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An Analysis of 72 PhD Theses from the Central University of Technology over A 5-Year Period Yields Notable Insights

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Abstract:

The successful completion of a PhD study is a noteworthy achievement that few people in the world experience. It represents the pinnacle of academic studies at a university which opens the doors to several opportunities. Despite the benefits associated with a PhD degree, it remains a daunting task. The purpose of this study is therefore to present an analysis of 72 PhD theses that were completed over a 5-year period (2014 – 2018) at the Central University of Technology (CUT), Free State, to help prospective doctoral candidates to better understand what is required, or acceptable, at this level of research. It can further create awareness among researchers in Higher Education about the type of research that was completed at CUT over this period. An ex-post facto study is employed where informetric analysis is used to obtain quantitative data. Key results indicate that 61% of the PhD students worked under the guidance of two or more promotors. 44% of the theses contained between 200 and 300 pages, with none below 100. PDF file sizes varied from less than 2 MB to more than 12 MB. A recommendation is made to create awareness among prospective doctoral candidates of the results of this study, further encouraging them to also include a sentence in their abstracts that clearly defines the scientific contribution of their study.

Keywords: quantitative, data analytics, structure, format.

1. Introduction

“No one undertakes research in physics with the intention of winning a prize. It is the joy of discovering something no one knew before” (Brainy Quote, 2020). Stephen Hawking, a renowned Physicist who passed away in 2018, reportedly uttered these words that highlight the beauty of research that relates to discovering something new or significant. Doctoral research falls squarely into this category, as postgraduate students are required to make a scientific contribution to knowledge within their individual fields of expertise.

It is globally acknowledged that good doctoral research must be able to provide new information as a contribution either to the field or to the body of knowledge in general (Ngxongo, 2021). A grade or mark is not awarded to a doctoral degree, nor can it be awarded the status of Cum Laude, or even Magna Cum Laude, as it is perceived as a distinction within its own class. Slovenia is reported to have the highest proportion of 25 to 64-year-olds with a doctoral degree, being 5% in 2021 (Master Academia, 2024). In 2022, the number of PhD graduates per one million in South Africa (SA) reached 61, while the proportion of the population above 25-years of age that held a doctoral degree was only 0.2% (Khuluvhe and Netshifhefhe, 2024). This indicates that those who complete a doctoral

qualification in SA join a "prestigious club", a distinguished group that is very limited in number. What could be attributed to this low percentage?

It has been noted that doctoral research can be a daunting prospect. Would-be scholars might be deterred from embarking on a PhD by financial stress, tales of isolation and difficult relationships with supervisors, or by the intimidating prospect of the required intellectual effort (Greer et al., 2022). The complex and challenging nature of doctoral research is further evidenced by high rates of anxiety and depression among candidates (Evans et al., 2018). One way of alleviating anxiety and making the intellectual effort less intimidating is by helping prospective doctoral candidates to understand what may be expected from them regarding the overall structure of a thesis. A well-known adage states "Forewarned is forearmed".

Frey et al. (2023) noted that when students know what is expected of them, it may help reduce anxiety, disengagement, and problematic behavior. Providing prospective students with guidelines on how to structure a thesis, or on what has been acceptable in previous theses, can help them to be better prepared for the daunting task that lies ahead. The structure of a thesis encompasses several variables from the title page through the various chapters to the reference list and annexures (Flamez et al., 2017). This includes the number of pages and total file size for the final PDF thesis. The number of co-promotors and the focus of the abstract can further help students to understand what is acceptable at the doctoral level of research.

The purpose of this study is therefore to present an analysis of 72 PhD theses that were completed over a 5-year period (2014 – 2018) at the Central University of Technology (CUT), Free State. This may help prospective doctoral candidates to better understand what is required, or acceptable, at this level of research. It can further create awareness among researchers in Higher Education about the type of research that was completed at CUT over this period. The following research questions are posed:

1) What can be deduced from the number of co-promotors that have been listed in the doctoral theses for different disciplines or faculties?
2) What insights can be gained by considering the total number of pages that students have used for their doctoral thesis within a specific discipline or faculty?
3) What can be inferred by the different file sizes of the submitted PDF theses?
4) What may we conclude about the doctoral research done at a university of technology over a 5-year period when considering the focus of the abstracts that exist in the theses?

An overview of doctoral research in South Africa is firstly given, followed by the context of the study. The methodology and results follow, with succinct conclusions.

2. Doctoral Research in South Africa

The Council on Higher Education (CHE) in SA is the Quality Council for higher education, responsible for the quality assurance of the qualifications on its sub-framework, called the Higher Education Qualifications Sub-Framework (HEQSF) (Council of Higher Education, 2022). The HEQSF provides for two variants of the doctoral qualification that may be offered by academic institutions in SA, being called the Doctoral degree (General) and the Doctoral degree (Professional). Table 1 outlines key

differences and similarities between these two degrees. Both degrees require a research component in the form of a thesis that exist at NQF (National Qualifications Framework) level 10.

Table 1. Key differences and similarities between the General and Professional doctorate

	General doctorate	**Professional doctorate**
Requirements	Requires a candidate to demonstrate high-level research capabilities and to make a significant and original academic contribution at the frontiers of a discipline or field.	Requires a candidate to demonstrate high-level research capabilities and to integrate theory with practice through the application of theoretical knowledge (e.g. coursework or work-integrated learning) to highly complex problems in a wide range of professional contexts.
Intended for	An academic career which has now changed to include non-academic careers due to national and global labor market expansion.	A career in the professions and/or industry and is designed around the development of high-level performance and innovation in a professional context.
Credits and period of study	360 credits at NQF level 10. According to the HEQSF, if one rates 10 notional study hours as equivalent to one credit and assumes a 45-week full-time academic year, then the 360 credits require two years of full-time study, or four years of part-time study, as the minimum period required to complete the degree.	

The HEQSF identifies two categories of graduate attributes that must be demonstrated by all PhD candidates, being the Knowledge and Skills attributes. Table 2 and Table 3 outline key aspects relating to these attributes along with possible evidence that may be considered to support their acquisition. Five main aspects are linked to the Knowledge Attribute, which requires students to demonstrate both broad and specialist knowledge, indicating the interconnectedness of their research to other fields of study, doing so in an ethical and professional manner. The Skills Attribute focuses on three key aspects, relating to the selection of appropriate methodologies, personal reflection and autonomy and effective communication.

Table 2. Key aspects relating to the Knowledge Attribute

Requirement	**Evidence to support its acquisition**
Broad current knowledge of fields or disciplines	Institutions to hold annual research seminars or have communities of practice where doctoral students can share their research and progress. Sufficient references from the past decade should feature in the first chapter of the thesis highlighting broad applications or areas relating to the research topic.
Specialized current knowledge of a specific area	Doctoral students to present their research at relevant conferences.

of research within a given field	Sufficient references from the past decade should feature in the literature review chapter of the thesis.
Insight into the interconnectedness between different research fields	Identifying interdisciplinary or transdisciplinary research within the thesis. Chapters within the thesis address different fields of study.
Original or scientific contribution of the research	Identifying key words such as invention, novelty, revised methodology, model, algorithm, framework and optimization This should be clear in the abstract.
Ethical awareness through professional conduct	Research ethics and ethical awareness should be fostered through seminars and workshops. Ethical clearance or professional conduct should be evident in a chapter of the thesis.

Table 3. Key aspects relating to the Skills Attribute

Requirement	**Evidence to support its acquisition**
Selection of appropriate research approaches	Institutions to provide workshops and seminars that cover research methodology. Research methodology or approach should be evident in a chapter of the thesis.
Reflection and autonomy	Research topics originating from the student and regular consultations with the promotor. The number of drafts reviewed for each chapter should be less than 10.
Communication and digital literacy	Doctoral students to complete at least two publications, one of which should be related to a conference. The provision of an online oral defence or VIVA where ad-hoc questions are posed to a student after a presentation has been made

Conducting doctoral research is not a sequential process, but an iterative one, where there is continuous dialogue between theory and practice (Chatzipanagiotou, 2021). Reflection, autonomy, debate, professionalism, knowledge and intellect must therefore feature in all doctoral candidates.

The first national tracer study report on doctoral graduates in SA, known as the PhD Tracer Study Report, revealed that 98% of graduates were employable (Naidoo, 2023). This indeed points to a worthwhile benefit of completing a doctoral degree, that of securing employment. Another benefit relates to an improved quality of life. Doctoral research is not merely a path to a higher station in life - it is a voyage of self-discovery and reflection (Shahin, 2023). Other benefits include promotion, an

enhanced reputation of being a finisher, starting to grow your own research expertise, gaining transferable skills and international travel to build a collaborative network.

The PhD Tracer Study Report further revealed that 61% of the respondents in the study completed their PhDs part-time, or while engaged in some employment, while nearly two-thirds were employed in the higher education sector (pursuing an academic career). This would link to the General doctorate listed in Table 1 as the preferred option of many candidates in SA.

South Africa has 26 public universities, of which 23 currently offer doctoral qualifications. There are also five private institutions in SA offering doctoral degrees. One of the public institutions is the Central University of Technology (CUT), Free State, from where the context of this study is drawn.

3. Study context

The context of this study is limited to one university of technology in SA who offer Doctoral degrees across several departments (see Table 4).

Table 4. Faculties, number of departments and staff members at CUT during 2022 – Adapted from Swart (2018)

Faculty Name	Number of departments	Number of academic staff	Undergraduate student enrollments	Staff to student ratio	Postgraduate student enrollments
Engineering, Built Environment and Information Technology (FEBIT)	6	90	6907	76.7	128
Humanities (FH)	6	81	3538	43.6	209
Health and Environmental Sciences (FHES)	4	53	1948	36.7	138
Management Sciences (FMS)	6	77	5391	70	234

The Faculty of Engineering, Built Environment and Information Technology (FEBIT) had the largest number of undergraduate student enrollments in 2022 (6907), while the Faculty of Management Sciences (FMS) had the largest number of first time enrolling postgraduate students (234). It must be noted that CUT is one of the smallest universities of technology in SA, with an average annual intake of approximately 20 000 students. CUT originally opened its doors as a Technikon in 1981 (with 285 students) and was awarded the status of a university in 2004 (Central University of Technology, 2024). Many of the students speak Sesotho, the dominant language of the Free State, with English being their second tongue or language.

4. Quantitative research methodology

An ex-post facto study is employed where informetric analysis is used to obtain quantitative data. All available PhD theses on the institution's repository were analyzed (this becomes the corpus of this study which totals 72). Some PhD theses have not been loaded onto the repository, while some of the PDF files exist as images that are difficult to analyze. The quantitative data was extracted using a software program that was specifically developed for this purpose by an external software developer. The software program automatically downloads the theses (which are in PDF format) from the institution's online repository. The program then extracts specific information from each PDF and inserts it into a spreadsheet for further analysis and presentation. This includes:

- Number of promotors;
- Number of pages;
- PDF file size; and
- Top ten words in the abstract.

Inter-rater reliability was used to establish the reliability of the data obtained from the software developer. This was achieved by using purposive sampling. Purposive sampling involves drawing a sample composed of cases that fulfil prior criteria chosen by the researcher. In this case, five theses were selected and analyzed manually by the researcher.

6. Results and discussions

Figure 1 presents the promotors, page numbers and file sizes of the PDF theses. Many PhD students (61%) worked under the guidance of two promotors. This may indicate that many younger, inexperienced staff members are being mentored by the main promotor. This is a common trend in higher education (Massyn, 2018). However, it may also indicate that cross-disciplinary research is taking place. Co-supervision is often driven by the increased need for experienced supervisors and for cross-disciplinary and innovative research (Grossman and Crowther, 2015). There is also the likelihood that a few supervisors will be experts in advising on all aspects of the research process. (Kaunda, 1998). In this current case, there exists 28 such expert promotors (39% of the total) who covered all aspects of the research process (this speaks to expertise in the university).

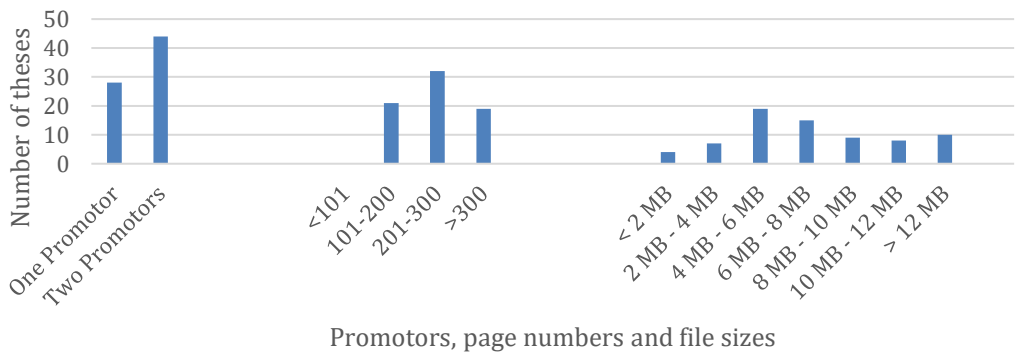

Figure 1. Brief synopsis of key aspects of the theses

44% of the theses contained between 200 and 300 pages, with none below 100 pages. This confirms research that a thesis is only as good as the supervisors who oversee their completion (Scott, 2014) and are deeply embedded in the practices of the discipline (Hodges, 2017, Jewell et al., 2017). This should also hold true when considering the file size of the PDF. This size (given in bytes) depends on the number of pages and pictures or metadata inside the file (Tafti et al., 2017). Previous research has shown that PDF file sizes can vary from less than 1.8 MB to more than 16 MB for a single assignment at the undergraduate level (Swart, 2014). The requirements for the assignment were the same for all students and the PDF file size was not correlated to the final grades awarded. This could suggest that some students were more adept at pasting specific images into a document to maintain a small file size than other students were, as they were not allowed to add extra images. Different image formats also have different levels of compression leading to different file sizes (e.g. JPEGs are usually much smaller in size than TIFFs). The current research also found that 50% of the PhD theses with a file size of more than 12 MB had more than 300 pages. Figure 2 presents the percentage of theses produced per Faculty (a) and the number of theses that had a co-promotor (b).

Clearly, the Faculty of Management Sciences (FMS) produced the greatest number of PhD graduates (35%), with the Faculty of Engineering, Built Environment and Information Technology (FEBIT) producing the least number of graduates (15%). This seems to highlight that challenges exist in FEBIT, and in FHES, in attracting and graduating PhD students. It could also be that these Faculties do not have a large pool of PhD students to distribute between its academic staff members. The number of co-promotors used in these Faculties adds another dimension to this challenge. The majority (82% and 85% respectively) of the small number of theses in these two Faculties had a main promotor and a co-promotor, suggesting that expertise, and maybe capacity, does not really exist in these Faculties. However, it could also be that these Faculties are engaging more in interdisciplinary research that requires expertise from several fields. On the other hand, the Faculty of Management Sciences (FMS) and the Faculty of Humanities (FH) have a high percentage of theses with only one main promotor. This suggests that these Faculties have a high number of experienced supervisors who may not really be engaging in cross-disciplinary research within their specific fields of interest, which are cited as reasons for using a number of supervisors (Grossman and Crowther, 2015). Cross-disciplinary research can enrich and benefit the researchers and disciplines involved (Brien and McAllister, 2016), which would not really be achieved in this case. However, it must also be stated that skilled, or experienced, supervisors are needed to guide postgraduate students to successful completion of their studies. Without effective supervision of postgraduate studies, new knowledge will hardly ever be produced (Lategan, 2008). Having many experienced supervisors in one Faculty may lead to a higher production of new knowledge within that field of study, leading to an improved reputation of the university. This reputation is perceived by the dissertations that showcase high-levels of research carried out in the university (Baro and Otiode, 2014). Figure 3 presents the average, maximum and minimum number of pages used in the theses per Faculty.

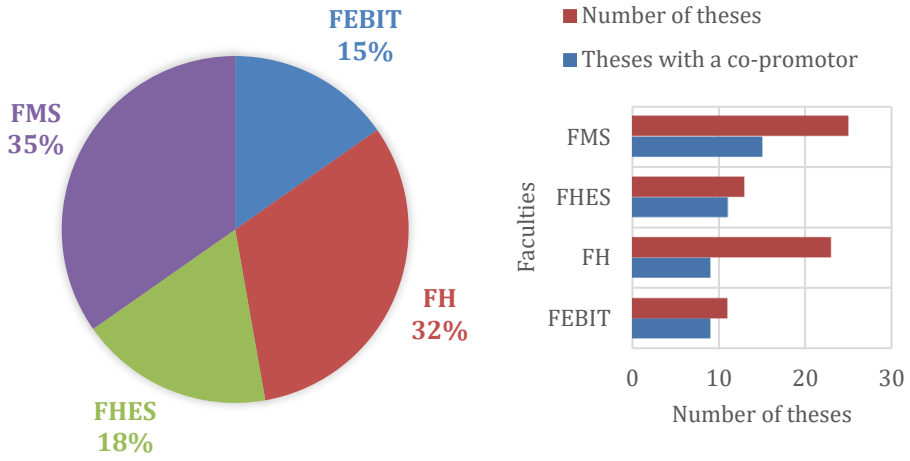

Figure 2. (a) Percentage of theses per Faculty (b) Number of theses and co-promotors per Faculty

A large variation (more than 200%) between the maximum and minimum number of pages is discernable for all the faculties. However, the FMS produced a PhD thesis with the highest number of pages (441) while the FEBIT produced a thesis with the lowest number of pages (121). No literature seems to exist giving the average number of pages of a thesis for specific fields of study at a university of technology. Table 5 highlights the main research topics per Faculty that were derived from the top 10 words in the abstract along with the title. The main topics per discipline were extracted based on an analysis of the abstracts.

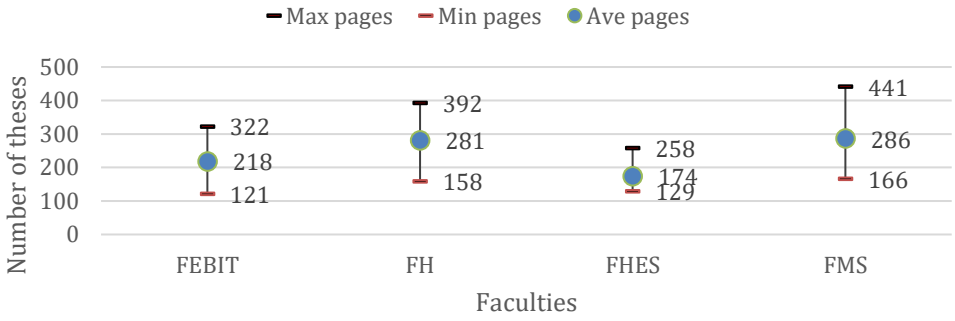

Figure 3. Number of pages used per theses per Faculty

Key terms used in doctoral research were somewhat lacking, which include the words “framework”, “model”, “algorithm”, “optimize” and “scientific contribution”. Key topics that occurred in at least two different theses include:

- Treatment of tuberculosis;
- Various aspects relating to small, micro and medium enterprises;
- Improvement of tourism;
- Mechanisms of implementation;
- Various systems management;

- Various aspects relating to schools, teachers, learners and students; and
- Municipal operations.

Table 5. Key topics identified from the 72 theses

Discipline	**Topics**
Agriculture	1. Treatment supplements for beef herds 2. Global food prices 3. Rhino anti-poaching model 4. Cactus-invaded rangelands 5. Shea butter processors
Biomedical Technology	6. Tuberculosis: HIV, genus mycobacterium 7. Oral health care 8. Medicinal plants usage
Business Administration	9. SMME: environmental issues, innovation, globalization, social responsibilities, technology transfer 10. Church management 11. Entrepreneurship Education 12. Skills development programme for postgraduate supervisors 13. Indigenous knowledge in project development 14. Credit risk management 15. Sustainable financial management strategy for hotel schools 16. Corporate community engagement framework in the extractive sector 17. Framework for the music industry 18. Tourism: competitiveness, development plan
Civil Engineering	19. Mechanisms; lean and sustainability, waste reduction 20. Problematic expansive soils 21. Sustainable design
Education Law and Policy	22. School learner safety
Education Management	23. Student representative councils in universities 24. Quality assurance of educational programmes
Electrical Engineering	25. Systems: Energy, loads, manufacturing
Environmental Health	26. Mice blood responses in an electromagnetic field 27. Treatment of eucalyptus hybrid cuttings with rhizopheric bacteria 28. Essential oils against antibiotic-resistant bacteria 29. Food safety

Humanities	30. Teachers: problem-solving skills, teaching efficacy beliefs, pedagogical practices, deconstructing teacher content, critical reflective teaching 31. Educators: Performance management 32. Principals: Leadership efficacy 33. Assessment: primary school model 34. Learners: Adapting to learning impairments, academic underperformance, corporal punishment, English learning 35. Schools; Role of governing bodies in governance, fundraising strategies, management of organizational systems 36. Students: Affairs practitioners, improving academic performance 37. FET: language and power relations, basis for societal development
Information Technology	38. Weather lore validation tool
Life Sciences	39. Drinking water quality and farming practices
Management Sciences	40. Municipal service delivery: impact of human resource management practices on quality, impact of political and administrative interactions 41. Municipal disaster management: intergovernmental relations, development of a model 42. Marketing model for hair salons, utilization of e-governments, business model for SMME pig farming 43. Effective financial accountability in local governments 44. Impact of workplace spiritually on organizational commitment
Mechanical Engineering	45. Development of a cost-effective, renewable energy greenhouse 46. Limited production plastic injection molding 47. Direct metal laser sintering of titanium alloys for biomedical applications

7. Conclusions

The purpose of this article was to present an analysis of 72 PhD theses that were completed over a 5-year period (2014 – 2018) at CUT that may help prospective doctoral candidates to better understand what is required, or acceptable, at this level of research. Four specific research questions were posed, which are answered below:

1) What can be deduced from the number of co-promotors that have been listed in the doctoral theses for different disciplines or faculties?

- Many PhD students (61%) worked under the guidance of two or more promotors. This may indicate that many younger, inexperienced staff members are being mentored by the main promotor, or that cross-disciplinary research is taking place.

2) What insights can be gained by considering the total number of pages that students have used for their doctoral thesis within a specific discipline or faculty?

- 44% of the theses contained between 200 and 300 pages, with none below 100 pages. A large variation (more than 200%) between the maximum and minimum number of pages is discernable for all the faculties. This is concerning, given the fact that all these PhD programmes have a credit value of 360, indicating that students need to spend at least 3600 notional hours at this level. Compiling a thesis of 441 pages (from the FMS) will take more time than compiling one with 121 pages (from the FEBIT). No literature seems to exist giving the average number of pages of a thesis for specific fields of study at a university of technology.

3) What can be inferred by the different file sizes of the submitted PDF theses?

- The PDF file sizes varied from less than 2 MB to more than 12 MB. The number of pages and pictures or metadata used in the thesis would dictate this size. However, it could also suggest that some students are more adept at pasting images (JPEG as compared to a TIFF) into a document to maintain a small file size than other students are. It was also found that 50% of PhD theses with a file size of more than 12 MB had more than 300 pages, suggesting either many images or poorly embedded images.

4) What may we conclude about the doctoral research done at a university of technology over a 5-year period when considering the content of the abstracts that exist in the theses?

- Although many of the abstracts were comprehensive in nature, key terms used in doctoral research were somewhat lacking, which include the words “framework”, “model”, “algorithm”, “optimize” and “scientific contribution”.

A limitation of this study relates to considering only a 5-year period at one single university. However, this study does provide insights into key aspects of 72 PhD theses that prospective doctoral candidates and academics in higher education could benefit from. Enlarging the study to cover additional years or undertaking a similar study at another university of technology may help to either validate the findings in this study or enhance them.

It is recommended to create awareness among prospective doctoral candidates of the results of this study, further encouraging them to also include a sentence in their abstracts that clearly defines the scientific contribution of their study. This may help them to better understand what is required, and acceptable, at this level of research, enabling them also to find the beauty in research that relates to discovering something new or significant.

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