.4%	**13.0%**	12.8%	12.7%
Electrical engineering	12.7%	11.7%	12.0%	12.1%
Sociology	9.4%	9.5%	10.3%	9.7%
National	*12.9%*	*12.3%*	*12.6%*	*12.6%*

With the exception of physics, there was little variance in the three five-year periods for each of the five disciplines. A problem associated with the use of the throughput rate, however, is that given the small numbers of graduates within disciplines, fluctuations between years are exacerbated. Throughput rates should then, where possible, be interpreted in conjunction with other indicators, such as completion or graduation rates, where more accurate measurements can be used. With respect to completion rates, I found that graduates in physics and the clinical health sciences recorded higher average four-year completion rates and, as found here, higher average throughput rates. In

Table 9-2 below, I summarise the profile of the five selected disciplines by means of four descriptive indicators.

Table 9-2 Pile-up effect, average completion rates and average throughput rates of doctoral students in five disciplines

	Pile-up effect (2014)	Average four-year completion rates	Average seven-year completion rates	Average throughput rate
		%		
Physics	26.8	**27.3**	43.6	**13.6**
Education	**44.9**	23.9	36.9	13.0
Clinical health Sciences	24.6	25.6	**46.2**	12.7
Electrical engineering	23.8	24.3	43.9	12.1
Sociology	38.5	15.8	31.2	9.7
National	*36.0*	*25.0*	*42.2*	*12.6*

In Chapter 6, I found that physics and sociology recorded the lowest pile-up effect, which suggests that the stock of existing enrolments in the system is smaller when compared to other disciplines. However, when we consider the below average throughput rate of students in sociology, it suggests that sociology is less efficient in graduating students when compared to other disciplines. Similarly, when we look at the average five- and seven-year completion rates, I found that graduates in sociology also recorded lower completion rates when compared to the other disciplines.

9.1.2 Institutional throughput rates

Given the small numbers of doctoral graduates per discipline per year, calculating completion rates for academic institutions was unfeasible. I, therefore, used throughput rates as a descriptive efficiency indicator of universities in South Africa. In Table 9-3 the throughput rates of academic institutions in South Africa are reported. In education, NMU recorded the highest throughput rate of 18.3%, followed by SU (15.6%) and UNIZULU (15.2%). In electrical engineering, NMU once again recorded the highest throughput rate of 20% followed by SU (15.7%) and NWU (13.6%). Walter Sisulu University (WSU) recorded the highest throughput rate of 18.5% in the clinical health sciences followed by CPUT (15.5%) and SU (14.9%). In physics, RU had the highest proportion of doctoral graduates to enrolments of 23%, followed by NMU (21.7%) and UFS (16.3%). In sociology, Unisa recorded the highest average throughput rate of 13.5% followed by UL (11.8%) and UFH (11.2%). Across all disciplines, SU and NMU had higher proportions graduates to enrolments. A limitation of the throughput rate, however, is that it is size dependent. Although SU, NMU and Unisa are big universities, all the other universities who recorded high throughput rates are smaller universities who a smaller number of doctoral students.

Table 9-3 Comparison of universities' average doctoral throughput rate of five disciplines (2000 to 2014)

	Education	Electrical engineering	Clinical health sciences	Physics	Sociology
NMU	**18.3**	**20.0**	8.3	21.7	6.6
SU	15.6	15.7	14.9	16.1	10.9
UNIZULU	15.2	-	10.4	14.3	9.8
UJ	14.8	11.8	12.8	8.2	5.8
UFS	14.5	-	11.7	16.3	8.2
DUT	14.3	10.5	12.1	-	-
UCT	14.0	12.2	15.8	12.7	10.4
NWU	13.7	13.6	14.5	11.1	8.1
UFH	13.3	-	-	11.4	11.2
Unisa	13.2	-	-	16.4	**13.5**
RU	13.2	-	-	**23.0**	9.8
UWC	13.1	-	7.2	7.2	9.1
CPUT	12.2	9.0	15.5	-	-
TUT	11.8	9.1	8.6	-	-
UP	11.6	10.8	14.4	11.0	8.4
WITS	11.2	11.8	12.0	15.7	10.4
UKZN	10.0	11.0	9.2	12.4	8.7
UNIVEN	9.0	-	-	-	-
CUT	8.7	12.3	-	-	-
WSU	6.7	-	**18.5**	-	-
UL	5.5	-	7.3	8.5	11.8
VUT	-	8.2	-	-	-

Although there are limitations associated with the use of the throughput rate, it is difficult to find a more robust indicator that would accommodate the small number of cases, particularly with reference to graduates, in each discipline per institution. In the next section, I use the throughput rates reported here to explore whether there exists a relationship between institutional throughput rates and the average doctoral time-to-degree of institutions.

There is no clear policy or strategy pertaining to increasing the efficiency of doctoral education at South African universities. The majority of South African universities state in their institutional or faculty or departmental guidelines, a minimum and maximum doctoral residency as determined by the Senate. Across all universities, the minimum doctoral residency is two years. This means that a doctoral candidate has to be registered for the doctorate for a minimum of two years before the degree can be conferred. In some cases, the minimum residency for part-time students is determined separately. For example at WITS and UKZN, the minimum part-time residency for a part-time doctoral candidate is four years. At UL, in the science faculty, the minimum residency for full-time students is three years and four years for part-time students.

In terms of maximum residency, some universities[83] stipulate a maximum duration for which a doctoral student may be registered. For full-time students, UJ, UFH (both sociology and education departments), UWC and UL state the maximum enrolment time as five years. At UP, TUT, UL (education, sociology and physics department) and NMU, full-time doctorates are allowed four years to complete their degrees. For development studies, NMU offers six years to full-time students, while no clear maximum duration for doctorates at SU, UCT, Unisa and UKZN could be found. For part-time students, UP allows for a six-year and UL a seven-year candidacy. TUT (engineering) and NWU allow part-time students to complete their studies in five years. In many cases, these guidelines are subject to faculty regulations and exemptions may be made by the Senate. The majority of institutional guidelines allow for an extended residency if sufficient motivation is given by the supervisor or department to the Senate after which it may be approved or not.

In the section below, I present the average time-to-degree across institutions in each discipline and investigate whether there is a correlation between throughput rates and time-to-degree.

9.1.3 Institutional throughput rates and time-to-degree

In this section, I investigate whether there is a correlation between higher institutional throughput rates and shorter average time-to-degree by means of a scatterplot. For each of the scatterplots below, the corresponding table is presented in Appendix D. The value presented for the institutional time-to-degree is an *average* of all the graduates' time-to-degree in each selected discipline for the 15-year period. The y-axis represents the average throughput rate as a percentage while the average time-to-degree, in number of years, in plotted on the x-axis.

The average time-to-degree of doctoral graduates in education was calculated per institution and is listed in Appendix D. A one-way ANOVA showed that there exist statistically significant

[83] The information was sourced from the respective universities' websites and yearbooks where available.

differences in the average time-to-degree between institutions (F=8.369; p=.000; partial η^2=.083). In Figure 9-1 below, a scatterplot of the mean time-to-degree of South African academic institutions for each of the five selected disciplines (with more than 50 graduates) for the period 2000 to 2014 were plotted.

In *education*[84], the shortest average time-to-degree of graduates in education was recorded for NMU (3.8 years), while RU and SU followed with 3.9 years. WITS recorded the longest average time-to-degree of doctorates in education (5.5 years). In Figure 9-1 below, I found that institutions with higher average throughput rates generally recorded a shorter mean time-to-degree of graduates in education. NMU, SU and UJ recorded the highest throughput rates and shorter average completion times of under 4.5 years. WITS recorded both a lower throughput rate and longer mean time-to-degree. Excluding WITS from the scatterplot had no effect on the trend line which show that within education, there is an observable association between high average throughput rates and short completion times of graduates.

With regard to institutions in *electrical engineering*[85], a one-way ANOVA showed that the differences in institutional mean time-to-degree are statistically significant (F=4.724; p=.000; partial η^2=.150). Graduates at SU recorded the shortest time-to-degree of 3.4 years, followed by NWU (4.1 years) and UCT (4.4 years). All of the traditional universities plotted recorded the shortest average time-to-degree while TUT, as a university of technology, matched UCT's mean time-to-degree in electrical engineering. UP recorded the longest time-to-degree for graduates in electrical engineering of 5.0 years. Figure 9-1 shows that in electrical engineering, institutions with higher throughput rates generally record shorter average time-to-degree. This is especially evident in the case of SU. TUT, however, appears as an outlier to the trend where both shorter mean time-to-degree and lower average throughput rates were recorded.

[84] In education, only institutions in which there were more than 50 cases were included in the scatterplot.
[85] In electrical engineering, institutions in which there were more than 20 cases were included in the scatterplot.

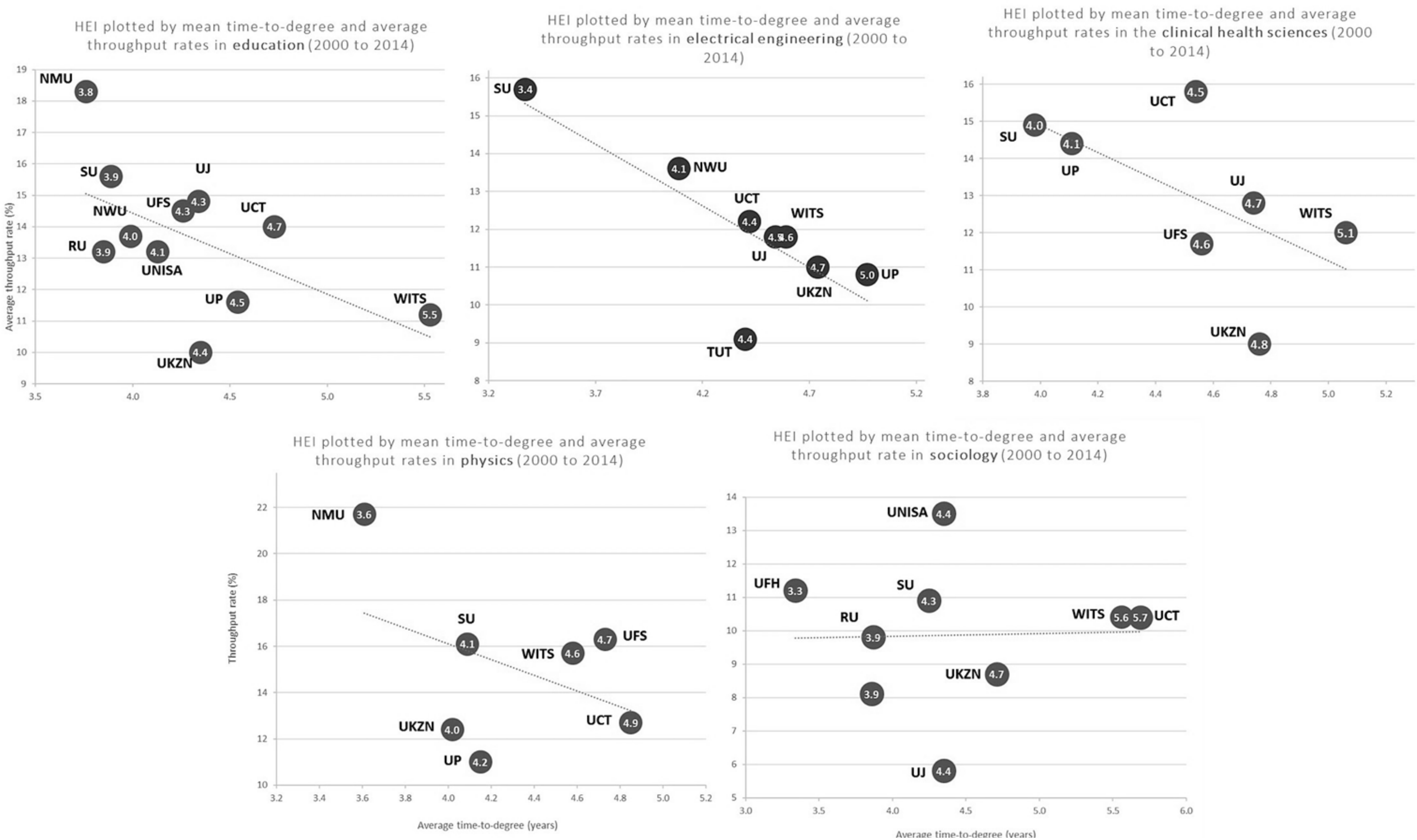


Figure 9-1 Academic institutions' average time-to-degree and average throughput rate plotted for five disciplines (2000 to 2014)

In Figure 9-1 above the average throughput rates and mean time-to-degree of institutions in the *clinical health sciences*[86] were plotted. A one-way ANOVA showed that there are statistically significant differences in the mean time-to-degree of institutions (F=3.011; p=.000; η^2= .072). I found that the shortest time-to-degree was recorded by graduates at SU (4.0 years) followed by UP (4.1 years) and UCT (4.5 years). WITS once again recorded the longest mean time-to-degree for doctoral graduates. A similar result, as was found for institutions in education and electrical engineering, was found for institutions in the clinical health sciences, where I observed a relationship between shorter time-to-degree and higher throughput rates for most institutions. Both SU and UP recorded shorter time-to-degree and higher average throughput rates while UCT and UKZN appear as outliers. UCT had a higher throughput rate and a mean time-to-degree of 4.5 years, while UKZN, recorded both lower throughput rates and longer mean time-to-degree.

Testing for significant differences in the mean time-to-degree of institutions in *physics*[87], I once again found statistically significant differences (F=4.431; p=.000; partial η^2=.148). NMU recorded the shortest time-to-degree of 3.6 years, followed by UKZN, SU and UP UFS. UCT recorded the longest time-to-degree of 4.9 years. In Figure 9-1 above, the average mean time-to-degree and average throughput rates of these institutions are plotted. Consistent with what was found for institutions in previous disciplines, I found, albeit a weaker relationship, between shorter time-to-degree and higher throughput rates for most institutions. Both NMU and SU recorded higher throughput rates and shorter time-to-degree while UKZN and UP recorded shorter time-to-degree, but lower throughput rates.

For institutions in *sociology*[88], a one-way ANOVA showed statistically significant differences in the mean time-to-degree of institutions (F=4.545; p=.000; partial η^2=.153). UFH recorded the lowest time-to-degree at 3.3 years, followed by RU and NMU with 3.9 years. UCT and UFS both recorded the longest times-to-degree with 5.6 and 5.7 years respectively. When plotting the average time-to-degree and average throughput rates of institutions in sociology, as seen in Figure 9-1 above, I did not find the same negative relationship between high throughput rates and short time-to-degree as with the other four disciplines. In fact, I found an inverse of the association (a positive correlation), albeit a weak one, between lower throughput rates and shorter time-to-degree.

[86] In the clinical health sciences, institutions with more than 20 cases were included in the scatterplot.
[87] In physics, institutions with more than 10 cases were included in the scatterplot.
[88] In sociology, institutions with more than 20 cases were included in the scatterplot.

By investigating whether there exists a relationship between throughput rates and average time-to-degree of graduates per institution, I found negative correlations between *higher* throughput rates and *shorter* time-to-degree in education, the clinical health sciences and electrical engineering. For institutions in physics the relationship was less clear, but institutions like NMU and SU, recorded higher throughput rates and shorter time-to-degree. In sociology, however, I found a positive relationship where institutions with *higher* throughput rates generally recorded *longer* average time-to-degree.

In the next section, I discuss the supervisory capacity within the five selected disciplines and for academic institutions per discipline. Subsequently, I explore whether there exists a relationship between the average supervisory capacity and time-to-degree of institutions.

9.2 Supervisory capacity

Statistics on the supervisory capacity, both in South Africa and internationally, are scarce. In Chapter 4, Cloete, Mouton and Sheppard indicated that in 2012, 39% of permanent academic staff at South African universities had a doctorate (Cloete, Mouton & Sheppard, 2015). As per the DHET aggregate staff data, permanent instructional and research personnel with a doctoral qualification at South African universities increased from 31.5% in 2000 to 42.9% in 2014. This marks a substantive increase in 15 years which has been driven by concerted efforts to increase the proportion of instructional and research staff with a PhD.

The proportion of permanent instructional and research staff[89] for the five selected disciplines was calculated. In 2014, I found that there was a significantly higher proportion of personnel with a doctoral qualification in physics when compared to the other disciplines. Similarly, sociology recorded a high percentage of staff with a PhD, although more than 20% lower compared to physics. In electrical engineering, only 34.5% of permanent instructional and research staff held a doctorate in 2014, which in 2014 was approximately 8% lower than the national average.

[89] Note that the benchmark of minimum 20% FTE in instruction AND research was used to identify personnel who would be more likely to supervise doctoral students.

Table 9-4 Percentage of permanent, valid staff with a doctoral qualification (2000 and 2014)

	Percentage of permanent staff (20% FTE in instruction and 20% FTE in research) with a doctoral qualification	
	2000	2014
Physics	**73.2%**	**82.9%**
Sociology	50.0%	61.9%
Education	41.1%	58.5%
Clinical health sciences	25.6%	44.1%
Electrical engineering	21.6%	34.5%
National[90]	*31.5%*	*42.9%*

In all five disciplines, there has been an increase in the proportion of staff with a doctorate of approximately 10%. However, in the clinical health sciences, we see the biggest increase of nearly 20%. Cloete, Mouton and Sheppard (2015) found that a higher proportion of staff in the social sciences, followed by the natural and agricultural sciences held a doctorate, while those in engineering sciences, materials and technologies had the lowest share. My findings in Table 9-4 above, however, show that physics had a higher proportion of PhD qualified staff compared to sociology. However, with regard to the proportion of engineering, my results are commensurate with that found by Cloete, Mouton and Sheppard (2015).

As discussed in Chapter 5, the number of permanent instructional and research staff with a PhD was used to calculate the supervisory capacity. In Table 9-5 below, the ratio of total doctoral enrolments to potential supervisors (permanent staff with a minimum of 20% FTE in instruction and research) are shown. In each of the five disciplines, the average for 2000 to 2014 was calculated. I found the lowest student-to-supervisor ratio in physics where I estimate an average of at least two doctoral students per potential supervisor over the total period analysed. From 2000 to 2014 this ratio increased from 1.5 students to 2.3. This suggests that although the proportion of personnel with a PhD increased, the supervisory capacity in physics decreased over the 15-year period. In 2000, the supervisory capacity in all five disciplines analysed was lower than the 1.4 recorded for the national average. It should be noted, however, that the measurement used here is a conservative estimation. In other words, in setting the benchmark of at least 20% FTE in research and instruction, I only select permanent personnel who spend at least one day a week on instruction and one day a week on

90 This statistics was not calculated using the HEMIS microdata, but from the aggregated DHET tables.

research. It might be possible, that in reality, there is more capacity to supervise doctoral candidates than is reported here.

Given that electrical engineering had the lowest proportion of permanent instructional and research staff with a PhD, it is not surprising that I found the lowest average supervisory capacity in electrical engineering.

Table 9-5 Supervisory capacity of doctoral students in five disciplines compared

	Supervisory capacity: Student to potential supervisor ratio		
	2000	2014	Average (2000 to 2014)
Physics	**1.5**	**2.3**	**2.0**
Sociology	2.6	6.0	4.2
Education	6.6	6.9	6.6
Clinical health sciences	9.3	11.0	10.2
Electrical engineering	7.1	9.4	12.7
National[91]	*1.4*	*2.3*	*n/a*

For each of the five disciplines, the ratio of enrolments-to-potential-supervisor increased between 2000 and 2014. This supports Cloete, Mouton and Sheppard's (2015) claim that the burden of supervision in South Africa is increasing. The CHE (2009) report indicated that the burden of supervision was the most palpable in the humanities and social sciences where a supervisory capacity of 2.9 in 2005 was recorded (a ratio of three students-to-supervisor in 2005). The report found that the natural and agricultural sciences had the highest supervisory capacity with less than two students-to-supervisor in 2005 (CHE, 2009). Nearly ten years later, these findings have not changed significantly.

9.2.1 Institutional supervisory capacity

In the following section, I determined the supervisory capacity of selected universities in South Africa. The ASSAf report (2010) found that traditional universities generally have higher supervisory capacity in comparison to universities of technology. However, the report found that the five strongest research-oriented universities (UCT, UKZN, UP, WITS and SU) did not necessarily have the lowest enrolments-to-supervisor ratios (ASSAf, 2010).

[91] This average was not calculated using microdata, but from DHET tables.

In Table 9-6 below, I report on the number of permanent instructional and research staff with a minimum FTE of 20% in research and instruction per discipline, per academic institution for 2014. For each institution, I also indicate the percentage of these personnel who have a PhD and are thus able to supervise doctoral students. Across the board the proportion of instructional and research staff with a PhD (with a minimum of 20% FTE) at UCT, SU and NMU were between 70% and 100%. UP had a low percentage of personnel with a PhD in electrical engineering, while WITS recorded low proportions of supervisory personnel in education and the clinical health sciences.

Table 9-6 Number of permanent instructional and research personnel with 20% FTE with a doctorate, per field (2014)

	Education		Electrical engineering		Clinical health sciences		Physics		Sociology	
	n	PhD (%)	n	PhD (%)	n	PhD (%)	n	PhD (%)	n	PhD (%)
CPUT	6	50.0	6	33.3	7	28.6	2	100.0	-	-
CUT	17	47.1	3	100.0	5	40.0	1	0.0	-	-
DUT	4	5.0	4	25.0	2	0.0	1	0.0	-	-
NMU	22	81.8	1	100.0	-	-	5	100.0	-	-
NWU	65	58.5	13	76.9	-	-	6	66.7	17	52.9
RU	21	57.1	-	-	-	-	3	100.0	8	62.5
SU	10	70.0	6	100.0	-	-	3	100.0	5	80.0
TUT	2	0.0	5	40.0	-	-	2	50.0	1	0.0
UCT	23	73.9	12	75.0	15	66.7	12	100.0	9	100.0
UFH	26	30.8	-	-			4	50.0	10	30.0
UFS	28	71.4	-	-	5	60.0	11	72.7	5	20.0
UJ	22	81.8	12	58.3	3	0.0	8	87.5	7	71.4
UKZN	73	64.4	16	87.5	10	70.0	15	100.0	18	72.2
UL	2	0.0			3	0.0	4	50.0	-	-
Unisa	51	68.6	3	66.7	2	100.0	8	100.0	16	43.8
UNIVEN	5	60.0	-	-	-	-	2	50.0	-	-
UNIZULU	21	42.9	1	100.0	-	-	1	0.0	1	0.0
UP	14	92.9	6	16.7	-	-	11	90.9	5	60.0
UWC	29	51.7	-	-	-	-	19	84.2	10	90.0
VUT	2	100.0	2	0.0	-	-	2	100.0	-	-
WITS	28	39.3	17	70.6	8	12.5	30	83.3	19	89.5
WSU	33	27.3	-	-	7	42.9	2	0.0	8	12.5
Total	504	58.5	113	63.7	68	44.1	152	82.9	139	61.9

In Table 9-7 below, I present the average supervisory capacity[92] (for the entire period) per institution, in the five selected disciplines.

Table 9-7 Supervisory capacity of doctoral students in five disciplines compared (average 2000 to 2014)

	Education	Electrical engineering	Clinical health sciences	Physics	Sociology
NMU	8.0	3.0	**0.8**	4.8	6.9
SU	7.7	3.8	11.3	6.7	6.3
UNIZULU	5.7	-	4.6	-	2.2
UJ	9.8	8.5	7.2	6.2	4.7
UFS	7.0	-	8.2	1.5	2.8
DUT	-	**1.5**	1.3	-	
UCT	4.9	5.1	11.9	3.0	3.1
NWU	8.9	3.5	5.3	2.7	8.2
UFH	11.6	-	-	4.4	24.4
Unisa	5.4	-	-	**0.9**	5.2
RU	9.2	-	-	2.1	3.0
UWC	5.9	-	2.4	**0.9**	3.2
CPUT	10.2	6.5	8.9	-	-
TUT	11.0	15.0	9	-	-
UP	20.4	8.9	9.6	1.8	5.0
WITS	6.7	3.6	34.3	2.0	2.6
UKZN	7.1	1.8	8.1	1.9	7.1
UNIVEN	**3.5**	-	-	1.8	**0.5**
CUT	9.3	4.3	-	-	-
WSU	5.3	-	3.7	-	-
UL	8.4	-	6.3	3.8	2.0
VUT	-	2.6	-	-	-

[92] In some years there were either missing data or no instructional and research personnel with a doctorate recorded for that institution. In these cases the supervisor capacity is zero. These years were not included in the average. Therefore, the averages were calculated by using years in which there were both entries for staff and enrolment. In the clinical health sciences, WITS recorded a very high ratio of enrolments-to-supervisor. As with the case of student data, the staff data of WITS was unreliable with erroneous entries. In some years the ratio of students-to-staff was very high which resulted in a high average supervisory capacity. Similarly, for UFH in sociology, doctoral enrolments increased significantly in 2010 which recorded unusually high ratios in certain years thus leading to a high students-to-staff ratios.

In education, the University of Venda (UNIVEN), followed by UCT and WSU had the highest supervisory capacity. It should be noted, however, that the actual number of doctoral enrolments at UNIVEN and WSU are small and, therefore, translates into low student-to-supervisor ratios. UP recorded the lowest supervisory capacity in *education* for the period with an average of more than 20 enrolments-to-supervisor. In *electrical engineering*, two of the top three universities with the lowest supervisory capacity, DUT and VUT, were universities of technology. UKZN had an average of 1.8 enrolments-to-supervisor ratio in electrical engineering. Once again the number of enrolments at DUT and VUT were small and, therefore, translates into low student-to-supervisor ratios. In the *clinical health sciences*, NMU had less than one student per supervisor, followed by DUT with a ratio of 1.3. In the clinical health sciences, both SU and UCT had high ratios of over 11 students per supervisor. In *physics*, both Unisa and UWC recorded a higher supervisory capacity with 0.9 enrolments per potential supervisor. In *sociology*, UNIVEN and UL had a low student-to-supervisor ratio. With the exception of the clinical health sciences, UCT and SU had on average between four and eight students per supervisor.

In the next and final section of this chapter, I explore whether there is a correlation between the average supervisory capacity and average doctoral time-to-degree of institutions per discipline. Below, I plot the average supervisory capacity, as calculated for each of the five disciplines and reported in Table 9-5 above, with the average[93] time-to-degree of doctoral students for the entire period studied. I aimed to investigate if a higher supervisory capacity, in other words, a smaller number of enrolments-per-supervisor, is associated with a shorter average time-to-degree. In plotting the averages, I took into account the limitations associated with this rough estimation. In Figure 9-2 below, I found that across the five disciplines, there was no clear relationship between a supervisory capacity and shorter time-to-degree.

[93] I used mean D in plotting the average time-to-degree of institutions.

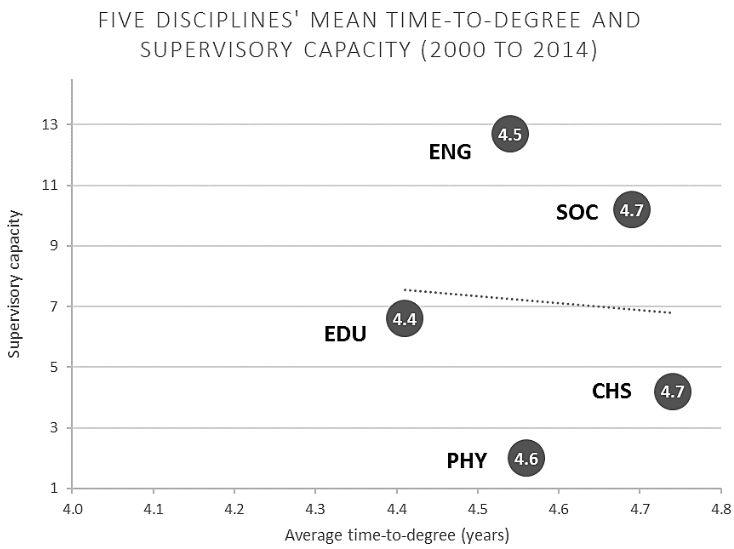


Figure 9-2 Average supervisory capacity and mean time-to-degree of five disciplines (2000 to 2014)

*more than 50 cases, mean TTD and average student per staff for 2000 to 2014
**average doctoral enrolments per instructional and research staff member (2000 to 2014)

In the Figure 9-3 below, I examined whether there is a correlation between the average institutional supervisory capacity and the average mean time-to-degree in each of the five disciplines. Looking at institutions in *education*[94], I found that institutions with a shorter time-to-degree, such as NMU, RU, SU and NWU recorded a higher ratio of doctoral enrolments-per-supervisor. However, the trend line suggests that there is no clear association between the two indicators.

I found that for institutions in *electrical engineering*[95] there is a positive correlation between lower student-to-supervisor ratios (high supervisory capacity) and shorter time-to-degree. SU recorded the lowest number of enrolments-per-supervisor and the shortest time-to-degree. For UP, I found the longest mean time-to-degree and also a high student-to-supervisor ratio.

For institutions in the *clinical health sciences*[96], I found a negative relationship between a high student-to-supervisor ratio and a shorter time-to-degree.

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[94] In education, institutions with more than 50 cases were included in the scatterplot.
[95] In electrical engineering, institutions with more than 20 cases were included in the scatterplot.
[96] In the clinical health sciences, institutions with more than 20 cases were included in the scatterplot.

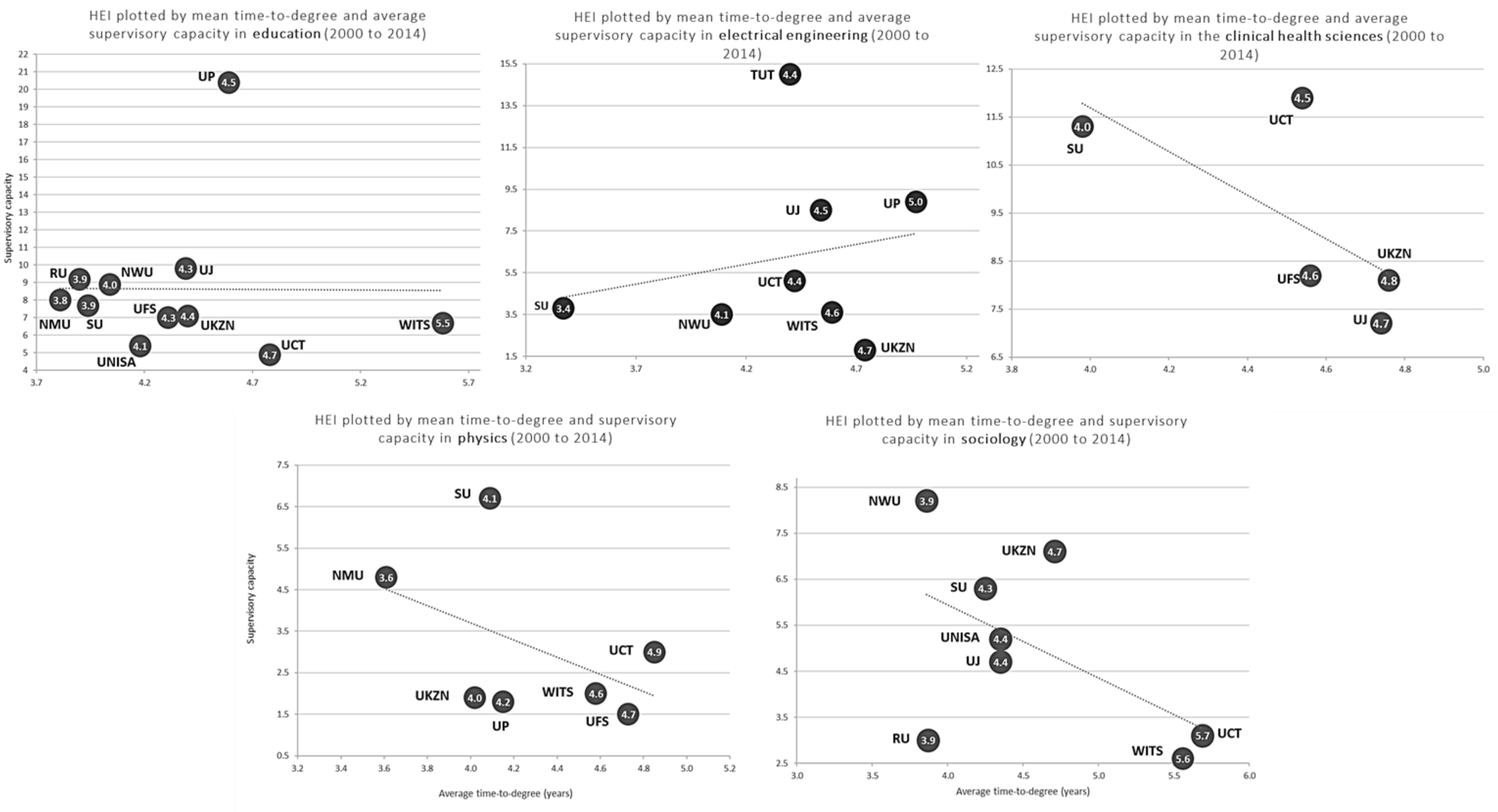

Figure 9-3 Academic institutions' average time-to-degree and average supervisory capacity for five disciplines (2000 to 2014)

As seen in the figure above, in the clinical health sciences, graduates at SU recorded average shorter completion times, but the ratio of students-to-supervisor was among the highest of the institutions studied. At UKZN and UJ, I found a longer average time-to-degree, but also a higher supervisory capacity.

For institutional time-to-degree in *physics*[97], I similarly found that a higher supervisory capacity is associated with a longer average time-to-degree.

For *sociology*[98], I found the same negative relationship between higher supervisory capacity and longer time-to-degree. NWU recorded the shortest time-to-degree but had the highest ratio of enrolments-to-supervisor. Conversely, UCT and WITS, recorded the longest mean time-to-degree, but a higher supervisory capacity.

Examining the relationship between the average time-to-degree and the supervisory capacity of institutions I found that, with the exception of institutions in electrical engineering, there is no correlation between a high supervisory capacity and a shorter time-to-degree. I found that for disciplines such as education, physics, sociology, and the clinical health sciences, institutions with a shorter mean time-to-degree generally recorded higher student-to-supervisory ratios. Electrical engineering is the only discipline for which a low ratio of students-per-supervisor is associated with shorter completion times. A possible explanation for the trends observed among academic institutions in education, physics, sociology and the clinical health sciences is that institutions who recorded a shorter average time-to-degree are generally traditional research-intensive universities with high numbers of enrolments. However, it seems that although the burden of supervision is increasing it does not necessarily have a direct negative effect on doctoral time-to-degree. As Mouton argued, the few doctoral supervisors who carry the biggest burden, are effective in their production of doctorates (Mouton, 2011).

9.3 Conclusion

In this chapter, I investigated the role of institutional factors, specifically throughput rates and the supervisory capacity, in doctoral time-to-degree. First, I determined the average throughput rates of

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[97] In physics, only institutions in which there more than 10 cases were included in the scatterplot.
[98] In sociology, only institutions in which there were more than 20 cases were included in the scatterplot.

doctoral students in the five selected disciplines. Over the total period analysed, physics recorded the highest average throughput rate of 13.6% followed by education (13.0%). Sociology recorded the lowest average throughput rate of 9.7% which is nearly 3% below the national average.

Second, I calculated the throughput rates of academic institutions in each of the disciplines and investigated whether high institutional throughput rates are associated with shorter completion times. With regard to institutional throughput rates, I found the highest average throughput rates in education and electrical engineering for NMU. WSU recorded the highest throughput rates in the clinical health sciences, while RU had the highest proportion of graduates to enrolments in physics. Unisa recorded the highest throughput rates of doctoral students in sociology in 2014 while also graduating the most doctoral graduates over the 15-year period analysed.

In four of the five disciplines, I found a positive correlation between higher institutional throughput rates and shorter time-to-degree. In sociology, although I found that institutions with a shorter average time-to-degree recorded a lower throughput rate, no clear relationship was observed.

Third, I determined the average supervisory capacity for doctoral students in the five selected disciplines. In 2014, 42.9% of permanent instructional and research staff at South African universities held a doctorate. Physics recorded the highest average supervisory capacity for the period 2000 to 2014 with the highest proportion of permanent instructional and research staff having a PhD. In electrical engineering, I found the smallest percentage of instructional and research staff with a doctorate which translated into low doctoral supervisory capacity. In Chapter 10, I suggest that the relevance, and, therefore, the rationale behind the pursuit of a PhD differs across the pure and applied disciplines. In fields such as physics and sociology, the doctorate is often pre-requisite for an academic career where it is not always the case in more applied fields such as engineering.

Fourth, I estimated the doctoral supervisory capacity of academic institutions for each discipline and explored whether low student-to-supervisor ratios are associated with shorter average time-to-degree. With regard to the institutional supervisory capacity, I found variation between institutions across disciplines. Generally, smaller universities recorded a higher supervisory capacity due to the smaller numbers of enrolments. For institutions in education, the clinical health sciences, physics and sociology, those who recorded a shorter mean time-to-degree generally had higher student-to-supervisor ratios. This suggests that high supervisory capacity is not associated with shorter time-to-degree. Institutions with shorter time-to-degree are generally traditional research-intensive universities with high numbers of doctoral enrolments. Although supervisors at these institutions generally have a heavier supervisory burden, they seem to be more effective in producing doctoral graduates.

Chapter 10 | The role of situational and dispositional factors in time-to-degree

In this chapter, I address how situational and dispositional factors are related to time-to-degree. Some scholars suggest that students often consider situational and institutional factors as more significant barriers towards successful completion (Cross, 1982; Mertesdorf, 1990). Situational barriers or external factors, such as insufficient time or financial support, challenges in balancing study, work and family commitments are arguably more "socially acceptable" obstacles in timely completion (Cross, 1986). Conversely, the study of dispositional factors on timely completion is often neglected given the difficulty in studying the psychosocial obstacles to student success. In a similar fashion, the bulk of this chapter is devoted to a study of survey respondents' situational factors on doctoral time-to-degree.

Using the survey data, I first explore the relationship of degree progression with respondents' projected time-to-degree. Second, I explore whether if students changed disciplines between their master's and doctoral degrees, they would anticipate longer completion times. Third, I explore if there is a relationship between students' mode of enrolment and employment status on completion times. In this chapter, I explore students' mode of study descriptively through the use of survey data given that the HEMIS database did not record students' mode of enrolment before 2010. In Chapter 11, I include mode of study as an independent variable in the regression model.

In the discussion of dispositional factors, I identify the importance of doctoral supervision in doctoral success. In the final section of this chapter, I explore whether there is an association between doctoral time-to-degree and satisfaction with supervision with the aid of the qualitative data. I similarly explore survey respondents' perceptions and consequently satisfaction with institutional factors (such as the hosting university) as either barriers or enablers to timely completion. Although the analysis of dispositional factors on time-to-degree is limited, one of the most important questions addressed in this chapter is whether a consideration to drop out influences time-to-degree. There are many factors that contribute to a student's consideration to discontinue their studies, but funding, part-time or full-time employment and type of employment are some of the key factors studied in this chapter.

10.1 Situational factors

In this section, I explore the association of four situational factors with doctoral time-to-degree using the survey data. The first question explores the trajectory of doctoral students leading up to the doctorate. Mean time-to-degree, both within and across the five selected disciplines, is compared between students who enrolled for their doctorate immediately after graduating from a previous degree and those who did not progress immediately. Survey data are used to highlight reasons underlying students' decisions for both the former and the latter. Second, I explore whether there are significant differences in the average time-to-degree of doctoral students who pursue their doctorates in fields dissimilar from that of their previous training.

The final situational factor addressed in this section is that of employment. Respondents' estimated time-to-degree are compared between those who indicated that they are employed full-time and those not employed full-time. One of the biggest concerns in the South African higher education system is that the majority of doctoral students are enrolled part-time (ASSAf, 2010). Many studies have found that the mode of study (i.e. full-time or part-time) is one of the most significant determinants of timely completion (HEFCE, 2005; Mouton et al., 2015; Seagram, Gould and Pyke, 1998). The reason for the high frequency of part-time enrolment in South African includes a lack of financial support during the PhD which compels candidates to either seek or continue with their current employment. The availability of funding or financial assistance is, therefore, paramount to the successful completion of the doctorate. One of the most significant limitations of this study, however, is that I could not measure the relationship of funding on *actual* time-to-degree. Since the survey data were used in the forthcoming analyses, it is important to remember that the means compared refer to an *estimated* time-to-degree and should be interpreted as *explorative* in highlighting barriers and enablers to timely completion.

10.1.1 Degree progression of doctoral graduates

The first situational factor which I analyse studies the relationship between immediate degree progression and time-to-degree. Survey respondents were asked whether they completed a university degree immediately prior to enrolling for their doctorate. There is, however, little literature on the relationship between a student's degree progression and doctoral success/timely completion. I state my null hypothesis below.

H_0: There is no statistically significant difference in the mean, projected time-to-degree of survey respondents who progressed immediately to the doctorate and those who did not.

$H_0: \mu_{dp} = \mu_{ip}$

Where μ_{dp} is the mean, projected time-to-degree of respondents who progressed immediately and μ_{ip} is the mean, projected time-to-degree of respondents who did not.

The majority of survey respondents indicated that they enrolled for their doctoral studies immediately after completing a previous degree. Across all disciplines, excluding education, survey respondents who progressed directly to the doctorate (from a previous degree) projected a shorter mean time-to-degree than respondents who cited indirect progression. More respondents in education, however, indicated that they did not immediately progress from a previous degree. Respondents enrolled in education, who did not progress directly from a previous degree to the doctorate, also projected a shorter time-to-degree than respondents who did.

Inter-disciplinary comparisons

Independent t-tests were done to see whether there exist significant differences between the means of students who immediately progressed from a previous degree compared with those who did not. When running a t-test of all survey respondents, statistically significant differences were found where respondents who progressed immediately cited a shorter mean projected time-to-degree (1.60 ± 0.105) compared with those respondents who did not (1.61 ± 0.111; p=.06). Univariate analyses showed that across all disciplines, no significant interaction effect existed between direct and indirect throughput on projected time-to-degree[viii].

Table 10-1 Mean projected time-to-degree compared between respondents who indicated direct progression and indirect progression

		Direct progression	**Indirect progression**	**Direct progression**	**Indirect progression**
		Original data		Transformed data	
All disciplines	n	652	503	652	503
	Mean	**41.03**	42.88	**1.60**	1.62
	Std. Dev.	*10.341*	*11.304*	*0.105*	*0.111*
	Results	t=2.771; p=.006; r = .008			
Education	n	38	56	-	-
	Mean	42.15	**41.46**	**-**	-
	Std. Dev.	*11.817*	*10.330*	-	-
Engineering	n	65	43	-	-

		Direct progression	Indirect progression	Direct progression	Indirect progression
		Original data		Transformed data	
	Mean	**42.20**	43.20	-	-
	Std. Dev.	*10.084*	*10.182*	-	-
Health sciences	n	64	65	-	-
	Mean	**41.06**	42.16	-	-
	Std. Dev.	*10.029*	*11.360*	-	-
Physical sciences	n	105	41	105	41
	Mean	**39.86**	43.98	**1.59**	1.63
	Std. Dev.	*9.901*	*12.059*	0.098	*0.117*
Social sciences	n	61	57	61	57
	Mean	**39.41**	**39.41**	**3.65**	3.73
	Std. Dev.	*12.199*	*9.662*	*0.274*	*0.241*

Intra-disciplinary comparisons

In replicating the test for differences within disciplinary groups, no statistically significant differences were found. Although in all fields, except education, students who progressed immediately anticipated shorter completion times.

Discussion

Student or degree progression refers to a student's progression from one degree qualification to the next.

Table 10-2 Number of students who immediately progressed from master's to doctoral studies.

		Education	Engineering	Health sciences	Physical sciences	Social sciences
Doctoral students who immediately enrolled for their doctoral degrees following the completion of a master's degree	n	44	70	66	111	63
	%	38.3	57.4	46.5	**69.4**	46.3

By analysing the survey results, as presented in Table 10-2 above, I found that respondents in the physical sciences (nearly 70%) were more likely to progress directly from a master's degree to the doctorate when compared to respondents in other fields. It is, therefore, not surprising that, when comparing the mean age at enrolment of students as seen in Chapter 6, enrolments in physics and electrical engineering are much younger when compared to the other three disciplinary fields. Respondents in education reported the lowest immediate progression rates (38.3%) which support the argument that doctorates in education are often professionals who pursue doctoral studies at a later stage of their careers.

> I was a school teacher and I only wanted a qualification. I was not motivated to register for PhD because I was not exposed to the academic environment. – education

Nearly 60% of respondents in engineering indicated that they immediately progressed between degrees. For most students in applied fields, however, the doctorate is not a requirement for a career.

> Doing a doctorate was never a natural continuation of other studies. – education

From the survey data I found that engineering students are more likely to directly progress from a master's to a doctoral degree. This is substantiated by the lower mean age of enrolments when compared to other disciplines.

From the survey data, however, another group of engineering students emerges. Forty-one percent of engineering respondents in engineering indicated that they were not enrolled in any degree programmes immediately prior to their doctoral enrolment. These are most likely students who found employment in the private sector following their master's studies and before returning for their doctoral studies. This can either be due to wanting to gain work experience or perhaps, the most plausible, as part of working off scholarships or bursaries received from industry. These doctorates are most likely permanently employed at the time of enrolment with the permission from or through opportunities provided by employers. Many engineering students receive private funding from companies (Akay, 2008) and often these bursaries are linked to work conditions. Respondents were asked why they did not immediately progress from their master's to doctoral degrees. The responses of respondents in engineering substantiate this argument.

> Current employer's conditions of service required that I work for a minimum of 2 years before taking another study leave for further studies. – engineering

> I had to work for my employer as required before they could give me another study leave. – engineering

> One need (sic.) to spend a minimum of three years before applying for study leave. However, there were many potential candidates on the awaiting (sic.) list for further studies. – engineering

> I am on study leave and as such I am required to be of service to my employer for a period equivalent to the time I spent studying. – engineering

To work as part of my agreement for a study leave. – engineering

Survey respondents were asked to why they interrupted their degree progression. In Table 10-3 below, the reasons for taking a "break" between degree programmes are presented.

Table 10-3 Reasons provided for "taking a break" before doctoral enrolment

	Education	Engineering	Health sciences	Physical sciences	Social sciences
Financial reasons or no funds to continue studying	6	5	13	9	6
	15.4%	12.8%	33.3%	23.1%	15.4%
Did not originally intend to further studies	5	0	5	4	3
	29.4%	0.0%	29.4%	23.5%	17.6%
To gain work experience or to work in the field	7	16	13	6	16
	12.1%	27.6%	22.4%	10.3%	27.6%
Family/personal obligations/reasons	10	4	9	4	9
	27.8%	11.1%	25.0%	11.1%	25.0%
Employment conditions, work obligations, community service, internship, articles	17	17	21	15	23
	18.3%	18.3%	22.6%	16.1%	24.7%
Decided to take a gap year/break from studying	5	2	3	1	4
	33.3%	13.3%	20.0%	6.7%	26.7%
Institutional factors such as programme admission, registration and supervision	8	2	2	5	0
	47.1%	11.8%	11.8%	29.4%	0.0%
Changed topics/fields or received other qualifications	3	2	4	2	2
	23.1%	15.4%	30.8%	15.4%	15.4%

Although the counts are small in each cell, the table above shows that the three most prominent reasons for indirect progression are first, due to employment conditions (i.e. work obligations, community service, internship, articles, etc.), second, wanting to gain experience and third, financial limitations. Respondents in the health sciences were particularly affected by financial constraints. In two of the three applied disciplines (except in electrical engineering), a higher percentage of respondents indicated that they did not originally intend to further their studies. In both engineering and the social sciences, a higher proportion of respondents indicated that they sought work experience before pursuing the doctorate.

Many respondents, however, indicated that they experienced "burn-out" following the completion of their master's degrees and felt that they needed to gain perspective and work experience before taking on a doctorate. This sentiment was expressed by respondents irrespective of disciplinary field.

> I needed to take a break from academia ... – education
>
> I felt I needed a break from studies before continuing. – education
>
> To rest and recuperate! – education
>
> After doing my masters, I was tired of studying, and had a particular stressful end to my masters … - engineering
>
> I just felt I needed a break after my master's degree. – engineering
>
> I needed a break from studying after my masters. – health sciences
>
> I needed to recover … – health sciences
>
> Burnout from my master's degree. – social sciences

Some respondents acknowledged that a doctorate is a taxing process and that they needed time to prepare.

> I also needed to reflect fast on my career path knowing that a PhD research undertaking demands a lot of emotional commitment. – engineering
>
> I was not ready to do a doctoral degree … – education
>
> Needed a break after my master's degree. Wasn't ready to commit to a PhD topic yet. – education

Many participants felt that they needed to gain work experience as many respondents, in especially engineering, indicated that they had to work for a period of time before being able to apply for study leave. For some respondents, the "break" served as the period during which to identify gaps in the literature and prepare a dissertation topic. Although a large number of respondents indicated that they experienced "burn-out" after completing their master's degrees, the statistical results indicated that students who progressed immediately estimated a shorter time-to-degree. One possible reason for this might be that students who enrolled for their doctorate directly following their master's degrees are more likely to be enrolled full-time and financially supported. Respondents who entered the workplace before enrolling in a PhD programme might not have the opportunities to enrol full-time and are, therefore, forced to study part-time. Another likely explanation might be that students who directly progress from one degree to another are younger than those who enter the workplace and return to their studies.

10.1.2 Change of academic fields in the trajectory toward the doctorate

Survey respondents were asked to indicate whether the fields in which they enrolled for a doctorate differed significantly with that of their previous degrees. Literature on the effect of changing disciplines over degree programmes on time-to-degree is scarce. My null hypothesis is stated below.

H_0: There is no statistically significant difference in the mean, projected time-to-degree of survey respondents who changed disciplinary fields and those who did not.

$H_0: \mu_{sf} = \mu_{df}$

Where μ_{sf} is the mean, projected time-to-degree of respondents who stayed the same field and μ_{df} is the mean, projected time-to-degree of respondents who have changed disciplinary fields.

Inter-disciplinary comparisons

Respondents were asked whether the field of their enrolled degree differs significantly from the field of their previously completed degree. More than 75% of respondents reported that their doctoral fields were similar to those of their previous degrees. An independent samples test of all doctorates (across the five disciplines) was conducted to test the hypothesis of whether there is an association between the changing of disciplinary fields and time-to-degree. Respondents who indicated that their disciplinary fields were similar anticipated a slightly shorter time-to-degree, but significance tests yielded insignificant results.

Table 10-4 Mean time-to-degree compared between respondents with a candidacy in the same field and different fields

		Same field	**Different field**	**Results**
All Disciplines	n	882	267	-
	Mean	**41.68**	42.27	
	Std. dev.	*10.782*	*10.869*	
Education	n	57	36	-
	Mean	**41.47**	42.08	
	Std. dev,	*11.761*	*10.960*	
Engineering	n	81	25	-
	Mean	42.63	**42.04**	
	Std. dev.	*10.052*	*10.494*	
Health sciences	n	100	32	-
	Mean	**41.15**	43.31	
	Std. dev.	*10.237*	*12.204*	
Physical sciences	n	115	27	t= -2.320; p = .025 r =.32
	Mean	40.96	**36.89**	
	Std. dev.	*9.969*	*7.723*	

		Same field	Different field	Results
Social sciences	n	90	27	-
	Mean	**40.88**	43.07	
	Std. dev.	*11.362*	*10.427*	

Intra-disciplinary comparisons

The test was repeated for each of the disciplinary groupings. Statistically significant results were only found among respondents in the physical sciences where respondents whose disciplinary fields were unchanged across degrees, recorded a *longer* mean projected time-to-degree (40.96 ± 9.969) than those whose fields differed significantly (36.89 ± 7.723; p=.025; r=.32). Although not statistically significant, similar results were found for respondents in engineering. For respondents in education, the health sciences and the social sciences whose fields remained unchanged, projected a shorter time-to-degree than those who changed fields.

Discussion

Examining the findings above, I found that in the physical sciences and engineering, respondents whose doctoral fields differed from their previous degrees anticipated shorter time-to-degree which is an unexpected result. One would expect that students entering new disciplinary fields would experience challenges with the assimilation with new and unfamiliar content as highlighted by some of the survey responses below.

> It is quite different from a pure science degree, so I have had to delve into a lot of philosophy in which I have not been trained. – education

> I had to start from scratch in learning the jargon, processes and methods used in the field. – engineering

> Background was in psychology. I struggled with the theoretical component in public health. As a result, I went through six PhD topics. – health sciences

The responses above refer to some of the challenges which are associated with the assimilation with the theoretical and conceptual frameworks of disciplines. In Chapter 3, I discussed how the knowledge structures in the hard and soft sciences are arguably dissimilar which makes migration across disciplinary fields challenging. The results above, however, point to an interesting finding in that respondents in both hard/abstract disciplines anticipated that a change in disciplinary fields would not negatively affect their completion times. This could speak to the nature of hard disciplines where knowledge structures are arguably more coherent and codified, which could ease the immersion of newcomers into these fields. It would have been illuminating to report on how many doctorates are enrolled in interdisciplinary fields and the challenges associated with studying across disciplinary borders. In interpreting the results presented here, I acknowledge the difficulty in gauging students' understanding of "significantly different". Doctoral students may, therefore, be enrolled in a discipline different from that of their previous training, but I could not estimate the significance of these differences.

10.1.3 Full-time employment as a barrier to completion

I investigated whether there is an association between respondents' employment status, and indirectly mode of study, and estimated time-to-degree. Studies on differences in degree attainment between full-time and part-time students are plentiful, as discussed in Chapter 4. I have previously mentioned the methodological limitations in determining students' mode of study as per the HEMIS data and I, therefore, used the survey data for the analyses below.

Survey respondents were asked to indicate whether they were employed *full-time* whilst enrolled for their doctorate. As per the literature reviewed, part-time students face many difficulties in balancing work, life and study commitments and scholars suggest that these students typically take longer to complete their studies (ASSAf, 2010; Bean & Merzner, 1985; Birch, 2009 Herman, 2011b; Mouton et al., 2015; Snyder, 2014). My null hypothesis is stated below.

H_0: There is no statistically significant difference in the mean, projected time-to-degree of survey respondents who are employed full-time and those who are not.

$$H_0: \mu_{ft} = \mu_{nft}$$

Where μ_{ft} is the mean, projected time-to-degree of respondents who are employed full-time and μ_{nft} is the mean time-to-degree of respondents who are not employed full-time.

Inter-disciplinary comparisons

The majority of survey respondents indicated that they were not employed full-time while pursuing the doctorate. However, of respondents in education, more respondents indicated that they were employed full-time. Across all disciplinary fields, respondents who indicated that they were not employed full-time estimated a shorter time-to-degree in both the original and transformed data. An independent samples t-test was done across all disciplines and a statistically significant difference in the mean time-to-degree of respondents working full-time and not, were found in the transformed data. Respondents who were employed full-time estimated a longer time-to-degree (1.64 ± 0.188) than those who were not working full-time (1.59 ± 0.098; p=.000; r=.24)[99].

Intra-disciplinary comparisons

Similarly, means tests were run for each discipline between respondents who indicated that they were employed full-time[100] and those who were not. The results are presented in Table 10-5 below.

Table 10-5 Mean projected time-to-degree compared between full-time employed respondents and not full-time employed respondents

		Employed full-time	Not employed full-time	Employed full-time	Not employed full-time
		Original data		Transformed data	
All disciplines	n	440	719	440	719
	Mean	44.89	**39.94**	1.64	**1.59**
	Std. dev.	*12.093*	*9.437*	*0.118*	*0.098*
	Results	-		t=6.876, p=.000; r=.24	
Education	n	64	30	64	30
	Mean	42.53	**40.07**	1.61	**1.59**
	Std. dev.	*11.708*	*8.882*	*0.121*	*0.0.99*
Engineering	n	39	69	39	69
	Mean	48.05	**39.52**	1.67	**1.59**
	Std. dev.	*9.913*	*8.864*	*0.090*	*0.096*
		t=4.601; p=.000; r=.41		t=4.587; p=.000; r=.41	
Health sciences	n	59	70	59	70
	Mean	42.98	**38.80**	1.62	**1.58**
	Std. dev.	*10.559*	*8.109*	*0.110*	*0.088*
	Results	t=2.487; p=.014; r= .23		t=2302; p=.023; r=.20	
Physical sciences	n	28	115	28	115
	Mean	43.64	**39.35**	1.62	**1.59**
	Std. dev.	*11.770*	*8.928*	*0.117*	*0.091*
Social sciences	n	47	71	47	71
	Mean	45.51	**38.61**	1.64	**1.58**
	Std. dev.	*13.111*	*8.583*	*0.125*	*0.097*

[99] A two-way ANOVA test was run to test whether there is a significant interaction effect between full-time employment and projected time-to-degree across all disciplines. No statistically significant results were found.
[100] This excluded respondents who indicated that they were employed, but are on study leave.

	Employed full-time	Not employed full-time	Employed full-time	Not employed full-time
	Original data		Transformed data	
Results	t=3.187; p=.002; r=.35		t=2.979; p=.004; r=.31	

T-tests were done across all disciplines and statistically significant differences in projected time-to-degree between respondents working full-time and those who were not were found both in the original and transformed data for engineering (t=4.587; p=.000; r=.41), the health sciences (t=2302; p=.023; r=.20) and the social sciences (t=2.979; p=.004; r=31). Across all three disciplines respondents who held full-time employment positions estimated a statistically significantly longer average time-to-degree when compared to respondents who were not employed full-time.

Discussion

Examining the results show that working full-time has a negative effect on estimated time-to-degree across all disciplinary fields. Although the results for respondents in education and the physical sciences were not statistically significant, in all cases respondents who were employed full-time estimated a longer mean time-to-degree than those who were not employed full-time. Studies by Bourke et al. (2004a) found that among doctoral students in Australia students who were employed as teaching assistants struggled towards completing their studies on time. A respondent in education experienced difficulty with tutoring demands.

> These tutoring jobs just disturb my progress but I have to do them because I need money. – education

Similarly, respondents experienced full-time employment and subsequently part-time or distance enrolment, as an obstacle to completion.

> I was enrolled for a previous doctoral degree, but then started working full time in industry. I could no longer spend enough time on my doctoral studies and did not complete the previous doctoral degree. – engineering

> I work full time and have a family to support. [The] PhD requires dedicated time and sometimes life issues hinder my studies. – education

> Completing a MA part-time while working was a stressful experience, and I preferred to be able to continue studying only if I could do so full-time. – social sciences

> Distance learning is very challenging. – education

> At UJ we get no option for full time of part time study. It's full time and only four years. [I]t's not enough time if you (are) working. – social sciences

Some respondents indicated that they struggled with balancing the demands of family life, work and their studies. I discuss this in a later section. Survey respondents were asked to identify their type of employer and the results are summarised in Table 10-6 below.

Table 10-6 Type of employer of survey respondents

	All disciplines	Education	Engineering	Health sciences	Physical sciences	Social sciences
A university	478	55	44	44	46	54
	58.6%	22.6%	18.1%	18.1%	18.9%	22.2%
A governmental organisation	156	32	6	32	11	14
	19.1%	33.7%	6.3%	33.7%	11.6%	14.7%
Industry; the private sector	81	5	17	7	5	4
	9.9%	13.2%	44.7%	18.4%	13.2%	10.5%
An organisation in civil society (e.g. NGO)	36	5	0	6	1	7
	4.4%	26.3%	0.0%	31.6%	5.3%	36.8%
Self-employed	65	5	8	6	6	8
	8.0%	15.2%	24.2%	18.2%	18.2%	24.2%

Nearly 60% of respondents who were employed full-time indicated that they were employed by a university. Not surprisingly, the majority of full-time employed respondents in engineering were employed in industry. Examining the results in Table 10-5 shows that in four of the five disciplinary fields, the majority of respondents did not hold full-time employment positions. The opposite, however, is true for respondents in education where the number of respondents employed full-time is nearly twice as many as those not employed full-time. Evidence for this was found in Chapter 6 where the institutional profile of doctoral students showed that Unisa enrolled and graduated the most doctoral students in education. In addition, the fact that the average age at enrolment of doctoral students in education was significantly higher than the national average suggests that students in education are the most likely to be enrolled part-time of the five disciplines analysed. This idea is confirmed in Chapter 11. However, throughout this study, I have found that students in education consistently recorded a shorter average time-to-degree despite having higher proportions of part-time enrolment. In an attempt to interpret the results I continue with the analysis of the rationale for a PhD as a factor in timely completion.

10.1.4 The PhD as job requirement

As seen in the previous section, almost 60% of survey respondents were employed full-time at a university. This raises the question of whether completing a doctorate as a job requirement affects time-to-degree? Currently, there is little scholarship that explores this directly. My null hypothesis is stated below.

H_0: There is no statistically significant difference in the mean time-to-degree of survey respondents who do a doctorate as a job requirement and those who do not.

$H_0: \mu_{jr} = \mu_{njr}$

Where μ_{jr} is the mean, projected time-to-degree of respondents doing a doctorate as a job requirement and μ_{njr} is the mean time-to-degree of respondents not doing a doctorate as a job requirement.

Inter-disciplinary comparisons

More than 60% of survey respondents indicated that doing a doctorate is a job requirement[101]. Comparing the mean time-to-degree between respondents who enrolled for a PhD as a job requirement and those who did not, across all disciplines, showed that the differences in estimated time-to-degree were small and statistically insignificant.

Intra-disciplinary comparisons

Within disciplines, respondents in engineering and the social sciences who pursued doctoral studies as a precondition for employment projected a shorter time-to-degree. However, respondents in education, the health and physical sciences who indicated that a doctorate was a job requirement, anticipated longer completion times. Independent sample t-tests were done in each discipline and found that, except for the social sciences, mean differences were small and statistically insignificant.

[101] These include respondents who indicated on a Likert scale, "important" and "very important" to the statement "enrolling for a PhD was a job requirement".

Table 10-7 Mean time-to-degree compared between respondents enrolled for a PhD as a job requirement and those who are not

		Job requirement	**Not a job requirement**	**Job requirement**	**Not a job requirement**
		Original data		**Transformed data**	
All disciplines	n	493	666	493	666
	Mean	42.06	**41.64**	1.61	**1.61**
	Std. dev.	*11.071*	*10.582*	*0.111*	*0.106*
Education	n	54	40	54	40
	Mean	41.83	**41.63**	1.61	**1.61**
	Std. dev.	*11.657*	*9.930*	*0.121*	*0.105*
Engineering	n	45	63	45	63
	Mean	**41.40**	43.46	**1.61**	1.63
	Std. dev.	*9.509*	*10.472*	*0.097*	*0.106*
Health sciences	n	45	88	45	88
	Mean	41.64	**41.61**	**1.61**	1.61
	Std. dev.	*10.382*	*10.924*	*0.105*	*0.110*
Physical sciences	n	55	92	55	92
	Mean	42.49	**40.08**	1.61	**1.59**
	Std. dev.	*12.276*	*9.492*	*0.115*	*0.097*
Social sciences	n	55	63	55	63
	Mean	**39.33**	43.13	**1.58**	1.62
	Std. dev.	*10.830*	*11.112*	*0.119*	*0.104*
	Results	-		t=-2.097; p=.038; r = .19	

Survey respondents in the social sciences who enrolled for a doctorate as a job requirement reported shorter projected time-to-degree (1.58 ± 0.119) than those respondents who did not enrol as a job requirement (1.62 ± 0.104; p=0.38 ; r=.19).

Discussion

From the results above, I found that doing a PhD as a job requirement is not a determinant of timely completion. However, in thinking about the pursuit of a doctorate as a job requirement one can make two arguments. First, it can be argued that students doing a PhD as a job requirement would take less time to complete their studies given the requirements from their employers or incentives for job promotion. Second, I can assume that respondents who enrol for a doctorate as a job requirement are employed full-time which could be perceived as a barrier to timely completion. Examining the data above shows that in the social sciences, doing a PhD as a job requirement may result in a shorter time-to-degree. However, across all the other disciplines the mean differences are small and insignificant which suggests that the rationale for doing a PhD, particularly enrolling as a job requirement, is neither a barrier to nor an enabler of timely completion. Turning to the qualitative data shows that some respondents suggested that students who enrol for a doctorate as a job requirement have higher completion rates given the added cost of non-completion. It was, however, unfeasible to test this with the available data.

> My job requires me to have this qualification, my employer has partly paid for my studies and I have an obligation to pay back. – education

> I am an employee of a Higher Education Institute. My earning of PhD can be considered as a job requirement. As (a) teacher educator in (the) Teacher Education Institute, I should earn a PhD in order for me to be promoted from lecturer to Assistant Professor. The same is true for all staff members of the institute. – education

One conclusion that can be drawn from these findings is that respondents experience the significant push from higher education institutions to support faculty members to obtain doctorates.

In the pure (reflective) sciences, such as physics and sociology, a doctorate has increasingly become a minimum requirement for a research career. Drawing on the survey data, I found some discernible differences among respondents in different fields regarding the impetus and subsequent rewards of doing a PhD. In the applied sciences, such as engineering, education and the clinical health sciences, a doctorate is often considered superfluous if graduates do not plan on pursuing employment in academia.

> Obtaining a PhD in engineering has no value in industry. It is actually frowned upon in industry since PhD students tend to focus on all detail and are not be able to deliver quick solutions to problems required by industry. – engineering

> I wish to teach at (an) university. Currently, I am teaching at a high school and I feel there is a mismatch between my qualifications and the job I am doing. I am also overqualified and cannot be paid a salary that is commensurate with my qualifications. – education

This points to an important question concerning doctorates in the applied sciences. Is doing a PhD in the applied sciences a good return on investment and what is the perceived added value of a PhD education in the applied sciences? Many survey respondents recorded the "worthlessness" of a PhD in fields such as engineering and the medical sciences. Akay reiterates this point by saying that often in industry, employers find doctoral students to be educated and trained too narrowly "… and that they lack key professional skills, such as effective collaboration, working in teams, organisational and managerial skills, appreciation of applied problems, and knowledge and culture of other fields" (Akay, 2008: 406). This idea is lamented by a respondent in the medical sciences.

> The fact that I have achieved a PhD has brought about no changes in terms of my employment. I will remain at the same salary notch, the same rank, and there is no scope to be employed at a higher managerial level, nor be promoted. Both the Department of Health and university basically disregard this achievement. – health sciences

Akay suggests that a PhD in engineering does not prepare the graduate for industry, but rather the academe (Akay, 2008). Enrolling for a doctorate in the applied sciences, therefore, is often with the intention of entering the academic world. This is more often than not the case with graduates in the pure sciences. However, given the responses of participants in the physical sciences below, one can see that students in the physical sciences often find it difficult to find employment (42.7%) and feel that a PhD would improve their employment prospects (81.1%). With reference to the former, even though the percentages are lower across the board, the percentage of respondents who indicated the inability to find employment as a rationale for enrolling in the doctorate as "important" is at least 10% higher for respondents in the physical sciences than respondents in other disciplines.

Table 10-8 Respondents' rationale for doctoral enrolment

	Education	Engineering	Health sciences	Physical sciences	Social sciences
Inability to find employment and hence decided to continue with studies	31.7%	30.8%	23.4%	**42.7%**	26.8%
Employment prospects on completion of the programme	79.0%	72.5%	**81.1%**	75.4%	78.6%

Notwithstanding the efforts to expand the supply of doctorates in the STEM sciences, particularly in the physical sciences, respondents feel that there has not been a concurrent increase in the demand for graduates. Respondents perceived employment opportunities for graduates in the physical sciences as scarce and difficult to obtain.

> I'll probably work in the physics department. I want to continue with research after getting my Doctorate but I'm not sure what I'll do for employment. Most likely it will be either tutoring or lecturing. – physical sciences

> My boyfriend (now husband) wanted to go to South Korea to teach English so I decided to join him for the year between MSc and PhD. I originally wanted to come back and get a job, but due to limited jobs as a result of the economic downturn I instead registered for my PhD. – physical sciences

The expected value of the PhD and the perceived relevance of the programme are important factors that influence students' pursuit of the doctorate. Respondents enrolled in education were of a firm belief that a doctoral qualification would improve or expand their career opportunities.

> Doing a doctorate will enable me to continue to grow and develop in my current field of work. It will be important for my future career and any future job applications. – education

> Having PhD will mean that I can change employer [and] opens up career prospects for me. – education

> Hope to get promoted. – education

> Hoping the qualification will improve my job options. – education

The perceptions of survey respondents stated above, support the notion that doctoral candidates in education are likely professionals, who are already established in their careers, but who wish to improve on their skills in order to improve their career prospects. However, a few respondents acknowledge that they would essentially need to leave their current employment.

> I would like to change from working for Department of Education to working at a university. – education

> I would like to change my current employment and join academia where my knowledge and expertise will be more useful and grow better. – education

Further evidence of this is presented in Table 10-9 below. Survey respondents were asked to identify their immediate plans after graduation.

Table 10-9 Doctoral students' immediate plans after graduation

	Education	Engineering	Health sciences	Physical sciences	Social sciences
Enrol for a post-doctoral fellowship	33.0%	28.3%	36.4%	**43.8%**	40.5%
Continue with my current employment	37.0%	33.6%	**38.0%**	14.6%	30.2%
Find employment (for the first time)	2.0%	19.5%	10.9%	**29.9%**	9.5%

Only 2% of respondents in education indicated that they were planning to find employment for the first time which suggests that the majority of doctoral candidates in education are employed at the time of enrolment. Nearly a third of respondents in the physical sciences indicated that they will be seeking employment for the first time upon graduation. This supports previous arguments of students in the physical sciences, or physics, as progressing directly from previous degree qualifications and pursuing the doctorate as a start to their careers. Not surprisingly, the highest proportion of respondents planning on enrolling for a post-doctoral fellowship is in the physical sciences and social sciences (arguably the more pure disciplines). The reasons for this may be two-fold. First, students in the pure (reflective) sciences perceive a clear trajectory to an academic career starting at the doctorate and continuing as a post-doctoral fellow. Second, some students perceive employment opportunities in the pure sciences to be limited.

> Prospects for work after graduation may be better with a different choice [a doctoral programme in another field]. – physical sciences

> I would like to be a researcher one day, so the next step would be to complete a post-doctoral fellowship, unless I could get a research position straight after completing my doctoral degree. – health sciences

> I believe a post-doctoral position will further equip me for a career in academia. – physical sciences

> Obviously my aim is to find permanent employment, but since a PostDoc has more certainty, I'm applying for this while looking out for a job opportunity. – social sciences

Other respondents, however, considered a post-doctoral fellowship as a fall-back if they are unable to find suitable employment.

> Since [I am] unemployed, [I] might consider [a] Post-doctoral fellowship, if I can't get [one] [a] job is the first option. – physical sciences

> My first choice would be to find employment that is meaningful and with decent pay. However, I will also consider a post-doc provided I'm given enough freedom to do my own research and the funding is sufficient. – physical sciences

> First prize: [to] find employment at a university; second prize: [to find a] post-doctoral fellowship. – social sciences

From the data above one can draw a few conclusions. Most respondents enrolled in education indicated that they would ideally pursue an academic career or be employed in a research capacity, particularly as a post-doctoral fellow. Across all fields, the majority of respondents were either employed in a faculty position or planned to pursue an academic or research career, and, therefore, felt that a PhD will improve their employment prospects. Respondents in the pure sciences were more inclined to enrol for a post-doctoral fellowship than their counterparts in the applied sciences. This is due to perceived limited employment opportunities available to graduates in the pure sciences. However, the qualitative data showed that, for many respondents, a post-doctoral fellowship is the next step to an academic career, while for others, it is merely a placeholder until suitable employment is found.

In the following section, I consider selected dispositional factors in exploring time-to-degree of doctoral students in South Africa.

10.2 Dispositional factors

In this section, I explore student satisfaction as a dispositional factor on doctoral timely completion. First, I explore if there is an association between satisfaction with supervision and projected time-to-degree and second, I consider institutional supervision as having an association with timely completion.

10.2.1 Student satisfaction with academic supervision

Student (dis)satisfaction is sometimes claimed to influence doctoral success (Lee, 2008). In this section, I explore whether student satisfaction, particularly with academic supervision, affects respondents' estimated time-to-degree. Survey respondents were asked to indicate whether they were satisfied with their doctoral supervision and approximately 90% of respondents indicated that they were satisfied with their academic supervision. My null hypothesis is stated below.

H_0: There is no statistically significant difference in the mean time-to-degree of survey respondents who are satisfied with their academic supervision and those who are dissatisfied.

$H_0: \mu_s = \mu_d$

Where μ_s is the mean time-to-degree of respondents who are satisfied with their supervision and μ_d is the mean time-to-degree of dissatisfied respondents.

Inter-disciplinary comparisons

An independent samples t-test was conducted to test whether there is a significant difference in the projected mean time-to-degree of respondents who were either satisfied or dissatisfied with the academic supervision they had received. The results are summarised in Table 10-10 below.

Table 10-10 Results of t-test of respondent satisfaction with doctoral supervision

		Satisfied	Dissatisfied	Satisfied	Dissatisfied
		Original data		Transformed data	
All disciplines	n	901	102	901	102
	Mean	**39.81**	45.71	**1.60**	1.66
	Std. dev.	*1.279*	*1.300*	*0.107*	*0.114*
	Results	-		t=-5.098; p=.000; r=.16	

The results of the independent samples t-test show that there is a statistically significant difference in the mean estimated time-to-degree between respondents who felt satisfied with their doctoral supervision and those who did not (t=5.098; p=.000; r=.16). Respondents who indicated that they were satisfied with their supervision projected a significantly shorter average time-to-degree than those who felt dissatisfied. These results suggest that student satisfaction with academic supervision is an enabler of timely completion. Unfortunately the sample was too small to test for student satisfaction on projected time-to-degree within the disciplinary fields.

Discussion

There is an extensive literature on the role of student satisfaction in degree success (Barnes & Randall, 2012; Schertzer & Schertzer, 2004; Zhao, Golde & Mccormick, 2005). Survey respondents were asked to rate, on a Likert scale ("very important" to "not important at all"), the importance of a lack of supervision as a barrier to completion. Approximately 38% or respondents indicated that a lack of supervision was an "important" reason (including "very important") for considering withdrawal from their studies. Just over a third of respondents cited academic supervision as a barrier as "somewhat important" with 28% indicating that they did not attribute a consideration for dropping out to a lack of academic supervision.

Similarly, respondents were asked to rate their satisfaction with academic supervision on a scale of "very satisfied" to "very dissatisfied". The results are presented below and disaggregated by disciplinary field. More than 81% of all respondents indicated that they were satisfied with their supervision while the majority of these respondents (22.3%) were enrolled in the health sciences. Of the nearly 10% of respondents who indicated that they were dissatisfied with their supervision (including very dissatisfied), 27% was enrolled in engineering.

Table 10-11 Survey respondents' satisfaction with their supervisors by academic discipline

	All disciplines	Education	Engineering	Health sciences	Physical sciences	Social sciences
Satisfied	1008	88	94	113	112	100
	81.2%	17.4%	18.5%	22.3%	22.1%	19.7%
Neutral	115	9	7	12	17	14
	9.3%	15.3%	11.9%	20.3%	28.8%	23.7%
Dissatisfied	119	8	16	8	14	14
	9.6%	13.3%	26.7%	13.3%	23.3%	23.3%

In exploring the reasons for respondents' dissatisfaction with their academic supervision, I turn to the qualitative responses collected in the survey. Respondents viewed a strained student-supervisor relationship as a significant barrier to (timely) completion.

> My first attempt was in 2009 and I had major fights with my supervisor and after that I did not want to enrol for PhD anymore. – education

> The standards set by the supervisor were extremely high, and I, at least three times, decided I could not meet the required standard, and planned to terminate my registration. – social sciences

Students often pursue a specific academic supervisor given their expertise in a field and their positioning within an institution. Doctoral candidates encounter significant challenges when supervisors change academic departments, faculties or institutions.

> I could not get a supervisor after my supervisor had left for another institution. – education

> My choice to enrol in my PhD course was primarily based on the academic supervisor connected to the project, however, this supervisor moved to another university part way though my PhD studies. This supervisor has made every effort to remain connected to the project, which I appreciate, but it has complicated my research, and delayed the completion of my thesis. If I was to choose again, knowing that my primary supervisor would leave, I may have chosen a different project/university. – physical sciences

> Availability of supervisors is very important. In my master's year I had applied to do my degree with a certain supervisor and had funding connected to that degree and the university I'm at. The supervisor left before I had even started the degree (she had told me this was a possibility upon my application) so I did know BUT I ended up with a horrible supervisor because I was now tied with funding to that specific university. – physical sciences

> As a student you should own your research from conception in case your supervisor decides to leave the university that you are enrolled with. – health sciences

In disciplinary fields, such as engineering, and the physical sciences, research projects and their subsequent funding are often linked to an individual supervisor. This is often perceived as a positive and successful model.

> I have hit a dead-end time and again in terms of securing funding for my research. It may have been better to approach an institution which could offer supervisor-linked funding. – health sciences

However, such an arrangement can also pose a set of additional challenges especially during the early stages of a project.

> Nobody at our department has worked in this specific field yet and we as a research group had no momentum. I would have rather chosen a topic in which my supervisors and our department were better geared for. – engineering

A Malaysian study on research students' perspectives on doctoral supervision (Ismail, Majid & Ismail, 2013) identify three primary challenges associated with the supervisory process which include a lack of positive communication, lack of necessary expertise to give support, and power conflicts. As stated by a respondent below, supervisors who have limited experience in supervision can significantly hamper a student's progress.

> It's been a very long and painful process. I've had issues with my supervisor (I'm only her third/fourth PhD student). If I could, I would definitely do a PhD, but in a different university (with a better programme in my specific field) or find a different supervisor in my department. – physical sciences

Similarly, personality clashes can underlie an unsuccessful relationship. Hemer posits that the experience of doctoral supervision has traditionally been viewed "… in terms of conflict, isolation from others, trauma and 'fraught discipleship'…" (Hemer, 2012). Although I have seen, in the literature, a shift towards a more collaborative approach of models of supervision which focusses on partnership, the actualisation of such relationships is not always the case as highlighted by survey respondents.

> Supervisor not listening to student's views … – health sciences

> I have a very difficult relationship with my supervisor and we don't get on at all. – health sciences

> I would get frustrated because I do a lot of reading and I still don't get what the supervisor wants. – health sciences

> Need more encouragement and mentoring. I feel very much left to my own devices. – social sciences

> Had to change supervisor in order to continue. Now I'm very satisfied. – social sciences

> Insufficient support, harsh comments from the supervisor. – education

> Enrolled in a different university out of the country but had to abandon it because of poor supervision and no follow up. – education

> I would choose another degree because I am not getting along very well with my current supervisor regarding my project. – health sciences

> Timeline for finishing not clear with supervisor, therefore leading to frustration. – engineering

Many respondents consider a healthy relationship between student and supervisor as crucial to a successful candidacy. Survey respondents were asked to rate the importance (on a Likert scale) of a relationship with their academic supervisor in influencing their choice to enrol in their academic programmes. Almost 90% of respondents indicated that they consider the relationship as either "very important" or "important". These views are underscored by scholars such as Ismail, Majid and Ismail (2013) and Wisker & Robinson (2013; 2014) who emphasise the importance of doctoral supervision in doctoral success. A study conducted in the UK states that more than 95% of postgraduate students deemed supervision as key to successful completion (Slight, 2017).

In this section, survey respondents' experiences concerning the supervisory relationship and the challenges associated with the process were identified. One of the primary challenges identified is the positioning of a supervisor within an institution, and the challenges associated when supervising faculty members move between departments or institutions. Supervisory inexperience and inter-personal difficulties were also mentioned in respondents' considerations for terminating their studies. Respondents' satisfaction with their academic supervision was measured against their estimated time-to-degree and found that there is an association between satisfaction with academic supervision and timely completion.

10.2.2 Student satisfaction with the academic institution

In the survey, respondents were not asked outright to indicate satisfaction with their respective institutions. I was, therefore, unable to statistically test whether institutional satisfaction is associated with projected time-to-degree. Respondents did, however, indicate on a Likert scale ("very important" to "not important at all"), how important the academic reputation of the university was in their decision to enrol for a doctorate. Almost 90% indicated the institution's reputation as "important" or "very important" while only 4% rated it as "not important" or "not important at all". Similarly, respondents were asked how important a lack of a university support system is in their consideration to drop out (of respondents indicating that they have considered terminating their studies). More than 26% rated institutional support as "very important" or "important" while over 40% indicated it as "not important". I found that survey respondents were generally satisfied with the universities at which they were enrolled. Below, however, I highlight some of the institutional difficulties experienced by respondents.

> My previous university was an administrative shambles (sic.), and I needed to negotiate a supervisor for my PhD at Rhodes. – education

> I changed institutions. I had started my doctoral degree at one institution and changed, where I studied a different topic. – engineering

> I completed my master's degree in 2004 and in 2008 my doctoral proposal was ready for submission. I then had to change the institution in which I originally intended to register. I therefore had to go through the new application process and it later turned out [that] I could not secure the funding for my study. In 2011, I then started working on a new research concept. – health sciences

Some respondents mentioned administrative challenges in their pursuit of the doctorate. Some respondents, when asked why they interrupted their degree progression, attributed the break in studies to institutional matters.

> Because there is no support for student[s] [at] the Inclusive Education section at Unisa. As a student, you struggle to be assisted especially in administration issues. Battled to be allocated a supervisor for the whole academic year (2012) even though I was a registered student. Then I have to register the following year (2013) and it was that I was allocated a supervisor, who is not in the Inclusive section, and that was very demoralising. - education

Students in the natural and applied sciences are particularly reliant on equipment and facilities and students in these disciplinary fields are more likely to experience challenges with insufficient infrastructure.

> There is serious lack of equipment to carry out my current research within my university – engineering

> Funding for humanities is horrible in this country. I wouldn't change my degree, nothing is wrong with the degree it is the institutions and the way resources are allocated that is a problem – social sciences

Some students pointed out that they experienced challenges related to the political climate surrounding higher education in South Africa.

> Rhodes doesn't make you feel excluded or unwanted because you are white. UKZN does. It was downright discouraging and unpleasant. – education

> UCT has not been as supportive, welcoming and tolerant as I'd hoped; the research could also have been better with different facilities or supervision. – physical sciences

Some respondents reiterated Portnoi's findings in that they experience both overt and covert racial tensions at South African institutions (Portnoi, 2009). In the next and final section of this chapter, I explore survey respondents' experiences of and perceptions towards the discontinuation of their doctoral studies.

10.2.3 Voluntary withdrawal from doctoral studies

The decision to withdraw from or pause doctoral studies is often the result of an accumulation of factors (dispositional, institutional, situational and so forth). One can assume that students who consider, or have considered, discontinuing their studies, experience significant obstacles to completion. Measuring the impact of considering withdrawal from doctoral studies on time-to-degree, therefore, necessitates a discussion of some of the factors that urge students to consider drop out, such as lack of funding and quality supervision. First, however, I investigate whether there are statistically significant differences in the estimated time-to-degree of students who have considered dropping out of their doctoral programmes and respondents who have not. I state my null hypothesis below.

H_0: There is no statistically significant difference in the mean, projected time-to-degree of survey respondents who have considered dropping out and those who have not.

$H_0: \mu_{do} = \mu_{ndo}$

Where μ_{do} is the mean, projected time-to-degree of respondents who considered dropping out and μ_{ndo} is the mean, projected time-to-degree of students who did not consider dropping out.

Inter-disciplinary comparisons

Survey respondents were asked whether he/she has considered withdrawing from their doctoral studies. The majority of respondents indicated that they have not considered discontinuing their studies. Across all disciplinary fields, with the exception of respondents in education, respondents who considered dropping out of their degree programmes projected a longer time-to-degree than those who have not considered dropping out. An independent samples t-test showed that the mean differences were statistically significant (t=5.313; p=.000; r=.18).

Intra-disciplinary comparisons

Independent sample t-tests were done by disciplinary field to test whether there are significant differences in respondents' projected time-to-degree depending on whether they have considered terminating their studies or not.

Table 10-12 Comparing mean projected time-to-degree of respondents considering drop out and those who did not

		Considered dropping out	Did not consider dropping out
		Original data	
All disciplines	n	421	647
	Mean	44.14	**40.43**
	Std. dev.	*11.562*	*10.097*
	Results		t = 5.377; p = .000; r =.16
Education	n	29	54
	Mean	**40.21**	42.30
	Std. dev.	*9.641*	*11.278*
Engineering	n	42	57
	Mean	47.36	**39.26**
	Std. dev.	*10.212*	*8.570*
	Results		t = 4.280; p = .000; r =.40
Health sciences	n	41	80
	Mean	44.54	**41.08**
	Std. dev.	*11.463*	*10.477*
Physical sciences	n	56	72
	Mean	42.36	**39.82**
	Std. dev.	*11.506*	*10.016*
Social sciences	n	44	68
	Mean	42.64	**40.04**
	Std. dev.	*12.035*	*10.312*

Statistically significant mean differences were only found for respondents in engineering where respondents who have not considered dropping out recorded a shorter mean time-to-degree than those who have considered dropping out (t=4.306; p=.000; r =.40). With the exception of respondents in education, I can reject the null hypothesis and argue that respondents who have considered discontinuing their doctoral studies would take longer to complete their degrees than those who have not.

Of those respondents who have considered discontinuing their doctoral programmes, respondents were asked to indicate the reasons underlying their attitudes towards possible termination on a Likert scale as “important” and “very important”. The results are presented in Table 10-13 below.

Table 10-13 Survey responses indicating reasons for considering dropping out

	All disciplines	Education	Engineering	Health sciences	Physical sciences	Social sciences
Financial challenges	243	18	20	28	32	26
	54.5%	14.5%	16.1%	22.6%	25.8%	21.0%
Challenges to find sufficient time for studies (e.g. to balance work and studies)	180	23	14	20	17	19
	45.2%	24.7%	15.1%	21.5%	18.3%	20.4%
Physical/mental health related challenges	85	11	7	7	14	3
	25.2%	26.2%	16.7%	16.7%	33.3%	7.1%
Challenges to cope with study demands (e.g. course load, difficulty of assignments)	109	17	9	9	10	10
	28.7%	30.9%	16.4%	16.4%	18.2%	18.2%
Challenges in my personal/family/social life	187	19	15	20	27	15
	43.1%	19.8%	15.6%	20.8%	28.1%	15.6%
Lack of university support systems (e.g. language support, mentors, counselling)	99	8	8	12	17	11
	26.1%	14.3%	14.3%	21.4%	30.4%	19.6%
Lack of sufficient academic supervision	151	9	16	19	18	17
	37.8%	11.4%	20.3%	24.1%	22.8%	21.5%
Uncertainty about career aspirations	151	5	12	10	23	13
	37.8%	7.9%	19.0%	15.9%	36.5%	20.6%

The results above show that a larger percentage of respondents in education cited that challenges with balancing work and studies and coping with study demands are important barriers to successful completion. This is presumably due to students in education being more likely to be employed full-time during their doctoral studies. In addition, given that the mean age at enrolment of doctorates in education are much higher than the other disciplines, one could assume that family responsibilities are a more pertinent barrier to completion for older students. A high proportion of respondents in the physical sciences indicated an uncertainty about career options as a noteworthy challenge. Respondents also made mention of the fact that the doctorate is a lonely and taxing process, irrespective of discipline.

> The contact sessions are appreciated and the research doctorate is a very lonely journey. – social sciences

> Doing this degree is physically, emotionally and mentally draining. There are moments on daily basis whereby I feel like I am loosing (sic.) my mind and this impacts highly on my mental stability hence family and social life. – engineering

> A lonely research (no peers nor working group). No academic contact or training provided in the subject area. Struggled a lot … – engineering

Portnoi (2009) listed isolation and challenges of balancing family, work and study commitments as key obstacles to a successful candidacy.

More than a half of survey respondents who indicated that they have considered discontinuing their studies attributed their attitudes to financial challenges. Respondents indicated that a lack of funding often prevented them from first, enrolling in their first-choice institution or programme. Second, financial constraints forced many students to take on additional employment which minimised their time available for doctoral studies. Third, a lack of funding often compromised the quality of the study given the limited funds available for data collection and so forth. In the South African context, future candidates are often deterred from enrolling in a degree given the high financial, emotional and time investment required.

> The financial challenges have been far bigger than expected, with an estimated R70 000+ required in tuition fees over four years of part-time study and an estimated R70 000+ required for my research itself. I have not managed to secure sufficient funding and at present my research is thus stonewalled. – health sciences

A higher percentage of respondents in the physical sciences indicated that they struggled with financial challenges, lack of university support systems and uncertainty about career options. The lack of infrastructure at certain institutions often posed great challenges to students in the physical/experimental sciences, as is seen in the quote below.

> Insufficient infrastructure for the project - despite the project proposal having been accept(ed). – physical sciences

The ASSAf Consensus report found that one of the central barriers to doctoral education in South Africa is financial constraints (ASSAf*,* 2010). A key finding by Mouton et al. (2015) is that doctoral success in South Africa is hindered by the fact that the majority of doctoral students in South Africa are enrolled part-time, which directly reflects on the lack of funding for full-time doctoral candidates. Survey respondents were asked to indicate their primary sources of funding[102]. Of respondents who received NRF funding, the majority (34.8%) were enrolled in the physical sciences.

[102] Respondents could indicate more than one source of funding.

Table 10-14 Top sources of funding as reported in survey by field

	Education	Engineering	Health sciences	Physical sciences	Social sciences
	(115)	(122)	(142)	(160)	(136)
NRF scholarship	14	34	49	70	34
	7.0%	16.9%	24.4%	34.8%	16.9%
Any other scholarship/bursary	28	60	52	56	53
	11.2%	24.1%	20.9%	22.5%	21.3%
Personal earnings/savings/ Family earnings	47	72	61	61	87
	14%	22%	19%	19%	27%
Loans	3	10	11	15	12
	5.9%	19.6%	21.6%	29.4%	23.5%
Employer reimbursement	25	24	17	12	24
	24.5%	23.5%	16.7%	11.8%	23.5%

The overwhelming majority of respondents, regardless of disciplinary field, mentioned that access to funding was (is) one of the primary reasons for first, not being able to enrol for a PhD at an earlier stage, second, not being able to enrol for their first-choice degree, and third, not able to always enrol at their institution of choice.

> There is so much emphasis placed on producing SA doctoral graduates, yet I faced enormous challenges when trying to get funding for the NRF, Due to inefficiencies I was not considered for other grants and given the lowest grant. Things are extremely expensive even with the top up from the research unit barely able to cover living expenses, have no funds to do data collection. Finding funding is extremely stressful, time-consuming and feel so under-valued by the university (sic.) study hard, work hard yet absolutely no fair benefits such as adequate remuneration or medical aid. – health sciences

> I have hit a dead-end time and again in terms of securing funding for my research. It may have been better to approach an institution which could offer supervisor-linked funding. – health sciences

Many students lamented that if they acquired sufficient funding, they would have been able to enrol at an international institution.

> Enrolling in a programme is not entirely a matter of choice, especially if you do not have money of your own to pay for your studies. We chase after funding everywhere we go. I would do something else but I cannot get funding for what I really want to do, so I have to do what I will receive funding for, for without funding I will not study at all. Worst of all, I cannot find work with the M. Ed that I hold right now, so I have to find a way to remain at university. – education

A number of studies identified financial assistance as a significant predictor of timely doctoral completion (Ampaw & Jaeger, 2012; Bourke et al., 2004a; Hoffer & Welch Jr., 2006; Jiranek, 2010). In the UK, HEFCE found that graduates who received funding from a research council were more likely to complete their degrees (HEFCE, 2005). In Table 10-14 above, I found that a higher percentage of respondents in the physical sciences received financial support from the NRF and in Chapter 6, I found that graduates in physics recorded the highest completion rates which points to a probable relationship between financial support and completion rates. Hoffer and Welch Jr. (2006) similarly found that students who received financial support recorded a shorter time-to-degree than those who relied on their own financial resources. A higher percentage of survey respondents in the social sciences, as reported in Table 10-14 above, indicated that they relied on personal savings or earnings for financing their studies while I also found longer completion time among doctoral graduates in sociology. Once again this finding supports that found in the literature regarding the significance of financial support in (timely) degree attainment.

In this section, I mentioned the discernible association between financial support and doctoral completion. In the final chapter of this study, I recommend that future research on time-to-degree should continue to explore this relationship on financial assistance and doctoral completion.

10.3 Conclusion

In this chapter, I addressed the relationship between selected situational and dispositional factors on projected time-to-degree as identified by survey respondents. Respondents in the physical and engineering sciences were more likely to directly progress from a previous degree to doctoral studies. A cross-disciplinary comparison showed that students who enrolled in their doctorate immediately after completing a previous university degree estimated a shorter time-to-degree than those students who had progressed indirectly from a previous degree. Reasons for taking “a break” before enrolling for a doctorate included financial constraints, burn-out after a previous degree and mentally preparing for the doctorate, taking time to identify research gaps, and lastly, gaining some work experience. Respondents, in the physical sciences, who indicated that their doctoral research field differed significantly from that of their previous degrees estimated a shorter time-to-degree than those who remained in the same field. In the table below, I summarise the results of descriptive analyses with reference to the role of selected situation factors on timely completion.

Table 10-15 Summary of the relationship between selected situational factors and expected time-to-degree

Factors	Direct degree progression	Change in field	Employed full-time (fart-time enrolment)	PhD as job requirement
All respondents	Statistically shorter time-to-degree than indirect progression (p=.006; r=.008)	-	Statistically longer time-to-degree than not employed full-time (p=.000; r=.24)	-
Education	-	-	-	-
Engineering	-	-	Statistically longer time-to-degree than not employed full-time (p=.000; r=.41)	-
Health sciences	-	-	Statistically longer time-to-degree than not employed full-time (p=.023; r=.20)	-
Physical sciences	-	Statistically shorter time-to-degree than no change in field (p=.025; r=0.32)	-	-
Social sciences	-	-	Statistically longer time-to-degree than not employed full-time (p=.002; r=.35)	Statistically shorter time-to-degree than not job requirement (p=.038; r=.19)

Across all disciplinary fields, respondents who held full-time employment positions during their studies projected a statistically significantly longer time-to-degree than respondents who were not employed full-time. Among all disciplines, and particularly for respondents in education and social sciences, the majority were employed at a university. This led to the question of whether doing a PhD as a job requirement is an indicator of shorter time-to-degree, but was found not to be an important enabler of timely completion. Statistically significant results were found only for respondents in the social sciences where respondents who pursued the PhD as a job requirement estimated shorter completion times. However, the doctorate is perceived as an important endeavour for respondents in education, whereas often in applied fields such as electrical engineering, the PhD is regarded as irrelevant and superfluous by those working in industry.

As dispositional factors, students' satisfaction with academic supervision and their academic institutions were explored. For all respondents, it was found that satisfaction with academic supervision is correlated with shorter completion times. Nearly all survey respondents indicated they considered satisfaction with their academic institution an important enabler of student success. One of the central questions addressed in this chapter was whether the consideration to discontinue doctoral studies significantly affected respondents' anticipated time-to-degree. An analysis of all survey respondents showed that respondents who have considered dropping out of their doctoral programmes estimated significantly longer time-to-degree than those who have not considered dropping out.

Table 10-16 Summary of the relationship between selected dispositional factors on expected time-to-degree

Factors	Satisfaction with supervision	Consider dropping out
All respondents	Statistically shorter time-to-degree than dissatisfied (p=.000; r=.16)	Statistically longer time-to-degree than no consideration of dropping out (p=.000; r=.16)
Education	-	-
Engineering	-	Statistically longer time-to-degree than no consideration of dropping out (p=.000; r=.40)
Health sciences	-	-
Physical sciences	-	-
Social sciences	-	-

The primary reasons given for having considered dropping out, in the physical sciences, included financial challenges, lack of university support and uncertainty about career aspirations. Respondents enrolled in education indicated that they faced challenges balancing work, study and life commitments.

The next chapter marks the final chapter dedicated to the empirical components of this study and seeks to identify predictors of timely degree attainment.

Chapter 11 | Towards an explanatory model of doctoral time-to-degree

Throughout this study, I have explored time-to-degree of doctoral students in South Africa by means of descriptive statistics. In an effort towards constructing a model explaining doctoral time-to-degree, I undertook a pooled multiple linear regression to identify the relationships of selected variables on average time-to-degree. The factors included in this model are the nature of a discipline as an epistemological factor, while gender, race, age and nationality were included as student demographics. The university as an institutional factor and mode of enrolment as a situational factor were included as independent variables in predicting the time-to-degree of doctoral students.

11.1 Profile of students in data set

In Chapter 5, I discussed the methodological assumptions underlying a pooled linear regression model which assumes that there are no exogenous variables that would change the result (in this case average time-to-degree) over time. In Chapter 6, I reported that the average time-to-degree of doctoral graduates in South Africa increased slightly between 4.4 years in 2000 and 4.7 years in 2014 and that this change was consistent over the five disciplines. For this reason, no time variable was included in the regression model.

The HEMIS student data for 2010 to 2016 were used for the regression analysis. I present a profile of the students included in the data set as selected for the regression analysis in Table 11-1. A total of 2 824 doctoral graduates were included in the data set. The majority of the graduates in education were female, black African and South African. Slightly more than 60% of the graduates in education were enrolled at traditional universities, while 46.4% were enrolled part-time and nearly 75% were aged 40 years or older. Graduates in electrical engineering were primarily male (88.7%), white (47.8%) and South African (56.6%). Nearly 70% of the graduates in electrical engineering were enrolled at traditional universities while 86.5% were enrolled full-time and 85.5% were younger than 40 years.

Table 11-1 Profile of doctoral graduates in five disciplines (2010 to 2016)

		Total of five disciplines		Education		Electrical engineering		Medical clinical sciences		Physics		Sociology	
		n	*%*	n	*%*	n	*%*	n	*%*	n	*%*	n	*%*
Gender	Male	1597	*56.6*	725	*47.2*	250	*88.7*	197	*49.4*	229	*82.4*	199	*59.6*
	Female	1227	*43.4*	812	*52.8*	32	*11.3*	199	*50.6*	49	*17.6*	135	*40.4*
Race	Black African	1499	*53.9*	883	*57.9*	108	*40.0*	113	*29.3*	165	*60.4*	230	*69.7*
	White	867	*31.2*	402	*26.4*	129	*47.8*	186	*48.2*	82	*30.0*	68	*20.6*
	Indian/Asian	246	*8.8*	124	*8.1*	23	*8.5*	68	*17.6*	18	*6.6*	13	*3.9*
	Coloured	171	*6.1*	115	*7.5*	10	*3.7*	19	*4.9*	8	*2.9*	19	*5.8*
Nationality	South African	1776	*63.4*	1035	*67.7*	158	*56.6*	298	*76.0*	143	*52.0*	142	*43.6*
	RoA	913	*32.6*	459	*30.0*	102	*36.6*	70	*17.9*	118	*42.9*	164	*50.3*
	RoW	111	*4.0*	34	*2.2*	19	*6.8*	24	*6.1*	14	*5.1*	20	*6.1*
HEI	Traditional	1977	*70.0*	940	*61.2*	196	*69.5*	350	*89.1*	227	*81.7*	264	*79.0*
	Comprehensive	678	*24.0*	502	*32.7*	27	*9.6*	28	*7.1*	51	*18.3*	70	*21.0*
	Technology	169	*6.0*	95	*6.2*	59	*20.9*	15	*3.8*	0	*0.0*	0	*0.0*
Mode of study	Full-time	1897	*67.2*	824	*53.6*	244	*86.5*	327	*83.2*	261	*93.9*	241	*72.2*
	Part-time	927	*32.8*	713	*46.4*	38	*13.5*	66	*16.8*	17	*6.1*	93	*27.8*
Age	<40 years	1321	*46.8*	394	*25.6*	242	*85.8*	258	*65.5*	238	*85.6*	189	*56.6*
	≥40 years	1503	*53.2*	1143	*74.4*	40	*14.2*	135	*34.4*	40	*14.4*	145	*43.4*

The profile of doctoral graduates in electrical engineering is similar to that of graduates in physics where 82.4% were male, 93.9% were enrolled full-time and 85.6% were younger than 40 years. Slightly more than 60% of the graduates in physics were black African, while just over half of the graduates were South African and 81.7% were enrolled at traditional universities.

Graduates in the medical clinical sciences were primarily female (50.6%), white (48.2%) and South African (76.0%). The majority of the graduates in the medical clinical sciences were enrolled at traditional universities (89.2%) and enrolled full-time (83.2%) while 65.5% of graduates were younger than 40 years old. The majority of doctoral graduates in sociology were male (59.6%), black African (69.7%) and from the rest of Africa (50.3%). The majority of graduates in sociology were enrolled at traditional universities (79.0%) and were enrolled full-time (72.2%). Slightly more than 56% of the graduates in sociology were 40 years old or older.

11.2 Regression models

A specific to general approach was taken to include variables in the model. Initially, a parsimonious model was run to study the differences in time-to-degree across the five selected disciplines. Here I included student demographics such as gender, race, and academic institution in the basic analysis of differences in doctoral time-to-degree across the five selected disciplines. This basic model included discipline (education, electrical engineering, the medical clinical sciences, physics and sociology), gender (male or female), race (black African, coloured, Indian/Asian and white) and higher education institution (traditional universities, comprehensive universities and universities of technology) as independent variables.

The institutions at which doctoral graduates were enrolled were classified into three categories which included traditional universities, comprehensive universities and universities of technology. An initial version of the regression model showed that there were no statistically significant relationships between students' academic institution and average time-to-degree. Although I found in Chapter 9 that there exist institutional differences in the timely completion of doctoral students, it was difficult to directly measure institutional support. Consequently, I used proxies such as throughput rates and supervisory capacity to explore the role of academic institutions in time-to-degree. Given the statistically insignificant results for academic institutions in the regression models and the fact that a grouping of institutions may obscure actual institutional differences in timely completion, it was decided to exclude universities from the regression model. Regression coefficients and standard errors can be found in Table 11-2 (below).

Table 11-2 Regression table

	Model 1	**Model 2**	**Model 3**	**Model 4**
Constant	5.244 ***	4.735 ***	4.701 ***	4.484 ***
	(0.134)	(0.143)	(0.142)	(0.150)
Male	-0.035	-0.072	-0.085	-0.068
	(0.090)	(0.088)	(0.088)	(0.087)
Education	-0.652 ***	-0.980 ***	-1.093 ***	-1.105 ***
	(0.123)	(0.125)	(0.126)	(0.126)
Electrical engineering	-0.555 **	-0.324	-0.324	-0.268
	(0.171)	(0.170)	(0.169)	(0.169)
Physics	-0.834 ***	-0.558 ***	-0.511 **	-0.474 **
	(0.169)	(0.169)	(0.168)	(0.167)
Sociology	-0.337 *	-0.388 *	-0.435 **	-0.377 *
	(0.167)	(0.164)	(0.163)	(0.164)
Coloured	0.470 *	0.426 *	0.447 *	0.219
	(0.183)	(0.180)	(0.178)	(0.186)
Indian/Asian	0.491 **	0.475 **	0.470 **	0.237
	(0.151)	(0.149)	(0.148)	(0.158)
White	0.149	0.189 *	0.162	-0.096
	(0.096)	(0.094)	(0.094)	(0.112)
40 years and older		0.952 ***	0.879 ***	0.877 ***
		(0.102)	(0.102)	(0.102)
Part-time			0.554 ***	0.515 ***
			(0.094)	(0.094)
ROW				0.436
				(0.240)
South Africa				0.479 ***
				(0.110)
n	2449.00	2447.00	2447.00	2447.00
R^2	0.025	0.058	0.071	0.079
				*** p < .001; ** p < .01; * p < .05.

In the first regression model (model 1), I found that male time-to-degree was slightly shorter when compared to female time-to-degree but the differences were not statistically significant. I found that graduates' average time-to-degree in electrical engineering, education and physics is significantly shorter when compared to the base category, the medical clinical sciences. In model 1, graduates in physics (p<.001) recorded the shortest time-to-degree when compared to graduates in the medical clinical sciences, followed by education (p<.001), electrical engineering (p<.010) and sociology (p<0.5). I found a statistically significant relationship between race and time-to-degree with coloured (p<.01), Indian/Asian (p<.01) graduates recording a longer average time-to-degree compared to black African graduates.

In both the literature reviewed (Chapters 3 and 4) and subsequent descriptive analyses (Chapter 8), I found that age is a significant factor associated with timely completion. Subsequently, age was included in the model (model 2). Graduates' age at enrolment was recoded into those younger than 40 years and those aged 40 years and older[103]. When tested for students' age, I found that graduates aged 40 years recorded statistically significant longer time-to-degree compared to younger graduates (p<.001). I, therefore, found a definitive relationship between younger age and shorter time-to-degree. I also found that the differences in time-to-degree of graduates in electrical engineering when compared to the medical clinical sciences, became less significant. Graduates in education reported the shortest average time-to-degree (p<.001) followed by physics (p<.001) and sociology (p<.05). This finding suggests that the original significant differences found between the average time-to-degree of graduates in electrical engineering when compared to the medical clinical sciences as base category, was driven by the fact that the majority of students in electrical engineering are younger than 40 years.

In the third model (model 3), I introduced students' mode of enrolment. I found that mode of enrolment is a predictor of time-to-degree (p=<.001) in that graduates who were enrolled part-time recorded statistically significantly longer time-to-degree than those who were enrolled full-time. With the inclusion of age (older age) and mode of study (part-time enrolment) in the model, the statistically significant differences in time-to-degree of students in physics, when compared to the medical clinical

[103] Students' age was recoded into two categories which included students aged younger than 40 years and 40 years and older. This distinction was made based on the distribution of data. These categories also resulted in a near equal split of students' age at enrolment.

sciences, weakened (p<.01) while that of sociology strengthened (p<.01). The average time-to-degree of graduates in education remained the shortest of the five disciplines (p<.001).

In Chapter 8, I found that graduates from the rest of Africa generally recorded a shorter time-to-degree when compared to domestic students. In the final model (model 4), I, therefore, also included nationality as an independent variable. Subsequently, I found that there is a correlation between nationality and average time-to-degree with South African graduates recording statistically significantly longer time-to-degree when compared to graduates from the rest of Africa (p<.001) as the base category. In the final model, the statistically significant differences in time-to-degree between Indian/Asian, white and coloured students when compared to black African graduates as base category, disappear. In previous models (as seen in model 1, 2 and 3), black African graduates recorded statistically shorter time-to-degree when compared to coloured (model 1, 2 and 3), Indian/Asian (model 1, 2 and 3) and white (model 2) graduates, but when I controlled for nationality, the race effect disappeared. This means that this association between race and time-to-degree was driven by black African graduates from the rest of Africa[104]. I, therefore, found that race[105] is not a predictor of time-to-degree, while nationality, pertaining specifically to students from Africa, is.

Across all four models, I found that gender is not a significant predictor of time-to-degree. Older age (p<.001) and part-time enrolment are strongly associated with longer time-to-degree (p<.001). Throughout all four models, I found that graduates in education recorded the shortest time-to-degree of the five disciplines. This is consistent with the findings throughout the study where I found that graduates in education take the least time to complete their doctoral studies. However, in model 4, I found that graduates in sociology no longer recorded the longest time-to-degree (p<.05) as was found in Chapters 6 and 7.

Five interaction effects were tested under model 4. These included first, disciplinary field and race, second, disciplinary field and age, third, disciplinary field and gender, fourth, nationality and disciplinary field, and finally, nationality and race. The former four interaction effects were included to test whether there is an interaction between a student's demographic profile and their disciplinary field. The only statistically significant result was found between gender and disciplinary field where female graduates' time-to-degree was statistically shorter than male graduates at the 10% confidence

[104] Only 25 graduates from the rest of Africa are NOT recorded as black African.

[105] For both race and nationality, and age and mode of enrolment, interaction terms were introduced in the model. No statistically significant results were found.

interval. This result substantiates the shorter time-to-degree found among female graduates in education as reported in Chapter 8. No significant interaction effect between nationality and race was found.

One should take care in interpreting regression models which include categorical variables. I would, however, like to offer a simple interpretation. In model 4, I interpret the constant value as the average time-to-degree of all observations as slightly more than four years (F=4.484; std. error = .150)[106]. From the values listed in the regression table, I can predict that a student enrolled in education would take 1.105 years *shorter* than the average of the whole model. However, if students are 40 years old or older, their predicted time-to-degree would *increase* by almost a year (0.877). However, results suggest that a student in education who is aged 40 years or older would have a similar average time-to-degree than a graduate in the medical clinical sciences who is younger than 40 years. This is explained by the 1.105 years "advantage" of a candidate in education which nearly cancels out the 0.877 years "disadvantage" of being older than 40 years. Part-time students in education would similarly predict a shorter time-to-degree of full-time students in the medical clinical sciences. In Appendix E, I report on the mean time-to-degree of statistically significant factors per discipline (including gender), as per the data used in the regression model, to substantiate my interpretation of the regression results. I discuss this in the next chapter.

Throughout the study, I have argued that factors that predict time-to-degree are interconnected. From model 1 to model 4, I found that the amount of variance explained (as calculated by R^2) increased with the introduction of new variables (from .025 in model 1 to .079 in model 4). This suggests that each variable introduced was jointly significant in exploring time-to-degree. This result substantiates my claim of the interrelation among variables. I also found, by controlling for the nationality of students (model 4), that it pointed to a spurious relationship between race and time-to-degree as found in model 1, 2 and 3. By adding more variables to the basic model, I found that previously observed relationships changed.

Looking at the total variation of the model as explained by the R^2 value (R^2 = .079 for model 4) slightly less than 8% of the variance is explained by the independent variables. The explanatory value of the regression model is thus limited given that the majority of variables included in the model were student demographics.

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[106] See Table E-1 in Appendix E for the mean time-to-degree of graduates by gender, race, age, discipline and mode of enrolment.

11.3 Discussion

A multiple linear regression model was used to explore the relationships of selected factors on doctoral time-to-degree. I found that gender is not a predictor of time-to-degree, even though male students recorded slightly shorter completion times time than female students. Although mixed results with regard to gendered differences in time-to-degree per discipline were found in Chapter 8, the insignificant results in the regression model suggest that there are no significant differences in time-to-degree between male and female students (Mouton, Valentine & Van Lill, 2017; Park, 2005a, Seagram Gould & Pyke, 1998) and I can, therefore, accept the null hypothesis that there exist no significant differences in doctoral time-to-degree between male and female students in the South African context. However, when looking at the disciplines specifically, I found that there exists an interaction effect between gender and disciplinary field and that female graduates recorded slightly shorter time-to-degree than male graduates in education.

The regression model showed that younger age (younger than 40 years) is a predictor of shorter completion times. These results are congruent with that found in Chapter 8, where for graduates in electrical engineering and physics, older students (aged 40 years and older) recorded longer time-to-degree than their younger counterparts. These findings also support those reported by Mouton (2011) who found that age is correlated with timely completion. However, for graduates in education, the medical clinical sciences and sociology, I found that older age (aged 40 years and older) is *not* a barrier to timely completion as older students recorded a shorter average time-to-degree than their younger counterparts. The fact that the average age at enrolment of students in education is higher than the national average does not negatively impact students' timely completion. From the regression results, I found that although younger age is a significant predictor or shorter time-to-degree, it is more pertinent in disciplines such as physics and electrical engineering.

Students' mode of enrolment was found to have a significant relationship with doctoral time-to-degree. Part-time graduates recorded statistically significantly longer time-to-degree when compared to full-time students. This finding is congruent with both the descriptive statistics presented in Chapter 10 and the literature reviewed in Chapter 4. Descriptive statistics found that respondents who indicated that they held full-time employment during their studies projected statistically significantly longer time-to-degree than respondents who were not employed full-time. Similarly, a number of studies have found shorter completion times among full-time students (Bourke et al., 2004b) and argue that balancing professional and study commitments are some of the most significant challenges facing doctoral students (ASSAf, 2010, Mouton et al., 2015).

The regression model found that South African students recorded longer time-to-degree when compared to students from the rest of Africa. I reported similar findings in Chapter 8 where I found shorter time-to-degree for international students when compared to domestic students, although not statistically significant. In the regression model, I found that nationality is a statistically significant predictor of time-to-degree which is supported by the literature where a number of studies have found shorter completion times for international students (ASSAf; 2010; Jiranek, 2010; Wright & Cochrane, 2000).

Finally, I found that the academic discipline is a predictor of time-to-degree. Doctoral graduates in education recorded the shortest time-to-degree when all other factors, such as age at and mode of enrolment, were held constant. These results are supported by my findings in Chapter 7 and 8 where graduates in education consistently reported shorter time-to-degree. In Chapter 7, I sought to explain why doctoral graduates in education take less time to complete their studies despite the fact that they are more likely to be enrolled part-time, are on average older than graduates in other disciplines and are enrolled in a soft-applied discipline. Generally, the differences in mean time-to-degree were small, but statistically significant results do suggest that there are differences in timely degree attainment between disciplines.

However, my findings are not consistent with that found in the literature which argues that students in softer disciplines tend to record longer completion times. A number of international studies found that graduates in education had among the longest completion times when compared to disciplines in the natural sciences and engineering (Baird, 1990; Elgar, 2003; Hoffer& Welch Jr., 2006; Sowell, Allum & Okahana; Wright & Cochrane, 2000). Heath (2002), however, found that in Australia, doctoral graduates in education recorded shorter time-to-degree when compared to health, engineering, arts, humanities and social science disciplines which seem to support my findings reported here.

In model 4, I found that graduates in sociology recorded significantly shorter time-to-degree when compared to the base category, the medical clinical sciences. This finding is not congruent with that reported in Chapter 7, where graduates in sociology consistently recorded the longest time-to-degree of the five disciplines studied. The finding of shorter completion times of graduates in education and sociology offer evidence to reject the hypothesis that graduates in softer disciplines take longer to complete their doctoral studies than fields in the hard sciences (Baird, 1990; Elgar, 2003; Hoffer & Welch Jr.,2006; Sowell, Allum & Okahana; Wright & Cochrane, 2000) given, that of the five disciplines studied, the two disciplines in which graduates recorded the longest completion times, when controlled for selected variables, are both considered as hard/abstract disciplines.

These findings compel us to ask three questions. First, why, in the regression model, did graduates in sociology no longer record the longest average completion times as found in Chapter 7[107]? Secondly, why are these findings not congruent with what is found in the literature? Third, how can one explain the shorter time-to-degree of doctoral graduates in education? I address the first two questions together. When controlling for the profile of students with factors such as gender, age, race, nationality and mode of enrolment, graduates in sociology no longer recorded the longest time-to-degree of the five disciplines as was found in earlier analyses. In looking at the regression model, one sees that with the introduction of nationality to the model, the differences in the average time-to-degree of graduates in sociology compared to the medical clinical sciences, increases and the relationships strengthens which suggest that the shorter completion times in sociology are driven by the large proportion of international students (particularly from the rest of Africa).

The results of the regression model suggest that one should consider factors beyond the nature of a discipline in interpreting disciplinary differences in time-to-degree. In other words, the profile (both demographic and other) of doctoral students within a discipline, may predict timely completion more accurately than merely the content and context of a discipline. Similarly, it is probable that the differences in time-to-degree between disciplines, as reported by existing research, do not control for the profile of students or other related factors that are associated with timely completion.

I take a cautionary approach in addressing the third question. I have argued throughout the study that explaining and predicting doctoral time-to-degree, as is the case with all human phenomena, is a complex task. I have as far as possible tried to include as many factors in investigating differences in timely completion, but the analyses were limited by the number of factors included in the HEMIS and survey data sets. In the regression model, only 11% of the variance was explained by the independent variables. I can, therefore, only offer an informed speculation as to why students in education take less time, albeit only slightly, to complete their doctoral candidacies when compared to graduates in the other disciplines, notwithstanding the demographic (i.e. student demographics) and situational profile (i.e. mode of study) of its students.

Turning to the qualitative data, as presented in Chapter 10, I found that many survey respondents in education indicated that doing a PhD would further their career options. A low

[107] When compared to means B, C, D and E.

percentage of survey respondents in education indicated that they experienced uncertainty about career aspirations while a high proportion of respondents in education received financial support from their employers for their doctoral studies. I have argued throughout this study that doctoral students in education are likely to be professionals who have well-established careers who seek to further their employment prospects on completion of a doctorate. Perhaps a clear pathway and expected return on investment fuel education graduates to attain their degrees in a timely fashion.

In this chapter, I identified predictors of doctoral time-to-degree. I found that mode of enrolment, nationality and age are important predictors of time-to-degree. Similarly, I found that the nature of a discipline is a significant factor in understanding differences in timely degree attainment. Although differences in the observed average time-to-degree of disciplines are small yet statistically significant, it supports the hypothesis of this study that the academic discipline is associated with the timely completion of the doctoral degree. I have attempted to explain, by means of selected factors, why these differences exist, but the shorter completion times of doctoral graduates in education might be explained by factors which were not included in the study. In the next chapter, I elaborate on this point and consider its implications for further study.

Chapter 12 | Conclusion

The primary objective of the study was to analyse and study doctoral time-to-degree in five disciplines at South African academic institutions. The theoretical and empirical literature showed that there exist, albeit small and inconsistent, differences in doctoral time-to-degree among graduates in different disciplines. Through a secondary analysis of the HEMIS student data, which was supplemented by a qualitative analysis of a survey on doctoral students' experiences, evidence in support of differences in doctoral timely completion between disciplines was found. Graduates in education recorded the shortest average time-to-degree of the five disciplines studied. Additionally, a candidate's age, nationality and mode of enrolment were highlighted as predictors of doctoral timely completion. In this chapter, I summarise the main findings of the study according to each of the relevant research questions. Subsequently, I consider some of the theoretical and policy implications of this study after which I discuss the contribution of the present study. Finally, I consider avenues for future research as well as ways in which the present study could be strengthened.

12.1 Main findings

The first research question: ***What is the profile of doctoral graduates in the five selected disciplines and what are the disciplinary differences specifically with regard to student characteristics, the pile-up effect, completion rates and average time-to-degree***?

As far as student characteristics are concerned, I analysed the profile of doctoral students within the five disciplines. With regard to gender, doctoral students in electrical engineering and physics are overwhelmingly male. Although there has been a steady increase in the number and proportional share of female enrolments over the 15-year period, male students constituted more than 80% of doctoral enrolments in physics in 2014 and 85% of enrolments in electrical engineering in 2014. The share of female enrolments in electrical engineering increased with nearly 8% between 2000 and 2014 while that of female enrolments in physics increased with 4%. In 2014, the proportional share of female graduates was identical to that of enrolments. In education and the clinical health sciences, there was a more equal distribution of male and female students while the proportion of female enrolments in the clinical health sciences increased with nearly 15% between 2000 and 2014. Female students in sociology were slightly underrepresented at 43% in 2014 with a slight decline of nearly 6% over the 15-year period.

Across all five disciplines, I found a rapid increase in the number of international graduates particularly from the rest of Africa. In four of the five disciplines, the proportional share of South African students decreased between 20 and 40% between 2000 and 2014, while the share of South African students in the clinical health sciences decreased slightly more than 10%. In sociology, more than half of doctoral enrolments in 2014 were international students, while more than 46% of enrolments in physics and 48% enrolments in electrical engineering were international students. The clinical health sciences had the smallest proportion of international students with less than 20% of enrolments in 2014. In education, less than 37% of doctoral enrolments were foreign students. For doctoral graduates, we witness similar trends for students in education, physics and electrical engineering while nearly 70% of graduates in sociology were non-South African students, and slightly more than 23% of graduates in the clinical health sciences were international students.

I found that the average age of doctoral students differed significantly across the five disciplines with graduates in education being much older, by at least seven to eight years than the national average which was 38 years in 2014. Conversely, graduates in electrical engineering and physics were five to six years younger than the national average at 33.6 years and 32.5 years respectively in 2014. The average age of students in sociology and the clinical health sciences were commensurate with the national average.

The profile of doctoral students by means of descriptive indicators showed that the pile-up effect of doctoral students worsened for electrical engineering and the clinical health sciences. In education, physics and sociology the ratio of new enrolments to historical enrolments increased which suggest that the pile-up effect improved. However, in sociology and physics, the number of new enrolments grew at a faster rate than that of existing enrolments, while for education, electrical engineering and the clinical health sciences, the number of historical enrolments grew at a faster rate compared to the growth of new students entering the system.

As far as the average completion rates of doctoral graduates are concerned, I found that nationally, 42% of doctoral students completed their studies after seven years. Slightly more than 46% of students in the clinical health sciences graduated after four years which constitute the best completion rates of the five selected disciplines. The average seven-year completion rates of students in physics and electrical engineering were slightly lower at 43.6% and 43.9% respectively. Students in sociology consistently recorded the lowest average completion rates with slightly more than 31% of students graduating after seven years. The increase in the average six- to seven-year completion rates of doctoral students in education were marginal and were nearly 6% lower than the national average and 10% lower than that of the clinical health sciences.

In 2014, the average time-to-degree of doctoral graduates in South Africa was 4.68 years. The study found a slight increase in the average time-to-degree of doctoral students in South Africa over the 15-year period with a commensurate increase in the five selected disciplines. Graduates in education recorded the shortest average time-to-degree of 4.15 years while doctoral graduates in the clinical health sciences recorded an average of 4.69 and sociology the longest at 4.74 years for the period 2000 to 2014. The table below summarises these results for the five selected disciplines.

Table 12-1 Doctoral education in five disciplines along six indicators

Indicator	Physics	Education	Clinical health sciences	Electrical engineering	Sociology	National
Ratio of first enrolments to total enrolments (Pile-up effect) (2014)	26.8%	**44.9%**	24.6%	23.8%	38.5%	36.0%
Average four-year completion rates	**27.3%**	23.9%	25.6%	24.3%	15.8%	25.0%
Average seven-year completion rates	43.6%	36.9%	**46.2%**	43.9%	31.2%	42.2%
Average throughput rate	**13.6%**	13.0%	12.7%	12.1%	9.7%	12.6%
Average supervisory capacity (ratio of students-to-supervisor)	**2.0**	6.6	10.2	12.7	4.2	2.3**
Mean time-to-degree* (years)	4.56	**4.15**	4.69	4.27	4.59	4.74^

*mean B reported here
**as calculated for 2014
^cases less than two years and more than 15 years were excluded

In South Africa the large proportion of international students in physics, electrical engineering and sociology contribute to the growth of these fields. But studying abroad is arguably less feasible in professional fields such as the clinical health sciences and education. In these fields doctoral training is often more context-specific and overseen by regulatory bodies. This may explain the lower proportions of international students in the clinical health sciences and education. Whether the increased inflow of students from the African continent is the result of increased efforts to internationalise doctoral education in South Africa (i.e. pull factors), or whether African students pursue doctoral studies abroad due to domestic challenges in their home countries (i.e. push factors), or whether (most likely) it is a combination of these and other factors, needs further investigation.

The substantial increase of international students in physics and sociology, in particular, ameliorates the pile-up effect of students, but there are still large numbers of students who remain in the system without graduating. This is supported by the below than average completion rates of doctoral students in sociology. Although the number of new enrolments in education grew at a slower rate than that of existing enrolments, I found the lowest pile-up effect of students in education. The fact that graduates in education recorded lower completion rates suggests that a large number of students in education do not complete their degrees. This may partially explain the finding that doctoral students in education complete their studies in a slightly shorter time compared to students in the other disciplines. Again, further studies and specifically qualitative studies, are required to produce and explain for these trends.

The second research question: *How do different contextual factors relate to doctoral time-to-degree in the five selected disciplines? What is the influence of the discipline, student demographics, institutional factors and student situational and dispositional factors?*

By means of descriptive statistics, I investigated differences in time-to-degree along student demographics *within* the five selected disciplines. Here the aim was not to identify predictors of time-to-degree, but rather to discern whether differences in student demographics correlate with differences in timely completion across academic disciplines.

With regard to gender, I found that male graduates recorded statistically significant shorter time-to-degree than female graduates in sociology, while no statistically significant differences were found in the other four disciplines. In education, there were statistically significant differences, albeit small, in the mean time-to-degree of graduates in the four racial groups, where coloured graduates reported a shorter average time-to-degree. In terms of age, graduates in electrical engineering who were aged younger than 40 years, recorded statistically significant shorter time-to-degree, while in the clinical health sciences and sociology, respondents older than 40 years recorded the shortest time-to-degree. In education and physics no statistically significant differences in the mean time-to-degree were found for graduates in terms of their age. The results of the descriptive statistics show that the role of student demographics within disciplines vary, but that it may also be as a result of the distinct demographic profile of doctoral students within each discipline.

With reference to institutional factors, I found that physics recorded the highest average throughput rate of 13.6%, followed by education at 13%, while sociology recorded the lowest at 3% below the national average. The highest average institutional throughput rates were found for NMU in education and electrical engineering, WSU in the clinical health sciences, RU in physics and Unisa in sociology. In four of the five disciplines, I found a positive correlation between higher institutional throughput rates and shorter average time-to-degree, while in sociology, a negative correlation was found.

I calculated the supervisory capacity of doctoral students in South Africa to be 2.3 students per supervisor and observed a steady decrease in the supervisory capacity over the 15-year period. I found that physics recorded the highest supervisory capacity for the period 2000 to 2014 with an average student-to-supervisor ratio of 2.0 in 2014. The lowest supervisory capacity was recorded in electrical engineering where only 35% of instructional staff held a PhD. A positive correlation between a low student-to-supervisor ratio and a shorter time-to-degree was found for academic institutions in electrical engineering. In all other disciplines, a negative relationship was found which suggests that the burden of supervision does not negatively impact on timely completion in sociology, physics, education and the clinical health sciences. However, in investigating the role of selected situational and dispositional factors by means of the survey data, I found that satisfaction with academic supervision was correlated with shorter estimated completion times. A number of respondents identified challenges with academic supervision as a significant barrier to completion.

I found an expected relationship between full-time employment and longer time-to-degree from the survey data while the majority of the survey respondents, particularly in education and the social sciences, were employed at a university. Respondents in engineering and the physical sciences who indicated a change in academic fields during their degree progression estimated shorter completion times. Respondents who have considered dropping out of their doctoral programmes also reported significantly longer time-to-degree compared to those who have not considered dropping out. The top reasons cited for considering the termination of studies include financial challenges, challenges in respondents' personal/family life and challenges to balance employment and study commitments irrespective of disciplinary field. I found that there is a relationship between immediate degree progression and the estimated completion time of survey respondents. Students in the physical sciences and engineering were more likely to directly progress to the doctorate.

As far as age is concerned, I found that being is not a constraining factor for graduates in education, but rather for electrical engineering. Students in education and the clinical health sciences are most likely professionals who enrol for the doctorate at a later stage in their careers, are enrolled part-time, have clear outcomes associated with the completion of the doctorate, and perceive the doctorate as a relevant and worthwhile return on investment. In seeking plausible explanations for the shorter time-to-degree of students in education, I have suggested that dispositional or psychosocial factors, such as motivation and the perceived cost-benefit of the doctorate with regard to professional prospects, are likely enablers of timely completion.

Diversely, students in engineering and the physical sciences are more likely to immediately progress towards the doctorate (after their master's degree), are typically younger students, are more likely to be enrolled full-time, and are likely to be supported financially either through scholarships or bursaries. Students in the physical sciences often have a direct trajectory towards the doctorate due to the fact that the doctorate is considered a minimum requirement for a faculty position, even though students in these fields face some uncertainty about career options. Students in the physical sciences are also more likely to enrol for a post-doctoral fellowship given the perceived scarcity of employment prospects. Students in electrical engineering, however, often experience challenges with the relevance of the doctorate but are likely to be supported financially by their employers in industry. However, the supervisory capacity for doctoral students is low, given the lower percentages of academic personnel with a PhD in electrical engineering.

Although there is a higher supervisory capacity for doctoral students in sociology, I found lower completion and throughput rates for doctoral graduates in sociology. Plausible explanations for the lower rates might be that students in the social sciences are more likely to rely on personal or family earnings in financially supporting their studies. Similar to what was found for students in the physical sciences, there is often a perception among students in pure disciplines that employment opportunities are scarce which suggest that the rationale for doing a PhD is a less consequential enabler of timely completion. Doctoral students in the soft-pure fields may also find challenges in the more individualistic nature of doing research and in the assimilation with the plethora of theoretical and conceptual frameworks in identifying research problems.

As the final research question, I considered whether it is possible to *predict which factors explain differences in time-to-degree in the selected disciplines.*

A multiple linear regression model was used to explore the relationships of selected factors on doctoral time-to-degree and to identify predictors of timely completion. I found that gender is not a predictor of time-to-degree with statistically insignificant differences in the mean time-to-degree of male and female students. Students' mode of enrolment was found to have a statistically significant relationship with doctoral time-to-degree with part-time graduates recording longer time-to-degree when compared to full-time students. Similarly, I found students' nationality to be a statistically significant predictor of time-to-degree where shorter completion times were found for international students compared to domestic students. Finally, I found that academic discipline is a predictor of time-to-degree. When factors such as gender, race, academic institution, nationality, age and mode of enrolment were held constant, graduates in education recorded a statistically significant shorter time-to-degree when compared to graduates in physics, electrical engineering and the medical clinical sciences.

In the study, I have investigated differences in time-to-degree along selected factors and have reported on statistically significant results. However, in the majority of cases, the observed differences were small. It is important to re-assert that the interaction of factors is fundamental to our understanding of doctoral success. The results of the regression analysis confirms this. In Figure 12-1 below, the mean time-to-degree of doctoral graduates between 2010 and 2016 are plotted by statistically significant predictors[108]. It is clear that when we investigate the interaction of selected factors, the differences in time-to-degree become more salient. The shortest average time-to-degree was recorded at 3.79 years for doctoral graduates who are male, enrolled full-time, are younger than 40 years old, are from the rest of Africa and enrolled in education (see Appendix E). The longest time-to-degree was recorded at 7.11 years for female students who were enrolled part-time, are younger than 40 years old, are South African and enrolled in the medical clinical sciences. The figure very clearly shows that mode of enrolment and nationality are the most important predictors of time-to-degree. Students who were enrolled part-time and students from the rest of Africa are clustered around an average of four to five years. We also see that the differences in age and gender are less definitive.

[108] Here I include gender, but not academic discipline. Means were plotted for groups in which there were more than ten cases. The supporting table is presented in Appendix E.

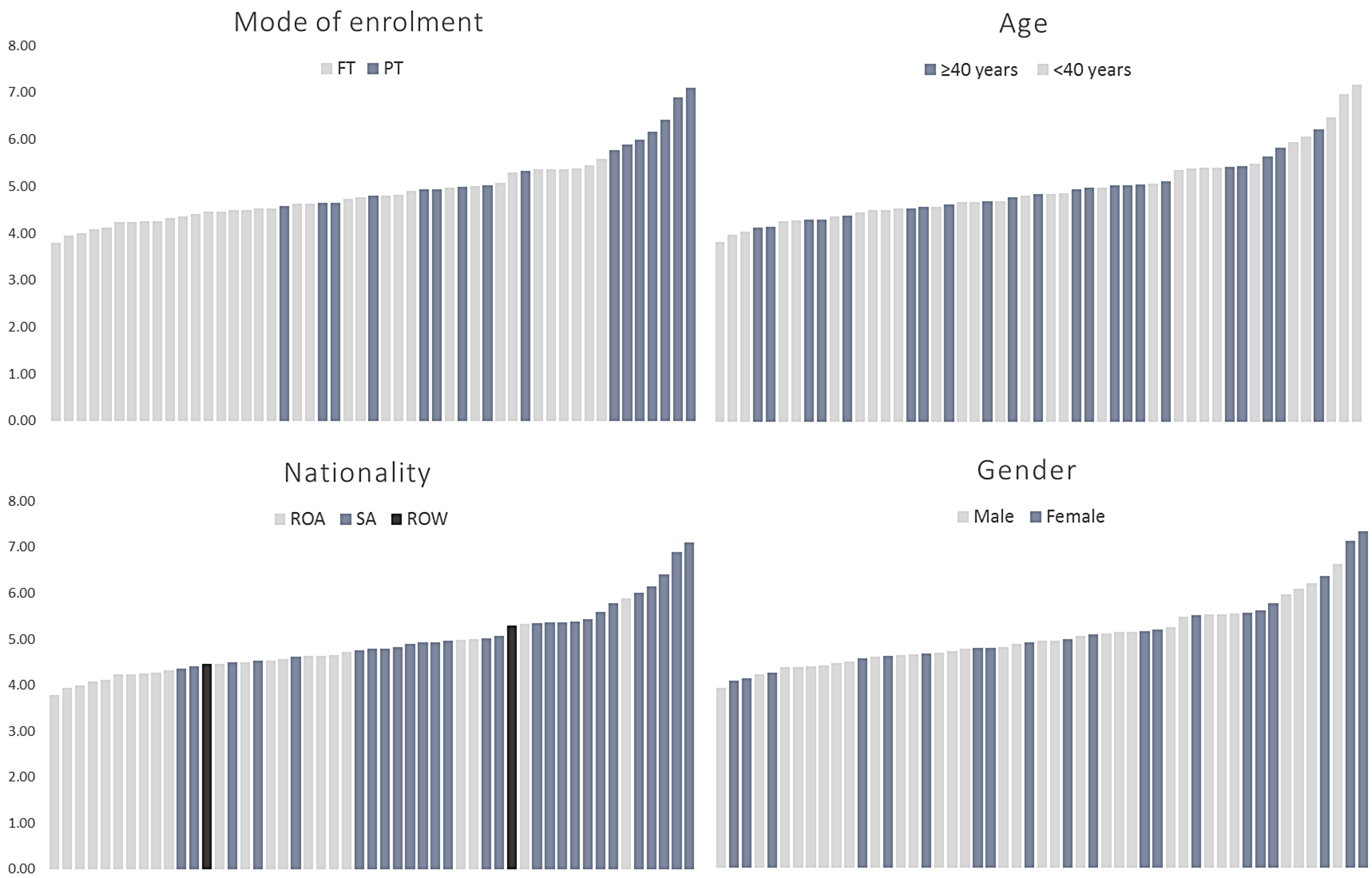

Figure 12-1 Predictors of doctoral time-to-degree

Throughout the literature, evidence in support of full-time enrolment as a significant enabler of doctoral success is plentiful. The current study, therefore, provides further evidence that a student's mode of study is a consequential enabler of timely completion. However, full-time enrolment often serves as a proxy for financial support, direct progression, younger age, etc. which are associated with timely degree attainment. In other words, full-time enrolment not only refers to the ostensible conspicuous advantages which include regular contact with supervisors, access to institutional and departmental support systems and being able to focus on studies without employment obligations, but students who enrol full-time are also more likely to be supported financially and are younger students who are able to directly progress to the doctorate.

I have suggested throughout the study that we should take caution in interpreting stand-alone indicators as it is important to contextualise them with various other indicators. Although doctoral students in education recorded the shortest-time-to-degree, they recorded some of the lowest completion rates. Conversely, students in the clinical health sciences recorded longer completion *times* but higher completion *rates.* Although shorter time-to-degree can be considered an indicator of efficiency on a doctoral level, it is imperative to consider wider contextual factors in thinking about the efficiency of students. Additionally, the accelerated and increased production of doctoral graduates should not be pursued at the cost of quality. In expanding doctoral education in South Africa we should, therefore, seek to find a balance between an increased number of doctoral outputs, an efficient system, retributive transformation, relevant and demand-oriented doctoral programmes and the production of high-quality doctoral graduates.

12.2 Theoretical and policy implications of this study

In the study, I identified predictors of timely completion and correlations between selected factors on time-to-degree and found that the nature of a discipline plays a consequential role in doctoral degree attainment. Although differences in the observed average time-to-degree between disciplines are small, it supports the hypothesis of this study that the academic discipline is associated with the timely degree attainment among doctoral students. Although I have attempted to explain, by means of selected contextual factors, why disciplinary differences exist, the shorter completion times of doctoral graduates in education might be explained by factors which were not included in the study. Moreover, the longer completion times found for graduates in electrical engineering and the clinical health sciences, when compared to education and sociology are not supported by the bulk of existing studies. The literature and theoretical arguments place education as a discipline high in complexity, lower in consensus and less rigorous in its methodologies and there is a consensus that "softer" fields, such as education, are generally associated with longer completion times. I have, however, argued throughout this study that the demarcation of academic fields is often the result of systemic or institutional factors, i.e. the context surrounding the discipline, rather than epistemological factors, i.e. the content of the discipline. Perhaps then the reason that the findings of the study are not consistent with that widely found in the literature suggests that a classification of academic disciplines based purely on epistemological grounds is not applicable and replicable to doctoral graduates in South Africa. Additionally, the selection of disciplines in the study was limited and not necessarily representative and it is plausible that if other disciplines were selected, alternative conclusions could have been drawn.

However, in Chapter 4 it was found that existing empirical evidence suggests that situational and demographic factors account for the most variability in student success. The results of this study are consistent with this hypothesis in that a student's mode of employment, nationality and age, in addition to disciplinary field, were found to be significant predictors of timely completion. It was the aim of the study to identify whether the role of these factors differ across disciplinary contexts and found, for e.g. that the role of age and gender is a less pertinent predictor of shorter time-to-degree in some fields, such as education, when compared to others. One of the key contributions of this study, therefore, recognises that the identified factors interact differently across disciplinary fields and suggests that the disciplinary field is a vital factor to include in the conceptual framework underlying our investigation of student success. However, it should be emphasised that not all the factors included in the conceptual framework were investigated in a similar fashion and that their contribution could not be measured equally. Although I can attribute significant variances in time-to-degree primarily to selected situational factors and student characteristics, the model of time-to-degree was limited to a number of measurable variables. The conceptual framework therefore served as the analytic plan of the empirical analysis, but given the research design of this study, the research questions were primarily data-driven.

As far as the policy implications of the study are concerned, the NDP's 2030 vision for the expansion of doctoral education through a significant increase in doctoral graduates, guided the rationale of the study. In actualising the NDP's vision, it is important to address the leaky pipeline leading up to the doctorate by identifying some of the more pertinent barriers to timely completion. The NDP's vision to increase doctoral output to 5000 students by 2030 is an idealistic one. A simple

ARIMA[109] forecasting, using the HEMIS student data between 2000 and 2016, showed that at the current growth rate, in 2025 it might be plausible to graduate 4000 doctoral students (see endnote[ix]). Although this signals a significant increase, given the current growth rate, it is still short of the envisioned 5000 graduates. The achievement of this target is also situated within a set of broader contextual factors (Cloete, Mouton and Sheppard, 2015). We cannot consider the NDP's vision towards the increase in doctoral output without a concurrent expansion, and sufficient expenditure, of the higher education system as a whole (HESA, 2012). Although there has been a noteworthy increase in the percentage of permanent full-time teaching personnel with a doctorate, the student-to-supervisor ratio has steadily increased over the 15-year period analysed. This is particularly the case in disciplines such as sociology where I found high growth rates in the number of enrolments and a concurrent *decrease* in the number of full-time staff members. Although the 2030 vision does call for an increase in the percentage of PhD qualified staff to 75%, a meaningful expansion of postgraduate education would only be conceivable if there is sufficient capacity to safeguard the quality of outputs produced.

Further policy implications arising from this study are not novel. Congruent with the findings of local and international studies, the consequential relationship between mode of study (full-time enrolment) and subsequent financial assistance is affirmed in this study. In Chapter 2, I discussed the recommendations made by Cloete, Sheppard and Mouton (2015) in thinking about the funding modalities in support of full-time doctoral candidates. The contribution of this study, however, could be pertinent in thinking about disciplinary modalities of funding. Although one may argue that the differences in disciplinary time-to-degree (as measured across the five selected disciplines) are marginal, these differences should not be renounced. Funding instruments, such as scholarships provided by the NRF, are ubiquitous in their applications to PhD candidates regardless of academic discipline. Although one can argue that differentiated funding mechanisms may invite perceived discriminatory practices, funders should be aware of the disciplinary peculiarities of degree attainment. Insufficient financial support could invariably compel a student to prolong their studies or

[109] An AutoRegressive Integrated Moving Average (ARIMA) was used as the statistical method for time series forecasting. A linear regression model was constructed including the specified number and type of terms, and the data was prepared by a degree of differencing in order to make it stationary, i.e. to remove trend and seasonal structures that negatively affect the regression model (*machinelearningmastery.com*). In endnote ix, I present the results. The model predicts that 4 000 graduates by 2 025 is feasible, however, the 90% confidence interval suggests a window of anything between 2 500 and 5 500 graduates is possible.

consider discontinuation. Both of these outcomes contribute to the leaky pipeline that is postgraduate education in South Africa.

In disciplines, such as physics and electrical engineering, I found that younger students recorded shorter time-to-degree. In these fields, students should be encouraged to enrol for the doctorate earlier in their careers. Similarly, postgraduate studies in these fields should be an attractive alternative to employment, particularly to female students. Another finding of this study relates to the nationality of students in that international students were found to complete their studies in less time than foreign students. Given the limited capacity in South Africa and the rationale for international students to complete their studies in a timely manner, It has been suggested that using the bilateral networks with international universities would be advantageous to doctoral production in South Africa (Higher Education South Africa [HESA], 2012).

The findings of this study may be valuable for financial offices, institutional planners and officers in postgraduate offices in identifying enablers and challenges to doctoral timely completion. In light of the global concern with efforts to increase student retention and success, recent years have seen an analogue interest within the South African context. Given the current climate in South Africa which calls for the extension of tertiary education, to particularly financially needy students, the need to improve the efficiency of the South African higher education system is pertinent. Student attrition (regardless of qualification level) is costly and efforts should be made to mitigate the most significant barriers. There is a large body of scholarship on feasible interventions and it was not this study's objective to evaluate them. Rather, I would like to suggest that institutional efforts towards combating attrition and prolonged candidacy times be tailored for academic disciplines. Here graduate schools within faculties can become key actors.

12.3 Contribution of the study

There have been numerous efforts to construct efficiency indicators of higher education and in most instances, time-to-degree, specifically on a doctoral level, has been considered under the heading of completion rates or throughput rates, as used by Cloete, Mouton and Sheppard (2015). The use of time-to-degree is more widely used in the international literature, but two reports, the first on retention of postgraduate students in South Africa (Mouton et al., 2015) and the second on the status of postgraduate students in engineering (Mouton, Valentine & Van Lill, 2017), were good starting blocks for studying doctoral time-to-degree in South Africa. Although existing studies compare time-to-degree across disciplines, the majority have done so on a broader disciplinary field. This study, therefore, makes an important methodological contribution in conceptualising and operationalising selected descriptive indicators such as supervisory capacity, completion rates and time-to-degree. With specific reference to selected academic disciplines, this study adds to the important discussion around the efficiency and effectiveness of doctoral education in South Africa and how to grow the pool of doctoral graduates.

Sverdlik et al. (2018) suggest that research on doctoral education should steer away from single-factor foci and should aim to explore the interactive nature of known determinants of success. I consider a key contribution of this study a model predicting factors that explain differences in doctoral time-to-degree which has been widely neglected in the South African context. Similarly, the authors recommend that studies of the doctorate should employ alternative methodologies and should consider multiple methods in their empirical efforts. I consider a strength of the current study its identification of factors underlying timely degree attainment and highlighted their interrelatedness through a mixed-methods design. The methodological contribution of this study refers to the integrative use of datasets and drawing from both quantitative and qualitative data towards a nuanced understanding of doctoral success.

A final significant contribution of the study is that of an extensive review of the literature on doctoral degree attainment which adds to our understanding of the relationship of the academic discipline with contextual internal and external factors. Throughout the study I have emphasised the challenges in studying doctoral success and I have as far as possible attempted to include numerous factors in the analyses. With the integrative use of the HEMIS and qualitative survey, this study is one of the most comprehensive studies of doctoral time-to-degree in the South African context.

12.4 Recommendations for future research

Given the complexity in identifying factors that contribute to degree attainment, I have suggested that the study be strengthened by adding more variables to the analysis. Given the centrality of funding in the discourse surrounding doctoral education, it is a shortcoming of this study that I was not able to directly examine the relationship of funding on doctoral time-to-degree. It would thus be fruitful to explore whether a student was financially supported throughout their candidacy and whether there is a relationship between financial aid and timely completion. Similarly, one could identify whether types of funding yield different results. Here the funding information from, for example, NRF bursary or scholarship holders, could be obtained and linked to the HEMIS student data. Future research could also measure whether certain events have effected a general trend in time-to-degree. This could include the restructuring of the higher education system in 2005 and the subsequent introduction of subsidies for research output (including student outputs) and whether this has incentivised students, or supervisors, to shorten doctoral candidacy time.

A more qualitative approach could additionally elucidate how students perceive their candidacies across disciplines as it would be particularly poignant to include students who have traversed disciplinary boundaries to explore how the content and context (either cognitive structures, cultural experiences or institutional organisation) of disciplines differ. I have emphasised in the study the importance of qualitative data, such as case studies and first-person accounts, in understanding a complex phenomenon such as student success. Finally, future research could build on this study by including an analysis of the grey literature on policies or incentives that promote shorter completion times. This could include formal and informal strategies on a national, institutional, faculty and departmental level.

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Appendices

Appendix A | Chapter 5: Methodology

In the table below I present the CESM level two fields in which the most doctoral students graduated in 2012 to 2014. These figures were obtained from the DHET summary tables and were generated using fractional counting. The figures presented below are either rounded up or down.

Table A-1 Number of doctoral graduates per CESM level two field (2012 to 2014)

2015		2014		2013		2012	
Field	n	Field	n	Field	n	Field	n
040100 : Business Administration, Management And Operations	120	170300 : Theology	100	140400 : Chemistry	111	140400 : Chemistry	89
140400 : Chemistry	111	070100 : Education, General	89	170300 : Theology	98	170300 : Theology	84
070100 : Foundations Of Education	106	140400 : Chemistry	86	070100 : Education, General	83	130100 : Biology, General	74
170300 : Theology	100	040100 : Business Administration, Management And Operations	83	040100 : Business Administration, Management And Operations	68	070100 : Education, General	69
090700 : Medical Clinical Sciences	68	140500 : Geography And Cartography	66	090700 : Medical Clinical Sciences	67	040100 : Business Administration, Management And Operations	62
140500 : Geography And Cartography	64	200700 : Sociology	61	140500 : Geography And Cartography	49	130600 : Zoology/Animal Biology	53
130200 : Biochemistry, Biophysics And Molecular Biochemistry	61	090700 : Medical Clinical Sciences	56	130200 : Biochemistry, Biophysics And Molecular Biochemistry	47	070300 : Educational Management And Leadership	48
040400 : Economics	59	190300 : Public Administration	52	200700 : Sociology	44	080900 : Electrical, Electronics And Communications Engineering	44
080900 : Electrical, Electronics And Communications Engineering	53	091300 : Public Health	51	140700 : Physics	37	040400 : Economics	41
200700 : Sociology	53	140700 : Physics	50	130600 : Zoology/Animal Biology	36	200700 : Sociology	41
091300 : Public Health	53	040400 : Economics	46	070300 : Educational Management And Leadership	34	090700 : Medical Clinical Sciences	38

180100 : Psychology, General	49	180100 : Psychology, General	41	080900 : Electrical, Electronics And Communications Engineering	33	140500 : Geography And Cartography	36
190300 : Public Administration	48	070200 : Curriculum And Instruction	40	180100 : Psychology, General	33	130200 : Biochemistry, Biophysics And Molecular Biochemistry	35
140700 : Physics	47	130200 : Biochemistry, Biophysics And Molecular Biochemistry	40	040400 : Economics	33	140700 : Physics	34
130500 : Microbiological Sciences And Immunology	41	080900 : Electrical, Electronics And Communications Engineering	39	091300 : Public Health	32	130600 : Zoology/Animal Biology	36

CESM categories: Codes and descriptions

The CESM (levels one and two) codes and description of disciplinary subfields for electrical, electronics and communications engineering for the periods 1982 to 2007; 2008 to 2009 and 2010 onwards, are presented in the tables below.

Table A-2 CESM level two classifications for electrical, electronics and communications engineering

1982 - 2007	Description	2008 - 2009	Description	2010-	Description
0808	Electrical Engineering and Technology	080800	Electrical Engineering and Technology	080900	Electrical, Electronics and Communications Engineering
080801	Digital Methods			080901	Electrical, Electronics and Communications Engineering
080802	Electromagnetic Circuits				
080803	Electromechanical Controls				
080804	Electronics				
080805	Fields and Waves				
080806	Electronic Information Theory				
080807	Electrical Instrumentation				
080808	Power and Energy				
0808099	Other Electrical Engineering and Technology				

In the table below the subfields included in education for the three periods, 1999-2007; 2008-2009 and 2010 onwards, are listed.

Table A-3 Education CESM codes and descriptions

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
0701	Foundations of Education	070100	Foundations of Education	070100	Education, General	0701	Foundations of Education
0702	Educational Administration	070200	Educational Administration	070101	Education, General	070101	Curriculum Studies
0703	Systems of Education	070300	Systems of Education	070102	Academic Literacy	070102	History of Education
0704	Teaching – Subject Matter	070400	Teaching – Subject Matter	070199	Education, General: Other	070103	International and Comparative Education
0705	Teaching – Programmes	070500	Teaching – Programmes	070200	Curriculum and Instruction	070104	Philosophy of Education
0706	Teacher Training	070600	Teacher Training	070201	Curriculum and Instruction	070105	Psychology of Education
0707	Counselling and Guidance	070700	Counselling and Guidance	070300	Educational Management and Leadership	070106	Sociology of Education
0708	Special Education Progr ammes	070800	Special Education Progra mmes	070301	Educational Leadership and Management, General	070107	Education Studies
0709	Community Service	070900	Community Service	070302	Management of Special Education	070199	Foundations of Education, Other
0710	Educational Development	071000	Educational Development	070303	Adult Education and Training Management	0702	Teaching, Leading and Researching in Early Childhood Education and Development Contexts
0711	Educational Evaluation and Research	071100	Educational Evaluation and Research	070304	Educational, Instructional and Curriculum Supervision	070201	Teaching, Leading and Researching in Early Childhood (birth - 5 years) education contexts
0712	Educational Technology and Media	071200	Educational Technology and Media	070305	Higher Education/Higher Education Management	0703	Teaching; Leading and Researching in Schooling Contexts (Grade R and Foundation Phase)
0799	Other Education	079900	Other Education	070306	Early Childhood Development and Primary School Management	070301	Grade R studies
				070307	Secondary School Management	070302	Foundation Phase Mathematics
				070308	Middle Management and Educational System Administration	070303	Foundation Phase Life Skills
				070399	Educational Management and Leadership, Other	070304	Foundation Phase Afrikaans
				070400	Educational/Instr uctional Media Design	070305	Foundation Phase English
				070401	Educational/Instr uctional Media Design	070306	Foundation Phase IsiNdebele
				070500	Educational Assessment, Evaluation and Research	070300 7	Foundation Phase IsiXhosa
				070501	Educational Evaluation and Research	070308	Foundation Phase IsiZulu
				070502	Educational Statistics and	070309	Foundation Phase Sepedi

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
					Research Methods		
				070503	Educational Assessment, Testing and Measurement	070310	Foundation Phase Sesotho
				070599	Educational Assessment, Evaluation and Research, Other	070311	Foundation Phase Setswana
				070600	International and Comparative Education	070312	Foundation Phase SiSwati
				070601	International and Comparative Education	070313	Foundation Phase Tshivenda
				070700	Social and Philosophical Foundations of Education	070314	Foundation Phase Xitsonga
				070701	Social and Philosophical Foundations of Education	070399	Grade R and Foundation Phase, Other
				070800	Special Needs Education	0704	Teaching; Leading and Researching in Schooling Contexts (Inter-mediate Phase)
				070801	Special Needs Education, General	070401	Intermediate Phase Life Skills
				070802	Education/Teaching of Individuals with Hearing Impairments/Deafness	070402	Intermediate Phase Social Sciences
				070803	Education/Teaching of the Gifted and Talented	070403	Intermediate Phase Natural Sciences and Technology
				070804	Education/Teaching of Individuals with Emotional Disturbances	070404	Intermediate Phase Mathematics
				070805	Education/Teaching of Individuals with Mental Disabilities	070405	Intermediate Phase Afrikaans
				070806	Education/Teaching of Individuals with Multiple Disabilities	070406	Intermediate Phase English
				070807	Education/Teaching of Individuals with Physical Health Impairments	070407	Intermediate Phase IsiNdebele
				070808	Education/Teaching of Individuals with Vision Impairments (including Blindness)	070408	Intermediate Phase IsiXhosa
				070809	Education/Teaching of Individuals	070409	Intermediate Phase IsiZulu

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
					with Specific Learning Disabilities		
				070810	Education/Teaching of Individuals with Speech or Language Impairments	070410	Intermediate Phase Sepedi
				070811	Education/Teaching of Individuals with Autism	070411	Intermediate Phase Sesotho
				070899	Special Needs Education, Other	070412	Intermediate Phase Setswana
				070900	Counsellor Education and Guidance Services	070413	Intermediate Phase SiSwati
				070901	Counsellor Education and Guidance Services, General	070414	Intermediate Phase Tshivenda
				071000	Teaching Education and Professional Development, Specific Levels and Methods	070415	Intermediate Phase Xitsonga
				071001	Adult Education and Training	070499	Intermediate Phase, Other
				071002	Early Childhood Development and General Education and Training	0705	Teaching; Leading and Researching in Schooling Contexts (Senior Phase)
				071003	Further Education and Training	070501	Senior Phase Arts and Culture
				071004	Teacher Education: Multiple Levels	070502	Senior Phase Life Orientation
				071099	Teacher Education and Professional Development, Specific Levels and Methods, Other	070503	Senior Phase Social Sciences
				071100	Teacher Education and Professional Development, Specific Subject Areas, Early Childhood Development (ECD) and General Education and Training (GET)	070504	Senior Phase Natural Sciences
				071101	Languages: Afrikaans (Grades R-9) – ECD and GET	070505	Senior Phase Mathematics
				071102	Languages: English (Grades R-9) – ECD and GET	070506	Senior Phase Technology
				071103	Languages: IsiNdebele	070507	Senior Phase Economic and Management Sciences

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
					(Grades R-9) – ECD and GET		
				071104	Languages: IsiXhosa (Grades R-9) – ECD and GET	070508	Senior Phase Afrikaans
				071105	Languages: IsiZulu (Grades R-9) – ECD and GET	070509	Senior Phase English
				071106	Languages: Sepedi (Grades R-9) – ECD and GET	070510	Senior Phase IsiNdebele
				071107	Languages: Sesotho (Grades R-9) – ECD and GET	070511	Senior Phase IsiXhosa
				071108	Languages: Setswana (Grades R-9) – ECD and GET	070512	Senior Phase IsiZulu
				071109	Languages: Siswat i (Grades R-9) – ECD and GET	070513	Senior Phase Sepedi
				071110	Languages: Tshivenda (Grades R-9) – ECD and GET	070514	Senior Phase Sesotho
				071111	Languages: Xitsonga (Grades R-9) – ECD and GET	070515	Senior Phase Setswana
				071112	Mathematics – ECD and GET	070516	Senior Phase SiSwati
				071113	Natural Sciences – ECD and GET	070517	Senior Phase Tshivenda
				071114	Social Sciences – ECD and GET	070518	Senior Phase Xitsonga
				071115	Arts and Culture – ECD and GET	070599	Senior Phase, Other
				071116	Life Orientation – ECD and GET	0706	Teaching; Leading and Researching in Schooling Contexts (Further Education and Training (FET) Phase)
				071117	Economic and Management Sciences – ECD and GET	070601	Further Education and Training Phase Accounting
				071118	Physical Education – ECD and GET	070602	Further Education and Training Phase Agricultural Management Practices
				071119	Technology – ECD AND GET	070603	Further Education and Training Phase Teaching Agricultural Sciences
				071199	Teacher Education and Professional Development, Specific Subject Areas, Early Childhood Development and General Education	070604	Further Education and Training Phase Agricultural Technology

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
					and Training, Other		
				071200	Teacher Education and Professional Development, Specific Subject Areas, Further Education and Training (FET)	070605	Further Education and Training Phase Business Studies
				071201	FET: Accounting	070606	Further Education and Training Phase Civil Technology
				071202	FET: Agricultural Management Practices	070607	Further Education and Training Phase Computer Applications Technology
				071203	FET: Agricultural Sciences	070608	Further Education and Training Phase Consumer Studies
				071204	FET: Agricultural Technology	070609	Further Education and Training Phase Dance Studies
				071205	FET: Business Sciences	070610	Further Education and Training Phase Design
				071206	FET: Civil Technology	070611	Further Education and Training Phase Dramatic Arts
				071207	FET: Computer Applications Technology	070612	Further Education and Training Phase Economics
				071208	FET: Consumer Studies	070613	Further Education and Training Phase Electrical Technology
				071209	FET: Dance Studies	070614	Further Education and Training Phase Engineering Graphics and Design
				071210	FET: Design	070615	Further Education and Training Phase Geography
				071211	FET: Dramatic Arts	070616	Further Education and Training Phase History
				071212	FET: Economics	070617	Further Education and Training Phase Hospitality Studies
				071213	FET: Electrical Technology	070618	Further Education and Training Phase Information Technology
				071214	FET: Engineering Graphics and Design	070619	Further Education and Training Phase Life Orientation
				071215	FET: Geography	070620	Further Education and Training Phase Life Sciences
				071216	FET: History	070621	Further Education and Training Phase Mathematical Literacy
				071217	FET: Hospitality Studies	070622	Further Education and Training Phase Mathematics
				071218	FET: Information Technology	070623	Further Education and Training Phase Mechanical Technology
				071219	FET: Languages: Afrikaans	070624	Further Education and Training Phase Music

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
				071220	FET: Languages: English	070625	Further Education and Training Phase Physical Sciences
				071221	FET: Languages: IsiNdebele	070626	Further Education and Training Phase Religion Studies
				071222	FET: Languages: IsiXhosa	070627	Further Education and Training Phase Tourism
				071223	FET: Languages: IsiZulu	070628	Further Education and Training Phase Teaching Visual Arts
				071224	FET: Languages: Sepedi	070629	Further Education and Training Phase Afrikaans
				071225	FET: Languages: Sesotho	070630	Further Education and Training Phase English
				071226	FET: Languages: Setswana	070631	Further Education and Training Phase IsiNdebele
				071227	FET: Languages: Siswat i	070632	Further Education and Training Phase IsiXhosa
				071228	FET: Languages: Tshivenda	070633	Further Education and Training Phase IsiZulu
				071229	FET: Languages: Xitsonga	070634	Further Education and Training Phase Sepedi
				071230	FET: Life Orientation	070635	Further Education and Training Phase Sesotho
				071231	FET: Life Sciences	070636	Further Education and Training Phase Setswana
				071232	FET: Mathematical Literacy	070637	Further Education and Training Phase SiSwati
				071233	FET: Mathematics	070638	Further Education and Training Phase Tshivenda
				071234	FET: Mechanical Technology	070639	Further Education and Training Phase Xitsonga
				071235	FET: Music	070640	Further Education and Training Phase Equine Studies
				071236	FET: Physical Science	070641	Further Education and Training Phase Maritime Economics
				071237	FET: Religious Studies	070642	Further Education and Training Phase Modern Greek
				071238	FET: Tourism	070643	Further Education and Training Phase Nautical Science
				071239	FET: Visual Arts	070644	Further Education and Training Phase Sport and Exercise Science
				071240	FET: Physical Education	070645	Further Education and Training Phase Arabic
				071299	Teacher Education and Professional Development, Specific Subject Areas, Further Education and Training, Other	070646	Further Education and Training Phase French
				079999	Education, Other	070647	Further Education and Training Phase German
						070648	Further Education and Training Phase Gujarati

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
						070649	Further Education and Training Phase Hebrew
						070650	Further Education and Training Phase Hindi
						070651	Further Education and Training Phase Italian
						070652	Further Education and Training Phase Latin
						070653	Further Education and Training Phase Portuguese
						070654	Further Education and Training Phase Spanish
						070655	Further Education and Training Phase Tamil
						070656	Further Education and Training Phase Telugu
						070657	Further Education and Training Phase Urdu
						070699	Further Education and Training Phase, Other
						0707	Teaching, Leading and Researching in Community and Adult Education and Training Contexts
						070701	Ancillary Health Care
						070702	Applied Agricultural Sciences and Agricultural Technology
						070703	Arts and Culture
						070704	Afrikaans
						070705	English
						070706	isiNdebele
						070707	isiZulu
						070708	Sepedi
						070709	Sesotho
						070710	Setswana
						070711	SiSwati
						070712	Tshivenda
						070713	Xitsonga
						070714	Early Childhood Development
						070715	Economic and Management Sciences
						070716	Human and Social Sciences
						070717	Information and Communication Technology
						070718	Life Orientation
						070719	Mathematical and Mathematical Sciences
						070720	Mathematical Literacy
						070721	Natural Sciences
						070722	Small Medium Micro Enterprises
						070723	Technology
						070724	Travel and Tourism
						070725	Wholesale and Retail
						070799	Teaching, Leading and Researching in Community and Adult

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
							Education and Training Contexts
						0708	Teaching; leading and researching in Technical and Vocational Education and Training (TVET) contexts
						070801	Art, Design and Decor
						070802	Civil Engineering and Building Construction
						070803	Clothing and Textiles
						070804	Cosmetology
						070805	Drawing Office Practice
						070806	Education and Development
						070807	Electrical Infrastructure Construction
						070808	Engineering and Related Design
						070809	Finance, Economics and Accounting
						070810	Hospitality
						070811	Information Technology and Communication Science
						070812	Languages
						070813	Life Orientation
						070814	Management
						070815	Marketing
						070816	Mathematics and Mathematical Literacy
						070817	Mechatronics
						070818	Office Administration
						070819	Physical Sciences
						070820	Primary Agriculture
						070821	Primary Health
						070822	Process Instrumentation
						070823	Process Plant Operations
						070824	Public Relations
						070825	Safety in Society
						070826	Tourism
						070827	Transport and Logistics
						070899	Teaching, Leading and Researching in Technical and Vocational Education and Training (TVET) contexts, Other
						0709	Teaching, Leading and Researching in Higher Education
						070901	Teaching, Leading and Researching in Higher Education
						0710	Teaching and Learning Support
						071001	Education Librarianship
						071002	Guidance and Counselling
						071003	Sport and Exercise Science and Coaching
						071004	Information and Communication Technology Support
						071005	Multi grade teaching

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
						071006	Inclusive teaching
						071007	Social Context and Barriers to Learning
						071099	Teaching and Learning Support – other
						0711	Educational Management and Leadership
						071101	Community and Adult Education and Training Management
						071102	Educational Leadership and Management, General
						071103	Education System Administration
						071104	Early Childhood Education and Development Management
						071105	Management of Special Education
						071106	Higher Education Management
						071107	School Management
						071108	Technical and Vocational Education and Training Management
						071199	Educational Management and Leadership, Other
						0712	Educational Assessment, Evaluation and Research
						071201	Educational Evaluation and Research
						071202	Educational Statistics and Research Methods
						071203	Educational Assessment, Testing and Measurement
						071299	Educational Assessment, Evaluation and Research, Other
						0713	Special Needs Education
						071301	Special Needs Education, General
						071302	Education/Teaching of Individuals with Hearing Impairments/ Deafness
						071303	Education/Teaching of the Gifted and Talented
						071304	Education/Teaching of Individuals with Emotional Disturbances
						071305	Education/Teaching of Individuals with Mental Disabilities
						071306	Education/Teaching of Individuals with Multiple Disabilities
						071307	Education/Teaching of Individuals with Physical Health Impairments
						071308	Education/Teaching of Individuals with Vision Impairments (including Blindness)

1999-2007	Description	2008-2009	Description	2010-2014	Description	2015-	Description
						071309	Education/Teaching of Individuals with Specific Learning Disabilities
						071310	Education/Teaching of Individuals with Speech or Language Impairments
						071311	Education/Teaching of Individuals with Autism
						071399	Special Needs Education, Other
						0714	Other fields of study in education
						071401	Academic Literacy
						071402	Community and Adult Education and Training
						071403	Education and Development
						071404	Education and Work
						071405	Educational/Instructional Media Design
						071406	Environmental Education
						071407	Higher Education Studies
						071408	HIV/AIDS Education
						071409	Inclusive Education
						071410	Subject Studies in Education
						071411	Technical and Vocational Education and Training Studies
						071499	Other fields of study in education, Other
						0799	Education, Other

In the table below the subfields included in physics for the three periods, 1999-2007; 2008-2009 and 2010 onwards, are listed. In the student and staff analysis of 2000 to 2009, Astrophysics is included due to the fact that the CESM codes of these years did not allocate CESM level two categories to these fields. In 2010 onwards, astrophysics is not included in the analysis as astronomy and astrophysics were assigned its own CESM code.

Table A-4 Physics CESM codes and descriptions

1982-2007	Description	2008-2009	Description	2010-	Description
1507	Physics	150700	Physics	140700	Physics
				140701	Physics, General
				140702	Atomic/Molecular Physics
				140703	Elementary Particle Physics
				140704	Plasma and High Temperature Physics
				140705	Nuclear Physics
				140706	Optics/Optical Sciences
				140707	Solid State and Low Temperature Physics
				140708	Acoustics
				140709	Theoretical and Mathematical Physics
				140799	Physics, Other

In the table below the subfields included in clinical health sciences and the medical clinical sciences for the three periods, 1999-2007; 2008-2009 and 2010 onwards are listed.

Table A-5 Clinical health sciences CESM codes and descriptions

1982-2007	Description	2008-2009	Description	2010 -	Description
0902	Clinical Health Sciences	090200	Clinical Health Sciences	090700	Medical Clinical Sciences
				090701	Aerospace Medicine
				090702	Allergies and Immunology
				090703	Anaesthesiology
				090704	Cardiology
				090705	Paediatric Cardiology
				090706	Chemical Pathology
				090707	Neurology
				090708	Paediatric Neurology
				090709	Psychiatry
				090710	Child Psychiatry
				090711	Colon and Rectal Surgery
				090712	Critical Care Anaesthesiology
				090713	Critical Care Medicine
				090714	Critical Care Surgery
				090715	Dermatology
				090716	Dermatopathology
				090717	Diagnostic Radiology
				090718	Emergency Medicine
				090719	Endocrinology and Metabolism
				090720	Family Medicine
				090721	Forensic Pathology
				090722	Gastroenterology
				090723	General Surgery
				090724	Hand Surgery
				090725	Paediatric Surgery
				090726	Geriatric Medicine
				090727	Haematology
				090728	Haematological Pathology
				090729	Immunopathology
				090730	Infectious Diseases
				090731	Internal Medicine
				090732	Laboratory Medicine
				090733	Musculoskeletal Oncology
				090734	Neonatal-Perinatal Medicine
				090735	Nephrology
				090736	Neurological Surgery/Neurosurgery
				090737	Neurology
				090738	Neuropathology
				090739	Nuclear Medicine
				090740	Nuclear Radiology
				090741	Obstetrics and Gynaecology
				090742	Occupational Medicine
				090743	Oncology
				090744	Ophthalmology
				090745	Orthopaedics/Orthopaedic Surgery
				090746	Otolaryngology
				090747	Pathology
				090748	Paediatric Endocrinology
				090749	Paediatric Haemato-Oncology

1982-2007	Description	2008-2009	Description	2010 -	Description
				090750	Paediatric Nephrology
				090751	Paediatric Orthopaedics
				090752	Paediatrics
				090753	Physical and Rehabilitation Medicine
				090754	Plastic Surgery
				090755	Preventive Medicine
				090756	Public Health Medicine
				090757	Pulmonary Disease
				090758	Radiation Oncology
				090759	Radio Isotopic Pathology
				090760	Rheumatology
				090761	Sports Medicine
				090762	Thoracic Surgery
				090763	Urology
				090764	Vascular Surgery
				090765	Adult Reconstructive Orthopaedics
				090766	Cytopathology
				090767	Geriatric Medicine (Internal Medicine)
				090768	Paediatric Urology
				090769	Orthopaedic Surgery of the Spine
				090770	Palliative Medicine
				090771	Genetic Counselling
				090799	Medical Clinical Sciences, Other

In the table below the subfields included in sociology for the three periods, 1999-2007; 2008-2009 and 2010 onwards are listed.

Table A-6 Sociology CESM categories and descriptions

1982-2007	Description	2008-2009	Description	2010 -	Description
2206	Sociology	220600	Sociology	200700	Sociology
				200701	Sociology
				200702	Demography and Population Studies
				200703	The Sociology of Developing Societies
				200799	Sociology, Other

Data cleaning of HEMIS database

In the tables below I list and describe the codes used in the HEMIS student and staff databases and describe how data were selected or transformed in the analysis.

Student data

Below I list the codes used in the HEMIS student database.

Table A-7 Variables in HEMIS student data

Code	Description	
529	Reporting year	Data from 2000 to 2014 were selected
005	Qualification type	The qualifications selected are as follow: Doctoral: 08: Doctoral Degree; 30: Doctor Technologiae Degree; 50: Doctoral Degree (HEQF) 74: Doctoral Degree (HEQSF)(included after 2015) 75: (Doctoral Degree (HEQSF)(Professional) (included after 2015)
007	Commencement date	The date on which a student first commenced the qualification at the reporting institution. This was recoded to "commencement year"
010	Entrance category	
011	Date of Birth	
012	Gender	Male; Female and Unknown
013	Race	African, coloured, white, Indian/Asian and "no information"
014	Nationality	Students nationality was recoded into three regional categories: Rest of World (ROW) Rest of Africa (ROA) South African (RSA) Nationality relates to citizenship, not to country of permanent residence.
025	Qualification requirement status	N= Enrolments F= Graduates
026	CESM category (for first area of specialisation)	A second-order CESM code which depicts the field of study of a student's first or sole area of specialisation, established in the collection Year This was the code used for the selection of students in the delineated disciplines.
063	Institution Code	In 2005, a number of higher education institutions merged to form new institutions. All records for the years 2000 to 2004 were mapped to the post-2005 merged institutions

In the table below I list and describe the indicators used throughout this study. In each case I offer a description of how the indicator was calculated and measured.

Table A-8 Definition of variables and indicators as obtained in HEMIS student database

Indicator	Working Definition	Calculation
Enrolments	All students registered for a selected degree (PhD) in the recording year, regardless of entrance category	
New (first) enrolments	These are first-time entering students	We did not use the "entrance category" classification of HEMIS. Rather, we define these students as those were the "reporting year – commencement year" = 0. Therefore all students whose commencement year is the same as the reporting year.
Graduates	Students who have fulfilled the requirements of the qualification	
Time-to-degree	Time-to-degree is the amount of time (in years) a student takes to complete their degree.	Time-to-degree is only calculated for graduates and is calculated as "reporting year"-"year commenced" + 1 under the condition that the qualification requirement status was coded as "F" - the HEMIS code for successful completion (graduates).
Completion rates	The percentage of students who have	Completion rates were calculated as follow: Graduates were selected (025 = F). The reporting year and the year commenced were crosstabulated. The cohort of students who

Indicator	Working Definition	Calculation
	completed their degree in x years	commenced in year x was then tracked to see when they graduated; i.e. what percentage of students who enrolled in year x graduated in year $x+1; x+2; x+3$, etc. This number of graduates (of cohort$x$) was then divided by the number of first enrolments (new) entrants of year x. This then gives us one- or two-, or three year completion rates as a percentage (number of graduates [year x +1; x+2 …] divided by number of first enrolments [year x]) For doctoral completion rates, an adjusted completion rate was used. The minimum residency for a PhD in South Africa is three years. The microdata show instances where a student graduates within the same year. In these cases, the adjusted completion rates excludes the number of students who graduated within the same year.
Average age at commencement	The average age of a student at the time of registration (enrolments only)	Enrolments only; "Reporting year" – "year of birth". The mean of all enrolments in each reporting year is calculated. Outliers were not excluded in the calculations.
Average age at graduation	The average age of a student at the year of graduation (graduates only)	Graduates only; "Reporting year" – "year of birth". The mean of all enrolments in each reporting year is calculated. Outliers were not excluded in the calculations.
Continuously compounded annual growth rate	A measure of growth over multiple time periods	The least squares growth rate is calculated as $r_{OLS} = \exp(\hat{\beta}) - 1$ Which is obtained by estimating the parameters of the time trend equation in $X_n = a + \beta n + \varepsilon$ where the time trend equation is obtained through a logarithmic transformation of the compound growth equation. Where $a = \ln X_0$; $\beta = \ln(1+r)$
Black students (AIC)	This includes students classified as African, Indian/Asian and coloured	

Staff data

The micro FTE staff data as provided by the DHET were used. The codes used to extract data and their descriptions are outlined below.

Table A-9 Variables in HEMIS staff database

Code	Description	
529	Reporting year	Data from 2000 to 2014 were used
063	Institution code	In 2005, a number of higher education institutions merged to form new institutions. All records for the years 2000 to 2004 were mapped to the post-2005 merged institutions
National Staff Register ID	A code which uniquely identifies a staff member at an institution.	This was used to uniquely identify staff members
012	Gender	Male; Female and Unknown
013	Race	African, coloured, white, Indian/Asian and "no information"
014	Nationality	Students nationality was recoded into three regional categories: Rest of World (RoW) Rest of Africa (RoA) South African (RSA)

Code	Description	
		Nationality relates to citizenship, not to country of permanent residence.
039	Personnel Category	A code indicating the personnel category of a staff member. Category 01 (Instruction/Research professional) was selected.
041	Permanent/Temporary	A code which indicates whether or not a staff member's most recent appointment at the institution was on a permanent basis. Only permanent staff were selected for our analysis.
042	Fulltime/Part time	A code which indicates whether a staff member has full-time or part-time employment status in respect of their most recent employment at the institution. In our analysis, both full-time and part-time staff were selected.
044	Staff Programme	A code indicating the type of programme in which a staff member is undertaking duties. The codes included in our selection is: 010: Instruction 020: Research
045	CESM	The area of specialisation is to be established each year by the institution. Personnel can have FTE in more than one CESM field. Personnel can have up to four areas of specialisations. For each unique personnel member, the sum FTE (across all specialisations) were added to calculate the total FTE that a unique staff member has in a reporting year.
046	Staff qualification	A code indicating the highest most relevant qualification of a staff member (if the Personnel category is Instructional/Research professional)
571	Age	
043	Staff time FTE	A value indicating the FTE time spent by a staff member on a particular programme (and staff programme CESM category if the programme is Instruction or Research). As indicated above, the FTE time were calculated across CESM categories to indicate a staff member's total FTE in a selected discipline.

Survey questionnaire

Below I present the questionnaire used in the online survey.

I hereby agree to participate in the national survey of Doctoral students.
I understand that I am participating freely and without being forced in any way to do so.
I also understand that I can stop completing the questionnaire at any time and withdraw as a participant in the research without this affecting me negatively in any way whatsoever.
I have received (in the email letter that introduced this survey) the details of a person to contact should I require information about any issues which may arise from this survey.
I understand that my answers will remain entirely confidential.
I also understand that my answers will not be shared with my study leader/supervisor/promoter and that the same survey is currently being conducted at other South African universities.
I understand that the final report to be produced from this survey will be a public document and that my responses will be combined with those of other participants without identifying me in any way.

☐ **I AGREE to these conditions of confidentiality.**

☐ **I DO NOT agree to these conditions of confidentiality.**

SECTION A: ACADEMIC HISTORY

1. Please give the name of the faculty/college in which you are currently enrolled for your Doctoral degree. ....

2. Please indicate the discipline/focus/specialisation area of your CURRENT Doctoral degree (e.g. Industrial Psychology, Agricultural Economics).

3. When did you first enrol in this programme at your current university?

   Month ☐☐ Year ☐☐☐☐

4. When do you expect to graduate?
   Month ☐☐ Year ☐☐☐☐

5. Did you originally enrol for your current academic programme/programme at another university?
   - ☐ yes
   - ☐ no

6. Did you complete any other university programme **IMMEDIATELY** before enrolling in your current Doctoral programme?

   - ☐ No

- ☐ Yes, a full-time Honours programme
- ☐ Yes, I completed a part-time Honours programme while working
- ☐ Yes, I completed a part-time Honours programme while not working

- ☐ Yes, I completed a full-time post-graduate diploma
- ☐ Yes, I completed a part-time post-graduate diploma while working
- ☐ Yes, I completed a part-time post-graduate diploma while not working

- ☐ Yes, a full-time Master's programme
- ☐ Yes, I completed a part-time Master's programme while working
- ☐ Yes, I completed a part-time Master's programme while not working

- ☐ Yes, I completed another Doctoral programme

7. If no, why did you take a break between your previous completed programme and your current programme of studies?
   ………
   ………

8. 8. Is the field (e.g. Genetics) of your CURRENT Doctoral degree significantly DIFFERENT than the field of your previously completed Masters/other degree?
   - ☐ yes
   - ☐ no

9. Does your academic programme have a research component (e.g. research thesis, research assignment)?
   - ☐ yes
   - ☐ no

10. If yes, what percentage of your total mark does the research component constitute?
    - ☐ 25%
    - ☐ 33% (60 out of 180 credits)
    - ☐ 100%

11. Are you currently employed whilst enrolled for your Doctorate
    - ☐ yes
    - ☐ no
    - ☐ Other, please specify …………………………………………………………………………………………………….

12. If yes, please select your type of employment.
    - ☐ Part-time
    - ☐ Full-time
    - ☐ Casual
    - ☐ Other, please specify …………………………………………………………………………………………………….

SECTION B: REFLECTION ON CHOICE OF STUDIES

13. Was your current academic programme (the Doctoral programme for which you are currently enrolled in) your first choice?
    - ☐ yes
    - ☐ no

14. If no, what was the PRIMARY reason that prevented you from enrolling in your first choice?
    - ☐ I was not accepted in my first choice programme
    - ☐ I did not have enough money to pay for registration/class fees
    - ☐ I did not have enough money for travel/accommodation/living expenses associated with enrolling for the academic programme
    - ☐ I did not receive any/timely feedback regarding my application to my first choice
    - ☐ Personal/situational factors prevented me from enrolling in my first choice factors
    - ☐ I received funding/scholarship/bursary to enrol in my current programme
    - ☐ Other, please specify
    ………

15. What sources of information did you consult in deciding to enrol in your current programme? (please select ALL that apply)
    - ☐ None
    - ☐ University prospectus
    - ☐ University websites
    - ☐ Other websites
    - ☐ University staff
    - ☐ Talking to parents/guardians/family
    - ☐ Talking to alumni of the chosen institution/course
    - ☐ Talking to peers/friends
    - ☐ Other
16. If you could choose again a Doctoral programme to enrol in, would you still choose your current programme?
    - ☐ yes
    - ☐ no
    - ☐ unsure

17. If no or unsure, please explain your answer
    ………

18. Please rate the importance of the following in choosing your current Doctoral degree. Please indicate from 1 to 5 (1 = very important ; 5 = not important at all) the importance of the following statements in choosing your current academic programme

	Very important	**Important**	**Neutral**	**Not important**	**Not important at all**	**Not applicable**
Encouragement from lecturers/tutors	○	○	○	○	○	○
Encouragement from peers	○	○	○	○	○	○
Encouragement from family (parents, guardians, spouse, etc.)	○	○	○	○	○	○
Availability of support services (writing lab, language centre)	○	○	○	○	○	○
Relationship with academic supervisor	○	○	○	○	○	○
Convenient class schedules	○	○	○	○	○	○
Availability of international exchange programmes	○	○	○	○	○	○
City/town in which the institution is located	○	○	○	○	○	○
Sport programmes offered	○	○	○	○	○	○

Inability to find employment and hence decided to continue with studies	○	○	○	○	○	○
Scholarship/funding/bursary provided	○	○	○	○	○	○
Getting a Doctoral degree was a job requirement	○	○	○	○	○	○
Encouragement from lecturers/tutors	○	○	○	○	○	○
Encouragement from peers	○	○	○	○	○	○
Encouragement from family (parents, guardians, spouse, etc.)	○	○	○	○	○	○
Availability of support services (writing lab, language centre)	○	○	○	○	○	○
Relationship with academic supervisor	○	○	○	○	○	○
Convenient class schedules	○	○	○	○	○	○
Availability of international exchange programmes	○	○	○	○	○	○
City/town in which the institution is located	○	○	○	○	○	○
Sport programmes offered	○	○	○	○	○	○
Inability to find employment and hence decided to continue with studies	○	○	○	○	○	○
Scholarship/funding/bursary provided	○	○	○	○	○	○
Getting a Doctoral degree was a job requirement	○	○	○	○	○	○
Course content	○	○	○	○	○	○
Academic reputation of the university	○	○	○	○	○	○
Social life associated with the university	○	○	○	○	○	○
Meeting the entry requirements	○	○	○	○	○	○
Availability of scholarships or bursaries	○	○	○	○	○	○
Employment prospects on completion of the programme	○	○	○	○	○	○
Availability or standard of university accommodation	○	○	○	○	○	○
Availability of special facilities specific to needs (e.g. braille centre)	○	○	○	○	○	○
Cost of living in the area	○	○	○	○	○	○
Availability of local employment whilst studying	○	○	○	○	○	○
Distance from home	○	○	○	○	○	○
Feeling like you will fit in	○	○	○	○	○	○

Other, please specify ……

19. When you entered you current programme, did the programme provide you with written expectations about academic progress?
    - ☐ yes
    - ☐ no
    - ☐ unsure

20. Thinking about your current programme, how satisfied are you with the quality of the

	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied	Not applicable
Teaching by the faculty	○	○	○	○	○	○
Supervision of dissertation/thesis/research project	○	○	○	○	○	○
Your research experience in the programme	○	○	○	○	○	○
Your programme's curriculum	○	○	○	○	○	○
Support services	○	○	○	○	○	○
The OVERALL quality of the programme	○	○	○	○	○	○

21. Have you ever felt that you wanted to leave/drop out of your CURRENT academic **programme**?

- ☐ yes
- ☐ no
- ☐ not sure

22. If yes, why did you consider discontinuing your studies? Please rate the importance of each of the following reasons for considering discontinuing your studies.

	Very Important	Somewhat important	Not important	Not applicable	Very Important
Financial challenges	○	○	○	○	○
Challenge to find sufficient time for studies (e.g. to balance work and studies)	○	○	○	○	○
Challenge to cope with study demands (e.g. course load, difficulty of assignments)	○	○	○	○	○
Challenges in my personal/family/social life	○	○	○	○	○
Physical/mental health related challenges	○	○	○	○	○
Lack of university support systems (e.g. language support, mentors, counselling)	○	○	○	○	○
Lack of sufficient academic supervision	○	○	○	○	○
Uncertainty about career aspirations	○	○	○	○	○
Pregnancy	○	○	○	○	○

Other, please specify ....

SECTION C: FUTURE PLANS

23. After completion of your current Doctoral programme, what are your immediate plans?

- ☐ Enrol for a post-doctorate fellowship
- ☐ Find employment (for the first time)
- ☐ Change my current employment
- ☐ Continue with my current employment
- ☐ Take a break / sabbatical
- ☐ Enrol for another Doctoral programme
- ☐ Enrol in a Master's programme
- ☐ Enrol for a post-graduate diploma

- ☐ Enrol for a Honours programme
- ☐ Enrol for an undergraduate programme
- ☐ Unsure
- ☐ Other

  Please specify...

24. Please elaborate on your answer given above
    ....
    ....
    ....
    ....

SECTION D: DEMOGRAPHIC INFORMATION

We want to reiterate that your response is completely anonymous. Responses will be presented in aggregated form. Please note that the request for demographic information will enable us to do analyses for statistical purposes only and we will in no way be able to identify any single respondent.

25. How old are you?
    ....

26. What is your gender?
    - ☐ Male
    - ☐ Female
    - ☐ Other

27. Please indicate your country of birth?
    ....

28. Which of the following best describes your current relationship status?
    - ☐ Single
    - ☐ Married/legal partners/cohabiting/in a relationship
    - ☐ Divorced
    - ☐ Widowed
    - ☐ Other

29. Please indicate the number of people you are financially responsible for (excluding yourself)
    ....

30. Which of the following have been your PRIMARY source(s) of financial support during your current Doctoral programme? (please select up to THREE sources)

    - ☐ NRF Scholarship
    - ☐ Any other scholarship/bursary
    - ☐ Teaching assistantship
    - ☐ Research assistantship
    - ☐ Internship
    - ☐ Personal earnings

- ☐ Loans (from any source)
- ☐ Personal savings
- ☐ Spouse’s, partner’s or family earnings or savings
- ☐ Employer’s reimbursement/assistance
- ☐ Other

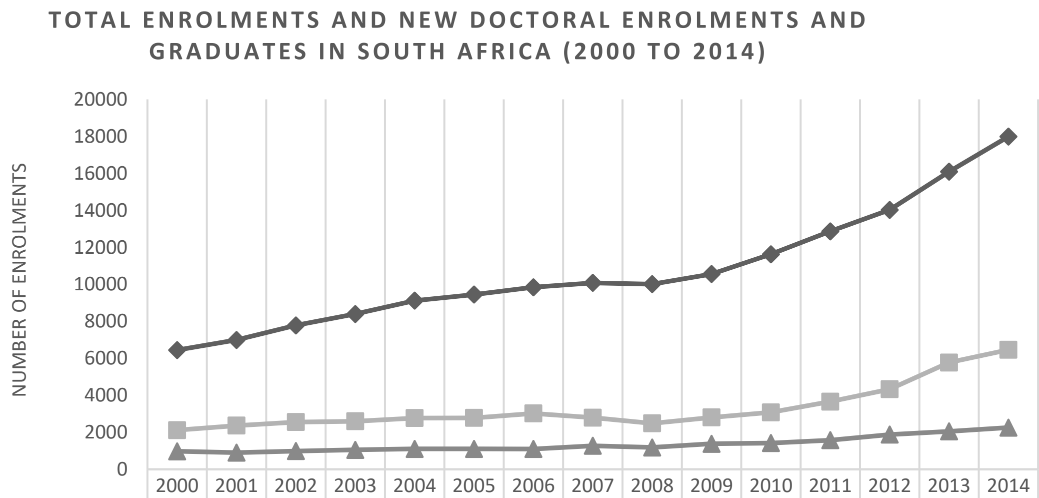
  Please specify ………

Appendix B | Chapter 6: A profile of doctoral enrolments and graduates

In the tables and figures below, I present supplementary graphs to Chapter 6 of doctoral enrolments and graduate nationally and for each of the five disciplines

Doctoral students in South Africa

In the figure below, the number of total doctoral enrolments and graduates between 2000 and 2014 are presented.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Doctoral enrolments	6446	6990	7778	8395	9119	9448	9842	10079	10011	10556	11623	12865	14023	16089	17986
First enrolments	2117	2365	2553	2596	2772	2780	3022	2793	2486	2804	3079	3660	4327	5773	6460
Graduates	972	900	985	1052	1105	1105	1100	1274	1182	1380	1419	1575	1878	2051	2256

YEAR

Figure B-1 Doctoral total and first enrolments and graduates in South Africa (2000 to 2014)

In the table below I present an overview of doctoral enrolments and graduates by demographic subgroup in 2000, 2008 and 2014.

Table B-1 Overview of doctoral students in South Africa, 2000, 2008 and 2014

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
Overall	Enrolments	No of **total** enrolments	6446	10011	17986		6.6%
		No of **new** enrolments	2117	2486	6460		6.4%
	Graduates	No of graduates	972	1182	2256		6.2%
Demographics of *total* enrolments	Gender	Proportion of **female** students of total enrolments	38.0%	42.7%	44.0%	6.0%	7.7%

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
	Race	Proportion of **black** students of total enrolments *(AIC)*	37.6%	57.7%	66.9%	29.3%	10.6%
		Proportion of **black African** students of total enrolments	25.2%	44.2%	53.7%	28.5%	12.1%
	Nationality	Proportion **RSA** students of total enrolments	84.1%	71.3%	61.7%	-22.4%	4.5%
	Age	Average age at commencement (years)	36.6	37.6	38.1	1.5 years	
Demographics of *graduates*	Gender	Proportion of **female** students of total graduates	41.2%	44.1%	41.4%	0.2%	6.9%
	Race	Proportion of **black** students of total graduates *(AIC)*	30.7%	45.5%	62.4%	31.7%	11.2%
		Proportion of **black African** students of total graduates	21.0%	32.4%	48.3%	27.3%	12.8%
	Nationality	Proportion **RSA** students of total graduates	81.2%	70.1%	58.5%	-22.7%	4.0%
	Age	Average age at graduation (years)	40.2	40.2	40.5	0.3 years	

In table below, the number of doctoral enrolments between 2000 and 2014 are disaggregated.

Table B-2 Doctoral enrolments per HEI, per year (2000 to 2014)

HEI	**Year**															**Total**
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Traditional Universities																
UP	1143	1285	1397	1529	1597	1546	1463	1495	1458	1444	1497	1660	1860	1979	2156	23509
UKZN	706	777	860	968	1121	1090	1131	1132	1099	1147	1181	1291	1638	2116	2453	18710
UCT	701	705	767	785	900	970	955	1002	1030	1058	1110	1226	1327	1428	1604	15568
WITS	625	626	632	623	646	698	978	979	988	1045	1135	1257	1428	1552	1646	14858
SU	708	741	746	757	780	804	815	879	880	993	1127	1215	1308	1382	1435	14570
NWU	327	401	462	558	615	670	792	829	760	796	878	959	1049	1171	1341	11608
UFS	429	449	510	531	522	544	571	618	580	592	574	564	531	560	668	8243
UWC	170	198	222	245	304	321	325	368	386	423	504	556	603	676	714	6015
RU	181	175	184	193	216	217	245	238	245	271	334	414	422	464	516	4315
UFH	28	18	23	23	30	84	90	155	216	227	247	263	284	358	477	2523
UL	76	71	122	139	143	167	153	157	136	139	163	193	193	217	249	2318
Vista	45	43	41	79	30	0	0	0	0	0	0	0	0	0	0	238
Comprehensive Universities																
NMU	141	175	210	229	263	259	296	327	337	392	446	441	452	454	527	4949
UJ	416	449	540	600	610	563	536	539	508	560	590	648	690	729	790	8768
Unisa	533	603	709	796	909	994	948	768	778	754	1024	1257	1173	1872	2100	15218
UNIVEN	12	19	36	29	41	41	46	49	50	90	105	118	140	172	209	1157
UNIZULU	89	102	122	128	151	144	119	157	154	156	163	182	179	161	209	2216
WSU	5	3	3	1	1	1	13	13	15	21	32	32	36	50	55	281
Universities of Technology																
TUT	45	69	74	83	101	117	131	138	146	179	209	248	311	315	329	2495
CPUT	17	18	36	37	50	68	98	89	106	128	133	173	198	183	200	1534
CUT	19	30	45	47	70	79	71	64	58	52	63	77	85	93	112	965
DUT	25	26	28	0	0	42	43	54	52	66	84	69	99	127	163	878
VUT	5	7	9	15	19	29	23	29	29	23	24	22	17	30	33	314
Total	6446	6990	7778	8395	9119	9448	9842	10079	10011	10556	11623	12865	14023	16089	17986	161250

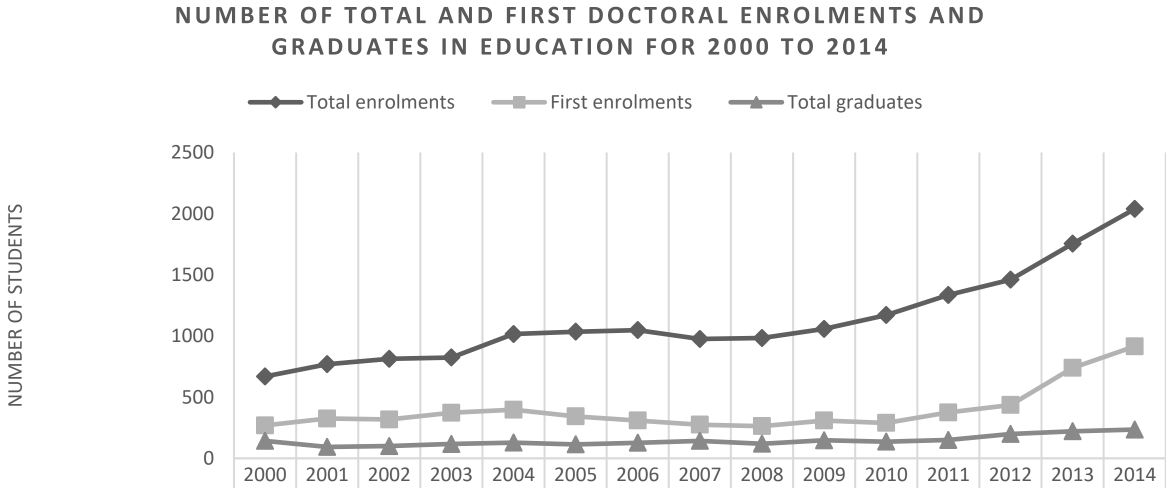
In the table below doctoral graduates are disaggregated by HEI, per year (2000 to 2014)

Table B-3 Doctoral graduates per HEI, per year (2000 to 2014)

HEI	Year															Total
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Traditional Universities																
UP	114	135	153	146	187	192	148	170	180	196	188	206	200	242	237	2694
UKZN	70	92	98	135	98	98	108	106	136	159	163	154	177	207	264	2065
UCT	104	86	109	103	99	182	133	142	151	178	160	163	198	205	204	2217
WITS	81	79	97	73	93	101	98	134	106	124	106	169	150	221	198	1830
SU	83	103	111	112	115	126	102	153	120	139	174	150	240	225	234	2187
NWU	51	59	59	92	87	82	110	124	100	123	129	115	154	168	171	1624
UFS	59	50	78	84	58	65	60	77	55	78	100	107	94	91	104	1160
UWC	20	22	15	27	23	35	28	41	42	47	58	79	75	111	103	726
RU	28	24	41	27	40	31	46	48	27	32	44	57	67	70	76	658
UFH	3	2	2	3	2	1	9	10	11	34	36	44	43	30	66	296
UL	6	4	4	10	20	15	12	17	14	17	10	17	17	14	25	202
Comprehensive Universities																
Unisa	221	121	68	76	96	92	81	78	67	71	55	93	152	201	268	1740
UJ	88	65	70	92	95	88	73	75	73	70	51	68	109	78	106	1201
NMU	11	27	23	28	35	30	25	35	47	39	64	59	86	74	72	655
UNIZULU	17	14	21	12	31	18	31	20	13	21	19	19	28	14	25	303
UNIVEN	0	1	0	3	3	3	0	6	2	4	9	9	4	3	1	48
WSU	1	0	2	1	0	0	0	0	2	0	1	4	3	3	8	25
Vista	10	3	14	5	0	0	0	0	0	0	0	0	0	0	0	32
Universities of Technology																
TUT	2	8	9	5	9	12	19	12	13	25	22	28	44	32	46	286
CPUT	0	2	5	5	2	6	6	10	13	12	11	13	24	28	17	154
CUT	3	1	4	7	7	6	6	11	5	4	3	5	5	12	12	91
DUT	0	2	1	0	0	4	4	5	3	5	12	14	6	18	18	92
VUT	0	0	1	3	2	2	1	0	2	2	4	2	2	4	1	26
Total	972	900	985	1052	1105	1189	1100	1274	1182	1380	1419	1575	1878	2051	2256	20318

Doctoral students in education

In the figure below the number of doctoral enrolments and graduates in education are presented (2000 to 2014).



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total enrolments	669	769	813	824	1016	1035	1048	975	983	1058	1171	1335	1460	1754	2038
First enrolments	269	325	317	372	397	343	309	275	263	309	289	375	436	739	915
Total graduates	143	93	100	117	128	114	127	143	119	147	136	150	199	221	235

Figure B-2 Doctoral total and first enrolments and graduates in education (2000 to 2014)

In the table below, an overview of doctoral enrolments and graduates in education are presented by demographic variable in 2000, 2008 and 2014.

Table B-4 Overview of doctoral students in education (2000, 2008 and 2014)

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
Overall	Enrolments	No of **total** enrolments	669	983	2038		6.5%
		No of **new** enrolments	269	263	915		5.0%
	Graduates	No of graduates	143	119	235		5.0%
Demographics of *total* enrolments	Gender	Proportion of **female** students of total enrolments	49.0%	53.0%	52.0%	3.0%	7.0%
	Race	Proportion of **black** students of total enrolments *(AIC)*	58.0%	67.0%	81.0%	23.0%	8.7%
		Proportion of **black African** students of total enrolments	39.0%	50.0%	64.0%	25.0%	10.2%
	Nationality	Proportion **RSA** students of total enrolments	89.4%	79.3%	62.9%	-26.5%	4.2%
	Age	Average age at commencement (years)	42.1	44.2	45.0	2.9 years	
Demographics of *graduates*	Gender	Proportion of **female** students of total enrolments	49.7%	57.1%	51.5%	2.2%	5.8%

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
	Race	Proportion of **black** students of total graduates *(AIC)*	48.3%	59.3%	79.8%	31.5%	7.9%
		Proportion of **black African** students of total graduates	32.2%	41.3%	62.7%	30.5%	9.8%
	Nationality	Proportion **RSA** students of total graduates	90.2%	78.0%	64.7%	25.5%	2.9%
	Age	Average age at graduation (years)	44.6	47.0	48.7	4.1 years	

In the table below doctoral enrolments in education are disaggregated by HEI, per year (2000 to 2014)

Table B-5 Doctoral enrolments in education per HEI, per year (2000 to 2014)

HEI	Year															Total	AAG
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
UP	122	156	140	180	215	190	177	182	164	141	123	122	129	141	152	2334	-1%
UKZN	52	90	82	85	99	121	104	108	99	102	117	141	199	266	388	2053	10%
NWU	50	57	54	65	82	105	138	140	127	132	107	96	90	90	89	1422	4%
WITS	25	34	38	35	34	40	70	66	63	68	92	100	102	112	106	985	11%
SU	52	45	44	50	53	52	43	42	47	70	61	66	83	89	95	892	5%
RU	15	14	20	28	41	43	40	29	32	26	39	74	75	83	84	643	12%
UWC	47	48	55	52	69	67	61	49	46	40	59	64	69	69	73	868	2%
UFS	23	29	29	41	46	48	47	58	47	55	50	70	56	69	109	777	8%
UCT	18	21	27	25	31	30	29	27	27	24	25	23	32	33	41	413	3%
UFH	0	0	0	0	0	12	19	12	23	34	37	35	40	47	86	345	n/a
UL	3	3	17	13	10	13	13	9	9	10	19	22	23	22	32	218	13%
Comprehensive universities																	
Unisa	90	87	87	106	114	122	110	*55*	86	104	178	227	240	382	429	2417	11%
UJ	92	104	119	126	112	97	79	79	85	95	84	97	113	138	136	1556	1%
NMU	17	21	23	19	31	26	26	29	29	35	46	42	41	45	41	471	7%
UNIZULU	34	24	30	31	30	16	16	19	28	27	25	29	22	21	30	382	-1%
WSU	4	2	2	0	1	0	12	12	13	16	22	29	31	42	37	223	n/a
UNIVEN	6	9	19	12	14	11	12	11	8	18	3	4	3	2	1	133	8%
Vista	16	19	16	36	0	0	0	0	0	0	0	0	0	0	0	87	3%
Universities of Technology																	
TUT	2	1	3	10	9	11	14	15	14	19	30	35	51	41	49	304	28%
CUT	0	3	7	8	24	22	27	23	16	18	24	26	35	40	38	311	15%
CPUT	1	2	0	2	1	9	11	10	11	15	23	27	22	19	19	172	n/a
DUT	0	0	1	0	0	0	0	0	9	9	7	6	4	3	3	42	n/a
Total	669	769	813	924	1016	1035	1048	975	983	1058	1171	1335	1460	1754	2038	17048	6%

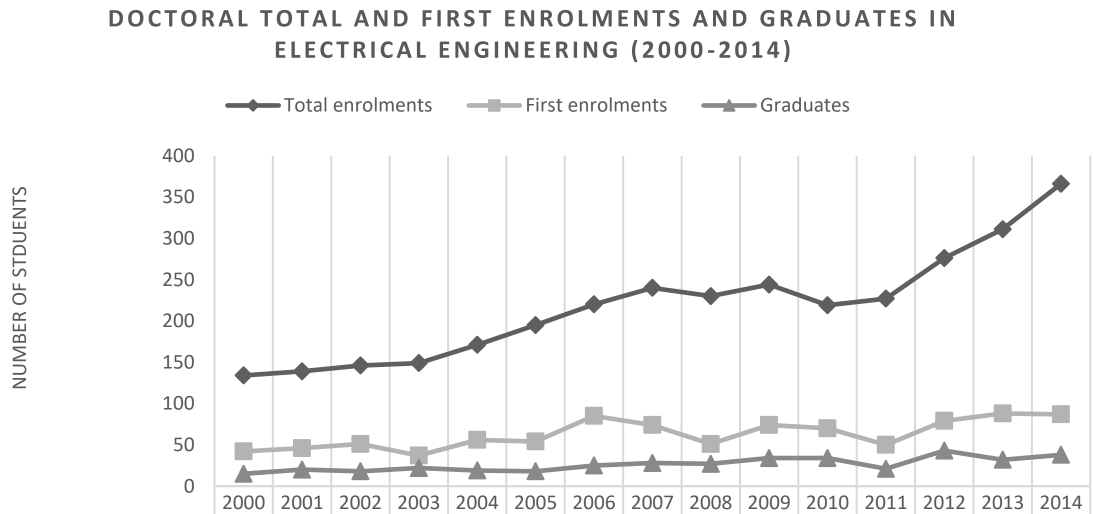
In the table below doctoral graduates in education are disaggregated by HEI, per year (2000 to 2014)

Table B-6 Doctoral graduates in education, per HEI and year (2000 to 2014)

HEI	Year															Total	AAG
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
UP	12	7	23	11	27	11	17	19	26	23	18	23	15	18	21	271	4%
UKZN	5	3	7	9	9	13	13	13	16	21	13	13	21	24	25	205	12%
NWU	9	8	3	13	6	14	14	21	13	20	19	16	20	14	5	195	5%
SU	4	10	6	10	8	10	7	10	6	12	9	6	13	10	18	139	5%
UWC	7	6	8	3	4	7	14	12	5	3	9	6	10	9	11	114	3%
UFS	5	3	5	3	8	5	7	7	3	11	6	11	14	12	13	113	9%
WITS	1	1	4	6	3	5	4	10	6	9	4	9	9	23	16	110	18%
RU	4	1	1	4	6	5	8	6	4	5	2	6	9	15	9	85	12%
UCT	0	2	3	4	2	8	6	5	3	4	5	6	4	0	6	58	n/a
UFH	0	0	0	0	0	0	3	2	1	2	8	8	8	2	12	46	n/a
UL	0	0	0	0	1	0	0	0	2	2	2	1	1	0	3	12	n/a
Comprehensive Universities																	
Unisa	54	26	14	18	16	14	7	6	7	7	10	13	32	50	46	320	1%
UJ	24	17	13	25	20	14	15	13	13	9	10	12	21	11	13	230	-4%
NMU	2	3	4	4	5	4	4	4	7	8	9	6	10	9	7	86	9%
UNIZULU	9	3	3	1	7	3	4	4	2	1	3	3	4	2	9	58	-1%
WSU	1	0	2	0	0	0	0	0	2	0	1	3	2	1	3	15	n/a
Vista	4	2	4	3	0	0	0	0	0	0	0	0	0	0	0	13	n/a
UNIVEN	0	0	0	2	1	1	0	2	0	2	1	3	0	0	0	12	n/a
Universities of Technology																	
TUT	2	0	0	1	2	0	1	1	1	4	5	0	3	6	10	36	n/a
CUT	0	0	0	0	3	0	1	7	1	1	1	2	0	5	6	27	n/a
CPUT	0	1	0	0	0	0	2	1	1	2	1	2	2	7	2	21	n/a
DUT	0	0	0	0	0	0	0	0	0	1	0	1	1	3	0	6	n/a
Total	143	93	100	117	128	114	127	143	119	147	136	150	199	221	235	2172	5%

Doctoral students in electrical engineering

In the figure below, the number of total doctoral enrolments and graduates between 2000 and 2014 are presented.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total enrolments	134	139	146	149	171	195	220	240	230	244	219	227	276	311	366
First enrolments	42	46	51	37	56	54	85	74	51	74	70	50	79	88	87
Graduates	15	20	18	22	19	18	25	28	27	34	34	21	43	32	38

YEAR

Figure B-3 Doctoral total and first enrolments and graduates in electrical engineering (2000 to 2014)

In the table below I present an overview of doctoral students in electrical engineering in 2000, 2008 and 2014.

Table B-7 Overview of doctoral students in electrical engineering (2000, 2008 and 2014)

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
Overall	Enrolments	No of **total** enrolments	134	230	366		7.0%
		No of **new** enrolments	42	51	87		5.0%
	Graduates	No of graduates	15	27	38		6.0%
Demographics of *total* enrolments	Gender	Proportion of **female** students of total enrolments	4.5%	11.3%	14.2%	7.7%	13.0%
	Race	Proportion of **black** students of total enrolments *(AIC)*	14.9%	39.8%	58.6%	43.7%	15.9%
		Proportion of **black African** students of total enrolments	6.7%	28.4%	42.2%	35.5%	19.6%
	Nationality	Proportion **RSA** students of total enrolments	88.8%	67.8%	51.5%	-37.3%	3.0%

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
	Age	Average age at commencement (years)	31.8	32.0	33.6	1.8 years	
Demographics of *graduates*	Gender	Proportion of **female** students of total graduates	4.5%	11.3%	14.2%	9.7%	8.0%
	Race	Proportion of **black** students of total graduates *AIC)*	6.7%	29.6%	40.5%	33.8%	n/a
		Proportion of **black African** students of total graduates	0.0%	22.2%	32.4%	32.4%	20.5%
	Nationality	Proportion **RSA** students of total graduates	93.3%	74.1%	68.4%	-24.9%	3.0%
	Age	Average age at graduation (years)	32.4	33.3	35.9	3.5 years	

In the table below, the number of doctoral enrolments in electrical engineering between 2000 and 2014 are disaggregated.

Table B-8 Doctoral enrolments in electrical engineering per year and HEI (2000 to 2014)

HEI	Year															Total	AAG
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
UCT	19	22	21	20	25	30	40	50	46	47	55	48	46	67	77	613	10%
SU	27	31	32	28	28	29	30	39	39	38	38	34	50	50	50	543	4%
UP	17	16	18	19	23	21	22	19	22	23	21	29	37	51	60	398	8%
WITS	25	27	26	24	28	28	38	37	36	37	*0*	*0*	13	28	44	391	n/a
UKZN	10	10	11	16	16	16	23	21	18	21	20	21	24	0	0	227	n/a
NWU	5	6	9	10	9	10	14	16	11	8	13	16	16	17	17	177	7%
Comprehensive Universities																	
UJ	11	10	8	8	7	13	13	20	15	21	23	23	31	35	49	287	13%
NMU	1	1	2	3	4	3	0	2	4	3	2	0	0	0	0	25	n/a
Universities of Technology																	
TUT	1	2	2	2	10	11	13	15	12	19	23	30	34	32	37	243	29%
CPUT	2	1	2	6	8	11	14	13	12	16	14	16	17	23	23	178	21%
VUT	5	4	7	7	6	17	8	3	9	6	4	4	1	2	2	85	-9%
CUT	5	6	7	5	6	6	4	4	5	5	6	6	6	5	5	81	0%
DUT	6	3	1	1	1	0	1	1	1	0	0	0	1	1	2	19	n/a
Total	134	139	146	149	171	195	220	240	230	244	219	227	276	311	366	3267	7%

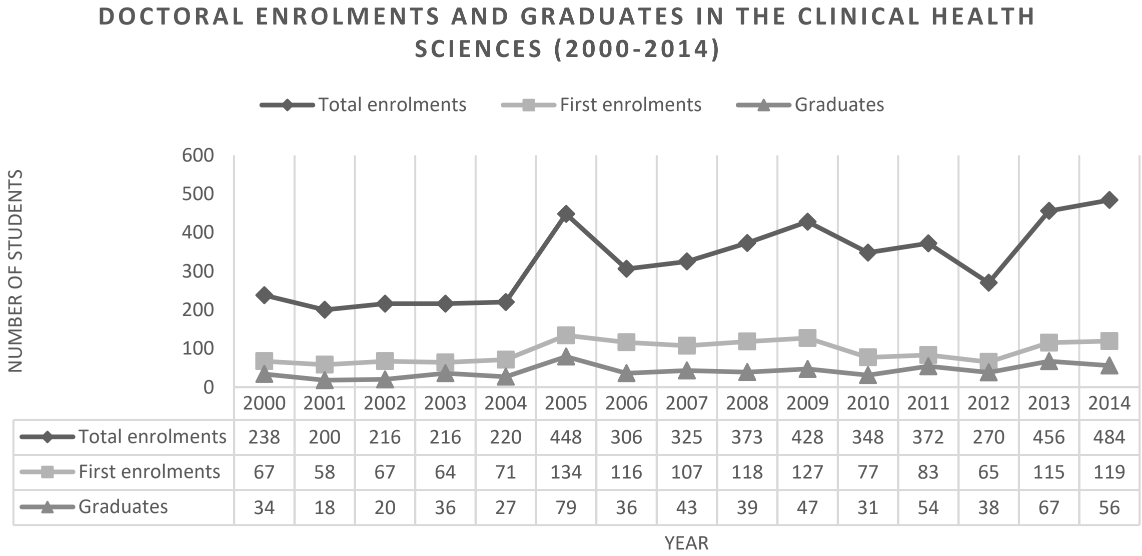
In the table below, the number of doctoral graduates in electrical engineering per HEI per year are disaggregated (2000 to 2014).

Table B-9 Doctoral graduates in electrical engineering per HEI, per year (2000 to 2014)

HEI	**Year**															**Total**	**AAG**
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
SU	3	7	6	6	3	4	4	5	7	7	10	2	4	9	8	85	3%
UCT	4	1	4	4	4	2	4	7	7	6	8	6	4	4	10	75	8%
WITS	1	6	3	2	1	0	5	4	3	5	0	0	9	3	4	46	n/a
UP	4	2	1	1	4	1	2	2	5	3	3	3	3	5	4	43	7%
UKZN	1	1	1	1	2	1	2	1	0	4	5	1	5	0	0	25	n/a
NWU	0	0	0	1	2	2	1	6	3	2	0	2	2	1	2	24	n/a
Comprehensive Universities																	
UJ	2	2	2	1	2	2	2	1	1	3	3	2	4	3	4	34	5%
NMU	0	1	0	0	0	3	0	0	0	0	1	0	0	0	0	5	n/a
Universities of Technology																	
TUT	0	0	0	0	0	1	3	1	0	1	1	2	7	5	1	22	n/a
CPUT	0	0	1	0	0	0	1	1	0	2	2	3	2	1	3	16	n/a
CUT	0	0	0	2	0	1	0	0	0	1	0	0	3	1	2	10	n/a
VUT	0	0	0	3	1	1	0	0	1	0	1	0	0	0	0	7	n/a
DUT	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	n/a
Total	15	20	18	22	19	18	25	28	27	34	34	21	43	32	38	394	6%

Doctoral students in the clinical health sciences

In the figure below, the number of total doctoral enrolments and graduates in the clinical health sciences between 2000 and 2014 are presented.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total enrolments	238	200	216	216	220	448	306	325	373	428	348	372	270	456	484
First enrolments	67	58	67	64	71	134	116	107	118	127	77	83	65	115	119
Graduates	34	18	20	36	27	79	36	43	39	47	31	54	38	67	56

Figure B-4 Doctoral total and first enrolments and graduate in the clinical health sciences (2000 to 2014)

In the table below I present an overview of doctoral students in the clinical health sciences in 2000, 2008 and 2014.

Table B-10 Overview of doctoral students in the clinical health sciences (2000, 2008 and 2014)

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
Overall	Enrolments	No of **total** enrolments	238	373	484		5.0%
		No of **new** enrolments	67	118	119		3.0%
	Graduates	No of graduates	34	39	56		5.8%
Demographics of *total* enrolments	Gender	Proportion of **female** students of total enrolments	40.8%	60.9%	53.3%	12.5%	6.0%
	Race	Proportion of **black** students of total enrolments *(AIC)*	33.2%	50.7%	56.8%	2436%	9.0%
		Proportion of **black African** students of total enrolments	13.9%	27.2%	32.2%	18.3%	12.3%
	Nationality	Proportion **RSA** students of total enrolments	93.3%	82.4%	82.5%	-10.8%	4.4%
	Age	Average age at commencement (years)	38.4	39.4	37.6	-0.8 years	
Demographics of *graduates*	Gender	Proportion of **female** students of total graduates	50.0%	61.5%	46.4%	-3.6%	6.1%
	Race	Proportion of **black** students of total graduates *(AIC)*	20.6%	32.4%	54.5%	33.9%	11.0%

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
		Proportion of **black African** students of total graduates	11.8%	12.8%	34.5%	22.7%	13.7%
	Nationality	Proportion **RSA** students of total graduates	96.7%	86.5%	76.8%	-19.9%	4.9%
	Age	Average age at graduation (years)	39.7	42.9	41.5	1.8 years	

In the table below, the number of doctoral enrolments in the clinical health sciences per HEI per year are disaggregated (2000 to 2014).

Table B-11 Doctoral enrolments in the clinical health sciences, per HEI, per year (2000 to 2014)

HEI	**Year**															**Total**	**AAG**
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
UCT	65	50	50	52	55	54	76	85	94	96	93	82	83	88	107	1130	5%
WITS	1	1	1	1	1	*221*	58	52	61	76	92	113	*3*	140	141	962	43%*
UKZN	39	38	37	35	30	45	45	48	56	80	44	46	56	88	74	761	6%
SU	39	39	37	32	22	28	26	35	36	32	56	65	61	69	79	656	6%
UFS	15	23	26	31	25	25	30	20	15	18	10	9	10	0	0	257	n/a
UP	55	14	12	15	12	10	6	7	15	17	12	14	14	21	26	250	0%
UWC	1	9	13	12	16	14	17	25	26	47	0	0	0	0	0	180	n/a
UL	2	4	9	10	12	9	8	7	11	11	8	10	7	10	6	124	4%
NWU	2	3	5	7	8	6	7	7	8	2	0	0	0	0	0	55	n/a
Comprehensive Universities																	
UJ	7	6	9	11	21	24	25	27	32	30	11	16	15	15	17	266	5%
UNIZULU	8	9	7	8	11	8	5	4	5	2	0	0	0	0	0	67	n/a
WSU	1	1	1	1	0	0	0	0	1	5	10	3	5	8	18	54	n/a
NMU	0	0	7	0	5	0	0	0	0	0	0	0	0	0	0	12	n/a
Universities of Technology																	
CPUT	2	2	0	0	0	1	0	2	1	2	9	9	12	11	7	58	n/a
TUT	0	0	0	0	0	2	2	5	10	8	1	2	1	2	2	35	n/a
DUT	1	1	2	1	2	1	1	1	2	2	2	3	3	4	7	33	11%
Total	238	200	216	216	220	448	306	325	373	428	348	372	270	456	484	4900	5%

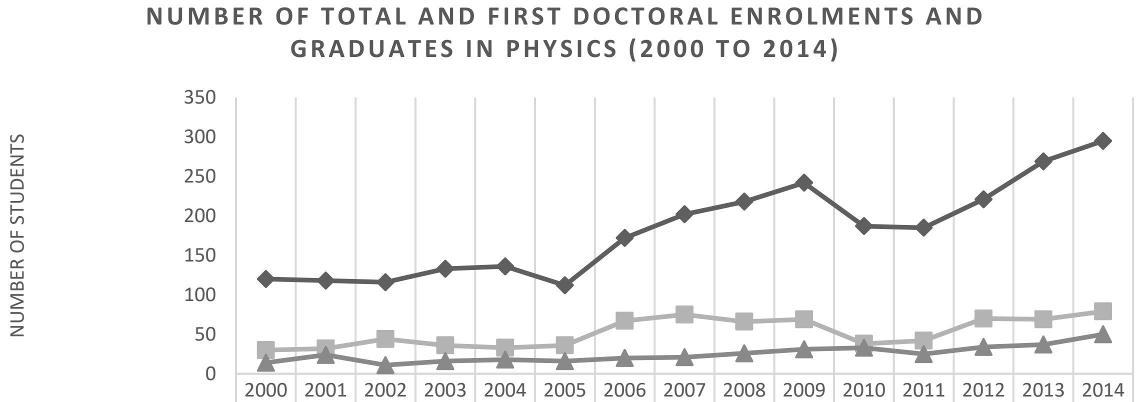
In the table below, the number of doctoral graduates in the clinical health sciences per HEI per year are disaggregated (2000 to 2014).

Table B-12 Doctoral graduates in the clinical health sciences, per HEI, per year (2000 to 2014)

HEI	**Year**															**Total**	**AAG**
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
UCT	12	5	6	8	5	12	17	17	17	14	14	12	15	15	9	178	5%
WITS	0	0	0	0	0	37	1	4	3	6	7	18	2	20	17	115	n/a
SU	6	5	8	8	0	6	2	8	7	2	6	8	6	15	11	98	n/a
UKZN	3	2	3	7	3	6	5	4	3	7	2	6	5	7	7	70	5%
UP	7	2	1	3	2	4	1	1	2	0	0	4	3	3	3	36	n/a
UFS	3	1	1	5	3	4	2	2	1	5	1	1	1	0	0	30	n/a
UWC	0	0	0	1	3	2	1	2	1	3	0	0	0	0	0	13	n/a
UL	0	1	1	0	0	1	2	0	0	1	1	0	1	1	0	9	n/a
NWU	0	0	0	1	0	2	1	2	2	0	0	0	0	0	0	8	n/a
Comprehensive University																	
UJ	2	1	0	1	6	4	4	3	2	6	0	1	1	0	3	34	n/a
WSU	0	0	0	1	0	0	0	0	0	0	0	1	1	2	5	10	n/a
UNIZULU	1	1	0	1	3	1	0	0	0	0	0	0	0	0	0	7	n/a
NMU	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	n/a
Universities of Technology																	
CPUT	0	0	0	0	0	0	0	0	0	1	0	0	3	4	1	9	n/a
TUT	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	3	n/a
DUT	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	4	n/a
Total	34	18	20	36	27	79	36	43	39	47	31	54	38	67	56	625	6%

Doctoral students in physics

In the figure below, the number of total doctoral enrolments and graduates in physics between 2000 and 2014 are presented.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total enrolments	120	118	116	133	136	112	172	202	218	242	187	185	221	269	295
New enrolments	30	32	44	36	33	36	67	75	66	69	38	42	70	69	79
Graduates	14	24	11	16	18	16	20	21	26	31	33	25	34	37	50

YEAR

Figure B-5 Doctoral total and first doctoral enrolments and graduates in physics (2000 to 2014)

In the table below I summarise the demographic profile of doctoral students in physics for in 2000, 2008 and 2014.

Table B-13 Overview of doctoral students in physics (2000, 2008 and 2014)

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
Overall	Enrolments	No of **total** enrolments	120	218	295		6.8%
		No of **new** enrolments	30	66	79		7.6%
	Graduates	No of graduates	14	26	50		8.3%
Demographics of *total* enrolments	Gender	Proportion of **female** students of total enrolments	15.0%	15.1%	19.0%	4.0%	7.2%
	Race	Proportion of **black** students of total enrolments *(AIC)*	48.3%	67.6%	77.0%	28.7%	9.7%
		Proportion of **black African** students of total enrolments	36.7%	55.1%	64.0%	27.3%	10.6%
	Nationality	Proportion **RSA** students of total enrolments	77.6%	59.9%	53.1%	-24.5%	4.1%
	Age	Average age at commencement (years)	31.4	32.5	32.5	+1.1 years	
Demographics of *graduates*	Gender	Proportion of **female** students of total graduates	0%	19.2%	20.0%	20.0%	5.7%

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
	Race	Proportion of **black** students of total graduates *AIC)*	35.7%	57.7%	70.8%	35.1%	12.5%
		Proportion of **black African** students of total graduates	28.6%	53.8%	58.3%	28.7	13.6%
	Nationality	Proportion **RSA** students of total graduates	78.6%	57.7%	54.0%	24.6%	5.6%
	Age	Average age at graduation (years)	31.9	37.9	34.3	2.4 years	

In the table below, the number of doctoral enrolments in physics per HEI per year are disaggregated (2000 to 2014).

Table B-14 Doctoral enrolments in physics, per HEI, per year (2000 to 2014)

HEI	Year															Total	AAG
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
WITS	86	41	36	32	29	0	41	39	33	30	0	0	1	52	51	471	n/a
UKZN	24	7	9	18	19	16	19	20	22	25	29	34	44	51	50	387	11%
UCT	24	11	10	15	19	20	24	24	19	20	20	19	21	29	33	308	5%
SU	22	11	10	13	9	13	10	13	22	25	26	30	35	34	32	305	9%
UP	15	9	3	4	3	3	7	10	17	16	19	20	27	28	38	219	16%
UFS	10	5	4	6	6	10	13	15	15	16	18	19	23	0	0	160	n/a
UL	6	4	8	9	10	9	9	10	9	9	12	8	9	8	9	129	3%
NWU	8	7	8	11	11	7	10	9	12	12	4	3	6	7	11	126	-2%
UWC	8	4	8	4	6	5	7	13	16	21	0	0	5	2	12	111	n/a
UFH	0	0	0	0	0	3	3	6	6	8	10	9	7	9	9	70	n/a
RU	0	2	2	2	3	3	3	4	4	8	7	7	3	5	8	61	10%
Comprehensive Universities																	
NMU	14	7	8	9	10	9	12	15	18	22	19	15	20	17	17	212	6%
UNIZULU	7	1	1	0	1	2	1	5	2	3	4	1	3	1	3	35	n/a
UNIVEN	2	0	0	0	0	0	0	0	1	1	1	0	1	4	3	13	n/a
UJ	6	5	5	7	7	9	11	15	17	20	14	17	15	18	18	184	11
Unisa	8	4	4	3	3	3	2	4	5	6	4	3	1	4	1	55	-6%
Total	240	118	116	133	136	112	172	202	218	242	187	185	221	269	295	2846	5%

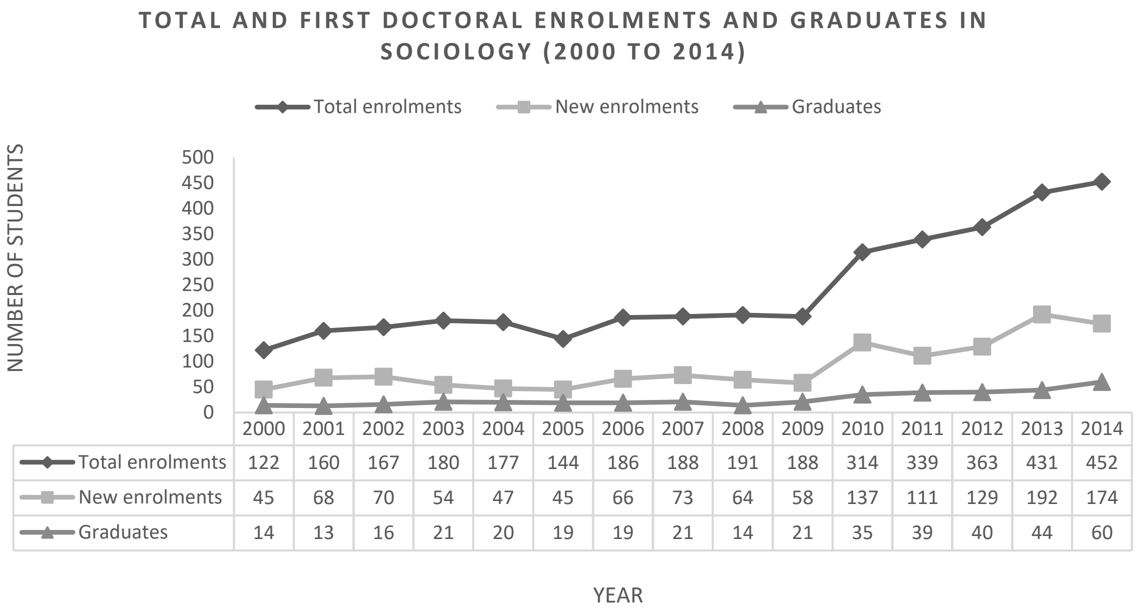
In the table below, the number of doctoral graduates in physics per HEI per year are disaggregated.

Table B-15 Doctoral graduates in physics, per HEI, per year (2000 to 2014)

HEI	**Year**															**Total**	**AAG**
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
WITS	14	8	5	4	3	0	1	9	8	4	0	0	1	7	10	74	n/a
SU	2	3	0	2	0	3	2	0	1	4	7	4	5	6	10	49	n/a
UKZN	2	0	1	1	2	2	3	3	3	3	2	3	7	8	8	48	n/a
UCT	0	2	1	2	1	3	2	3	2	4	3	3	5	3	5	39	10%
UFS	2	3	0	1	0	1	4	0	2	2	5	5	1	0	0	26	n/a
UP	0	1	0	0	1	0	1	0	1	3	3	1	3	2	8	24	n/a
NWU	2	2	0	2	1	1	1	0	1	2	1	0	1	0	0	14	n/a
RU	0	1	1	0	1	1	0	2	0	1	1	4	1	1	0	14	n/a
UL	0	1	0	0	2	2	1	1	1	0	0	0	1	2	0	11	n/a
UWC	0	0	1	1	2	1	0	0	0	3	0	0	0	0	0	8	n/a
UFH	0	0	0	0	0	0	1	0	0	2	0	2	0	2	1	8	n/a
Comprehensive Universities																	
NMU	2	3	1	1	4	1	4	1	4	3	6	2	6	3	5	46	8%
UJ	0	0	0	2	0	0	0	2	3	0	2	0	1	3	2	15	n/a
Unisa	4	0	1	0	1	1	0	0	0	0	1	1	0	0	0	9	n/a
UNIZULU	0	0	0	0	0	0	0	0	0	0	2	0	2	0	1	5	n/a
Total	28	24	11	16	18	16	20	21	26	31	33	25	34	37	50	390	6%

Doctoral students in sociology

In the figure below, the number of total doctoral enrolments and graduates in sociology between 2000 and 2014 are presented.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total enrolments	122	160	167	180	177	144	186	188	191	188	314	339	363	431	452
New enrolments	45	68	70	54	47	45	66	73	64	58	137	111	129	192	174
Graduates	14	13	16	21	20	19	19	21	14	21	35	39	40	44	60

Figure B-6 Doctoral total and first enrolments and graduates in sociology (2000 to 2014)

In the table below I present a summary of the demographic profile of doctoral students in sociology in 2000, 2008 and 2014.

Table B-16 Overview of doctoral students in sociology (2000, 2008 and 2014)

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
Overall	Enrolments	No of **total** enrolments	136	205	512		9.0%
		No of **new** enrolments	45	64	174		9.5%
	Graduates	No of graduates	14	14	60		9.8%
Demographics of *total* enrolments	Gender	Proportion of **female** students of total enrolments	47.1%	55.6%	42.8%	-5.7%	8.6%
	Race	Proportion of **black** students of total enrolments *(AIC)*	44.1%	68.1%	88.0%	43.9%	5.3%
		Proportion of **black African** students of total enrolments	29.4%	50.0%	73.3%	43.9%	16%
	Nationality	Proportion **RSA** students of total enrolments	87.5%	76.6%	47.0%	-40.5%	4.6%

Dimension		Indicator	2000	2008	2014	Shift (2000 to 2014)	AAG
	Age	Average age at commencement (years)	37.7	38.0	38.1	0.4 years	
Demographics of *graduates*	Gender	Proportion of **female** students of total enrolments	35.7%	71.4%	35.0%	-0.7%	9.4%
	Race	Proportion of **black** students of total graduates *(AIC)*	21.4%	50%	83.3%	61.9%	18.6%
		Proportion of **black African** students of total graduates	14.3%	28.6%	75.0%	60.7%	20.8%
	Nationality	Proportion **RSA** students of total graduates	85.7%	92.3%	32.2%	-53.5%	3.6%
	Age	Average age at graduation (years)	42.8	41.9	42.4	-0.4 years	

In the table below, the number of doctoral enrolments in sociology per HEI per year are disaggregated (2000 to 2014).

Table B-17 Doctoral enrolments in sociology, per HEI, per year (2000 to 2014)

HEI	**Year**															**Total**	**AAG**
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
WITS	19	19	22	27	29	0	26	21	19	*17*	*54*	64	59	68	84	528	n/a
SU	34	40	34	34	28	27	28	24	21	22	26	36	31	46	35	466	0%
UKZN	17	19	26	20	30	28	26	20	20	19	35	38	40	56	55	449	7%
UFH	0	0	0	0	0	0	0	0	5	*5*	*78*	63	63	73	89	376	n/a
UCT	13	10	10	11	13	15	19	25	27	31	24	30	41	36	40	345	11%
NWU	9	17	14	19	20	16	17	29	29	26	22	19	21	26	37	321	6%
UWC	7	9	9	9	9	8	13	15	14	19	21	21	25	33	29	241	12%
RU	0	7	8	9	5	7	9	15	17	15	19	19	21	27	36	214	n/a
NMU	1	3	9	15	15	13	18	10	8	7	6	6	10	9	6	136	4%
UP	9	15	9	10	8	9	9	6	5	8	2	2	2	4	9	107	-9%
UFS	6	10	9	10	11	9	8	7	4	5	2	2	2	0	0	85	n/a
UL	3	1	2	3	0	1	0	0	3	2	0	0	0	0	2	17	n/a
Comprehensive Universities																	
Unisa	13	19	22	29	21	20	25	17	15	11	31	48	53	68	54	446	9%
UJ	4	0	4	3	4	6	6	16	14	19	28	28	32	27	33	224	n/a
UNIZULU	0	3	5	2	4	4	1	4	4	3	1	2	3	2	3	41	n/a
UNIVEN	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	n/a
Total	136	173	183	201	197	163	205	209	205	209	349	378	403	475	512	3998	9%

In the table below, the number of doctoral graduates in sociology per HEI per year are disaggregated (2000 to 2014).

Table B-18 Doctoral graduates in sociology per HEI, per year (2000 to 2014)

HEI	**Year**															**Total**	**AAG**
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Traditional Universities																	
WITS	2	0	3	1	2	0	5	1	1	3	9	11	5	5	7	55	n/a
SU	0	5	2	4	4	4	1	4	2	2	4	1	4	6	8	51	2%
UFH	0	0	0	0	0	0	0	0	0	0	10	8	8	3	13	42	n/a
UKZN	2	1	2	4	3	3	2	2	1	1	3	3	0	8	4	39	n/a
UCT	1	0	2	1	2	2	2	3	3	3	0	3	7	4	3	36	n/a
NWU	1	2	1	2	2	3	1	2	2	2	0	3	0	1	4	26	n/a
UWC	0	1	0	2	0	0	0	1	0	0	4	3	5	3	3	22	n/a
RU	0	0	2	2	1	1	1	0	1	2	3	3	1	2	2	21	n/a
UP	0	1	0	0	0	0	1	2	1	3	0	0	0	0	1	9	n/a
UFS	0	0	0	0	2	2	0	1	1	1	0	0	0	0	0	7	n/a
UL	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	n/a
Comprehensive Universities																	
Unisa	4	3	3	4	4	3	4	3	0	2	1	2	4	11	12	60	n/a
UJ	3	0	0	0	0	0	0	0	1	0	1	1	5	1	1	13	n/a
NMU	0	0	0	0	0	1	2	1	0	1	0	1	1	0	2	9	n/a
UNIZULU	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	4	n/a
Total	14	13	16	21	20	19	19	21	14	21	35	39	40	44	60	396	10%

Four-year completion rates in five disciplines

In the section below present the calculations of four-year completion rates of doctoral students, nationally and per discipline.

Table B-19 Calculation of four-year doctoral completion rates (national) (2000 to 2011)

National		2000 - 2003	2001 - 2004	2002 - 2005	2003 - 2006	2004 - 2007	2005 - 2008	2006 - 2009	2007 - 2010	2008 - 2011	2009 - 2012	2010 - 2013	2011 - 2014
year 1	n	129	119	72	78	80	88	106	111	89	85	69	117
year 2	n	134	167	146	166	134	123	137	116	99	120	177	182
year 3	n	194	209	213	219	193	209	207	247	200	239	386	351
year 4	n	249	240	242	250	262	244	333	272	268	380	506	490
Total graduates (after 4 years)	n	706	735	673	713	669	664	783	746	656	824	1138	1140
Total first enrolments	n	2117	2365	2553	2596	2772	2780	3022	2793	2486	2804	3079	3660
Completion rates (after 4 years)	%	33.3	31.1	26.4	27.5	24.1	23.9	25.9	26.7	26.4	29.4	37.0	31.1
Graduates same year	n	129	119	72	78	80	88	106	111	89	85	69	117
Adjusted graduates	n	577	616	601	635	589	576	677	635	567	739	1069	1023
Adjusted completion rate	%	**27.3**	**26.0**	**23.5**	**24.5**	**21.2**	**20.7**	**22.4**	**22.7**	**22.8**	**26.4**	**34.7**	**28.0**

Table B-20 Calculation of four-year doctoral completion rates in education (2000 to 2011)

Education		2000 - 2003	2001 - 2004	2002 - 2005	2003 - 2006	2004 - 2007	2005 - 2008	2006 - 2009	2007 - 2010	2008 - 2011	2009 - 2012	2010 - 2013	2011 - 2014
year 1	n	28	12	16	9	13	12	18	21	10	8	2	9
year 2	n	18	14	23	29	18	16	15	15	15	14	21	13
year 3	n	19	27	36	27	30	20	14	20	21	31	30	32
year 4	n	27	22	10	30	29	21	24	27	25	66	55	59
Total graduates (after 4 years)	n	92	75	85	95	90	69	71	83	71	119	108	113
Total first enrolments	n	269	325	317	372	397	343	309	275	263	309	289	375
Completion rates (after 4 years)	%	34.2	23.1	26.8	25.5	22.7	20.1	23.0	30.2	27.0	38.5	37.4	30.1
Graduates same year	n	28	12	16	9	13	12	18	21	10	8	2	9
Adjusted graduates	n	64	63	69	86	77	57	53	62	61	111	106	104
Adjusted completion rate	%	**23.8**	**19.4**	**21.8**	**23.1**	**19.4**	**16.6**	**17.2**	**22.5**	**23.2**	**35.9**	**36.7**	**27.7**

Table B-21 Calculation of four-year doctoral completion rates in electrical engineering (2000 to 2011)

Electrical engineering		2000 - 2003	2001 - 2004	2002 - 2005	2003 - 2006	2004 - 2007	2005 - 2008	2006 - 2009	2007 - 2010	2008 - 2011	2009 - 2012	2010 - 2013	2011 - 2014
year 1	n	1	5	2	0	1	2	3	1	3	3	2	3
year 2	n	3	4	5	0	3	0	5	3	2	3	1	0
year 3	n	3	5	6	2	4	5	8	8	4	3	7	6
year 4	n	6	3	5	5	6	6	5	11	6	13	7	4
Total graduates (after 4 years)	n	13	17	18	7	14	13	21	23	15	22	17	13
Total first enrolments	n	42	46	51	37	56	54	85	74	51	71	70	50
Completion rates (after 4 years)	%	31.0	37.0	35.3	18.9	25.0	24.1	24.7	31.1	29.4	31.0	24.3	26.0
Graduates same year	n	1	5	2	0	1	2	3	1	3	3	2	3
Adjusted graduates	n	12	12	16	7	13	11	18	22	12	19	15	10
Adjusted completion rate	%	**28.6**	**26.1**	**31.4**	**18.9**	**23.2**	**20.4**	**21.2**	**29.7**	**23.5**	**26.8**	**21.4**	**20.0**

Table B-22 Calculation of four-year doctoral completion in the clinical health sciences (2000 to 2011)

Clinical health sciences		2000 - 2003	2001 - 2004	2002 - 2005	2003 - 2006	2004 - 2007	2005 - 2008	2006 - 2009	2007 - 2010	2008 - 2011	2009 - 2012	2010 - 2013	2011 - 2014
year 1	n	1	1	0	3	5	6	6	7	5	3	0	1
year 2	n	5	3	4	2	6	6	4	5	8	3	3	4
year 3	n	5	7	5	13	6	8	11	5	4	3	4	8
year 4	n	9	4	24	9	9	3	10	6	14	9	17	8
Total graduates (after 4 years)	n	20	15	33	27	26	23	31	23	31	18	24	21
Total first enrolments	n	67	58	67	64	71	134	116	107	118	127	77	83
Completion rates (after 4 years)	%	29.9	25.9	49.3	42.2	36.6	17.2	26.7	21.5	26.3	14.2	31.2	25.3
Graduates same year	n	1	1	0	3	5	6	6	7	5	3	0	1
Adjusted graduates	n	19	14	33	24	21	17	25	16	26	15	24	20
Adjusted completion rate	%	**28.4**	**24.1**	**49.3**	**37.5**	**29.6**	**12.7**	**21.6**	**15.0**	**22.0**	**11.8**	**31.2**	**24.1**

Table B-23 Calculation of four-year doctoral completion rates in physics (2000 to 2011)

Physics		2000 - 2003	2001 - 2004	2002 - 2005	2003 - 2006	2004 - 2007	2005 - 2008	2006 - 2009	2007 - 2010	2008 - 2011	2009 - 2012	2010 - 2013	2011 - 2014
year 1	n	1	3	1	1	2	1	4	2	1	4	0	0
year 2	n	0	2	2	0	0	1	2	3	2	3	1	0
year 3	n	1	2	6	3	1	1	2	2	4	3	8	14
year 4	n	4	3	4	3	6	9	14	10	4	10	7	12
Total graduates (after 4 years)	n	7	10	13	7	9	12	22	17	11	20	16	26

Total first enrolments	n	30	32	44	36	33	36	67	75	66	69	38	42
Completion rates (after 4 years)	%	11.7	31.3	29.5	19.4	27.3	33.3	32.8	22.7	16.7	29.0	42.1	61.9
Graduates same year	n	1	3	1	1	2	1	4	2	1	4	0	0
Adjusted graduates	n	6	7	12	6	7	11	18	15	10	16	16	26
Adjusted completion rate	%	**20.0**	**21.9**	**27.3**	**16.7**	**21.2**	**30.6**	**26.9**	**20.0**	**15.2**	**23.2**	**42.1**	**61.9**

Table B-24 Calculation of four-year doctoral completion rates in sociology (2000 to 2011)

Sociology		2000 - 2003	2001 - 2004	2002 - 2005	2003 - 2006	2004 - 2007	2005 - 2008	2006 - 2009	2007 - 2010	2008 - 2011	2009 - 2012	2010 - 2013	2011 - 2014
year 1	n	0	1	2	5	0	1	2	2	0	1	12	3
year 2	n	5	1	3	5	2	1	0	1	1	0	8	2
year 3	n	2	0	5	2	0	2	1	5	2	7	13	10
year 4	n	4	4	6	5	3	2	3	3	3	6	10	12
Total graduates (after 4 years)	n	11	6	16	17	5	6	6	11	6	14	43	27
Total first enrolments	n	45	68	70	54	47	45	66	73	64	58	137	111
Completion rates (after 4 years)	%	24.4	8.8	22.9	31.5	10.6	13.3	9.1	15.1	9.4	24.1	31.4	24.3
Graduates same year	n	0	1	2	5	0	1	2	2	0	1	12	3
Adjusted graduates	n	11	5	14	12	5	5	4	9	6	13	31	24
Adjusted completion rate	%	**24.4**	**7.4**	**20.0**	**22.2**	**10.6**	**11.1**	**6.1**	**12.3**	**9.4**	**22.4**	**22.6**	**21.6**

A comparison of four-, five-, six- and seven-year completion rates of doctoral graduates in five disciplines

In the tables below, the adjusted four-, five-, six- and seven- year doctoral completion rates per discipline, are presented.

Table B-25 Adjusted four-, five-, six- and seven-year doctoral completion rates (2000 to 2011)

Completion rates	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
4 year	27.3	26.0	23.5	24.5	21.2	20.7	22.4	22.7	22.8	26.4	34.7	28.0	25.0
5 year	35.0	35.1	30.4	33.1	28.7	28.5	32.6	32.0	34.4	39.3	47.8		34.3
6 year	40.3	39.9	36.3	38.1	34.4	34.2	40.8	39.2	41.8	48.2			39.3
7 year	43.1	43.3	40.2	41.8	37.8	37.9	44.6	44.0	46.8				42.2

Table B-26 Adjusted four-, five-, six- and seven-year doctoral completion rates in education (2000 to 2011)

Completion rates	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
4-year	23.8	19.4	21.8	23.1	19.4	16.6	17.2	22.5	23.2	35.9	36.7	27.7	23.9
5-year	29.7	24.6	27.4	29.6	25.2	23.9	27.8	27.3	34.2	50.8	50.5		31.9
6-year	34.6	27.4	30.6	34.4	31.2	27.7	36.6	36.0	41.4	63.4			36.3
7-year	35.7	32.3	34.1	39.2	33.5	30.0	38.8	42.5	46.0				36.9

Table B-27 Adjusted four-, five-, six- and seven-year doctoral completion rates in electrical engineering (2000 to 2011)

Completion rates	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
4-year	28.6	26.1	31.4	18.9	23.2	20.4	21.2	29.7	23.5	26.8	21.4	20.0	24.3
5-year	33.3	30.4	39.2	29.7	30.4	31.5	27.1	33.8	41.2	36.6	38.6		33.8
6-year	40.5	43.5	45.1	29.7	35.7	42.6	30.6	41.9	45.1	40.8			39.6
7-year	40.5	47.8	49.0	45.9	41.1	44.4	35.3	41.9	49.0				43.9

Table B-28 Adjusted four-, five-, six- and seven-year doctoral completion rates in the clinical health sciences (2000 to 2011)

Completion rates	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
4-year	28.4	24.1	49.3	37.5	29.6	12.7	21.6	15.0	22.0	11.8	31.2	24.1	25.6
5-year	34.3	44.8	55.2	46.9	39.4	17.2	26.7	19.6	27.1	25.2	53.2		35.4
6-year	47.8	48.3	61.2	51.6	49.3	20.9	37.1	27.1	33.9	32.3			40.9
7-year	49.3	55.2	64.2	57.8	53.5	26.1	41.4	29.0	39.8				46.2

Table B-29 Adjusted four-, five-, six- and seven-year doctoral completion rates in physics (2000 to 2011)

Completion rates	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
4-year	20.0	21.9	27.3	16.7	21.2	30.6	26.9	20	15.2	23.2	42.1	61.9	27.3
5-year	26.7	34.4	40.9	25.0	27.3	38.9	40.3	30.7	27.3	34.8	68.4		35.9
6-year	33.3	43.8	45.5	38.9	36.4	44.4	52.2	38.7	33.3	40.6			40.7
7-year	36.7	46.9	50.0	38.9	39.4	44.4	52.2	42.7	40.9				43.6

Table B-30 Adjusted four-, five-, six- and seven-year doctoral completion rates in sociology (2000 to 2011)

Completion rates	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
4 year	24.4	7.4	20.0	22.2	10.6	11.1	6.1	12.3	9.4	22.4	22.6	21.6	15.8
5 year	28.9	10.3	21.4	31.5	14.9	20.0	16.7	21.9	15.6	34.5	30.7		22.4
6 year	33.3	11.8	27.1	33.3	21.3	33.3	24.2	31.5	21.9	46.6			28.4
7 year	42.2	14.7	32.9	35.2	21.3	37.8	25.8	38.4	32.8				31.2

Estimated time-to-degree of survey respondents

The survey data were used to approximate *projected* time-to-degree of survey respondents. This is presented in Table B-31. In the calculation of mean A (no outliers) respondents in education projected the shortest time-to-degree of 3.54 years (42.46 months). For all other means calculated respondents in the physical sciences projected the shortest mean time-to-degree. Across the board, respondents in engineering reported the longest projected time-to-degree. Examining the projected means it is clear that the projected mean time-to-degree is noticeably lower than that recorded by the HEMIS data. It is important to remember, that the disciplines categorised above were not analysed at CESM level two as was the case with the HEMIS data. Additionally, survey respondents might have indicated their planned dates of submission, rather than graduation, which might also explain the lower mean. The projected mean time-to-degree as calculated using the survey data are used in the analyses on the relationships of situational and dispositional factors on timely completion (Chapter 10).

Table B-31 Summary of mean time-to-degree calculated from the survey data

Survey		All disciplines		Education[x]		Engineering[xi]		Health sciences[xii]		Physical sciences[xiii]		Social sciences[xiv]	
		Mean	*Std. dev.*	*Mean*	*Std. dev.*	*Mean*	*Std. dev.*	*Mean*	*Std. dev.*	*Mean*	*Std. dev.*	*Mean*	*Std. dev.*
Mean A (all cases)	n		1270		108		119		139		155		131
	Mean (months)	43.74	18.91	42.46	16.175	46.38	22.651	43.27	14.429	42.87	27.891	42.93	16.021
	Mean (years)		3.65		**3.54**		3.87		3.61		3.57		3.58
Mean B	Exclude <24 months; and ≥x months (boxplot)			41.53	10.426	42.36	11.529	41.14	9.945	**40.85**	9.600	41.81	10.789
	Outliers[110]			≥24	≥72	≥24	≥80	≥24	≥70	≥24	≥67	≥24	≥75
Mean C	Transformed individual distributions*			1.60 (39.81)	0.105 (1.274)	1.61 (40.73)	0.112 (1.294)	1.60 (39.81)	0.102 (1.265)	1.59 **(38.90)**	0.100 (1.259)	1.60 (39.81)	0.108 (1.282)
	Distribution			Positively skewed		Positively skewed		Positively skewed		Positively skewed		Positively skewed	
	Transformation			Log		Log		Log		Log		Log	
Mean D	Exclude <24 months; and ≥73months years (all disciplines)	41.81	10.789	42.463	16.175	46.386	10.088	41.62	10.704	**40.97**	10.642	41.35	11.099
Mean E	Transformed comparative data (all 5 disciplines)	1.60 (39.81)	0.108 (1.282)	1.60 (39.81)	0.114 (1.300)	1.61 (40.73)	0.102 (1.264)	1.60 (39.81)	0.107 (1.279)	1.59 **(38.90)**	0.104 (1.270)	1.60 (39.81)	0.113 (1.297)
		Log transformation											

[110] Percentage of cases excluded: All disciplines (11.7%), education (12.6), engineering (10.3%), health sciences (13.7%), physical sciences (14.6%), social sciences (11.7%)

Appendix C | Chapter 7: The role of the nature of a discipline in time-to-degree

In the table below I report on the mean[111] time-to-degree of doctoral students in five disciplines over the 15-year period studied.

Table C-1 Mean time-to-degree of doctoral graduates in five disciplines (2000 to 2014)

Year	Clinical health sciences		Education		Electrical engineering		Sociology		Physics	
	Mean	*Std. dev.*	Mean	*Std. dev.*	Mean	*Std. dev.*	Mean	*Std. dev.*	Mean	*Std. dev.*
2000	4.41	*1.66*	3.97	*1.94*	5.38	*2.53*	3.79	*1.93*	4.62	*2.28*
2001	4.12	*2.29*	3.84	*1.65*	4.27	*1.87*	3.58	*1.73*	4.71	*1.31*
2002	4.37	*2.17*	4.17	*1.87*	4.38	*2.42*	4.62	*1.71*	4.50	*2.22*
2003	4.78	*2.24*	3.88	*1.63*	3.91	*1.87*	5.2	*2.46*	4.67	*1.80*
2004	4.33	*1.39*	3.59	*1.44*	4.89	*1.84*	3.79	*1.75*	4.63	*1.82*
2005	4.49	*1.61*	4.35	*1.94*	4.19	*1.56*	4.71	*2.02*	4.57	*1.22*
2006	3.90	*1.54*	3.93	*1.42*	5.05	*1.75*	5.67	*1.91*	4.80	*1.26*
2007	4.42	*1.70*	4.66	*1.87*	4.19	*1.72*	5.63	*1.80*	5.11	*2.22*
2008	4.24	*1.92*	4.70	*1.80*	4.04	*1.71*	5.62	*1.94*	4.67	*1.86*
2009	4.75	*2.18*	4.93	*1.88*	4.71	*1.72*	4.56	*1.62*	4.13	*1.03*
2010	5.00	*2.00*	4.53	*1.68*	4.5	*1.44*	5.16	*1.34*	4.45	*1.50*
2011	5.35	*1.88*	4.59	*2.05*	4.72	*1.84*	4.53	*2.17*	4.96	*1.43*
2012	4.84	*1.77*	4.51	*1.58*	4.67	*1.24*	4.34	*1.63*	4.38	*1.07*
2013	4.93	*1.64*	4.66	*1.82*	4.83	*2.04*	4.68	*1.69*	4.43	*1.52*
2014	5.20	*1.54*	4.84	*1.60*	4.51	*1.67*	5.07	*2.00*	4.42	*1.54*

[111] The mean was calculated by excluding cases less than two years and more than 11 years.

Appendix D | Chapter 9: Institutional factors and timely completion

Below are supplementary tables to Chapter 9.

Throughput rates of five disciplines

In the tables below, I report on the throughput rates as calculated nationally and for each discipline for the three periods 2000-2004; 2005-2009 and 2010-2014.

Table D-1 Throughput rates of doctoral students in three five-year periods (nationally) (2000 to 2014)

		2000-2004	2005-2009	2010-2014
Enrolments	n	38728	49936	72586
Graduates	n	5014	6125	9179
Throughput rates	%	12.9	12.3	12.6

Table D-2 Throughput rates of doctoral students in education in three five-year periods (2000 to 2014)

		2000-2004	2005-2009	2010-2014
Enrolments	n	4191	5099	7758
Graduates	n	581	650	941
Throughput rates	%	13.9	12.8	12.2

Table D-3 Throughput rates of doctoral students in electrical engineering in three five-year periods (2000 to 2014)

		2000-2004	2005-2009	2010-2014
Enrolments	n	739	1129	1399
Graduates	n	94	132	168
Completion rates	%	12.7	11.7	12.0

Table D-4 Throughput rates of doctoral students in the clinical health sciences in three five-year periods (2000 to 2014)

		2000-2004	2005-2009	2010-2014
Enrolments	n	1090	1880	1930
Graduates	n	135	244	246
Throughput rates	%	12.4	13.0	12.8

Table D-5 Throughput rates of doctoral students in physics in three five-year periods (2000 to 2014)

		2000-2004	2005-2009	2010-2014
Enrolments	n	623	946	1157
Graduates	n	83	114	179
Throughput rate	%	13.1	12.1	15.5

Table D-6 Throughput rates of doctoral students in sociology in three five-year periods (2000 to 2014)

		2000-2004	2005-2009	2010-2014
Enrolments	n	890	991	2117
Graduates	n	84	94	218
Throughput rate	%	9.4	9.5	10.3

Institutional throughput rates of five disciplines

In the tables below I report on the average throughput rates per institution per discipline for the years 2000, 2008 and 2014 as well as the total throughput rate for the 15-year period.

Table D-7 Throughput rates of HEIs in education (2000, 2008 and 2014)

HEI	2000			2008			2014			Total (2000 to 2014)		
	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate
NMU	17	2	11.8	29	7	24.1	41	7	17.1	471	86	18.3
SU	52	4	7.7	47	6	12.8	95	18	18.9	892	139	15.6
UNIZULU	34	9	26.5	28	2	7.1	30	9	30.0	382	58	15.2
UJ	92	24	26.1	85	13	15.3	136	13	9.6	1556	230	14.8
UFS	23	5	21.7	47	3	6.4	109	13	11.9	777	113	14.5
DUT	0	0	-	9	0	0	3	0	0	42	6	14.3
UCT	18	0	0	27	3	11.1	41	6	14.6	413	58	14.0
NWU	50	9	18.0	127	13	10.2	89	5	5.6	1422	195	13.7
UFH	0	0		23	1	4.3	86	12	14.0	345	46	13.3
Unisa	90	54	60.0	86	7	8.1	429	46	10.7	2417	320	13.2
RU	15	4	26.7	32	4	12.5	84	9	10.7	643	85	13.2
UWC	47	7	14.9	46	5	10.9	73	11	15.1	868	114	13.1
CPUT	1	0	0	11	1	9.1	19	2	10.5	172	21	12.2
TUT	2	2	100	14	1	7.1	49	10	20.4	304	36	11.8
UP	122	12	9.8	164	26	15.9	152	21	13.8	2334	271	11.6
WITS	25	1	4.0	63	6	9.5	106	16	15.1	985	110	11.2
UKZN	52	5	9.6	99	16	16.2	388	25	6.4	2053	205	10.0
UNIVEN	6	0	0	8	0	0	1	0	0	133	12	9.0
CUT	0	0	-	16	1	6.3	38	6	15.8	311	27	8.7
WSU	4	1	25.0	13	2	15.4	37	3	8.1	223	15	6.7
UL	3	0	0	9	2	22.2	32	3	9.4	218	12	5.5
Total	669	143	21.4	983	119	12.1	2038	235	11.5	17048	2172	12.7

Table D-8 Throughput rates of HEIs in electrical engineering (2000, 2008 and 2014)

HEI	2000			2008			2014			Total (2000 to 2014)		
	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate
NMU	1	0	0	4	0	0	0	0		25	5	20.0
SU	27	3	11.1	39	7	17.9	50	8	16	543	85	15.7
NWU	5	0	0	11	3	27.3	17	2	11.8	177	24	13.6
CUT	5	0	0	5	0	0	5	2	40	81	10	12.3
UCT	19	4	21.1	46	7	15.2	77	7	9.1	613	75	12.2
UJ	11	2	18.2	15	1	6.7	49	4	8.2	287	34	11.8
WITS	25	1	4.0	36	3	8.3	44	4	9.1	391	46	11.8
UKZN	10	1	10.0	18	0	0	0	0		227	25	11.0
UP	17	4	23.5	22	5	22.7	60	4	6.7	398	43	10.8
DUT	6	0	0	1	0	0	2	0	0	19	2	10.5
TUT	1	0	0	12	0	0	37	1	2.7	243	22	9.1
CPUT	2	0	0	12	0	0	23	3	13	178	16	9.0
VUT	5	0	0	9	1	11.1	2	0	0	85	7	8.2
Total	134	15	11.2	230	27	11.7	366	38	10.4	3267	394	12.1

Table D-9 Throughput rates of HEIs in clinical health sciences (2000, 2008 and 2014)

HEI	2000			2008			2014			Total (2000 to 2014)		
	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate
WSU	1	0	0	1	0	0	18	5	27.8	54	10	18.5
UCT	65	12	18.5	94	17	18.1	107	9	8.4	1130	178	15.8
CPUT	2	0	0	1	0	0	7	1	14.3	58	9	15.5
SU	39	6	15.4	36	7	19.4	79	11	13.9	656	98	14.9
NWU	2	0	0	8	2	25.0	0	0	-	55	8	14.5
UP	55	7	12.7	15	2	13.3	26	3	11.5	250	36	14.4
UJ	7	2	28.6	32	2	6.3	17	3	17.6	266	34	12.8
DUT	1	0	0	2	1	50.0	7	0	0	33	4	12.1
WITS	1	0	0	61	3	4.9	141	17	12.1	962	115	12.0
UFS	15	3	20.0	15	1	6.7	0	0	-	257	30	11.7
UNIZULU	8	1	12.5	5	0	0	0	0	-	67	7	10.4
UKZN	39	3	7.7	56	3	5.4	74	7	9.5	761	70	9.2

HEI	2000			2008			2014			Total (2000 to 2014)		
	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate
TUT	0	0	-	10	0	0	2	0	0	35	3	8.6
NMU	0	0	-	0	0	-	0	0	-	12	1	8.3
UL	2	0	0	11	0	0	6	0	0	124	9	7.3
UWC	1	0	0	26	1	3.8	0	0	-	180	13	7.2
Total	238	34	14.3	373	39	10.5	484	56	11.6	4900	625	12.8

Table D-10 Throughput rates of HEIs in physics (2000, 2008 and 2014)

HEI	2000			2008			2014			Total (2000 to 2014)		
	Enrolments	Graduates	Throughput rates	Enrolments	Graduates	Throughput rates	Enrolments	Graduates	Throughput rates	Enrolments	Graduates	Throughput rates
RU	0	0	-	4	0	0	8	0	0	61	14	23.0
NMU	14	2	14.3	18	4	22.2	17	5	29.4	212	46	21.7
Unisa	8	4	50.0	5	0	0	1	0	0	55	9	16.4
UFS	10	2	20.0	15	2	13.3	0	0	0	160	26	16.3
SU	22	2	9.1	22	1	4.5	32	10	31.3	305	49	16.1
WITS	86	14	16.3	33	8	24.2	51	10	19.6	471	74	15.7
UNIZULU	7	0	0	2	0	0	3	1	33.3	35	5	14.3
UCT	24	0	0	19	2	10.5	33	5	15.2	308	39	12.7
UKZN	24	2	8.3	22	3	13.6	50	8	16.0	387	48	12.4
UFH	0	0	0	6	0	0	9	1	11.1	70	8	11.4
NWU	8	2	25	12	1	8.3	11	0	0	126	14	11.1
UP	15	0	0	17	1	5.9	38	8	21.1	219	24	11.0
UL	6	0	0	9	1	11.1	9	0	0	129	11	8.5
UJ	6	0	0	17	3	17.6	18	2	11.1	184	15	8.2
UWC	8	0	0	16	0	0	12	0	0	111	8	7.2
UNIVEN	2		0	1	0	0	3	0	0	13	0	0
Total	240	28	11.7	218	26	11.9	295	50	16.9	2846	390	13.7

Table D-11 Throughput rates of HEIs in sociology (2000, 2008 and 2014)

HEI	2000			2008			2014			Total (2000 to 2014)		
	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate	Enrolments	Graduates	Throughput rate
Unisa	13	4	30.8	15	0	0	54	12	22.2	446	60	13.5
UL	3	1	33.3	3	1	33.3	2	0	0	17	2	11.8
UFH	0	0	-	5	0	0	89	13	14.6	376	42	11.2
SU	34	0	0	21	2	9.5	35	8	22.9	466	51	10.9
UCT	13	1	7.7	27	3	11.1	40	3	7.5	345	36	10.4
WITS	19	2	10.5	19	1	5.3	84	7	8.3	528	55	10.4
RU	0	0	0	17	1	5.9	36	2	5.6	214	21	9.8
UNIZULU	0	0	0	4	0	0	3	0	0	41	4	9.8
UWC	7	0	0	14	0	0	29	3	10.3	241	22	9.1
UKZN	17	2	11.8	20	1	5	55	4	7.3	449	39	8.7
UP	9	0	0	5	1	20.0	9	1	11.1	107	9	8.4
UFS	6	0	0	4	1	25.0	0	0	-	85	7	8.2
NWU	9	1	11.1	29	2	6.9	37	4	10.8	321	26	8.1
NMU	1	0	0	8	0	0	6	2	33.3	136	9	6.6
UJ	4	3	75.0	14	1	7.1	33	1	3	224	13	5.8
UNIVEN	0	0	0	0	0	0	0	0	0	1	0	0
Total	136	14	10.3	205	14	6.8	512	60	11.7	3998	396	9.9

Mean time-to-degree, throughput rates and supervisory capacity of academic institutions of five disciplines

In the tables below I present the number of doctoral graduates, mean time-to-degree, standard deviation, average throughput rates and the average supervisory capacity per higher education institution for the period 2000 to 2014 for each of the five disciplines. The first table reports on the aforementioned indicators for graduates in education.

Table D-12 Mean time-to-degree of doctoral students in education by HEI (2000 to 2014)

HEI	n	Mean (years)	Std. deviation	Throughput rates (%)	Supervisory capacity 2000 to 2014 (avg.)
Traditional Universities					
UFH	46	3.35	1.303	13.3	11.6
RU	79	3.85	1.312	13.2	9.2
SU	132	3.89	1.551	15.6	7.7
NWU	183	3.99	1.595	13.7	8.9
UFS	102	4.26	1.541	14.5	7.0
UKZN	193	4.35	1.521	10.0	7.1
UCT	52	4.73	1.416	14.0	4.9
UL	12	4.50	1.087	5.5	8.4
UP	260	4.54	1.455	11.6	20.4
WITS	96	5.53	1.443	11.2	6.7
Comprehensive Universities					
WSU	15	3.47	.990	6.7	5.3
NMU	84	3.76	1.633	18.3	8.0
Unisa	285	4.13	1.572	13.2	5.4
UJ	204	4.34	1.600	14.8	9.8
UNIZULU	28	4.36	2.022	15.2	5.7
UNIVEN	6	6.50	1.643	9.0	3.5
Universities of Technology					
CPUT	21	3.90	1.338	12.2	10.2
TUT	34	4.32	1.249	11.8	11.0
CUT	23	4.43	1.532	8.7	9.3
DUT	3	7.33	1.155	14.3	n/a
Total	1871	4.26	1.579	-	-

Below I report on the indicators for electrical engineering.

Table D-13 Mean time-to-degree of doctoral students in electrical engineering by HEI (2000 to 2014)

HEI	n	Mean	Std. deviation	Throughput rates (%)	Supervisory capacity 2000 to 2014 (avg.)
Traditional Universities					
SU	63	3.37	1.082	15.7	3.8
NWU	23	4.09	1.703	13.6	3.5
UCT	71	4.42	1.295	12.2	5.1
WITS	34	4.59	1.540	11.8	3.6
UKZN	23	4.74	1.251	11.0	1.8
UP	36	4.97	1.424	10.8	8.9
Comprehensive Universities					
NMU	5	3.60	.548	20.0	3.0
UJ	28	4.54	1.319	11.8	8.5
Universities of Technology					

HEI	n	Mean	Std. deviation	Throughput rates (%)	Supervisory capacity 2000 to 2014 (avg.)
VUT	6	3.50	1.517	8.2	2.6
TUT	20	3.95	1.191	9.1	15.0
CPUT	14	4.36	1.336	9.0	6.5
CUT	10	4.80	1.549	12.3	4.3
Total	333	4.26	1.412	-	-

Below I report on the indicators for the clinical health sciences.

Table D-14 Mean time-to-degree of doctoral students in the clinical health sciences by HEI (2000 to 2014)

HEI	n	Mean		Std. deviation		Throughput rates (%)	Supervisory capacity (2000 to 2014) (avg.)
Traditional Universities							
UNIZULU	5	1.71	2.93	0.293	0.086	10.4	4.6
NWU	8	1.95	3.81	0.269	0.073	14.5	5.3
SU	95	1.99	3.98	0.375	0.140	14.9	11.3
UP	34	2.03	4.11	0.465	0.216	14.4	9.6
UCT	166	2.13	4.54	0.432	0.187	15.8	11.9
UFS	26	2.13	4.56	0.321	0.103	11.7	8.2
UKZN	59	2.18	4.76	0.463	0.214	9	8.1
WITS	106	2.25	5.06	0.409	0.165	12.0	34.3
UL	8	2.43	5.91	0.492	0.242	7.3	6.3
Comprehensive Universities							
NMU	1	1.73	3.00	.		8.3	0.8
UJ	34	2.18	4.74	0.409	0.167	12.8	7.2
WSU	10	2.25	5.06	0.189	0.036	18.5	3.7
Universities of Technology							
DUT	3	1.69	2.85	0.475	0.225	12.1	1.3
TUT	3	1.88	3.55	0.423	0.179	8.6	9.0
CPUT	9	1.91	3.64	0.188	0.033	15.5	8.9
Total	567	2.12	4.52	0.421	0.177	12.8	10.2

*there are missing data in the data set for WITS in some years

Below I report on the indicators for the clinical health sciences.

Table D-15 Mean time-to-degree of doctoral students in physics per HEI (2000 to 2014)

HEI	n	Mean		Std. deviation		Throughput rate (%)	Supervisory capacity (2000 to 2014) (avg.)
Traditional Universities							
UNIZULU	3	.3597	2.29	.10167	1.264	14.3	
RU	14	.5643	3.67	.13632	1.369	23.0	2.1
NWU	14	.5920	3.91	.09751	1.252	11.1	2.7
SU	47	.6113	4.09	.13959	1.379	16.1	6.7
UP	22	.6181	4.15	.16927	1.477	11.0	1.8
UL	11	.6488	4.45	.17651	1.501	8.5	3.8
WITS	71	.6608	4.58	.16200	1.452	15.7	2.0
UFS	26	.6753	4.73	.11656	1.308	16.3	1.5
UCT	37	.6857	4.85	.13933	1.378	12.7	3.0
UFH	7	.7077	5.10	.05971	1.147	11.4	4.4

HEI	n	Mean		Std. deviation		Throughput rate (%)	Supervisory capacity (2000 to 2014) (avg.)
Comprehensive Universities							
NMU	43	.5579	3.61	.12169	1.323	21.7	4.8
UKZN	43	.6046	4.02	.14232	1.388	12.4	1.9
UJ	13	.7616	5.78	.14653	1.401	8.2	6.2
Unisa	7	.7704	5.89	.14464	1.395	16.4	0.9
Total	358	.6335	4.30	.15118	1.416	13.6	2.0

Below I report on the indicators for the sociology.

Table D-16 Mean time-to-degree of doctoral students in sociology by HEI (2000 to 2014)

HEI	n	Mean		Std. deviation		Throughput rate (%)	Supervisory capacity (2000 to 2014) (avg.)
Traditional Universities							
NWU	23	1.96	3.86	0.532	0.284	8.1	8.2
RU	19	1.97	3.87	0.370	0.137	9.8	3.0
UFH	36	1.83	3.34	0.401	0.161	11.2	24.4
UL	2	2.00	4.00	0.000	0.000	11.8	2.0
SU	44	2.06	4.25	0.375	0.141	10.9	6.3
UNIZULU	2	2.09	4.37	0.507	0.257	9.8	2.2
UFS	7	2.36	5.58	0.393	0.154	8.2	2.8
WITS	53	2.36	5.56	0.355	0.126	10.4	2.6
UP	8	2.37	5.60	0.410	0.168	8.4	5.0
UCT	35	2.39	5.69	0.378	0.143	10.4	3.1
Comprehensive Universities							
NMU	8	2.03	4.11	0.406	0.165	6.6	6.9
Unisa	55	2.08	4.35	0.451	0.204	13.5	5.2
UJ	13	2.09	4.35	0.350	0.123	5.8	4.7
UKZN	35	2.17	4.71	0.460	0.211	8.7	7.1
Total	340	2.13	4.55	0.440	0.194	9.9	4.2

Supervisory capacity of five disciplines

Below I indicate the average supervisory capacity of doctoral students in South Africa in 2000 and 2014. The DHET aggregated data were used in the calculation below,

Table D-17 Average national doctoral supervisory capacity (2000 and 2014)

	Headcount of permanent instructional/research personnel	**With doctoral qualification**		**Headcount of permanent instructional/research personnel**	**With doctoral qualification**	
	2000	PHD	%	2014	PhD	%
Instructional/research professional	14842	4671	31.5%	18250	7825	42.9%
Enrolments	6446			17986		
Supervisory capacity*			1.38			2.3

*includes all permanent research/instructional staff and not those with a minimum FTE in research and instruction as is the case with the five analysed disciplines

In the tables below the average supervisory capacity of doctoral students for each of the five disciplines per 2000 and 2014 are reported.

Table D-18 Average doctoral supervisory capacity in education (2000 to 2014)

Year	Headcount of all permanent instructional FTE in education	At least 20% instruction and at least 20% in research	Qualification		PhD Enrolments (total)	Student to supervisor ratio
	n	n	PhD	%	n	
2000	691	248	102	41.1	669	6.6
2001	682	255	119	46.7	769	6.5
2002	814	245	110	44.9	813	7.4
2003	897	321	129	40.2	924	7.2
2004	853	297	110	37	1016	9.2
2005	918	288	116	40.3	1035	8.9
2006	1027	331	146	44.1	1048	7.2
2007	1027	363	165	45.5	975	5.9
2008	1091	351	157	44.7	983	6.3
2009	1074	412	192	46.6	1058	5.5
2010	1140	465	242	52	1171	4.8
2011	1227	500	247	49.4	1335	5.4
2012	1222	532	269	50.6	1460	5.4
2013	1224	470	269	57.2	1754	6.5
2014	1292	504	295	58.5	2038	6.9

Table D-19 Average doctoral supervisory capacity in electrical engineering (2000 to 2014)

Year	Headcount of all permanent instructional FTE in electrical engineering	At least 20% instruction and at least 20% in research	Qualification		PhD Enrolments (total)	Student to supervisor ratio
	n	n	PhD	%	n	
2000	342	88	19	21.6	134	7.1
2001	325	97	11	11.3	139	12.6
2002	378	115	25	21.7	146	5.8
2003	379	109	18	16.5	149	8.3
2004	392	129	17	13.2	171	10.1
2005	387	123	8	6.5	195	24.4
2006	376	151	18	11.9	220	12.2
2007	361	128	8	6.3	240	30
2008	378	120	11	9.2	230	20.9
2009	373	120	13	10.8	244	18.8
2010	337	114	32	28.1	219	6.8
2011	348	121	31	25.6	227	7.3
2012	357	116	35	30.2	276	7.9
2013	352	114	38	33.3	311	8.2
2014	358	113	39	34.5	366	9.4

Table D-20 Average doctoral supervisory capacity in physics (2000 to 2014)

Year	Headcount of all permanent instructional FTE in physics	At least 20% instruction and at least 20 % research	Qualification		PhD enrolments (total)	Student-to-supervisor ratio
	n	*n*	*PhD*	*%*	*n*	
2000	296	*112*	*82*	73.2	*120*	1.5
2001	310	*102*	*75*	73.5	*118*	1.6
2002	334	*104*	*71*	68.3	*116*	1.6
2003	331	*105*	*67*	63.8	*133*	2.0
2004	322	*103*	*68*	66.0	*136*	2.0
2005	325	*108*	*73*	67.6	*112*	1.5
2006	359	*132*	*96*	72.7	*172*	1.8
2007	363	*118*	*93*	78.8	*202*	2.2
2008	369	*136*	*98*	72.1	*218*	2.2
2009	354	*125*	*96*	76.8	*242*	2.5
2010	261	*89*	*65*	73.0	*187*	2.9
2011	341	*120*	*94*	78.3	*185*	2.0
2012	351	*136*	*113*	83.1	*221*	2.0
2013	361	*142*	*119*	83.8	*269*	2.3
2014	375	*152*	*126*	82.9	*295*	2.3

Table D-21 Average doctoral supervisory capacity in the clinical health sciences (2000 to 2014)

Year	Headcount of all permanent instructional FTE in clinical health sciences	At least 20% instruction and at least 20% research	Qualification		PhD enrolments (total)	Student-to-supervisor ratio
	n	n	PhD	%	n	
2000	460	117	30	25.6	238	9.3
2001	463	116	26	22.4	200	8.9
2002	623	173	33	19.1	216	11.3
2003	623	168	32	19.0	216	11.3
2004	592	124	35	28.2	220	7.8
2005	654	148	50	33.8	448	13.3
2006	665	144	47	32.6	306	9.4
2007	668	127	42	33.1	325	9.8
2008	837	175	72	41.1	373	9.1
2009	930	228	89	39.0	428	11
2010	344	73	25	34.2	348	10.2
2011	347	66	22	33.3	372	11.2
2012	342	67	25	37.3	270	7.2
2013	355	64	25	39.1	456	11.7
2014	368	68	30	44.1	484	11

Table D-22 Average doctoral supervisory capacity in sociology (2000 to 2014)

Year	Headcount of all permanent instructional FTE in sociology	At least 20% instruction and at least 20% in research	Qualification		Enrolments	Student to supervisor ratio
	n	n	PhD	%	n	
2000	220	106	53	50	136	2.6
2001	182	95	44	46.3	173	3.9

Year	Headcount of all permanent instructional FTE in sociology	At least 20% instruction and at least 20% in research	Qualification		Enrolments	Student to supervisor ratio
	n	n	PhD	%	n	
2002	201	93	42	45.2	183	4.4
2003	203	99	49	49.5	201	4.1
2004	190	87	40	46	197	4.9
2005	204	89	43	48.3	163	3.8
2006	218	100	56	56	205	3.7
2007	201	95	57	60	209	3.7
2008	333	145	87	60	205	2.4
2009	337	160	91	56.9	209	2.3
2010	226	120	76	63.3	349	4.6
2011	218	114	75	65.8	378	5
2012	225	132	79	59.8	403	5.1
2013	227	138	80	58	475	5.9
2014	241	139	86	61.9	512	6

Supervisory capacity of academic institutions of five disciplines

In the tables below I show the calculation of the doctoral supervisory capacity per institution per discipline for the period 2000 to 2014.

Table D-23 Average doctoral supervisory capacity of academic institutions in education (2000 to 2014)

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
CPUT	Potential supervisor						1	1				1			2	1	3.0
	Enrolments	1	2	0	2	1	9	11	10	11	15	23	27	22	19	19	
	Supervisory capacity	n/a	n/a	n/a	n/a	1	9	n/a	n/a	n/a	15	n/a	n/a	11	19	6.3	10.2
CUT	Potential supervisor					1							1	6	5	5	8.0
	Enrolments	0	3	7	8	24	22	27	23	16	18	24	26	35	40	38	
	Supervisory capacity	n/a	n/a	n/a	8	n/a	n/a	n/a	n/a	n/a	n/a	24	4.3	7	8	4.8	9.3
NMU	Potential supervisor	1	1	1		5	4	4	7	7	6	9	10	14	14	18	
	Enrolments	17	21	23	19	31	26	26	29	29	35	46	42	41	45	41	
	Supervisory capacity	17	21	23	n/a	6.2	6.5	6.5	4.1	4.1	5.8	5.1	4.2	2.9	3.2	2.3	8.0
NWU	Potential supervisor	9	10	14	6	4	3	8	17	14	30	44	30	36	29	38	
	Enrolments	50	57	54	65	82	105	138	140	127	132	107	96	90	90	89	
	Supervisory capacity	5.6	5.7	3.9	10.8	20.5	35	17.3	8.2	9.1	4.4	2.4	3.2	2.5	3.1	2.3	8.9
RU	Potential supervisor			1	1	5	2	3	4	6	7	8	10	11	11	12	12
	Enrolments	15	14	20	28	41	43	40	29	32	26	39	74	75	83	84	
	Supervisory capacity	n/a	14	20	5.6	20.5	14.3	10	4.8	4.6	3.3	3.9	6.7	6.8	6.9	7	9.2
SU	Potential supervisor			15	13	12	9	7	13	15	16	9	5	5	5	8	7.0
	Enrolments	52	45	44	50	53	52	43	42	47	70	61	66	83	89	95	
	Supervisory capacity	n/a	3	3.4	4.2	5.9	7.4	3.3	2.8	2.9	7.8	12.2	13.2	16.6	11.1	13.6	7.7
TUT	Potential supervisor	1	1									1					
	Enrolments	2	1	3	10	9	11	14	15	14	19	30	35	51	41	49	
	Supervisory capacity	2	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	30	n/a	n/a	n/a	n/a	11.0
UCT	Potential supervisor	5	4	3	3	2	2	8	18	21	20	21	17	16	14	17	
	Enrolments	18	21	27	25	31	30	29	27	27	24	25	23	32	33	41	
	Supervisory capacity	3.6	5.25	9	8.3	15.5	15	3.6	1.5	1.3	1.2	1.2	1.4	2	2.4	2.4	4.9
UFH	Potential supervisor	1	2	1				1	1	2	2	5	5	4	5	8	
	Enrolments	0	0	0	0	0	12	19	12	23	34	37	35	40	47	86	
	Supervisory capacity	0	0	0	n/a	n/a	n/a	19	12	11.5	17	7.4	7	10	9.4	10.8	11.6
UFS	Potential supervisor	3	1	3	3		9	10	15	12	13	20	24	22	25	20	
	Enrolments	23	29	29	41	46	48	47	58	47	55	50	70	56	69	109	
	Supervisory capacity	7.7	29	9.7	13.7	n/a	5.3	4.7	3.9	3.9	4.2	2.5	2.9	2.5	2.8	5.5	7.0

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
UJ	Potential supervisor	11	11	8	9	8	8	10	10	14	6	11	15	16	19	18	
	Enrolments	92	104	119	126	112	97	79	79	85	95	84	97	113	138	136	
	Supervisory capacity	8.4	9.5	14.9	14	14	12.1	7.9	7.9	6.1	15.8	7.6	6.5	7.1	7.3	7.6	9.8
UKZN	Potential supervisor	7	12	12	14	13	14	10	11	8	21	31	38	54	50	47	
	Enrolments	52	90	82	85	99	121	104	108	99	102	117	141	199	266	388	
	Supervisory capacity	7.4	7.5	6.8	6.1	7.6	8.6	10.4	9.8	12.4	4.9	3.8	3.7	3.7	5.3	8.3	7.1
UL	Potential supervisor	7	2		2	2	1	2	2	2	1	1	1				
	Enrolments	3	3	17	13	10	13	13	9	9	10	19	22	23	22	32	
	Supervisory capacity	0.4	1.5	n/a	6.5	5	13	6.5	4.5	4.5	10	19	22	n/a	n/a	n/a	8.4
Unisa	Potential supervisor	24	21	18	26	21	27	34	24	19	27	43	38	37	35	35	
	Enrolments	90	87	87	106	114	122	110	55	86	104	178	227	240	382	429	
	Supervisory capacity	3.8	4.1	4.8	4.1	5.4	4.5	3.2	2.3	4.5	3.9	4.1	6	6.5	10.9	12.3	5.4
UNIVEN	Potential supervisor	4	4	3	4				1	1	3	3	4	3	2	3	
	Enrolments	6	9	19	12	14	11	12	11	8	18	3	4	3	2	1	
	Supervisory capacity	1.5	2.25	6.3	3	n/a	n/a	n/a	11	8	6	1	1	1	1	0.3	3.5
UNIZULU	Potential supervisor	2	4	4	4	3	3	5	7	6	8	6	7	7	8	9	
	Enrolments	34	24	30	31	30	16	16	19	28	27	25	29	22	21	30	
	Supervisory capacity	17	6	7.5	7.8	10	5.3	3.2	2.7	4.7	3.4	4.2	4.1	3.1	2.6	3.3	5.7
UP	Potential supervisor	3	5	5	9	15	13	21	16	5	12	8	4	6	10	13	
	Enrolments	122	156	140	180	215	190	177	182	164	141	123	122	129	141	152	
	Supervisory capacity	40.7	31.2	28	20	14.3	14.6	8.4	11.4	32.8	11.8	15.4	30.5	21.5	14.1	11.7	20.4
UWC	Potential supervisor	14	14	18	19	12	11	6	3	8	10	10	13	10	12	15	
	Enrolments	47	48	55	52	69	67	61	49	46	40	59	64	69	69	73	
	Supervisory capacity	3.4	3.4	3.1	2.7	5.8	6.1	10.2	16.3	5.8	4	5.9	4.9	6.9	5.8	4.9	5.9
WITS	Potential supervisor	8	5	5	12	12	8	8	11	11	12	10	12	14	10	11	
	Enrolments	25	34	38	35	34	40	70	66	63	68	92	100	102	112	106	
	Supervisory capacity	3.1	6.8	7.6	2.9	2.8	5	8.8	6	5.7	5.7	9.2	8.3	7.3	11.2	9.6	6.7
WSU	Potential supervisor						1	1	1	1	4	3	3	7	7	9	9.0
	Enrolments	4	2	2	0	1	0	12	12	13	16	22	29	31	42	37	
	Supervisory capacity	n/a	n/a	n/a	n/a	1	0	12	12	3.3	5.3	7.3	4.1	4.4	4.7	4.1	5.3

Table D-24 Average doctoral supervisory capacity of academic institutions in electrical engineering (2000 to 2014)

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
CPUT	Potential supervisor	1	2			2	2	6	2	3	1	3	2	2	2	2	
	Enrolments	2	1	2	6	8	11	14	13	12	16	14	16	17	23	23	
	Supervisory capacity	2	0.5	n/a	n/a	4	5.5	2.3	6.5	4	16	4.7	8	8.5	11.5	11.5	6.5
CUT	Potential supervisor						1	1	1	1	1	1	3			1	3.0
	Enrolments	5	6	7	5	6	6	4	4	5	5	6	6	6	5	5	
	Supervisory capacity	n/a	n/a	n/a	n/a	6	6	4	4	5	5	2	n/a	n/a	5	1.7	4.3
DUT	Potential supervisor											1				1	1.0
	Enrolments	6	3	1	1	1	0	1	1	1	0	0	0	1	1	2	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0	n/a	n/a	n/a	1	2	1.5
NMU	Potential supervisor							1				1		2	1	1	1.0
	Enrolments	1	1	2	3	4	3	0	2	4	3	2	0	0	0	0	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	3	n/a	n/a	n/a	3	n/a	0	0	0	0	3
NWU	Potential supervisor	1	2		1	2		4	3	5	6	8	6	7	6	10	
	Enrolments	5	6	9	10	9	10	14	16	11	8	13	16	16	17	17	
	Supervisory capacity	5	3	n/a	10	4.5	n/a	3.5	5.3	2.2	1.3	1.6	2.7	2.3	2.8	1.7	3.5
SU	Potential supervisor			12	11	11	9	10	19	19	16	17	17	11	6	6	6.0
	Enrolments	27	31	32	28	28	29	30	39	39	38	38	34	50	50	50	
	Supervisory capacity	n/a	2.6	2.9	2.5	3.1	2.9	1.6	2.1	2.4	2.2	2.2	3.1	8.3	8.3	8.3	3.8
TUT	Potential supervisor	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	
	Enrolments	1	2	2	2	10	11	13	15	12	19	23	30	34	32	37	
	Supervisory capacity	1	2	2	2	10	11	13	15	12	19	23	30	34	32	18.5	15
UCT	Potential supervisor	8	6	6	5	4	3	11	8	9	10	12	12	12	11	9	
	Enrolments	19	22	21	20	25	30	40	50	46	47	55	48	46	67	77	
	Supervisory capacity	2.4	3.7	3.5	4	6.3	10	3.6	6.3	5.1	4.7	4.6	4	3.8	6.1	8.6	5.1
UJ	Potential supervisor	7	7	7	6	5	2	2	1	1	1	1	3	4	6	7	
	Enrolments	11	10	8	8	7	13	13	20	15	21	23	23	31	35	49	
	Supervisory capacity	1.6	1.4	1.1	1.3	1.4	6.5	6.5	20	15	21	23	7.7	7.8	5.8	7	8.5
UKZN	Potential supervisor	11	7	10	7	7	7	10	9	8	8	9	10	8	9	14	
	Enrolments	10	10	11	16	16	16	23	21	18	21	20	21	24	0	0	
	Supervisory capacity	0.9	1.4	1.1	2.3	2.3	2.3	2.3	2.3	2.3	2.6	2.2	2.1	3	0	0	1.8
UP	Potential supervisor	0	0	5	5	8	8	12	9	8	5	5	3	4	6	1	
	Enrolments	17	16	18	19	23	21	22	19	22	23	21	29	37	51	60	
	Supervisory capacity	n/a	n/a	3.6	3.8	2.9	2.6	1.8	2.1	2.8	4.6	4.2	9.7	9.3	8.5	60	8.9
VUT	Potential supervisor						2	3	3	1	2	3	3	4	4		

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
	Enrolments	5	4	7	7	6	17	8	3	9	6	4	4	1	2	2	
	Supervisory capacity	n/a	n/a	n/a	n/a	3	5.7	2.7	3	4.5	2	1.3	1	0.3	n/a	n/a	2.6
WITS	Potential supervisor	7	4	6	7	7	10	9	8	8	8		11	12	12	12	
	Enrolments	25	27	26	24	28	28	38	37	36	37	0	0	13	28	44	
	Supervisory capacity	3.6	6.8	4.3	3.4	4	2.8	4.2	4.6	4.5	4.6	n/a	0	1.1	2.3	3.7	3.6

Table D-25 Average doctoral supervisory capacity of academic institutions in the clinical health sciences (2000 to 2014)

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
CPUT	Potential supervisor												1	1	1	2	
	Enrolments	2	2	0	0	0	1	0	2	1	2	9	9	12	11	7	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	9	12	11	3.5	8.9
DUT	Potential supervisor						2				1						
	Enrolments	1	1	2	1	2	1	1	1	2	2	2	3	3	4	7	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	0.5	n/a	n/a	n/a	2	n/a	n/a	n/a	n/a	n/a	1.3
NMU	Potential supervisor		1		1	2	2										
	Enrolments	0	0	7	0	5	0	0	0	0	0	0	0	0	0	0	
	Supervisory capacity	n/a	0	n/a	0	2.5	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.8
NWU	Potential supervisor							1	1	4	7						
	Enrolments	2	3	5	7	8	6	7	7	8	2	0	0	0	0	0	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	n/a	7	7	2	0.3	n/a	n/a	n/a	n/a	n/a	5.3
SU	Potential supervisor		7	7	6	4	11	6	4	8	9	4	1				
	Enrolments	39	39	37	32	22	28	26	35	36	32	56	65	61	69	79	
	Supervisory capacity	n/a	5.6	5.3	5.3	5.5	2.5	4.3	8.8	4.5	3.6	14	65	n/a	n/a	n/a	11.3
TUT	Potential supervisor									1	1						
	Enrolments	0	0	0	0	0	2	2	5	10	8	1	2	1	2	2	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	10	8	n/a	n/a	n/a	n/a	n/a	9.0
UCT	Potential supervisor	1					2	15	8	12	11	8	6	6	9	10	
	Enrolments	65	50	50	52	55	54	76	85	94	96	93	82	83	88	107	
	Supervisory capacity	65	n/a	n/a	n/a	n/a	27	5.1	10.6	7.8	8.7	11.6	13.7	13.8	9.8	10.7	11.9
UFS	Potential supervisor	2	1	2	3		2	3	3	5	3	1		2	3	3	
	Enrolments	15	23	26	31	25	25	30	20	15	18	10	9	10	0	0	
	Supervisory capacity	7.5	23	13	10.3	n/a	12.5	10	6.7	3	6	10	n/a	5	0	0	8.2

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
UJ	Potential supervisor	8	7	6	5	4	3	3	2	2	2						
	Enrolments	7	6	9	11	21	24	25	27	32	30	11	16	15	15	17	
	Supervisory capacity	0.9	0.9	1.5	2.2	5.25	8	8.3	13.5	16	15	n/a	n/a	n/a	n/a	n/a	7.2
UKZN	Potential supervisor	9	3	5	2	12	16	7	8	7	18	6	7	8	5	7	
	Enrolments	39	38	37	35	30	45	45	48	56	80	44	46	56	88	74	
	Supervisory capacity	4.3	12.7	7.4	17.5	2.5	2.8	6.4	6	8	4.4	7.3	6.6	7	17.6	10.6	8.1
UL	Potential supervisor						1	1	2	2	2						
	Enrolments	2	4	9	10	12	9	8	7	11	11	8	10	7	10	6	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	9	8	3.5	5.5	5.5	n/a	n/a	n/a	n/a	n/a	6.3
UNIZULU	Potential supervisor	1	1	2	2	3	2	1	2	1	1						
	Enrolments	8	9	7	8	11	8	5	4	5	2	0	0	0	0	0	
	Supervisory capacity	8	9	3.5	4	3.7	4	5	2	5	2	n/a	n/a	n/a	n/a	n/a	4.6
UP	Potential supervisor	4	2		1	2	1	1									
	Enrolments	55	14	12	15	12	10	6	7	15	17	12	14	14	21	26	
	Supervisory capacity	13.8	7	n/a	15	6	10	6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	9.6
UWC	Potential supervisor	2	2	5	7	2	6	5	10	21	21	1	2				
	Enrolments	1	9	13	12	16	14	17	25	26	47	0	0	0	0	0	
	Supervisory capacity	0.5	4.5	2.6	1.7	8.0	2.3	3.4	2.5	1.2	2.2	0	0	n/a	n/a	n/a	2.4
WITS	Potential supervisor	2	2	3	1	2	2	2	2	5	4	2	2	2	2	1	
	Enrolments	1	1	1	1	1	221.0	58	52	61	76	92	113	3	140	141	
	Supervisory capacity	0.5	0.5	0.3	1	0.5	110.5	29	26	12.2	19	46	56.5	1.5	70	141	34.3
WSU	Potential supervisor												1	3	2	3	
	Enrolments	1	1	1	1	0	0	0	0	1	5	10	3	5	8	18	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3	1.7	4	6	3.7

Table D-26 Average doctoral supervisory capacity of academic institutions in physics (2000 to 2014)

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
NMU	Potential supervisor	1		3	3	2	3	3	2	4	5	6	5	4	4	5	
	Enrolments	14	7	8	9	10	9	12	15	18	22	19	15	20	17	17	
	Supervisory capacity	14	n/a	2.7	3.0	5.0	3.0	4.0	7.5	4.5	4.4	3.2	3.0	5.0	4.3	3.4	4.8
NWU	Potential supervisor	2	4	5	3	4		7	7	11	9	1	2	2	1	4	
	Enrolments	8	7	8	11	11	7	10	9	12	12	4	3	6	7	11	

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
	Supervisory capacity	4	1.75	1.6	3.7	2.8	n/a	1.4	1.3	1.1	1.3	4.0	1.5	3.0	7.0	2.8	2.7
RU	Potential supervisor	3	1	1	2	2	3	2	3	3	2	1	3	2	3	3	
	Enrolments	0	2	2	2	3	3	3	4	4	8	7	7	3	5	8	
	Supervisory capacity	0	2	2	1	1.5	1	1.5	1.3	1.3	4.0	7.0	2.3	1.5	1.7	2.7	2.1
SU	Potential supervisor		8	6	5	6	6	7	6	2	3	4	2	2	3	3	
	Enrolments	22	11	10	13	9	13	10	13	22	25	26	30	35	34	32	
	Supervisory capacity	n/a	1.375	1.7	2.6	1.5	2.2	1.4	2.2	11.0	8.3	6.5	15.0	17.5	11.3	10.7	6.7
UCT	Potential supervisor	10	5				2	14	10	9	8	6	10	10	10	12	
	Enrolments	24	11	10	15	19	20	24	24	19	20	20	19	21	29	33	
	Supervisory capacity	2.4	2.2	n/a	n/a	n/a	10.0	1.7	2.4	2.1	2.5	3.3	1.9	2.1	2.9	2.8	3.0
UFH	Potential supervisor					1						2	2	2	2	2	
	Enrolments	0	0	0	0	0	3	3	6	6	8	10	9	7	9	9	
	Supervisory capacity	n/a	n/a	n/a	n/a	0	n/a	n/a	n/a	n/a	n/a	5	4.5	3.5	4.5	4.5	4.4
UFS	Potential supervisor	6	4	5	5		5	7	7	8	9	9	9	8	9	8	
	Enrolments	10	5	4	6	6	10	13	15	15	16	18	19	23	0	0	
	Supervisory capacity	1.7	1.3	0.8	1.2	n/a	2.0	1.9	2.1	1.9	1.8	2.0	2.1	2.9	0.0	0.0	1.5
UJ	Potential supervisor						3	1	2	2	2	2	3	4	7	7	
	Enrolments	6	5	5	7	7	9	11	15	17	20	14	17	15	18	18	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	3	11	7.5	8.5	10	7	5.7	3.8	2.6	2.6	6.2
UKZN	Potential supervisory	17	17	11	11	13	13	14	14	15	12	10	16	15	14	15	
	Enrolments	24	7	9	18	19	16	19	20	22	25	29	34	44	51	50	
	Supervisory capacity	1.4	0.4	0.8	1.6	1.5	1.2	1.4	1.4	1.5	2.1	2.9	2.1	2.9	3.6	3.3	1.9
UL	Potential supervisor		2	2	3	3	2	2	2	3	2	3	3	2	2	2	
	Enrolments	6	4	8	9	10	9	9	10	9	9	12	8	9	8	9	
	Supervisory capacity	n/a	2	4	3	3.3	4.5	4.5	5.0	3.0	4.5	4.0	2.7	4.5	4.0	4.5	3.8
Unisa	Potential supervisor	6		5	4	5	3	5	2	3	3	3	5	7	8	8	
	Enrolments	8	4	4	3	3	3	2	4	5	6	4	3	1	4	1	
	Supervisory capacity	1.3	n/a	0.8	0.8	0.6	1.0	0.4	2.0	1.7	2.0	1.3	0.6	0.1	0.5	0.1	0.9
UNIVEN	Potential supervisor											1	1	1	1	1	
	Enrolments	2	0	0	0	0	0	0	0	1	1	1	0	1	4	3	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1	0	1	4	3	1.8
UNIZULU	Potential supervisor	1	2	2	2	2	2	2	1	2	3	1	1	2			
	Enrolments	7	1	1	0	1	2	1	5	2	3	4	1	3	1	3	
	Supervisory capacity	7	0.5	0.5	0	0.5	1	0.5	5	1	1	4	1	1.5	n/a	n/a	1.8
UP	Potential supervisor	12	9	8	5	9	7	10	9	6	8	12	5	8	9	10	
	Enrolments	15	9	3	4	3	3	7	10	17	16	19	20	27	28	38	

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
	Supervisory capacity	1.3	1.0	0.4	0.8	0.3	0.4	0.7	1.1	2.8	2.0	1.6	4.0	3.4	3.1	3.8	1.8
UWC	Potential supervisor	8	8	9	10	7	8	5	11	11	11			13	16	16	
	Enrolments	8	4	8	4	6	5	7	13	16	21	0	0	5	2	12	
	Supervisory capacity	1	0.5	0.9	0.4	0.9	0.6	1.4	1.2	1.5	1.9	n/a	n/a	0.4	0.1	0.8	0.9
WITS	Potential supervisor	15	14	14	14	14	16	17	17	18	17		23	24	24	25	
	Enrolments	86	41	36	32	29	0	41	39	33	30	0	0	1	52	51	
	Supervisory capacity	5.7	2.9	2.6	2.3	2.1	0.0	2.4	2.3	1.8	1.8	n/a	0.0	0.0	2.2	2.0	2.0

Table D-27 Average doctoral supervisory capacity of academic institutions in sociology (2000 to 2014)

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
NMU	Potential supervisor	1	0	0	1	0	1	2	1	4	3	2	0	0	0	0	
	Enrolments	1	3	9	15	15	13	18	10	8	7	6	6	10	9	6	
	Supervisory capacity	1	n/a	n/a	15	n/a	13	9	10	2	2.3	3	n/a	n/a	n/a	n/a	6.9
NWU	Potential supervisor	2	2	1	1	1	5	9	1	12	7	7	6	7	8	9	
	Enrolments	9	17	14	19	20	16	17	29	29	26	22	19	21	26	37	
	Supervisory capacity	4.5	8.5	14	19	20	3.2	1.9	29	2.4	3.7	3.1	3.2	3	3.3	4.1	8.2
RU	Potential supervisor	3	3	3	4	4	3	6	6	6	6	7	4	4	5	5	
	Enrolments	0	7	8	9	5	7	9	15	17	15	19	19	21	27	36	
	Supervisory capacity	0	2.3	2.7	2.3	1.3	2.3	1.5	2.5	2.8	2.5	2.7	4.8	5.3	5.4	7.2	3.0
SU	Potential supervisor	0	4	4	6	6	5	5	6	9	8	4	4	3	4	4	
	Enrolments	40	34	34	28	27	28	24	21	22	26	36	31	46	35	8	
	Supervisory capacity	n/a	8.5	8.5	4.7	4.5	5.6	4.8	3.5	2.4	3.3	9	7.8	15.3	8.75	2	6.3
UCT	Potential supervisor	6	4	4	5	5	5	8	8	9	8	7	10	10	8	9	
	Enrolments	13	10	10	11	13	15	19	25	27	31	24	30	41	36	40	
	Supervisory capacity	2.2	2.5	2.5	2.2	2.6	3	2.4	3.1	3	3.9	3.4	3	4.1	4.5	4.4	3.1
UFH	Potential supervisor	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	
	Enrolments	0	0	0	0	0	0	0	0	5	5	78	63	63	73	89	
	Supervisory capacity	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	26	21	21	24.3	29.7	24.4
UFS	Potential supervisor	3	3	3	3	0	1	1	1	5	7	4	3	5	3	1	
	Enrolments	6	10	9	10	11	9	8	7	4	5	2	2	2	0	0	
	Supervisory capacity	2	3.3	3	3.3	n/a	9	8	7	0.8	0.7	0.5	0.7	0.4	0	0	2.8
UJ	Potential supervisor	3	3	3	3	4	0	2	2	2	2	3	6	4	5	5	

HEI		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average supervisory capacity
	Enrolments	4	0	4	3	4	6	6	16	14	19	28	28	32	27	33	
	Supervisory capacity	1.3	0	1.3	1	1	n/a	3	8	7	9.5	9.3	4.7	8	5.4	6.6	4.7
UKZN	Potential supervisor	5	2	2	1	0	2	2	5	6	13	14	13	11	11	13	
	Enrolments	17	19	26	20	30	28	26	20	20	19	35	38	40	56	55	
	Supervisory capacity	3.4	9.5	13	20	n/a	14	13	4	3.3	1.5	2.5	2.9	3.6	5.1	4.2	7.1
UL	Potential supervisor	3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	
	Enrolments	3	1	2	3	0	1	0	0	3	2	0	0	0	0	2	
	Supervisory capacity	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3	2	n/a	n/a	n/a	n/a	n/a	2.0
Unisa	Potential supervisor	5	0	4	3	6	9	7	8	13	14	6	4	8	7	7	
	Enrolments	13	19	22	29	21	20	25	17	15	11	31	48	53	68	54	
	Supervisory capacity	2.6	n/a	5.5	9.7	3.5	2.2	3.6	2.1	1.2	0.8	5.2	12	6.6	9.7	7.7	5.2
UNIVEN	Potential supervisor	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	
	Enrolments	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Supervisory capacity	0	0.5	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.5
UNIZULU	Potential supervisor	1	1	1	2	2	2	0	0	0	0	0	0	0	0	0	
	Enrolments	0	3	5	2	4	4	1	4	4	3	1	2	3	2	3	
	Supervisory capacity	0	3	5	1	2	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2.2
UP	Potential supervisor	1	2	2	2	2	2	1	0	0	1	1	1	1	1	3	
	Enrolments	9	15	9	10	8	9	9	6	5	8	2	2	2	4	9	
	Supervisory capacity	9	7.5	4.5	5	4	4.5	9	n/a	n/a	8	2	2	2	4	3	5.0
UWC	Potential supervisor	6	6	3	4	0	0	3	6	10	9	5	4	6	7	9	
	Enrolments	7	9	9	9	9	8	13	15	14	19	21	21	25	33	29	
	Supervisory capacity	1.2	1.5	3	2.3	n/a	n/a	4.3	2.5	1.4	2.1	4.2	5.3	4.2	4.7	3.2	3.2
WITS	Potential supervisor	10	10	10	12	10	8	10	13	10	12	13	17	16	17	17	
	Enrolments	19	19	22	27	29	0	26	21	19	17	54	64	59	68	84	
	Supervisory capacity	1.9	1.9	2.2	2.3	2.9	0	2.6	1.6	1.9	1.4	4.2	3.8	3.7	4	4.9	2.6

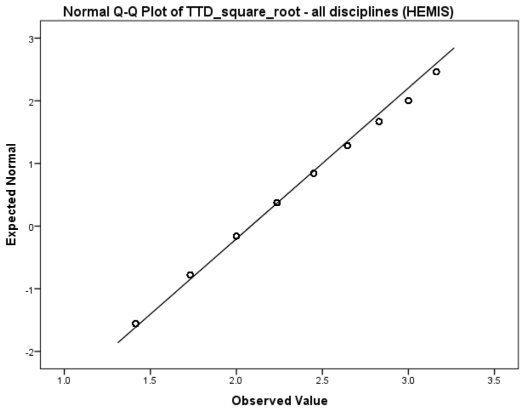
Appendix E | Chapter 12: Conclusion

In the table below the mean time-to-degree of demographic subgroups per discipline for doctoral graduates between 2010 and 2016 were calculated. The data set used for the regression model was used to calculate the means reported below. It is important to note that the mean values would not be equal to that reported in the regression model, but rather aids in interpreting the results of the regression model. Only the means of cases more than 10 are reported.

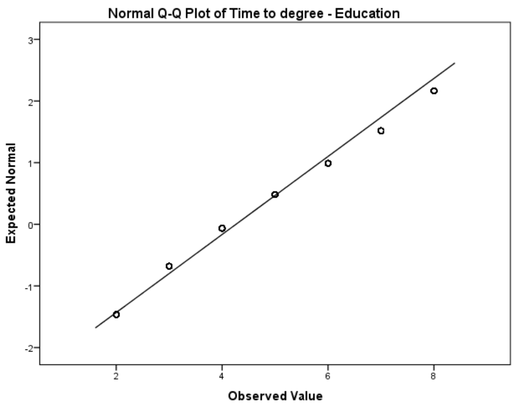
Table E-1 Mean time-to-degree of doctoral graduates by statistically significant predictor in five disciplines (2010 to 2016)

Discipline	**Mean time-to-degree**																							
	Male												Female											
	Full-time						Part-time						Full-time						Part-time					
	Younger than 40 years			40 years and older			Younger than 40 years			40 years and older			Younger than 40 years			40 years and older			Younger than 40 years			40 years and older		
	RSA	ROA	ROW	RSA	ROA	ROW	RSA	ROA	ROW	RSA	ROA	ROW	RSA	ROA	ROW	RSA	ROA	ROW	RSA	ROA	ROW	RSA	ROA	ROW
Education	5.4	**3.8**	-	5.0	4.1	-	4.9	4.7	-	4.8	5.0	-	4.8	4.0	-	4.5	4.1	-	5.0	5.3	-	4.9	4.6	-
Electrical engineering	4.6	4.3	4.5	5.4	4.5	-	6.0	-	-	-	-	-	-	4.6	-	-	6.3	-	-	-	-	-	-	-
Medical clinical sciences	5.4	4.2	-	5.1	4.7	-	6.4	-	-	-	-	-	5.4	4.5	-	5.4	10.0	-	7.1	-	-	6.2	-	-
Physics	4.5	4.2	-	4.9	4.3	-	-	-	-	-	-	-	4.4	-	-	-	3.0	-	-	-	-	-	-	-
Sociology	4.8	4.5	-	4.4	4.3	-	-	5.9	-	5.8	4.6	-	4.8	3.9	-	5.6	5.0	-	6.9	-	-	-	-	-

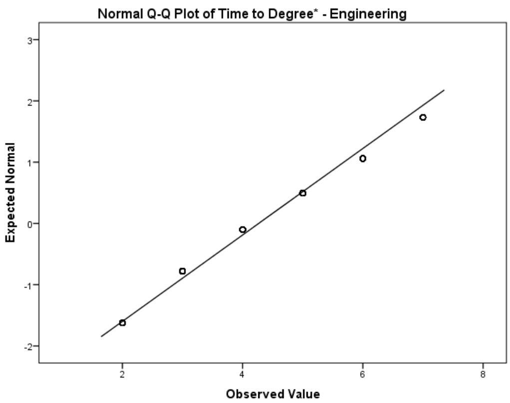
i


Normal Q-Q Plot of TTD_square_root - all disciplines (HEMIS)
Expected Normal
Observed Value

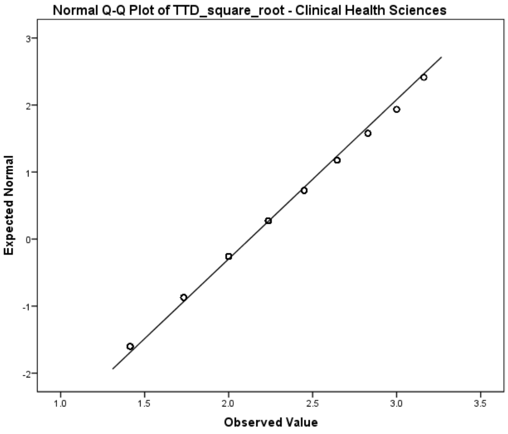
ii


Normal Q-Q Plot of Time to degree - Education
Expected Normal
Observed Value

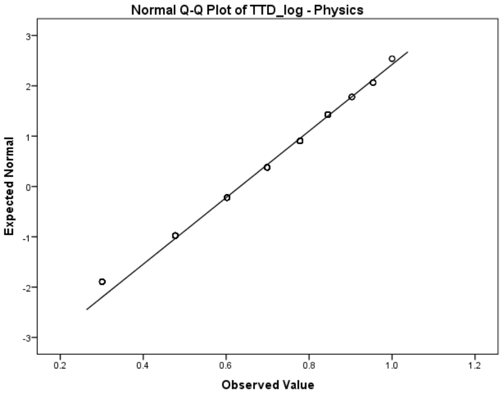
iii


Normal Q-Q Plot of Time to Degree* - Engineering
Expected Normal
Observed Value

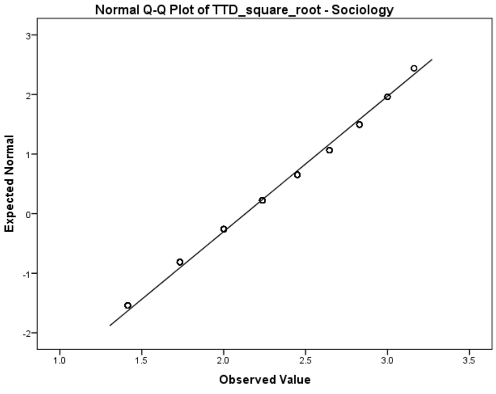
iv


Normal Q-Q Plot of TTD_square_root - Clinical Health Sciences
Expected Normal
Observed Value

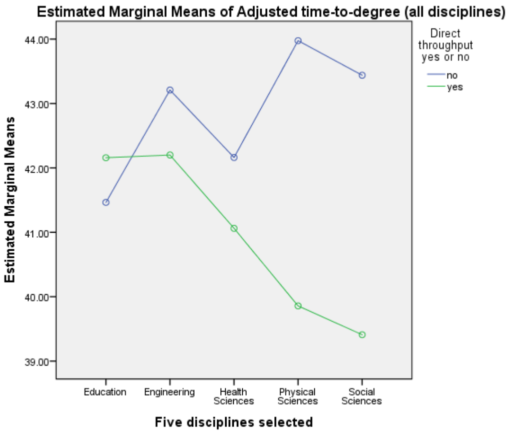
v

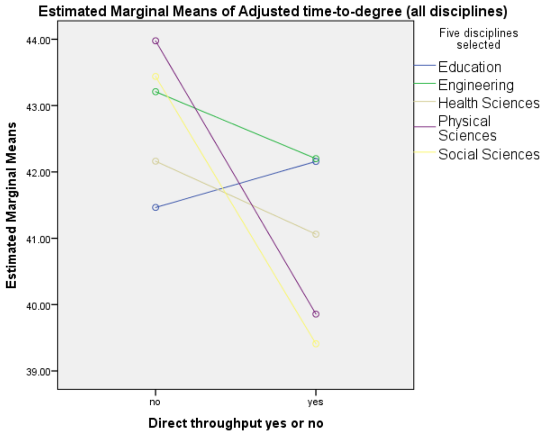

Normal Q-Q Plot of TTD_log - Physics
Expected Normal
Observed Value

vi

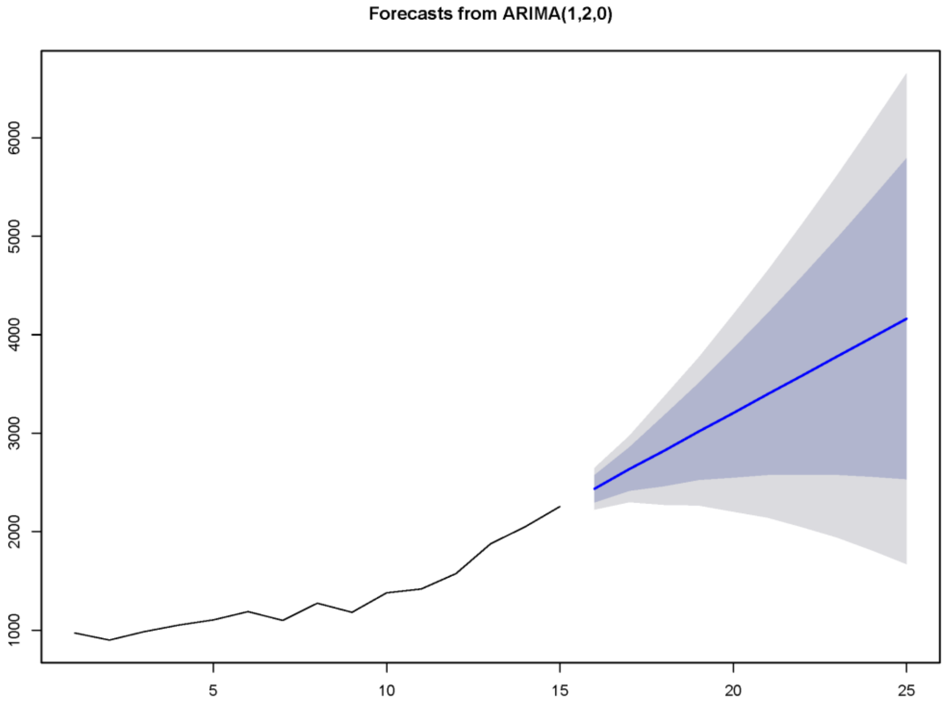

Normal Q-Q Plot of TTD_square_root - Sociology
Expected Normal
Observed Value

vii

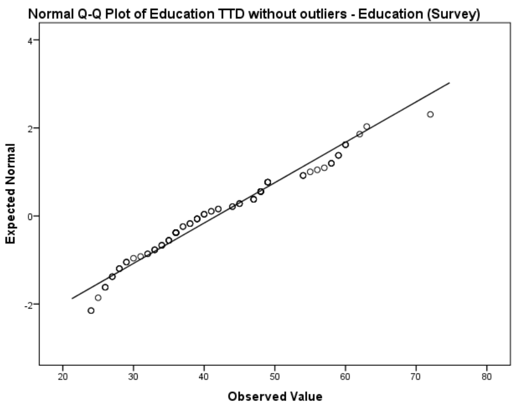

Estimated Marginal Means of Adjusted time-to-degree (all disciplines)
Estimated Marginal Means
Direct throughput yes or no
no
yes
Education
Engineering
Health Sciences
Physical Sciences
Social Sciences
Five disciplines selected


Estimated Marginal Means of Adjusted time-to-degree (all disciplines)
Estimated Marginal Means
Five disciplines selected
Education
Engineering
Health Sciences
Physical Sciences
Social Sciences
no
yes
Direct throughput yes or no

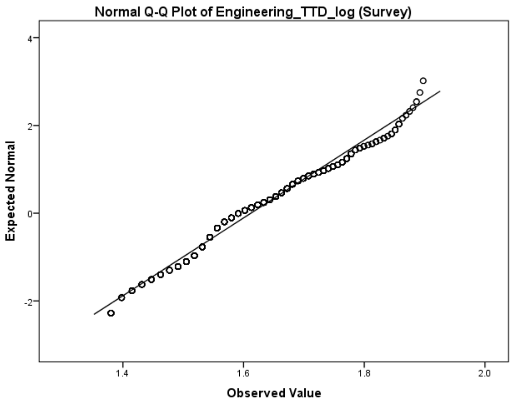
viii


Forecasts from ARIMA(1,2,0)

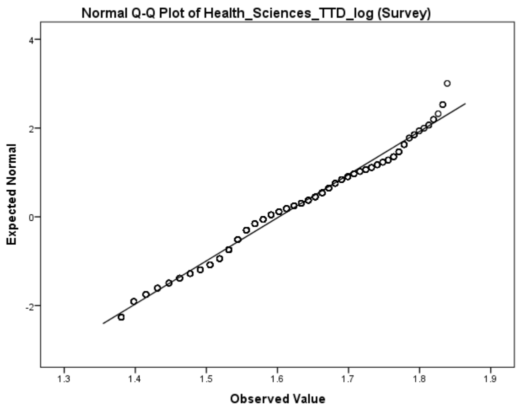
ix


Normal Q-Q Plot of Education TTD without outliers - Education (Survey)
Expected Normal
Observed Value

x



xi



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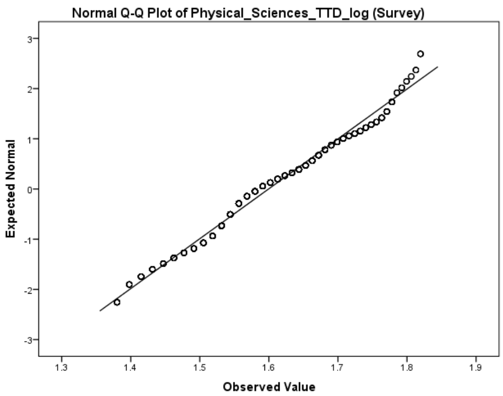
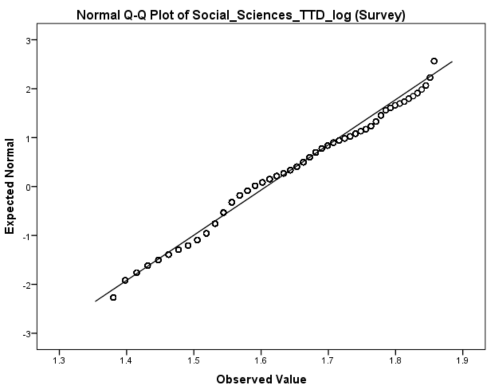


xiii



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