A STUDY OF DOCTORAL TIME-TO-DEGREE IN SELECTED DISCIPLINES AT SOUTH AFRICAN PUBLIC UNIVERSITIES

M. H. van Lill
Centre for Research on Evaluation, Science and Technology (CREST) and
DSI-NRF Centre of Excellence on Scientometrics, Science, Technology and Innovation Policy (SciSTIP)
Stellenbosch University
Stellenbosch, South Africa
https://orcid.org/0000-0002-6189-4824

ABSTRACT

Scholarship on doctoral success highlights differences in timely degree attainment between disciplines. However, research on doctoral education in South Africa is limited to identifying general factors that affect the successful completion of a doctoral degree with very little reference to differences across disciplines.

This study's objective is to compare time-to-degree, as the number of years between a doctoral student's commencement year and graduation year, across selected disciplines as well as to identify factors, above and beyond that of disciplinary field, which are explanatory of shorter time-to-degree. The study investigates the role of selected student demographics (such as commencement age, gender, race, and nationality), institutional (type of higher education institution), and situational factors (such as part-time or full-time enrolment) in predicting doctoral time-to-degree.

Results of multiple linear regression models indicate that mode of enrolment is the strongest predictor of completion time with part-time students recording a statistically significantly longer time-to-degree when compared to full-time students. A student's discipline, nationality, and institution are also identified as statistically significant predictors of time-to-degree while gender, race, and age are not. However, the interaction between commencement age and enrolment mode is indicated to be a strong predictor of doctoral completion time. Although shorter completion times can be considered an indicator of efficiency at doctoral level, it is imperative to consider wider contextual factors in thinking about this issue.

Key words: doctoral education, time-to-degree, indicators, efficiency, disciplinary differences

INTRODUCTION

There is a clearly articulated interest, both at a national and institutional level, to identify strategies to increase the number of doctoral graduates in South Africa (NPC 2012; DSI 2022) and to improve the efficiency of the doctoral pipeline (Mouton et al. 2015; CHE 2018). The prolonged enrolment of doctoral students has financial implications for universities[1] as well as contributing to the increasing supervisory burden of academics at South African universities

(Cloete, Mouton, and Sheppard 2015). The size and scope of the existing body of scholarship demonstrate that factors affecting student success are numerous, complex, and interrelated (Agbonlahor 2022). South African policy imperatives and target-setting for the expansion of higher, and specifically, doctoral education are not differentiated to accommodate disciplinary differences in degree-attainment (NPC 2012; DSI 2022). Moreover, the existing scholarship on doctoral education in South Africa is limited to identifying general factors that are associated with the successful completion of a doctoral degree without considering disciplinary contexts (Herman 2011a; Letseka and Breier 2005; Letseka and Maile 2008; Portnoi 2009; ASSAf 2010).

International empirical research on student success suggests that the disciplinary context should be central to our understanding of doctoral education (Baird 1990; Biglan 1973; Gardner 2009a; 2009b; Neumann, Becher and Parry 2002). Gardner notes:

> "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 … the discipline and the department become the central focus of the doctoral experience ..." (2009a)

This study's objective is to examine how disciplinary factors contribute to differences in doctoral time-to-degree. Through a secondary analysis of national student data, differences in doctoral time-to-degree of South African graduates in five selected disciplines are investigated.

REVIEW OF LITERATURE

Doctoral completion times

A number of empirical studies report differences between disciplines in degree attainment (Bourke et al. 2004; Bowen and Rudenstine 1992; Gardner 2009b; Golde 2005; Herman 2011b; Lovitts 2001; Smeby 2000). Research shows that American doctoral students, in the fields of science and engineering (such as the biological, mathematical, and physical sciences) record the shortest time-to-degree whereas those in the humanities, health and other professional fields have the longest (Baird 1990; Bowen and Rudenstine 1992; Hoffer and Welch Jr. 2006; Sowell, Allum, and Okahana 2015). Similarly, Baird found that the "fastest" fields, in the American context, included chemistry (5.9 years' duration), chemical engineering (5.9 years), and biochemistry (6.0 years) while disciplines in which students take the longest to complete include music (10 years), art history (9.3 years), French (9.2 years) and history (9.2 years)

(Baird 1990). Studies done in Canada (Elgar 2003) as well as the UK (Seagram, Gould, and Pyke 1998) report similar results where students in the humanities and social sciences complete their studies in significantly longer time than their counterparts in the natural sciences. In the Australian context, Bourke et al. (2004) report the shortest candidacy times for doctoral students in education, followed by business, health, engineering, arts, humanities and social sciences.

In South Africa, contrary to the Australian findings, research has shown that doctoral students in the natural and agricultural sciences, and humanities record longer completion times compared to those in the engineering sciences, materials and technologies, and health sciences, where students in the social sciences recorded the shortest completion times (ASSAf 2010) . Mouton et al. (2015) found that postgraduate students in the natural sciences report higher completion and progression rates when compared to their counterparts in other disciplines (Mouton et al. 2015). Herman (2011b) reports that doctoral students in the humanities, social sciences, and health sciences, consider academic challenges an obstacle significantly more than students in other fields (Herman 2011b).

Disciplinary differences

Disciplinary fields differ in their organisational forms, cultural habitus, cognitive structures, and methodologies (Foucault 1970; Comte 1865; Bush 1945; Storer 1967; Kuhn 1970; Pantin 1968; Becher 1989). Storer (1967) considers "hard" sciences such as physics to have more mathematical rigour where the level of difficulty needed in mastering the discipline is ostensibly higher than for the "soft" sciences. The basic/applied typology of Bush (1945) distinguishes disciplines based on the goals of research where he considers basic (pure) sciences are to be driven by intellectual curiosity, and research in the applied sciences as more responsive to societal needs. Fields such as engineering, education, and the clinical health sciences, as applied or professional disciplines, are considered as pragmatic and service-oriented disciplines (Kolb 1981; Biglan 1973; Creswell and Bean 1981). However, the institutionalisation of academic fields is largely influenced through socio-political contexts and historical processes (Whitley 1980) where disciplinary boundaries are often artificial constructs rather than "intellectual' or epistemological divisions (Turner 2006). Despite the archetypal thinking around these taxonomies, there are significant differences in the rationale or value associated with doing a doctorate between the basic and applied, or more professional fields.

Scholarship on the epistemological differences between academic fields considers knowledge production in the field of physics to be cumulative and guided by a codified and clear consensus (Becher 1989; Smeby 2000). The positivist underpinnings of fields in the natural sciences, such as physics, render it empiricist and highly analytical where new findings

are generated in a linear fashion, and disciplinary boundaries and methods are clearly defined as a result of high paradigm development (Becher 1989; Kuhn 1970). Sociology, as a social science, by contrast, is observed as complex and unrestricted in its subject matter and methods of enquiry (Kolb 1981; Pantin 1968; Comte 1865). Practitioners within these fields are often confronted with competing paradigms and there is greater permeability between disciplinary boundaries.

Scholars argue that levels of student success are arguably higher in fields where "directed" supervision is the norm (Smeby 2000). The frequent exposure (both academically and socially) to faculty members and other graduate students contributes to a strong sense of community, which impacts the persistence outcomes of its doctoral students (Lovitts 2001; Heath 2002; Wright and Cochrane 2000). This is contrary to the experience in the social sciences and humanities where students typically work in isolation, without the close support of faculty members and peers (Lovitts 2001; Smeby 2000; Herman 2011b). Thus, Girves and Wemmerus (1988) argue that the isolated nature of doctoral research in the social sciences and humanities can neglect the socialisation process of the postgraduate student which is central to intellectual and professional development.

It is further argued that the body of scholarship in the natural sciences is more "coherent" and "vertically integrated" than that in the social sciences, and that this makes it easier for students to master the theoretical frameworks of the former (Lovitts 2001). Lovitts (2001) suggests that the "horizontal" structure of subject matter in the social sciences and humanities challenges graduate students to grasp a vast range of classical and theoretical approaches. In these fields, interpretation and synthesis are fundamental skills which are "... less transmissible in a straightforward didactic way ..." (Smeby 2000, 54). The complexity of theoretical and methodological paradigms in the social sciences and humanities presents challenges to the student in the selection of a supervisor (Smeby 2000). Identifying and formulating a topic for the doctoral thesis is often difficult and time-consuming and students are more likely to change their dissertation topic than students in the natural sciences (Seagram, Gould, and Pyke 1998).

Factors that influence time-to-degree: A conceptual framework

This study seeks to examine the relationship between disciplinary differences and doctoral time-to-degree. Additionally, this research aims to identify predictors of doctoral completion time in South Africa. The data collection and analysis of this study are guided by Cross' *Chain of response model* which identifies factors associated with timely degree completion (Cross 1982). The model is based on "mature-aged" students' participation in education and offers a classification of barriers to and enablers of success as (1) institutional, (2) situational, and

(3) dispositional factors.

Institutional factors include "... all those practices and procedures that exclude or discourage working adults from participating in educational activities" (Cross 1982, 98). Adult and working students may experience challenges around the perceived accessibility of university programmes which Latona and Browne (2001) refer to as environmental barriers which could lead to a student's dissatisfaction with the institution or programme.

A student's particular life circumstances at the time of their studies are conceptualised as situational factors. Five key situational factors are identified by Carroll, Ng, and Birch (2009) and include (1) employment pressures, (2) financial pressures, (3) family commitments, (4) the independent study context, and (5) the health of the student (also see Cross 1982; Gibson and Graff 1992). Research has shown that situational barriers are more often cited as obstacles to learning than institutional or dispositional barriers (Cross 1982).

Personal or attitudinal factors, as dispositional factors, include (1) student motivation, (2) having realistic goals, (3) students' self-confidence as learners, and (4) student satisfaction (Carroll et al. 2009). Student satisfaction, and the motivations or intentions of the student to complete their qualifications are key dispositional factors. The aforementioned are often the most difficult to identify or study and are likely under-explored given the methodological challenges in their measurement (Cross 1982).

Garland (1992), and Morgan and Tam (1999) extend Cross' model to include epistemological factors as barriers to learning, including the (potential) difficulties that students experience with the content and context of a discipline (also see Manathunga 2002). In yet another extension of Cross' model, Bourke et al. (2004) found that the characteristics or demographics of the doctoral student account for the most variance in their measurement of time-to-degree (also see Aljohani 2016; Morgan and Tam 1999).

METHODS

Data source

The analysis for this article is based on the full student records of the national Higher Education Management Information Systems (HEMIS) data as provided by the South African Department of Higher Education (DHET) for the years 2000 to 2021. The HEMIS data contain micro records of all students from the 26 South African public universities and include the students' qualification, gender, race, birthdate, nationality, mode of enrolment, disciplinary field, institution, year of commencement, and year of graduation.

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 2021 was used as a selection criterion as well as the top 15 most productive disciplines (in terms of doctoral graduates). Selecting fields in which there are high numbers of graduates ensures sufficient numbers for the statistical analyses. Second, the Biglan-Kolb classification model was used to select the five disciplines used in this study which include (1) physics, (2) electrical engineering, (3) sociology, (4) the medical clinical sciences, and (5) foundations of education.

The Biglan classification model is a taxonomy of academic fields based on the similarities and differences of disciplinary subject matter and their cognitive structures (Biglan 1973). Disciplinary fields are differentiated along three dimensions which include (1) hard/soft, (2) pure/applied, and (3) life/non-life. Kolb (1981; 1984), having studied the learning styles of students, particularly with respect to the cognitive styles of disciplines, added two dimensions to Biglan's model. In Figure 1, the Biglan-Kolb model and its classification of the five disciplines selected in this study, is presented. The disciplines include (1) foundations of education as soft-applied (concrete-active), (2) electrical engineering as hard-applied (abstract-active), (3) physics as hard-pure (abstract-reflective), (4) clinical health sciences as hard-applied (abstract-active) and (5) sociology as soft-pure (concrete-reflective). It was imperative for this study to select heterogeneous and maximally disparate fields in terms of research cultures, epistemology, and methodological practices to enable a comprehensive analysis.

Abstract-reflective (hard pure) *Natural sciences* *Mathematics* **Physics**	Abstract-active (hard applied) *Science-based professions (engineering)* **Clinical Medical Sciences** **Electrical Engineering**
Concrete-reflective (soft pure) *Humanities* *Social Sciences* **Sociology**	Concrete-active (soft-applied) *Social professions (education, social work, law)* **Education**

Figure 1: Biglan-Kolb classification of disciplines

A second-order Classification of Educational Subject Matter (CESM) code, which depicts the field of study of a student's first or sole area of specialisation in HEMIS, was used to select students in the delineated disciplines. The CESM classification is a standard hierarchical classification of academic disciplines and lists disciplines on three levels.[2] The selection of the disciplines for the analysis was done using CESM level two categories. It is worth noting that although the medical clinical sciences were selected and analysed at this level, it contain a range of sub-fields. However, these are primarily surgical fields, which are considered similar in terms of their epistemological structures (which include methodological structures) as well as how doctoral programmes are organised.

Data analysis: Construction of the model

Pooled linear regression models were used to identify the relationship between factors associated with differences in time-to-degree in the selected disciplines. Time-to-degree is defined as the number of years between a student's commencement year and graduation year of the doctoral qualification as captured in HEMIS. Given the minimum formal time for a doctoral degree in South Africa, all cases where a graduate's time-to-degree was less than two years were removed from the dataset. Table 1 lists descriptive statistics for each discipline for the entire period (2010 to 2021) which include the mean, standard deviation, maximum completion time as well as the number of observations. The data show that the mean time-to-degree (ttd) was between 4.5 and 5.5 years where graduates in physics recorded the shortest completion over the entire period (4.48 years, SD = 1.69), followed by electrical engineering (4.6 years, SD = 1.99), foundations of education (4.63 years, SD = 2.07), sociology (5.1 years, SD = 2.20) and medical clinical sciences (5.34 years, SD = 2.31). Inspecting how the mean time-to-degree differs across years shows some fluctuations, but no noteworthy trend in terms of a steady increase or decrease is recorded. In the appendix (Table A.1) descriptive statistics are reported in a detailed table to show where fluctuations in the mean time-to-degree between years can be observed.

Table 1: Mean time-to-degree of doctoral students in the five selected students

	Electrical Engineering	Foundations of Education	Medical Clinical Sciences	Physics	Sociology
Mean ttd	4.60	4.63	5.34	4.48	5.10
Std. Dev.	1.99	2.07	2.31	1.69	2.20
Maximum ttd	18	17	22	18	17
n	570	1039	807	605	637
Outliers removed					
Mean ttd (1< & <12)	4.49	4.55	5.15	4.43	4.93

	Electrical Engineering	Foundations of Education	Medical Clinical Sciences	Physics	Sociology
Std. Dev.	1.69	1.89	1.89	1.53	1.84
Maximum ttd	11	11	11	11	11
n	562	1021	789	602	620

Source: Author's own

A linear regression model, which uses ordinary least squares, is sensitive to outliers, assumes independence of the variables as well as homoscedasticity of the data. To mitigate the impact of outliers on the results, observations where the time-to-degree was longer than 12 years were removed as well as where a student's commencement age was 65 years and older. In Table 1 the statistics for each field after removing outliers are reported.

The selection of the variables for the data analysis is guided by Cross' (1982) conceptual framework as well as the availability of data. The term "factors" includes both enablers of and obstacles to degree attainment. The measurable factors in the study are included along the five categories of the conceptual framework, which includes the nature of a discipline, both the content and context, as an epistemological factor. The role of doctoral students' gender, race, nationality, and age on time-to-degree are investigated as student characteristics, while institutional factors include an analysis across academic institutions. Finally, students' enrolment mode is studied as a situational factor. Table 2 lists the variables included in the regression model.

Table 2: List of predictor variables included in the regression model

Conceptual framework	Predictor variable	Categories
Epistemological factors	Nature of a discipline	Physics hard/soft (abstract-reflective)
		Electrical Engineering (abstract-active)
		Medical Clinical Sciences (abstract-active)
		Sociology (concrete-reflective)
		Foundations of Education (concrete-active)
Student characteristics	Gender*	Male
		Female (base category)
	Age	Commencement age in years
	Race (SA only)**	Black African (base category)
		Indian
		Coloured
		White
	Nationality	Rest of Africa (base category)
		Rest of World
		South Africa
Situational	Mode of enrolment	Full-time (base category)
		Part-time

Conceptual framework	Predictor variable	Categories
Institutional	University (classified into three types)***	Traditional university (base category)
		Comprehensive university
		Universities of Technology

Source: Author's own

*In this study the variable "gender" is used to report students' self-reported gender as captured in HEMIS. HEMIS uses a binary classification of male, female and unknown. The category unknown was omitted from the analysis

**Race is analysed by using the categories black African, White, Coloured, and Indian/Asian as captured in HEMIS which is consistent with the classification used by Statistics SA. HEMIS collects data on the self-reported race of all students, but given the Population Act of South Africa, race categories should only refer to South African nationals.

***In 2004 there was a restructuring of the South African higher education landscape which put forth a typology of public universities. The comprehensive university was established as a new institutional type through the merging of Technikons and universities which integrated university and Technikon-type programmes (DoE 2004). Traditional universities refer to universities which has historically offered theoretically oriented university degrees whereas universities of technology offer vocational oriented diplomas and degrees. Currently this differentiation of public universities is being reconsidered (CHE 2022).

RESULTS

A specific to general approach was taken to include variables in the regression models. Initially, a parsimonious model was run to study time-to-degree differences across the five selected disciplines. For each of the four models a constant value, as the average time-to-degree of all observations, is reported. In model four, a mean time-to-degree of 4.25 years is reported across all 3 551 observations in the dataset. The regression coefficients and standard errors of the regression model can be found in Table 3.[3]

A key objective of the study is to determine whether epistemological factors are associated with differences in doctoral completion time. The results of the fourth model show statistically significant differences in the mean time-to-degree between the five selected disciplines. Doctoral graduates in the medical clinical sciences (0.438) and sociology (0.362) record the longest average time-to-degree compared to students in electrical engineering (as the base category) where the results are statistically significant. In other words, graduates in the medical clinical sciences would complete their studies on average 0.438 years later than students in electrical engineering. Graduates in foundations of education (-0.249) record the shortest mean completion times followed by students in physics (-0.047).

Table 3: A model explaining doctoral time-to-degree

	Model 1	Model 2	Model 3	Model 4
Constant	4.325 ***	4.082 ***	4.181 ***	4.253 ***
	(0.107)	(0.163)	(0.162)	(0.164)
Foundations of Education	-0.056	-0.145	-0.275 *	-0.249 *
	(0.101)	(0.110)	(0.110)	(0.112)
Medical Clinical Sciences	0.484 ***	0.458 ***	0.489 ***	0.438 ***
	(0.103)	(0.104)	(0.103)	(0.106)

	Model 1	Model 2	Model 3	Model 4
Physics	-0.055	-0.043	-0.014	-0.047
	(0.106)	(0.106)	(0.105)	(0.108)
Sociology	0.473 ***	0.446 ***	0.403 ***	0.362 **
	(0.108)	(0.109)	(0.108)	(0.111)
Male	-0.098	-0.104	-0.106	-0.105
	(0.066)	(0.066)	(0.065)	(0.065)
Coloured	0.241	0.239	0.236	0.225
	(0.146)	(0.146)	(0.144)	(0.144)
Indian	0.326 **	0.328 **	0.299 *	0.282 *
	(0.122)	(0.122)	(0.121)	(0.121)
White	0.014	0.016	0.016	-0.012
	(0.087)	(0.087)	(0.086)	(0.087)
Race, other	0.077	0.096	0.176	0.126
	(0.204)	(0.204)	(0.202)	(0.203)
Rest of world	0.056	0.064	0.027	0.052
	(0.154)	(0.154)	(0.153)	(0.153)
South Africa	0.426 ***	0.429 ***	0.367 ***	0.365 ***
	(0.079)	(0.079)	(0.078)	(0.078)
Commencement age		0.007	0.003	0.003
		(0.004)	(0.004)	(0.004)
Part-time enrolment			0.624 ***	0.720 ***
			(0.075)	(0.081)
Comprehensive Universities				-0.287 ***
				(0.085)
Universities of Technology				-0.157
				(0.128)
N	3 553	3 553	3 553	3 551
R^2	0.043	0.044	0.063	0.066
logLik	-7079.499	-7077.571	-7043.100	-7033.535
AIC	14184.997	14183.142	14116.199	14101.069
*** p < 0.001; ** p < 0.01; * p < 0.05.				

DISCUSSION

Multiple linear regression models were used to explore the relationships of selected factors on doctoral time-to-degree.

The results of all four models show that gender is not a significant predictor of time-to-degree. The fourth model shows that male time-to-degree is slightly shorter (-0.105) when compared to female time-to-degree (base category), but this is not statistically significant. This result is consistent with previous research in South Africa (CHE 2009; ASSAf 2010; Mouton, Valentine, and Van Lill 2017) and internationally (Van de Schoot et al. 2013; Park 2005; Seagram et al. 1998; Wright and Cochrane 2000; Ampaw and Jaeger 2012) which found no significant differences in doctoral time-to-degree between male and female students.

South African graduates' race, included in the model, indicate that white graduates

recorded the shortest completion times (-0.012) followed by black African (base category), Coloured (0.225), and Indian (0.282) graduates. However, no statistically significant relationship between a student's race and mean completion time was found. This result corroborates the findings of existing research in South Africa which found race not to be associated with differences in doctoral completion times (CHE 2009; ASSAf 2010; Mouton et al. 2017).

The results show nationality to be a significant predictor of completion times across all four models. South African graduates recorded the longest completion times and a statistically significant longer mean time-to-degree (0.365) than graduates from other African countries (as base category). Graduates from the rest of the World (0.052) recorded slightly longer completion times than those from Africa. This result might be explained by Jiranek (2010) who argues that the competitive nature of doctoral programmes may result in a higher calibre of international students accepted. Furthermore, international students are subjected to visa requirements which may compel them to complete their degrees within a certain timeframe (Jiranek 2010; Agbonlahor 2022).

From the literature there is ample evidence for the relationship between age and degree completion time where higher age is identified as a risk factor of non or prolonged completion (CHE 2009; ASSAf 2010; Mouton 2011). The results of the regression models present an unexpected result where the commencement age of doctoral students is not statistically associated with time-to-degree. Visual inspection of the data corroborated this result and is listed in Figure A.1. A possible explanation may lie in the demographic profile of doctoral students within a discipline as well as the interaction between variables (particularly age and enrolment mode). The age profile of doctoral students differs substantially across disciplinary fields where those in physics are on average much younger when enrolling for their doctoral studies than those in education or the clinical health sciences.[4] At the same time, students in the natural and engineering sciences are more likely to directly progress through the academic pipeline, study full-time, enrol for their doctoral degrees at a younger age and are likely to be supported financially through scholarships or bursaries (Mouton et al. 2015).

Both within the South African context and internationally, shorter time-to-degree and higher completion rates are strongly associated with full-time enrolment (Wingfield 2011; Mouton et al. 2015; HEFCE 2005). In model three, students' mode of enrolment was thus introduced. The results confirm the expected result where mode of enrolment is the strongest predictor of time-to-degree and indicates that part-time students take on average 0.7 years longer than full-time students to complete their doctoral studies. The latter typically receive more supervision time than those who study part-time while work commitments (outside of the

PhD) of part-time candidates negatively impact doctoral completion (ASSAf 2010). 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, and fewer family responsibilities, which are associated with timely degree attainment. In other words, full-time enrolment encompasses many advantages which include regular contact with supervisors, access to institutional and departmental support systems, and being able to focus on studies without family and employment obligations.

Institutional factors, as the final set of predictor variables, were included in the fourth model, including the graduate student's university. The results show that doctoral graduates in traditional (research-intensive) universities (as base category) recorded the longest time-to-degree where graduates from comprehensive universities recorded statistically significant shorter completion times (-0.287). The results of institutional factors indicate that the university type is a predictor of doctoral completion times. Higher education institutions, particularly in South Africa, have varying interests towards doing research which ultimately affect the institutional culture and the academic department. Academic institutions also have varying policies on, for example, minimum and maximum candidacy times, enrolment requirements and differ substantially in their supervisory capacity which jointly contribute to student completion times (CHE 2018).

Interaction effects were included for all independent variables in the model. These included gender and race, disciplinary field and age, age and enrolment mode, discipline and enrolment mode, discipline and institution type, and finally, race and institution. A statistically significant interaction was found between age at commencement and enrolment mode. Age at commencement was found not to be a statistically significant predictor of time-to-degree in the regression models. However, when combined with the mode of enrolment, the interaction between age at commencement and mode of enrolment becomes a strong predictor of doctoral completion time. The regression model confirms the interaction between age at commencement and enrolment mode as a strong and statistically significant predictor of time-to-degree and thus substantiates the hypothesis that younger age as a determinant of student success acts as a proxy for many situational factors.

The study's primary objective of investigating the association between epistemological factors and time-to-degree has shown that the academic discipline is a statistically significant predictor of time-to-degree. The results of the regression models show that graduates in education recorded the shortest completion times which is not consistent with that found in the literature. Among scholars, there is a consensus that "softer" fields, such as education, are

generally associated with longer completion times when compared to disciplines in the natural sciences and engineering (Baird 1990; Elgar 2003; Hoffer and Welch Jr. 2006; Sowell et al. 2015; Wright and Cochrane 2000). However, the Biglan-Kolb typology classifies education as concrete-active or soft-applied where the applied, or professional, dimension may explain the shorter mean completion time. Additionally, there are disciplinary differences in what constitutes a doctoral study in terms of its contribution to the body of knowledge, thesis structure (such as length and dissertation type) and types of data used, and the methods used to collect it. Applied disciplines in its pragmatism may present clearer outcomes associated with the completion of the doctorate. Doctoral students in education, are typically professionals who enrol for their doctoral studies at an older age (see Figure A.2) where the "benefit of these doctoral students is their ability to apply career experiences to their understanding of course concepts and conversely applying theory-to-practice in their practitioner roles" (McBrayer, Tolman, and Fallon 2020, 184).

LIMITATIONS OF THE STUDY

The predictor variables included in the statistical model were selected based on the available data in the HEMIS database and are therefore limited to student characteristics. Many other factors, not included in this study, contribute to timely completion across disciplines where dispositional or intrinsic factors, such as self-motivation and student satisfaction, or extrinsic factors, such as the perceived cost-benefit of the doctorate in terms of professional prospects, and financial support have been considered the most consequential in determining student success (Allen 1999; Sowell et al. 2015; Agbonlahor 2022).

Sverdlik et al. (2018) suggest that research on doctoral education should steer away from single-factor foci and aim to explore the interactive nature of known determinants of success. It is therefore prudent that the results of the statistical relationship between selected variables of doctoral completion times presented here be interpreted within the wider disciplinary and demographic context of doctoral education in South Africa.

RECOMMENDATIONS

The findings of this study underscore existing research that younger, full-time enrolled students are likely to complete their doctoral studies in the shortest time. However, the results show that younger age in itself is not a significant predictor of shorter completion times, but rather its interaction with enrolment mode. In South Africa, more than 60 per cent of doctoral students study towards their doctorates part-time (Mouton et al. 2022). It is thus this study's primary recommendation that in order to improve the efficiency of doctoral students, the focus should

be on increasing opportunities for doctoral candidates to pursue their studies full-time.

A second recommendation is that the development of indicators for monitoring doctoral education in South Africa consider disciplinary differences. This study has shown that doctoral education is not monolithic, and that the epistemological and organisational structures of disciplines should be central to our understanding of doctoral education.

Third, although shorter time-to-degree can be considered an indicator of efficiency on a doctoral level, it is recommended to consider wider contextual factors in thinking about the efficiency of students. The accelerated and increased production of doctoral graduates in South Africa should be situated within the broader context of doctoral education. In expanding doctoral education in South Africa, we should 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.

CONCLUSION

The study's primary objective was to analyse and study doctoral time-to-degree in five disciplines at South African public universities. The theoretical and empirical literature indicate that there exist statistically significant differences in doctoral time-to-degree among graduates in different disciplines. Through a simple modelling of HEMIS student data the study provides evidence that the nature of a discipline, as an epistemological factor, is associated with doctoral completion times. The findings show that doctoral graduates in education recorded the shortest average time-to-degree of the five disciplines studied where students in sociology and the clinical health sciences recorded the longest. Additionally, a candidate's institution type and nationality were highlighted as predictors of doctoral timely completion where gender, race, and commencement age were not. The strongest predictor of doctoral completion time was enrolment mode where the interaction of full-time study and younger age was strongly associated with shorter doctoral completion time.

ACKNOWLEDGEMENTS

I wish to acknowledge the support of the South African Department of Higher Education and Training in providing access to the HEMIS student data.

NOTES

1. This pertains to the delayed subsidy payments from the National Department of Higher Education that are awarded to universities for student output as well as negatively affecting the annual teaching input sub-block grant which are allocated to universities based on the average time-to-degree.

2. The framework contains 20 broad subject categories, described as "first order categories". To allow for greater detail, each broad (first order) subject matter area is disaggregated into descending hierarchical levels, also referred to as "orders". The first order categories are broken down into a set of second order categories, and each of these second order categories are broken down into a set of third order categories.
3. The amount of variance explained (as calculated by R^2) increased with the introduction of new variables (from 0,043 in model 1 to 0,066 in model 4). This suggests that each variable introduced was jointly significant in exploring time-to-degree.
4. The distributions of doctoral graduates' age at commencement in the five disciplines are illustrated in appendix in Figure A.2.

REFERENCES

Academy of Science of South Africa. 2010. "The PhD Study: An Evidence-based Study on how to meet the Demands for High-level Skills in an Emerging Economy." DOI http://dx.doi.org/10.17159/assaf.2016/0026.

Agbonlahor, O. 2022. "Multilevel Analysis of Factors Predicting International Doctoral Students' Time-to-Degree Completion." *Journal of Graduate Education Research* 3(7): 20–34.

Aljohani, O. 2016. "A comprehensive review of the major studies and theoretical models of student retention in higher education." *Higher Education Studies* 6(2):1–18. DOI: 10.5539/hes.v6n2p1.

Ampaw, F. D. and A. J. Jaeger. 2012. "Completing the three stages of doctoral education: An event history analysis." *Research in Higher Education* 53(6): 640–660. DOI: 10.1007/s11162-011-9250-3.

ASSAf see Academy of Science of South Africa.

Baird, L. L. 1990. "Disciplines and doctorates: The relationships between program characteristics and the duration of doctoral study." *Research in Higher Education* 31(4): 369–385. DOI: 10.1007/BF00992273.

Becher, T. 1989. *Academic tribes and territories: Intellectual enquiry and the cultures of disciplines*. Bristol: Open University Press.

Biglan, A. 1973. "The characteristics of subject matter in different academic areas." *Journal of Applied Psychology* 57(3): 195–203. DOI: 10.1037/h0034701.

Bourke, S., A. Holbrook, T. Lovat, and P. Farley. 2004. "Attrition, completion and completion times of PhD Candidates." In *Proceedings of the Australian Association for Research in Education Annual Conference*, Melbourne 1–14. https://www.aare.edu.au/data/publications/2004/bou04849.pdf. (Accessed 16 June 2016).

Bowen, W. G. and N. L. Rudenstine. 1992. *In pursuit of the PhD*. Princeton: Princeton University Press.

Bush, V. 1945. "Science the endless frontier." Washington: United States of America. https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm. (Accessed 21 March 2018).

Carroll, D., E. Ng, and D. Birch. 2009. "Retention and progression of postgraduate business students: An Australian perspective." *Open Learning: The Journal of Open and Distance Learning* 24(3): 197–209. DOI: 10.1080/02680510903201599.

CHE *see* Council on Higher Education.

Cloete, N., J. Mouton, and C. Sheppard. 2015. *Doctoral education in South Africa*. Cape Town: African Minds.

Comte, A. 1865. *A general view of positivism. Vol. 1*. Cambridge: Cambridge University Press.

Council on Higher Education. 2009. "Postgraduate studies in South Africa: A statistical profile." *HE Monitor* 7(7): 1–86.

Council on Higher Education. 2018. *Higher Education Qualifications Sub-Framework Qualification Standard for Doctoral degrees.* Pretoria: South Africa.

Council on Higher Education. 2022. "New Higher Education Institutional Types in South Africa: A Missed Opportunity for Articulation and Differentiation?" *Briefly Speaking* No. 22, August 2022: 1–22.

Creswell, J. W. and J. P. Bean. 1981. "Research output, socialization, and the Biglan Model." *Research in Higher Education* 15(1): 69–91. DOI: 10.1007/BF00976549.

Cross, K. P. 1982. *Adults as learners*. 1st Edition. San Francisco: Jossey-Bass.

Department of Education. 2004. "Creating Comprehensive Universities in South Africa: A Concept Document." Pretoria: South Africa.

Department of Science and Innovation. 2022. *Decadal Plan*. Pretoria: South Africa.

DoE see Department of Education.

DSI *see* Department of Science and Innovation

Elgar, F. J. 2003. *PhD degree completion in Canadian Universities*. Halifax: Graduate Students Association of Canada.

Foucault, M. 1970. *The order of things: An archaeology of the human sciences*. 2005 Edition. Routledge Classics.

Gardner, S. K. 2009a. "Conceptualizing success in doctoral education: Perspectives of faculty in seven disciplines." *The Review of Higher Education* 32(3): 383–406. DOI: 10.1353/rhe.0.0075.298.

Gardner, S. K. 2009b. "Student and faculty attributions of attrition in high and low-completing doctoral programs in the United States." *Higher Education* 58(1): 97–112. DOI: 10.1007/s10734-008-9184-7.

Garland, M. R. 1992. "Variables affecting persistence in distance education in the natural resource sciences." PhD dissertation.

Gibson, C. C. and A. O. Graff. 1992. "Impact of adults' preferred learning styles and perception of barriers on completion of external baccalaureate degree programs." *Journal of Distance Education* 7(1): 39–51.

Girves, J. E. and V. Wemmerus. 1988. "Developing models of graduate student degree progress." *The Journal of Higher Education* 59(2): 163–189. DOI: 10.2307/1981691.

Golde, C. M. 2005. "The role of the department and discipline in doctoral student attrition: Lessons from four departments." *Journal of Higher Education* 76(6): 669+.

Heath. 2002.

HEFCE see Higher Education Funding council for England.

Herman, C. 2011a. "Expanding doctoral education in South Africa: Pipeline or pipedream?" *Higher Education Research and Development* 30(4): 505–517. DOI: 10.1080/07294360.2010.527928.

Herman, C. 2011b. "Obstacles to success: Doctoral student attrition in South Africa." *Perspectives in Education* 29: 40–52.

Higher Education Funding council for England. 2005. *PhD research degrees: Entry and completion*. Bristol: HEFCE

Hoffer, T. B. and V. Welch Jr. 2006. "Time to degree of U.S. research doctorate recipients." *NSF InfoBrief: Science Resources Statistics* 06-312.

Jiranek, V. 2010. "Potential predictors of timely completion among dissertation research students at an Australian faculty of sciences." *International Journal of Doctoral Studies* 5(1–12): 1–13.

Kolb, D. A. 1981. "Learning styles and disciplinary differences." In *The modern American college*, edited by A. W. Chickering & Associates, 232–255. San Francisco: Jossey-Bass.

Kolb, D. A. 1984. *Experiential Learning: Experience as the source of learning and development*. Englewood Cliffs: Prentice Hall.

Kuhn, T. S. 1970. *The structure of scientific revolutions*. 2nd Edition. Chicago: The University of Chicago Press.

Latona, K. and M. Browne. 2001. *Factors associated with completion of research higher degrees*. Canberra: Higher Education Division Department of Education, Training and Youth Affairs.

Letseka, M. and M. Breier. 2005. "Student poverty in higher education: The impact of higher education dropout on poverty." *Education and poverty reduction strategies: Issues of policy coherence* 82–101. Cape Town: HSRC Press. http://hdl.handle.net/20.500.11910/5178. (Accessed 31 July 2017).

Letseka, M. and S. Maile. 2008. *High university drop-out rates: A threat to South Africa's future*. Cape Town: HSRC Press.

Lovitts, B. E. 2001. *Leaving the ivory tower: The causes and consequences of departure from doctoral study*. Oxford: Rowman & Littlefield.

Manathunga, C. 2002. "Detecting and dealing with early warning signs in postgraduate research education: A work-in-progress." In *Quality in Postgraduate Research: Integrating perspectives*, edited by M. Kiley and G. Mullins, 80–88.

McBrayer, J. S., S. Tolman, and K. E. Fallon. 2020. "Doctoral candidacy examination scores and time-to-degree completion. *International Journal of Doctoral Studies* 15: 171–198. DOI:10.28945/4529.

Morgan, C. K. and M. Tam. 1999. "Unraveling the complexities of distance education student attrition." *Distance Education* 20(1): 96–108. DOI: 10.1080/0158791990200108.

Mouton, J., M. van Lill., H. Prozesky, T. Bailey, M. Duncan, N. Boshoff, C. Albertyn, and R. Treptow. 2022. *A national tracer study of doctoral graduates in South Africa*. Stellenbosch: Centre for Research on Evaluation, Science and Technology.

Mouton, J. 2011. "Doctoral production in South Africa: Statistics, challenges and responses." *Perspectives in Education* 29(3): 13–29.

Mouton, J., A. Valentine, and M. van Lill. 2017. *Status of postgraduate research training in Engineering*. Stellenbosch: Centre for Research on Evaluation, Science and Technology.

Mouton, J., M. van Lill, J. Botha, N. Boshoff, A. Valentine, N. Cloete, and C. Sheppard. 2015. *A study on the retention, completion and progression rates of South African postgraduate students*. Stellenbosch: Centre for Research on Evaluation, Science and Technology.

National Planning Commission. 2012. *National Development Plan*. Pretoria: South Africa.

Neumann, R., T. Becher, and S. Parry. 2002. "Teaching and learning in their disciplinary contexts: A conceptual analysis." *Studies in Higher Education* 27(4): 405–417. DOI: 10.1080/0307507022000011525.

NPC *see* National Planning Commission

Pantin, C. F. A. 1968. *The relations between the sciences*. Cambridge: Cambridge University Press.

Park, C. 2005. "War of attrition: Patterns of non-completion amongst postgraduate research students." *Higher Education Review* 38(1): 48–53.

Portnoi, L. 2009. "To be or not to be an academic: South African graduate students' vocational choices." *International Journal of Educational Development* 29(4): 406–414. DOI: 10.1016/j.ijedudev.2009.01.005.

Seagram, B. C., J. Gould, and S. W. Pyke. 1998. "An investigation of gender and other variables on time to completion of doctoral degrees." *Research in Higher Education* 39(3): 319–335. DOI: 10.1023/a:1018781118312.

Smeby, J. C. 2000. "Disciplinary differences in Norwegian graduate education." *Studies in Higher Education* 25(1): 53–67. DOI: 10.1080/030750700116019.

Sowell, R., J. Allum, and H. Okahana. 2015. *Doctoral initiative on minority attrition and completion*. Washington: Council of Graduate Schools.

Storer, N. W. 1967. "The hard sciences and the soft: Some sociological observations." *Bulletin of the Medical Library Association* 55(1): 75–84.

Sverdlik, A., N. C. Hall, L. McAlpine, and K. Hubbard. 2018. "Journeys of a PhD student and

unaccompanied minors." *International Journal of Doctoral Studies* 13: 361–388. DOI: 10.28945/4113.

Turner, B. S. 2006. "Discipline." *Theory, Culture & Society* 23(2/3): 183–186. DOI: 10.1177/0263276406062698

Van de Schoot, R., M. A. Yerkes, J. M. Mouw, and H. Sonneveld. 2013. "What took them so long? Explaining PhD delays among doctoral candidates." *PLOS ONE* 8(7): 1–11. DOI: 10.1371/journal.pone.0068839.

Whitley, R. 1980. "The context of scientific investigation." In *The social process of scientific investigation,* edited by D. Knorr, Karin R. Krohn, and R. Whitley, 297–322. London: D. Reidel.

Wingfield, B. 2011. "Can we improve postgraduate degree throughput rates?" *South African Journal of Science* 107(11/12): 1–2. DOI: 10.4102/sajs.v107i11/12.967.

Wright, T. and R. Cochrane. 2000. "Factors influencing successful submission of PhD theses." *Studies in Higher Education* 25(2): 181–195. DOI: 10.1080/71369613.

APPENDIX

In Table A.1 descriptive statistics are reported to show where fluctuations in the average time-to-degree between years can be observed.

Table A.1: Descriptive statistics of time-to-degree for each discipline and year (2010–2021)

	Electrical Engineering	Foundations of Education	Medical Clinical Sciences	Physics	Sociology
2010					
Mean ttd	4,45	4,43	5,19	4,88	5,16
Std. Dev.	1,48	2,67	2,24	2,18	1,34
Maximum ttd	7	15	11	11	9
n	29	40	31	32	19
2011					
Mean ttd	4,72	4,68	6,09	4,96	4,53
Std. Dev.	1,84	2,53	3,40	1,43	2,17
Maximum ttd	10	12	22	9	9
Mean ttd	18	44	53	25	36
2012					
Mean ttd	4,90	4,39	5,00	4,38	4,33
Std. Dev.	1,82	1,78	2,01	1,07	1,60
Maximum ttd	13	11	11	6	8
Mean ttd	39	59	38	32	36
2013					
Mean ttd	4,82	5,35	5,57	4,47	4,68
Std. Dev.	2,07	2,15	2,84	1,52	1,69
Maximum ttd	9	13	18	9	8
Mean ttd	28	75	65	36	41
2014					
Mean ttd	4,51	5,40	5,30	4,41	5,30
Std. Dev.	1,67	2,39	1,72	1,55	2,30
Maximum ttd	9	17	11	10	12
Mean ttd	35	83	56	49	56
2015					
Mean ttd	4,85	4,29	4,94	4,39	5,80
Std. Dev.	2,08	2,17	2,02	1,72	2,95
Maximum ttd	14	14	13	11	17
Mean ttd	47	84	63	38	40
2016					
Mean ttd	4,82	4,36	5,41	4,15	4,60
Std. Dev.	1,83	1,86	2,27	1,35	1,91
Maximum ttd	11	11	13	7	13
Mean ttd	57	100	76	55	53
2017					
Mean ttd	4,60	3,85	5,03	4,38	5,28
Std. Dev.	2,43	1,87	2,07	2,39	2,74
Maximum ttd	18	10	13	18	14
Mean ttd	58	138	78	63	58
2018					
Mean ttd	4,34	4,43	5,46	4,56	4,90

	Electrical Engineering	Foundations of Education	Medical Clinical Sciences	Physics	Sociology
Std. Dev.	1,74	2,05	2,22	1,79	2,04
Maximum ttd	12	13	13	12	12
Mean ttd	61	106	80	79	81
2019					
Mean ttd	4,44	4,79	5,39	4,35	5,46
Std. Dev.	1,96	1,80	2,25	1,38	2,05
Maximum ttd	14	11	13	9	13
Mean ttd	70	92	82	68	70
2020					
Mean ttd	4,87	4,87	5,06	4,88	5,35
Std. Dev.	2,09	1,69	1,96	1,86	2,21
Maximum ttd	12	9	13	13	14
Mean ttd	55	114	90	76	81
2021					
Mean ttd	4,27	5,04	5,54	4,12	5,32
Std. Dev.	2,23	1,97	2,35	1,08	2,17
Maximum ttd	15	10	16	7	16
Mean ttd	73	104	95	52	66
Total Mean ttd	**4,60**	**4,63**	**5,34**	**4,48**	**5,10**
Total Std. Dev.	**1,99**	**2,07**	**2,31**	**1,69**	**2,20**
Total Maximum ttd	**18**	**17**	**22**	**18**	**17**
Total Mean ttd	**570**	**1039**	**807**	**605**	**637**

Source: Author's own

In Figure A.1 the relationship between age and commencement and time-to-degree is plotted for each of the five disciplines.

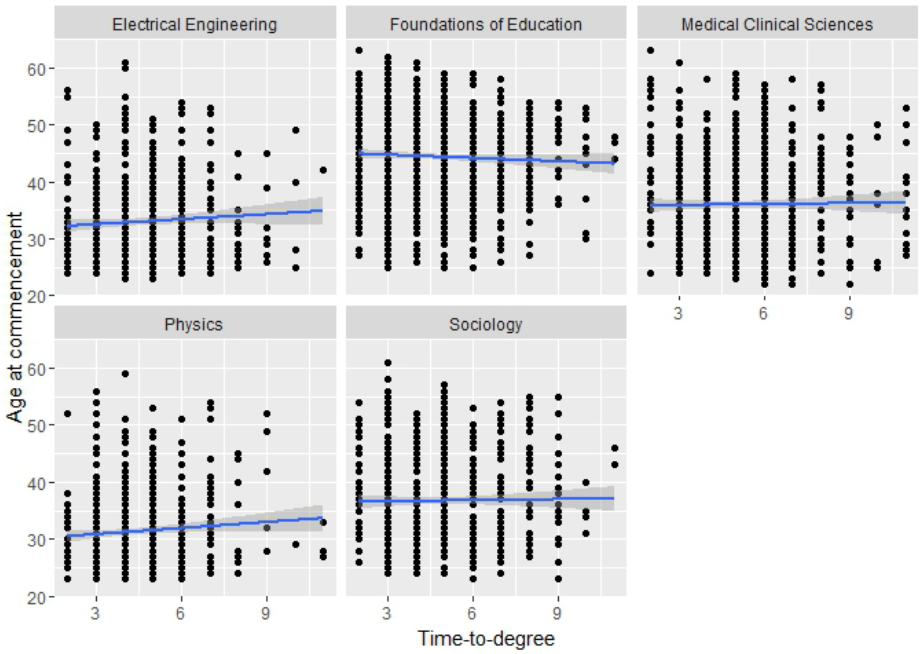

Figure A.1: Relationship between commencement age and time-to-degree

In Figure A.2 the distribution of doctoral graduates' age at commencement is plotted for each of the disciplines.

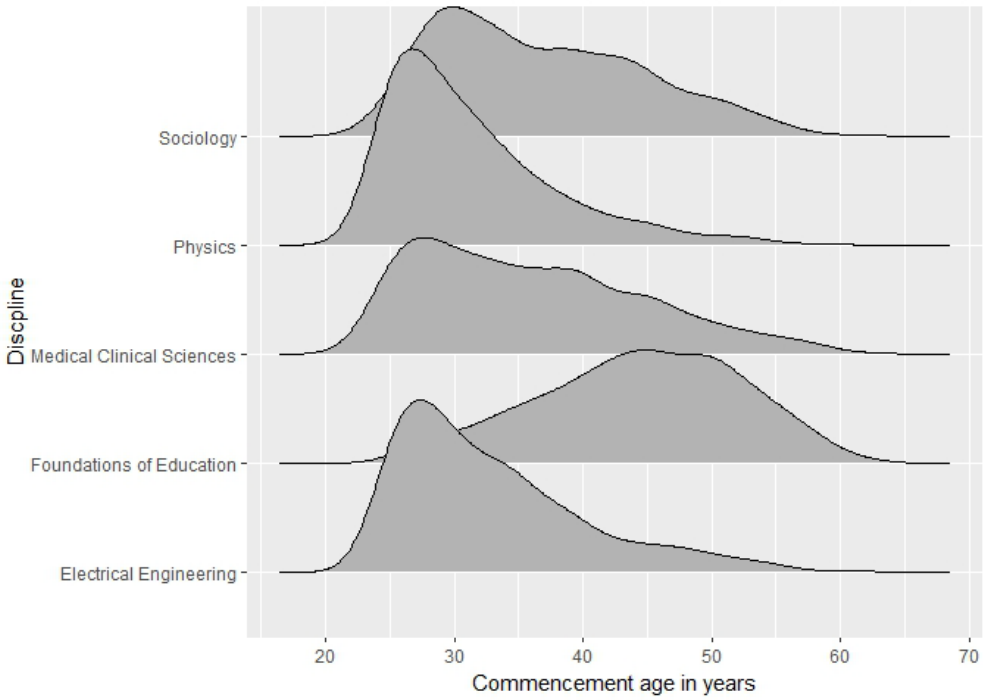

Figure A.2: Distribution of commencement age of the five disciplines