A scientometric assessment of the field of Physics in South Africa

A final draft report submitted by:

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2. Acronyms

CAGR	Compound Average Annual Growth Rate
CESM	Classification of Subject Educational Matter
CoE	Centre of Excellence
CPUT	Cape Peninsula University of Technology
CREST	Centre for Research on Evaluation, Science and Technology
CUT	Central University of Technology
DHET	Department of Higher Education and Training
DSI	Department of Science and Innovation
DUT	Durban University of Technology
FTE	Full-time Equivalent
HEMIS	Higher Education Management Information System
IBSS	International Bibliography of the Social Sciences
NMU	Nelson Mandela University
NRF	National Research Foundation
NWU	North-West University
ROA	Rest of Africa
ROW	Rest of World
RU	Rhodes University
SAK	South African Knowledgebase
SPU	Sol Plaatje University
SMU	Sefako Makgatho Health Science University
SU	Stellenbosch University
TUT	Tshwane University of Technology
UCT	University of Cape Town
UFH	University of Fort Hare
UFS	University of Free State
UJ	University of Johannesburg
UKZN	University of KwaZulu-Natal
UL	University of Limpopo
UMP	University of Mpumalanga
UNISA	University of South Africa
UNIZULU	University of Zululand
UP	University of Pretoria
UWC	University of the Western Cape
Wits	University of the Witwatersrand
WoS	Web of Science

3. Executive Summary

The aim of scientometric studies is to provide academics and scientists in the field as well as science and research managers and relevant policymakers and decision-makers with a high-level, standardized framework against which the strengths as well as the weaknesses and vulnerabilities of the selected basic science disciplines can be monitored. Based on the first round of studies of the natural sciences in 2017 and the subsequent studies of the social sciences and humanities in 2019, a benchmarking framework could be developed. This framework assesses the disciplines in terms of four key dimensions: investment (funding) of research in the field, the academic staff capacity in the field, the trends in student enrolments and graduations in the field and the research publication performance of the field. In this report, we present the results of the most recent analyses of the 84 indicators that are currently in the framework. In each report we report in detail on the trends between 2000 (sometimes 2005) and 2020 on each indicator. The summary findings are underpinned by more than 80 individual graphs and tables.

Given the very rich and comprehensive detail presented in this report, we have developed a **Field Benchmarking Dashboard** that presents, in a more summarised and visual manner, an indication of the current status (strengths and vulnerabilities) of the field. This overview informs a brief narrative that highlights the more likely future trends in the field as well as areas where interventions may be needed to either strengthen or expand the field as well as interventions that may be required to correct for possible weakening of the field or some aspect thereof. The dashboard includes the dynamic indicators of the field framework as these provide insight into the trends (positive or negative) in the recent past.

Legend for trends in **numbers**

Colour	Description
	Decline in absolute numbers over reporting period
	No significant decline or increase (stagnation)
	Increase in absolute numbers over reporting period

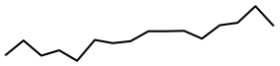
Legend for **percentage increases or declines**

Colour	Description
	Decline in percentage of more than 10%
	Decline in percentage between 3% and 10%
	No significant decline or increase (stagnation) (between -3% and +3%)
	Increase in percentage between 3% and 10%
	Exceptional increase in percentages of more than 10%

Legend for trends as measured in increases or decreased in rates of growth (**CAGR**-values)

Colour	Description
	Exceptional negative growth where CAGR-value is less than **-10%**
	Negative growth of more than **-3%** between 2000 and 2020
	No significant decline or increase – CAGR between **-3% and +3%**
	Significant positive growth: CAGR **3%+**
	Exceptional growth where CAGR-value is more than **10%**

Investment in research: Grant-holders

Indicator	2005	2010	2015	2020	2005 - 2010	2010 - 2020	2005 - 2020	Sparkline
Number of grant-holders	109	189	274	139				
Rate of growth in the number of grant-holders				1.6%				
Female grant-holders as a share of all grant-holders	9%	13%	16%	18%				
Rate of growth in the number of female grant-holders				5.7%				
Black grant-holders as a share of all grant-holders	27%	32%	37%	46%				
Rate of growth in the number of black grant-holders				3.4%				

Investment in research: Grant values

Indicator	2005	2010	2015	2020	2005 - 2010	2010 - 2020	2005 - 2020	Sparkline
Total value of individual grants	R18,942,097m	R149,979,371m	R190,197,630m	R121,343,439m				
Rate of growth in the total value of individual grants			13.2%					
Total value of grants for women	R453,082	R7,976,291	R7,072,346	R6,183,943				
Rate of growth in the total value of grants for women			19.0%					
Total value of grants for black scholars	R2,928,312	R21,149,134	R36,879,105	R18,248,383				
Rate of growth in the total value of grants for black scholars			13.0%					

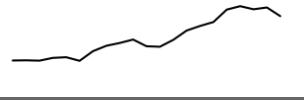
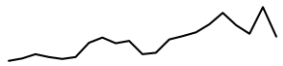
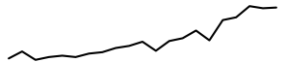
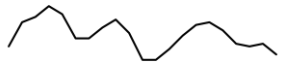
Academic staff capacity

Indicator	2000	2005	2010	2015	2020	2000 - 2010	2010 - 2020	2000 - 2020	Sparkline
Sum of permanent instructional research staff (FTE)	196	216	218	315	300				
Rate of growth in permanent instructional/research staff FTE					2.2%				
Percentage of staff with a doctoral qualification	55%	48%	56%	64%	73%				
Difference in % of staff with a doctoral qualification)					18.0%				

Academic staff diversity

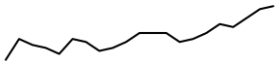
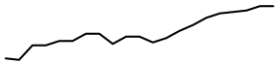
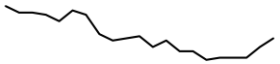
Indicator	2000	2005	2010	2015	2020	2000 - 2010	2010 - 2020	2000 - 2020	Sparkline
Percentage of female staff	14%	13%	18%	26%	23%				
Change in percentage of female staff					9%			10%	
Percentage of black South African staff	31%	46%	49%	61%	68%	18%	19%		
Difference in percentage of black South African staff					37%			38%	

Trends in Doctoral enrolments and graduates

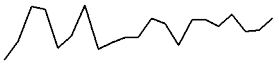
Indicator	2000	2005	2010	2015	2020	2000 - 2010	2010 - 2020	2000 - 2020	Sparkline
Number of total Doctoral enrolments	122	120	209	357	393				
Rate of growth in the number of total enrolments				6%					
Number of new Doctoral enrolments	30	38	44	107	81				
Rate of growth in the number of new Doctoral enrolments				5.1%					
Number of Doctoral graduates	14	16	38	40	87				
Rate of growth in the number of Doctoral graduates				9.6%					
Average age at commencement of Doctoral studies	31.3	31.6	30.8	32.2	31.0				
Change in the average age at commencement of Doctoral studies				-0.3 years					
Average time-to-degree of Doctoral studies	4.6	5.0	4.8	4.4	5.0				
Change in average time-to-degree of Doctoral studies				-0.4 years					
Average age at graduation of Doctoral students	30.9	39.1	34.6	35.5	35.7				

Indicator	2000	2005	2010	2015	2020	2000 - 2010	2010 - 2020	2000 - 2020	Sparkline
Change in the average age at graduation of Doctoral students				4.8 years					

Doctoral enrolments: Demographic trends

Indicator	2000	2005	2010	2015	2020	2000 - 2010	2010 - 2020	2000 - 2020	Sparkline
Percentage of female Doctoral enrolments of total enrolments	16%	23%	25%	25%	34%				
Rate of growth in the number of female Doctoral enrolments				8.7%					
Percentage of black Doctoral enrolments of South African enrolments	40%	52%	55%	68%	76%				
Rate of growth in the number of black Doctoral enrolments				8.1%					
Percentage of South African Doctoral enrolments	75%	73%	61%	50%	60%				
Rate of growth in the number of South African Doctoral enrolments				5.1%					

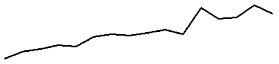
Doctoral graduates: Demographic trends

Indicator	2000	2005	2010	2015	2020	2000 - 2010	2010 - 2020	2000 - 2020	Sparkline
Percentage of female Doctoral graduates of total graduates	0%	18%	17%	30%	32%				
Rate of growth in the number of female Doctoral graduates					-				
Percentage of black Doctoral graduates of South African graduates	27%	55%	39%	45%	81%				
Rate of growth in the number of black Doctoral graduates					9.2%				
Percentage of South African Doctoral graduates	79%	69%	55%	51%	41%				
Rate of growth in the number of South African Doctoral graduates					5.1%			5.5%	

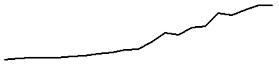
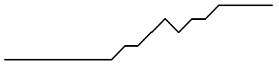
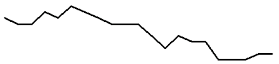
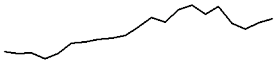
Publications in SA Knowledgebase

Indicator	2005	2010	2015	2020	2005 - 2010	2010 - 2020	2005 - 2020	Sparkline
Number of articles	180	328	592	954				
Rate of growth in the number of articles				11.8%				
Number of contributing authors	238	495	925	1 301				
Rate of growth in the number of contributing authors				12.0%				

Demographics of publishing authors

Indicator	2005	2010	2015	2020	2005 - 2010	2010 - 2020	2005 - 2020	Sparkline
Percentage of university female authors	4%	12%	12%	18%				
Rate of growth in the number of university female authors				24.8%				
Percentage of university black authors (South African)	14%	32%	34%	51%				
Rate of growth in the number of university black authors				22.6%				

Indicators of global standing and citation impact of publications

Indicator	2000	2005	2010	2015	2020	2000 - 2010	2010 - 2020	2000 - 2020	Sparkline
Total number of SA articles in WoS	290	374	576	1 178	1 724				
Rate of growth in the number of South African articles in WoS				9.3%					
World share of WoS articles	0.2%	0.2%	0.3%	0.5%	0.6%				
Change in world share (2000 to 2020)				0.4%					
World rank position in WoS	42	44	41	38	36				
Change in the world rank position				6					
Percentage of WoS articles in the top 1% of highly cited papers	0.7%	0.6%	2.4%	2.4%	2.9%				
Change in the percentage of WoS articles in the top 1% of highly cited papers				2.2%					
Percentage of WoS articles in the top 5% of highly cited papers	2.5%	4.5%	8.0%	10.9%	9.9%				
Change in the percentage of WoS articles in the top 5% of highly cited papers				7.4%					
Percentage of WoS articles in the top 10% of highly cited papers	4.3%	8.9%	14.6%	19.4%	16.3%				

Indicator	2000	2005	2010	2015	2020	2000 - 2010	2010 - 2020	2000 - 2020	Sparkline
Change in the percentage of WoS articles in the top 10% of highly cited papers				11.9%					

Salient points

We identify the most positive salient trends as those where there is a sustained and consistent improvement in the value of the underlying indicators. Our discussion is organised by the dimensions of the scientometric assessment.

- Physics is a well-funded discipline in South Africa and the NRF has continued to fund research in this field. This is reflected in the overall increase in the number of grant-holders and grant values for most of the reporting period. The decline in numbers and grant values since 2019 is a general trend that affected most scientific fields. The increased participation of women academics in Physics (number of individual grants and especially grant values) is noteworthy while we see similar increases for black academics in the field.
- The increase in academic staff capacity at a compound annual growth rate of 2.2% and especially the increase in the percentage of academics in Physics with a doctorate to 73% in 2020 are positive developments. These increases should be understood against the average increase in academic staff capacity in the system across all scientific fields of less than 2% and the average percentage of staff with doctorate at all universities in 2021 at 48%.
- Not only has the academic staff capacity grown, but it has also become more inclusive of the designated groups. This is true both as far as gender is concerned where the percentage of female staff increased with 9 percentage points from 14% in 2000 to 23% in 2020 and especially black staff where the share of black staff increased with 37% percentage points to 68% in 2020.
- The demand for Doctoral studies in Physics has continued to grow with total and new enrolments increasing at growth rates of 6% and 5.1% respectively. We see that there has been some decline in the number of new enrolments in 2020 which could be indicative of a downward trend. A positive trend is the high rate of increase of Doctoral graduates, at 9.6%, which indicates an effective system of Doctoral throughput in Physics. The average age at commencement of Doctoral studies remained unchanged at a young 31 years in 2020.
- The overall demographics of Doctoral enrolments and graduates in Physics is positive. The number of female Doctoral enrolments has increased by 18 percentage points to 34% in 2020 whilst a similar positive trend is evident as far as race is concerned with the number of black Doctoral enrolments increasing by 36 percentage points to constitute 76% of all Physics enrolments in 2020. These positive trends are mirrored when we look at Doctoral graduates with more women (32% in 2020) and especially black graduates (81%) in the field of Physics.
- The research publication output of Physics academics and students reveals a very positive picture: the number of articles produced as recorded in SA Knowledgebase increased notably to 954 in 2020 at an annual growth rate of 11.8% as did the number of contributing authors (from 238 in 2005 to 1 301 in 2020). This means that the field has managed to broaden its active publishing base through the inclusion of post-graduate students, post-Doctoral fellows and visiting scholars.
- The positive trends in research publication output are also evidenced by positive trends in transformation with an increase in the contribution of women authors (from 4% in 2005 to 18% in 2020) as well as by black authors (14% in 2005 to 51% in 2020) with high rates of growth for both groups.
- The global standing of South African physicists as measured by their publications in the [CA]Web of Science is overwhelmingly positive. The total number of articles has increased at an annual growth rate of 9.3% from 290 in 2000 to 1 724 in 2020. The world share increased somewhat

to 0.6% while the field of Physics improved its world rank position most notably, from 42nd in 2000 to 36th in 2020. We also see that there were good increases in the percentage of WoS articles in the top 1% (2.9% in 2020), 5% (9.9% in 2020) and 10% (16.3% in 2020) of highly cited papers.

We list areas of concern as 'red flag' areas where there is either a consistently negative trends in the value of underlying indicators or, in some cases, a more recent decline in such values after a longer period of growth. We also include under this heading, instances where there is – against all expectations – no improvement of positive change.

- A possible area of concern is the slight increase in the average time-to-degree to 5 years in 2020 and age at graduation of Doctoral students to 35.7 years in 2020. This might suggest that Doctoral students in Physics are taking slightly longer to complete their studies possibly due to increasing supervisory burden in the field.

PART 1: MAIN REPORT

4. Introduction

The aim of the study has been to undertake a scientometric assessment of the performance of selected basic disciplines in South Africa, of which Physics is one. Scientific disciplines are complex 'objects' and differ in multiple ways from each other. A deep and detailed assessment of the performance of a discipline is not an easy undertaking. Ideally, one would combine quantitative and qualitative methodologies to arrive at such an assessment and, in the best-case scenario, such an assessment would be informed both by insider and outsider accounts of the strengths and weaknesses regarding the performance of the field.

Our approach has been predominantly quantitative (scientometrics as the quantitative measurement of science systems). The request by the DSI was for a predominantly quantitative approach that would be based on the selection of appropriate indicators for the selected fields. This approach resulted in the development of a 'dashboard' of 89 indicators that aim to cover four dimensions of the performance of a scientific field. We describe these dimensions and the choice of indicators in detail below.

It is important to emphasise that the indicators do not presume to make any general or comprehensive statement on the state and quality of a discipline. All indicators have shortcomings, and this scientometric assessment of the performance of one such discipline in South Africa is no exception. However, the weaknesses of science indicators are also their strength. As Barr (2001, p. 13) would argue, although science indicators "cannot make claims for truth", they do "have the unique capability of generating significant debates through the criticism they stir, which can make them socially robust". It is therefore hoped that our set of indicators will generate informed criticism, as well as positive reflection, in order for new and refined indicators to be constructed with input from all relevant stakeholders. A socially robust assessment of the state and performance of a discipline is a joint effort. This scientometric assessment of Physics aims to provide a crucial input into such an endeavour.

4.1. The main assessment dimensions and their indicators

Four main dimensions of the performance of Physics as a field have been included in our assessment of the discipline. The choice of these dimensions is in line with good practice in scientometric studies, but also takes into consideration the availability of appropriate data sources. For each of the main dimensions we include a list of performance indicators.

4.1.1. Investment in research

The first dimension aims to produce an estimate of the available funding for Physics research in South Africa. For this purpose, we were given access to NRF-funding data of grant-holders, for the period 2005 to 2020. We are aware that there may be other public and private sources of funding for Physics. However, these databases are neither centrally housed nor necessarily accessible. Our decision to confine this dimension to the research funding data from the NRF has the advantage that it is readily available (under a data sharing agreement) and also consistent in terms of data fields. As far as NRF data is concerned, it is furthermore important to note that only grant-holder funding is reported here and not free-standing scholarship funding. We include four (4) state indicators under this dimension and four (4) dynamic indicators.

State indicators

The state indicators that we used are:

1. the number of grant-holders;
2. female grant-holders as a share of all grant-holders;
3. black grant-holders as a share of all grant-holders; and
4. the rate of growth in the total value of individual grants.

Dynamic indicators

The dynamic indicators that we used are:

1. the rate of growth in the number of grant-holders;
2. the rate of growth in the number of female grant-holders;
3. the rate of growth in the number of black grant-holders; and
4. the rate of growth in the total value of individual grants

The inclusion of these indicators allowed us not only to assess the size and magnitude of the monetary value of grants and changes over time, but also whether the investment has become more inclusive over time to benefit more female and black researchers than before.

4.1.2. Staff capacity and diversity

The second dimension included in this assessment concerns the academic staff capacity in the country to produce knowledge, teach and supervise postgraduate students; in other words, the academic pipeline of future researchers and academics in Physics. We include seven (7) state and twelve (12) dynamic indicators under this dimension. Data for these indicators are sourced from the Higher Education Management Information System (HEMIS) for the period 2000 to 2020. In order to calculate the staff capacity per discipline, we use the FTE (full-time equivalent) values assigned to individual staff members in HEMIS. This means that we sum the proportional time allocated to each CESM category (in this case Physics) for each individual. The result is that the FTE values of these indicators invariably are fractions.

State indicators

The state indicators that we use are:

1. sum FTE of permanent instructional/research staff;
2. the percentage of staff FTE with a Doctoral qualification;
3. the ratio of Doctoral enrolments to staff FTE with a Doctoral qualification;
4. the percentage of female staff FTE;
5. the percentage of South African black (black African, Indian/Asian, Coloured) FTE;
6. the percentage South African staff FTE;
7. the percentage of instructional/research staff FTE 40 years and younger.

Dynamic indicators

The dynamic indicators that we used are:

1. the rate of growth in permanent instructional/research staff FTE;
2. the change in the percentage of staff with a Doctoral qualification;
3. the rate of growth in staff with a Doctoral qualification;
4. the change in the ratio of Doctoral enrolments per supervisor;
5. the change in the percentage of female staff FTE;
6. the rate of growth in female staff FTE;
7. the change in the percentage of black South African staff FTE;
8. the rate of growth in black South African staff FTE;
9. the change in the percentage of South African staff FTE;
10. the rate of growth in South African staff FTE;
11. the change in the percentage of staff 40 years and younger; and
12. the rate of growth in staff 40 years and younger.

4.1.3. The academic pipeline

Considering the strategic interest of the country in building the next generation of researchers and academics, this dimension focuses on the production of Doctoral students in Physics. The indicators that were selected cover both sub-dimensions of quantity (the numbers of enrolments and graduates), efficiency (time-to-degree), as well as transformation (gender and race) and internationalisation (nationality). We include twelve (12) state indicators and nineteen (19) dynamic indicators. Data for these indicators were sourced from HEMIS for the period 2000 to 2020.

State indicators

The state indicators that we used are:

1. the number of total enrolments;
2. the number of new enrolments;
3. the number of graduates;
4. average time-to-degree;

5. the percentage of female students of total enrolments;
6. the percentage of black students of total enrolments;
7. the percentage of South African students of total enrolments;
8. the average age at commencement of Doctoral studies;
9. the percentage of female students of total graduates;
10. the percentage of black students of total graduates;
11. the percentage of South African students of total graduates; and
12. average age at graduation.

Dynamic indicators

The dynamic indicators that we used are:

1. the rate of growth in the number of total enrolments;
2. the rate of growth in the number of new enrolments;
3. the rate of growth in the number of graduates;
4. the change in average time-to-degree;
5. the change in the percentage of female enrolments;
6. the rate of growth in the number of female enrolments;
7. the change in the percentage of black enrolments;
8. the rate of growth in the number of black enrolments;
9. the change in the percentage of South African enrolments;
10. the rate of growth in the number of South African enrolments;
11. the change in the average age at commencement of Doctoral studies;
12. the change in the percentage of female students of total graduates;
13. the rate of growth in the number of female graduates;
14. the change in the percentage of black students of total graduates;
15. the rate of growth in the number of black graduates;
16. the change in the percentage of South African students of total graduates;
17. the rate of growth in the number of South African graduates;
18. the change in the average age at graduation; and
19. Conversion rates from one degree programme to the next.

4.1.4. Research

Various dimensions of the research performance of Physics as a scholarly field of knowledge production were assessed by a set of indicators (see below) which can be grouped into the broad categories of research production or output, transformation of the human resource base for research in the field (female and black), and research (citation) impact. Two data sets were used for these analyses. SA Knowledgebase at CREST was used for analyses related to university research output and research transformation, and the Web of Science (^{CA}WoS) for analyses related to global performance and citation impact. Results are reported for the years 2000 to 2020.

State indicators

The state indicators that we used are

1. the number of university authors;
2. the percentage of university female authors;
3. the percentage of university black authors;
4. the percentage of university authors younger than 40 years;
5. the number of articles by university authors;
6. the percentage of university articles in WoS journals;
7. the total number of SA articles in WoS;
8. the world share of WoS articles;
9. world rank position in WoS;
10. the percentage of WoS articles in top 1% of highly cited papers;
11. the percentage of WoS articles in top 5% of highly cited papers; and
12. the percentage of WoS articles in top 10% of highly cited papers.

Dynamic indicators

The dynamic indicators that we used are:

1. the rate of growth in the number of university authors;
2. the change in the percentage of university female authors
3. the rate of growth in the number of university female authors;
4. the change in the percentage of university black authors;
5. the rate of growth in the number of university black authors;
6. the change in the percentage of university authors younger than 40 years;
7. the rate of growth in the number of university authors younger than 40 years;
8. the rate of growth in the number of articles by university authors;
9. the change in the percentage of university articles in WoS journals;
10. the rate of growth in the number of university articles in WoS journals;
11. the rate of growth of all SA articles in WoS;
12. the change in world share;
13. the change in world rank position;

14. the change in the percentage of WoS articles in top 1% of highly cited papers;
15. the change in the percentage of WoS articles in top 5% of highly cited papers; and
16. the change in the percentage of WoS articles in top 10% of highly cited papers.

4.2. Data and Methods

In compiling this report, four sources of data were used: the funding database of the National Research Foundation (NRF), the academic staff and student data from the HEMIS database of the Department of Higher Education and Training (DHET), SA Knowledgebase at CREST which contains the article output of university researchers, and the raw publication data CREST's version of the WoS database under a license with Clarivate Analytics. Each of these is discussed below.

4.2.1. NRF Funding database

The NRF provided the grant-holder data for the period 2005 to 2020. Two existing variables in the database aided in the development of an address-based field classification of NRF grant-holders. The first of these contains the centre and departmental affiliations of grant-holders at the time of their application ("*NRF Department_Phoenix*"). The second variable contains similar information for each grant-holder, but as provided by them when they report on their grants ("*NRF Department_Submission_ProgressReport*"). By considering information from both variables, the discipline reported on here was 'constructed'. In cases where the two variables contained missing information or provided conflicting information for a single grant-holder, alternative sources were consulted. These were the available address information for publication authors in SA Knowledgebase, and the websites of South African universities that list the names of academic staff in departments in the relevant discipline.

All monetary values were adjusted for inflation based on the Consumer Price Index (CPI) as released by Statistics South Africa, and by using 2021 as the base year for inflation.

4.2.2. HEMIS database

The analysis of human resources (academic staff and students) is based on the classification of disciplines as outlined in the CESM (Classification of Educational Subject Matter) framework. The CESM Classification of Educational Subject Matter (CESM) has changed three times over the past two decades. In the Technical Appendix we give a detailed breakdown of the disciplinary definitions used to identify the human capabilities in Physics as well as the specific HEMIS and CESM codes used in our analyses. We also provide a glossary of the indicators used throughout the report.

4.2.3. Publication databases

SA Knowledgebase by CREST, Stellenbosch University, is a comprehensive database of research publications produced by the South African universities in compliance with the DHET's Research Publishing Framework. CREST received the annual individual records that are submitted under a data

sharing agreement with DHET. The data covers for categories of publications (articles, books, book chapters and published conference proceedings) that are submitted to the DHET for subsidy every year. The database also includes the demographics of authors (gender, race, age, and institution) as well as journal source information. Relevant authors in Physics were identified based on the available departmental affiliations of authors in SA Knowledgebase, as well as by sourcing the names of academic staff in the field from the university websites and incorporating that information into SA Knowledgebase.

In addition to the analysis of data in SA Knowledgebase, we also include analyses of the performance of Physics as reflected in the [CA]Web of Science. These analyses include more comparative results related to research collaborations, citation impact and publications by journal quartile and subject category.

5. Main findings

5.1. Investment in research

We present the results of our analysis of the NRF investment in Physics under two headings: the profile of grant-holders in the field, and the grant values awarded to grant-holders in the field.

5.1.1. Grant-holders

The number of grant-holders in Physics increased from 109 in 2005 to 274 in 2015, after which it dropped again to 139 in 2020. However, the overall growth rate in the period 2005–2020 is positive (1.6%). For the shorter period from 2005 to 2015 (before the decline in 2020), the growth rate is even higher at 9.7%. Black representation in Physics appears to be more promising than female representation – the share of black grant-holders increased from 27% in 2005 to 46% in 2020, while that of female grant-holders increased at a noticeably lower level from 9% to 18%. The growth in the actual numbers of female and black grant-holders is positive in both cases (respectively 5.7% and 3.4% during the period 2005 to 2020).

Table 1: Indicators of NRF investment in research (grant-holders)

Indicator category	Indicator	2005	2010	2015	2020
State indicator	Number of grant-holders	109	189	274	139
Dynamic indicator	Rate of growth in the number of grant-holders	1.6%			
State indicator	Female grant-holders as a share of all grant-holders	9%	13%	16%	18%
Dynamic indicator	Rate of growth in the number of female grant-holders	5.7%			
State indicator	Black grant-holders as a share of all grant-holders	27%	32%	37%	46%
Dynamic indicator	Rate of growth in the number of black grant-holders	3.4%			

5.1.2. Grant values

An analysis of grant values, shows positive growth at 13.2% for the overall funding amounts in the period 2005–2020. The data show that that the grant values have increased systematically annually between 2005 and 2010. However, since 2010 there appears to be evidence of fluctuations, if not a decline, in funding. If the growth rate is calculated for the more recent period 2010–2020, a negative rate is observed (-7.0%). A similar trend applies to the value of grants for women. A positive growth rate of 19% for the overall period is observed, but it becomes negative (-7.0%) if only the last three reporting years are considered. The funding values for black graduates fluctuate, with an overall growth of 13.0%.

Table 2: Indicators of NRF investment in research (grant values)

Indicator category	Indicator	2005	2010	2015	2020
State indicator	Total value of individual grants	R18,942,097	R149,979,371	R190,197,630	R121,343,439
Dynamic indicator	Rate of growth in the total value of individual grants (CAGR) (2005 to 2020)		13.2%		
State indicator	Total value of grants for women (SA nationals only)	R453,082	R7,976,291	R7,072,346	R6,183,943
Dynamic indicator	Rate of growth in the total value of grants for women (CAGR) (2005 to 2020)		19.0%		
State indicator	Total value of grants for black scholars (SA nationals only)	R2,928,312	R21,149,134	R36,879,105	R18,248,383
Dynamic indicator	Rate of growth in the total value of grants for black scholars (CAGR) (2005 to 2020)		13.0%		

5.2. Staff capacity and diversity

Our analysis of the human resources capacity in the field of Physics is based on the HEMIS database of DHET for the period 2000 to 2020. We present the results of our analysis under two headings: staff capacity (instructional and research staff FTE) in the field, and the staff diversity profile (gender, race, nationality, and age). The detailed analysis of staff capacity and diversity can be found in Part 2 of this report. The trends and patterns are presented in several figures and tables.

5.2.1. Staff capacity

In the table below we report on indicators measuring staff capacity for selected years in Physics.

When looking at the capacity of university staff in Physics, we see that the count of permanent instructional/research staff grew steadily from 196 in 2000 to 300 in 2020. In Appendix 2 we report on the impact of the reclassification of the HEMIS CESM codes on the data trends reported across the disciplines, but notwithstanding these explanations we report negative growth rates in the staff capacity for both the periods 2000 to 2020 and 2010 to 2020.

When we look at the percentage of staff with a Doctoral qualification, we see that the percentage of staff with PhDs increased substantially by 18 percentage points from 55% in 2000 to 73% in 2020. The ratio of Doctoral students per staff with a PhD (a measure of supervisory capacity) increased somewhat from 1.1 to 1.8 over this period. This means that the supervisory burden of Doctoral students has increased in the field of Physics because of increasing numbers of Doctoral enrolments and decreasing (or stagnating) staff capacity.

Table 3: Indicators of staff capacity

Indicator category	Indicator	2000	2005	2010	2015	2020
State indicator	Sum FTE of instructional/research staff	196	216	218	315	300
State indicator	Total headcount of instructional/research staff	320	352	320	468	476
Dynamic indicator	Rate of growth (%) in staff FTE (CAGR) (2000 to 2020)			2.2%		
Dynamic indicator	Rate of growth (%) in staff FTE (CAGR) (2010 to 2020)			3.2%		
State indicator	Percentage of staff FTE with a Doctoral qualification	55%	48%	56%	64%	73%
Dynamic indicator	Change in the percentage of staff with a PhD (2000 to 2020)			18%		
Dynamic indicator	Rate of growth (%) in staff FTE with a PhD (CAGR) (2000 to 2020)			3.6%		
Dynamic indicator	Rate of growth (%) in staff FTE with a PhD (CAGR) (2010 to 2020)			5.9%		
State indicator	Ratio of Doctoral enrolments to staff FTE with a Doctoral qualification	1.1	1.2	1.7	1.8	1.8
Dynamic indicator	Change in the ratio of Doctoral enrolments to staff with a Doctoral qualification (2000 to 2020)			0.7		

5.2.2. Staff diversity

In the table below we summarise the main indicators on staff diversity in Physics for selected years. Over the recorded period, we see that the percentage of female staff in Physics increased slightly with 9 percentage points from 14% in 2000 to 23% in 2020, with an annual average growth rate of 4.2%.

We see a large percentage shift among black[1] staff where in 2020 the percentage of black staff constituted 68% of all South African instructional/research staff with a significant increase from 31% in 2000. The percentage of South African staff members remained fairly stable with a slight decrease of -8 percentage points during the period analysed. When we look at the age profile of academic staff, we see that in 2020 38% of staff was younger than 40 years, but there has been a decline of 4 percentage points in the percentage younger staff between 2000 and 2020.

[1] Here we include all South African staff who are classified in HEMIS as black African, Indian, and Coloured/Asian.

Table 4: Indicators of staff diversity

Indicator category	Indicator	2000	2005	2010	2015	2020
State indicator	Percentage of female staff FTE	14%	13%	18%	26%	23%
Dynamic indicator	Change in the percentage of female staff FTE			9%		
Dynamic indicator	Rate of growth (%) in female staff FTE (CAGR) (2000 to 2020)			4.2%		
State indicator	Percentage of black staff (AIC) FTE (South African staff)	31%	46%	49%	61%	68%
Dynamic indicator	Change in the percentage of black staff			37%		
Dynamic indicator	Rate of growth (%) in black staff FTE (CAGR) (2000 to 2020)			5.4%		
State indicator	Percentage of staff FTE from South Africa	83%	89%	84%	78%	75%
Dynamic indicator	Change in the percentage of staff from South Africa			-8%		
Dynamic indicator	Rate of growth (%) in staff FTE from South Africa (CAGR) (2000 to 2020)			1.6%		
State indicator	Percentage of staff younger than 40 years	42%	38%	41%	36%	38%
Dynamic indicator	Change in the percentage of staff younger than 40 years			-4%		
Dynamic indicator	Rate of growth in staff younger than 40 years (CAGR) (2000 to 2020)			1.6%		

5.3. The academic pipeline

The HEMIS database of DHET for the period 2000 to 2020 also informed the analysis of the academic pipeline in Physics. In this section results are presented for Doctoral students only, under three headings: general trends in Doctoral enrolments and graduates, the demographics of enrolled Doctoral students, and the demographics of Doctoral graduates. The detailed analysis for the academic pipeline can be found in Part 2 of this report where the trends and patterns are presented in a number of figures and tables.

5.3.1. General trends in Doctoral enrolments and graduates

In the table below we summarise the general trends in Doctoral enrolments and graduates in Physics.

When we look at the growth of Doctoral enrolments in Physics, we see that there has been a steady increase between 2000 and 2020 in both total enrolments, at an annual average growth rate of 6%, and new (or first-time) enrolments, at an annual average growth rate of 5.1%. However, given the change in the HEMIS CESM classifications of disciplinary fields, the inclusion and exclusion of sub fields in the field of Physics (as explained in the Appendix 2), impacts on the data trends presented below. We therefore also report on the growth of enrolments from 2010 onward and see increased growth of 6.5% for total enrolments and 6.3% for new enrolments.

In terms of graduates, the growth (9.6% between 2000 and 2020 and 8.6% between 2010 and 2020) was higher than those for total and new enrolments which points to an efficient system of Doctoral throughput.

However, when we look at the average time-to-degree of Doctoral graduates we see that the average time-to-completion remained relatively stable with a slight increase to 5.0 years over the period analysed. The average age at commencement for Doctoral students in Physics in 2020 was 31.0 years, while the average age at graduation for the same year was 35.7 years. We also see that the average age at graduation increased somewhat from 30.9 years in 2000 to 35.7 years in 2020.

Table 5: Indicators of future research capacity (Doctoral enrolments and graduates)

Indicator category	Indicator	2000	2005	2010	2015	2020
State indicator	Number of total Doctoral enrolments	122	120	209	357	393
Dynamic indicator	Rate of growth (%) in the number of total enrolments (CAGR) (2000 to 2020)			6%		
Dynamic indicator	Rate of growth (%) in the number of total enrolments (CAGR) (2010 to 2020)			6.5%		
State indicator	Number of new Doctoral enrolments	30	38	44	107	81
Dynamic indicator	Rate of growth (%) in the number of new Doctoral enrolments (CAGR) (2000 to 2020)			5.1%		
Dynamic indicator	Rate of growth (%) in the number of new Doctoral enrolments (CAGR) (2010 to 2020)			6.3%		
State indicator	Number of Doctoral graduates	14	16	38	40	87
Dynamic indicator	Rate of growth (%) in Doctoral graduates (CAGR) (2000 to 2020)			9.6%		
Dynamic indicator	Rate of growth (%) in Doctoral graduates (CAGR) (2010 to 2020)			8.6%		
State indicator	Average age at commencement of Doctoral studies	31.3	31.6	30.8	32.2	31.0
Dynamic indicator	Change in the average age at commencement of Doctoral studies (2000 to 2020)			-0.3 years		
State indicator	Average time-to-degree of Doctoral studies	4.6	5.0	4.8	4.4	5.0
Dynamic indicator	Change in average time-to-degree of Doctoral studies (2000 to 2020)			-0.4 years		
State indicator	Average age at graduation of Doctoral students	30.9	39.1	34.6	35.5	35.7
Dynamic indicator	Change in the average age at graduation of Doctoral students (2000 to 2020)			4.8 years		

5.3.2. Demographics of enrolled Doctoral students

Turning to the demographics of Doctoral enrolments, we see that in 2020, 16% of Doctoral enrolments were female. The number of female enrolments increased steadily since 2000 at an average annual growth rate of 8.7%. Over the same period the number of black (black African, Indian/Asian, and Coloured) enrolments grew at a slightly slower rate at 7.9% where the percentage of black enrolments of South African Doctoral enrolments nearly doubled to 76% in 2020. We see that the percentage of South African students has decreased slightly between 2000 and 2020 to 60%. This is driven by increasing numbers of international students, particularly from the African continent, who are pursuing Doctoral studies in Physics at South African universities. However, in recent years we do find that this trend is declining with the percentage of African enrolments in Physics steadily declining from 2014/2015 onward.

Table 6: Demographics of Doctoral enrolments

Indicator category	Indicator	2000	2005	2010	2015	2020
State indicator	Percentage of female Doctoral enrolments of total enrolments	16%	23%	25%	25%	34%
Dynamic indicator	Change in the percentage of female Doctoral enrolments			18%		
Dynamic indicator	Rate of growth (%) in the number of female Doctoral enrolments (CAGR) (2000 to 2020)			8.7%		
State indicator	Percentage of black Doctoral enrolments (AIC) of South African enrolments	40%	52%	55%	68%	76%
Dynamic indicator	Change in the percentage of black Doctoral enrolments			36%		
Dynamic indicator	Rate of growth (%) in the number of black staff Doctoral enrolments (CAGR) (2000 to 2020)			7.9%		
State indicator	Percentage of South African Doctoral enrolments	75%	73%	61%	50%	60%
Dynamic indicator	Change in the percentage of South African Doctoral enrolments			-15%		
Dynamic indicator	Rate of growth (%) in the number of South African Doctoral enrolments (CAGR) (2000 to 2020)			4.8%		

5.3.3. Demographics of Doctoral graduates

When we look at the demographic profile of Doctoral graduates, we see the share of female graduates in Physics increased substantially over the period analysed with 32% of graduates in 2020 reported as female. Once again, we see that the percentage of South African black graduates increased with 54 percentage points at a growth rate of 11.4% to 81% in 2020. Similar to what was observed for the enrolment data we see that the percentage of South African graduates decreased substantially between 2000 and 2020. In 2020, only 44% of Doctoral graduates in Physics were of South African nationality.

Table 7: Demographics of Doctoral graduates

Indicator category	Indicator	2000	2005	2010	2015	2020
State indicator	Percentage of female graduates of total graduates	0%	18%	19%	33%	32%
Dynamic indicator	Change in the percentage of female Doctoral graduates			32%		
Dynamic indicator	Rate of growth (%) in the number of female Doctoral graduates (CAGR) (2000 to 2020)			-		
State indicator	Percentage of black Doctoral graduates (AIC) of South African graduates	27%	55%	39%	45%	81%
Dynamic indicator	Change in the percentage of black Doctoral graduates			54%		
Dynamic indicator	Rate of growth (%) in the number of black Doctoral graduates (CAGR) (2000 to 2020)			11.4%		
State indicator	Percentage of South African Doctoral graduates	79%	69%	55%	52%	44%
Dynamic indicator	Change in the percentage of South African Doctoral graduates			-35%		
Dynamic indicator	Rate of growth (%) in the number of South African Doctoral graduates (CAGR) (2000 to 2020)			6.4%		

5.4. Research

We have analysed the research 'performance' of Physics in terms of three dimensions: the volume of research output, the transformation of research production as reflected in the author demographics, and the global standing and citation visibility or impact of research. The detailed analysis for research outputs and performance can be found in Part 2 of this report where we present the trends and patterns in a number of figures and tables.

5.4.1. Volume of research output

Based on *SA Knowledgebase*, the number of Physics articles by university authors and number of contributing authors over the period 2005 to 2020 are presented in the Table below. The results show a substantial increase in the number of articles over the past sixteen year at an annual growth rate of 11.8%. Interestingly enough, we also see that the number of contributing authors increased at a very similar rate which means that the field has managed to produce this exceptional growth with the assistance of large numbers of students, post-Doctoral fellows and visiting fellows.

Table 8: Nr of articles in Physics and the contributing authors (2005 to 2020)

Indicator category	Indicator	2005	2010	2015	2020
State indicator	Number of articles	180	328	592	954
Dynamic indicator	Rate of growth in the number of articles		11.8%		
State indicator	Number of contributing authors	238	495	925	1,301
Dynamic indicator	Rate of growth in the number of contributing authors		12.0%		

5.4.2. Author demographics

We have selected three indicators to assess to what extent the field of Physics research has transformed over the 20-year period, namely, the gender, race, nationality, and age of Physics authors as captured in SA Knowledgebase.

Table 9: Demographics of authors

Indicator category	Indicator	2005	2010	2015	2020
State indicator	Percentage of university female authors	4%	12%	12%	18%
Dynamic indicator	Change in the percentage of university female authors		14%		
Dynamic indicator	Rate of growth (%) in the number of university female authors (CAGR) (2005 to 2020)		23.8%		
State indicator	Percentage of South African authors	75%	65%	40%	49%
Dynamic indicator	Change in the percentage of South African authors		-26%		
Dynamic indicator	Rate of growth (%) in the number of South African authors (2005 to 2020)		11.4%		
State indicator	Percentage of university black authors (South African)	14%	32%	34%	51%
Dynamic indicator	Change in the percentage of university black authors		37%		
Dynamic indicator	Rate of growth (%) in the number of university black authors (CAGR) (2005 to 2020)		22.6%		
State indicator	Percentage of university authors younger than 40 years	30%	36%	40%	44%
Dynamic indicator	Change in the percentage of university authors younger than 40 years (2005 to 2020)		14%		
Dynamic indicator	Rate of growth in the number of authors younger than 40 years		21.0%		

5.4.3. Global standing and citation visibility

The most basic measure of the South African performance in the field of Physics is the number of publications (articles and review articles) being produced per year. In the table below we see that the field of Physics significantly increased its output in the WoS from 290 publications in 2000 to 1724 in 2020. This has translated into an increased world share, from 0.2% to 0.6%. Physics improved its world rank from being in the 42nd position in 2000 to the 36th position in 2020 - although the world rank of the field of Physics is quite low. It is important to note that the indicators presented in the table below are calculated for all South African articles (and review articles) in journals that belong to the subject category of Physics. Thus, the authors of these articles could be from departments and centres outside the field of Physics but have been included in this specific analysis based on the fact that they had published in journals classified as belonging to Physics.

The visibility of science is partially captured by looking at the number of times research publications are referenced ('cited') in the publications of other researchers. Citation practices differ vastly across fields though, making it impossible to compare numbers of citations across fields. The indicators that we present here report on the percentage of Physics articles in the top 1%, 5% and 10% of highly cited Physics papers in the world. The results reveal a positive picture: the share of Physics articles published in the top 1% of highly cited papers marginally increased over time (from 0.72% to 2.88%). The increase in the shares of articles in the top 5% is also positive (from 2.54% to 9.91%), as well as the share in the top 10% of highly cited papers (from 4.35% to 16.28%).

Table 10: Indicators of global standing and citation visibility

Indicator category	Indicator	2000	2005	2010	2015	2020
State indicator	Total number of SA articles in WoS	290	374	576	1,178	1,724
Dynamic indicator	Rate of growth (%) in the number of South African articles in WoS (CAGR) (2000 to 2020)			9.3%		
State indicator	World share of WoS articles	0.2%	0.2%	0.3%	0.5%	0.6%
Dynamic indicator	Change in world share (2000 to 2020)			0.4%		
State indicator	World rank position in WoS	42	44	41	38	36
Dynamic indicator	Change in the world rank position			6		
State indicator	Percentage of WoS articles in top 1% of highly cited papers	0.72%	0.56%	2.37%	2.35%	2.88%
Dynamic indicator	Change in the percentage of WoS articles in the top 1% of highly cited papers (2000 to 2020)			2.2%		
State indicator	Percentage of WoS articles in top 5% of highly cited papers	2.54%	4.46%	8.03%	10.86%	9.91%
Dynamic indicator	Change in the percentage of WoS articles in the top 5% of highly cited papers (2000 to 2020)			7.4%		
State indicator	Percentage of WoS articles in top 10% of highly cited papers	4.35%	8.91%	14.60%	19.37%	16.28%
Dynamic indicator	Change in the percentage of WoS articles in the top 10% of highly cited papers (2000 to 2020)			11.9%		

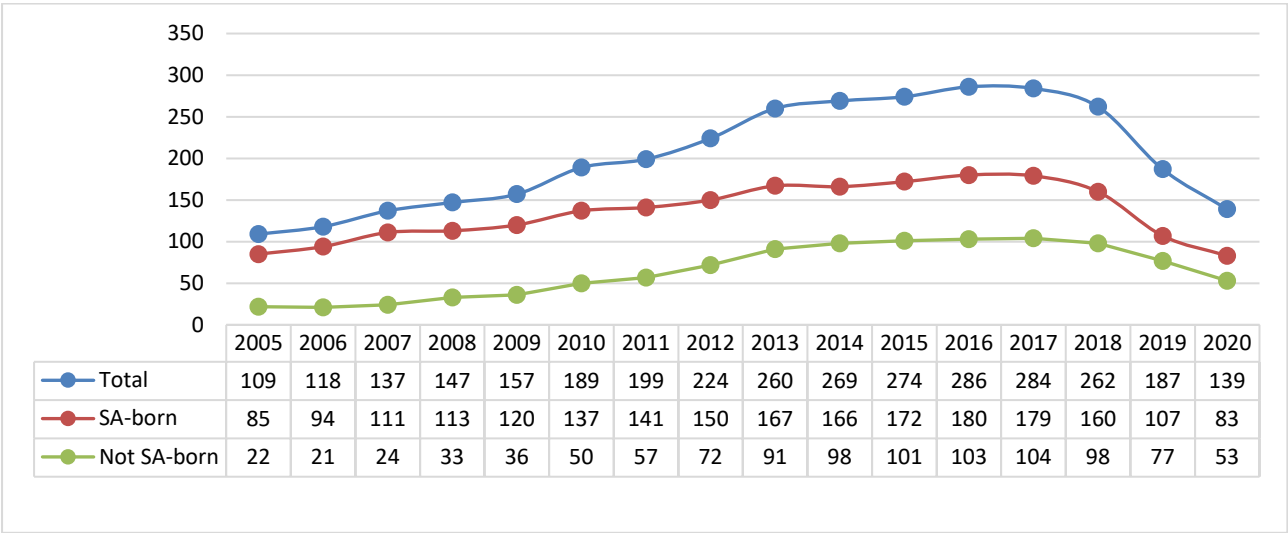
PART 2: DETAILED GRAPHS AND TABLES

6. NRF grant-holders and grant values

Table 11: Number of grant-holders and grants in Physics, and the total grant value, by year: 2005 – 2020

Year	Number of grant-holders	Number of grants	Total grant value
2005	109	184	R18 942 097
2006	118	188	R35 657 614
2007	136	220	R59 269 118
2008	146	247	R88 838 551
2009	157	279	R117 372 101
2010	189	333	R149 979 371
2011	199	331	R139 518 258
2012	224	331	R102 440 558
2013	260	375	R156 086 250
2014	269	446	R188 108 692
2015	274	459	R190 197 630
2016	286	496	R197 283 047
2017	283	466	R134 719 181
2018	261	412	R130 322 784
2019	185	245	R164 118 920
2020	136	162	R121 343 439

Figure 6-1: Number of grant-holders in Physics by year, broken down in terms of whether grant holders are SA-born or not: 2005 – 2020



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total	109	118	137	147	157	189	199	224	260	269	274	286	284	262	187	139
SA-born	85	94	111	113	120	137	141	150	167	166	172	180	179	160	107	83
Not SA-born	22	21	24	33	36	50	57	72	91	98	101	103	104	98	77	53

Table 12: Profile of grant-holders and grant values in Physics by year and gender of grant-holder (SA-born only): 2005 – 2020

Year	Grant-holders (number)		Gant-holders (percentage)		Total grant values (ZAR)		Total grant values (percentage)		Average grant value per grant-holder	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
2005	7	77	8	92	R453 082	R13 252 427	3	97	R64 726	R172 109
2006	12	82	13	87	R792 960	R22 682 720	3	97	R66 080	R276 619
2007	9	102	8	92	R981 891	R52 432 710	2	98	R109 099	R514 046
2008	11	102	10	90	R954 337	R71 045 470	1	99	R86 758	R696 524
2009	8	112	7	93	R1 257 738	R93 444 936	1	99	R157 217	R834 330
2010	18	119	13	87	R7 976 291	R111 533 009	7	93	R443 127	R937 252
2011	18	123	13	87	R2 818 664	R102 221 488	3	97	R156 592	R831 069
2012	19	131	13	87	R6 070 164	R62 798 590	9	91	R319 482	R479 379
2013	27	140	16	84	R4 078 014	R99 347 817	4	96	R151 038	R709 627
2014	27	139	16	84	R13 210 435	R108 207 198	11	89	R489 275	R778 469
2015	29	143	17	83	R7 072 346	R117 667 088	6	94	R243 874	R822 847
2016	26	154	14	86	R4 245 630	R137 232 784	3	97	R163 293	R891 122
2017	33	146	18	82	R6 210 787	R77 331 706	7	93	R188 206	R529 669
2018	30	130	19	81	R4 434 686	R70 775 985	6	94	R147 823	R544 431
2019	27	80	25	75	R6 945 453	R55 059 249	11	89	R257 239	R688 241
2020	16	67	19	81	R6 488 943	R39 520 922	14	86	R405 559	R589 865
Total	--	--	--	--	**R73 991 420**	**R1 234 554 100**	**6**	**94**	--	--

Table 13: Profile of grant-holders and grant values in Physics by year and race of grant-holder (SA-born only): 2005 – 2020

Year	Grant-holders (number)		Gant-holders (percentage)		Total grant values (ZAR)		Total grant values (percentage)		Average grant value per grant-holder	
	Black	**White**	**Black**	**White**	**Black**	**White**	**Black**	**White**	**Black**	**White**
2005	23	61	27	73	R2 928 312	R10 777 197	21	79	R127 318	R176 675
2006	27	66	29	71	R8 930 384	R12 745 295	41	59	R330 755	R193 111
2007	37	73	34	66	R9 327 406	R34 051 445	22	78	R252 092	R472 937
2008	38	74	34	66	R23 676 459	R37 116 312	39	61	R623 065	R508 443
2009	37	82	31	69	R22 683 454	R71 795 420	24	76	R613 066	R875 554
2010	43	93	32	68	R21 149 134	R88 425 166	19	81	R491 840	R950 808
2011	46	95	33	67	R18 297 281	R86 742 871	17	83	R397 767	R913 083
2012	50	100	33	67	R18 128 900	R50 739 853	26	74	R362 578	R507 399
2013	58	109	35	65	R26 515 698	R76 910 133	26	74	R457 167	R705 598
2014	56	109	34	66	R29 372 311	R92 026 145	24	76	R524 506	R844 277
2015	63	109	37	63	R36 879 105	R87 860 328	30	70	R585 383	R806 058
2016	65	115	36	64	R24 646 810	R116 831 605	17	83	R379 182	R1 015 927
2017	68	111	38	62	R26 456 416	R56 976 077	32	68	R394 872	R513 298
2018	62	98	39	61	R23 048 158	R52 072 513	31	69	R377 839	R531 352
2019	54	53	50	50	R22 433 319	R39 450 383	36	64	R423 270	R744 347
2020	38	45	46	54	R18 248 383	R27 366 482	40	60	R506 900	R608 144
Total	--	--	--	--	**R332 721 530**	**R941 887 226**	**26**	**74**	--	--

Table 14: Profile of grant-holders and grant values in Physics by year and age of grant-holder: 2005 – 2020

Year	Grant-holders (number)		Gant-holders (percentage)		Total grant values (ZAR)		Total grant values (percentage)		Average grant value per grant-holder	
	<40	≥40	<40	≥40	<40	≥40	<40	≥40	<40	≥40
2005	30	75	29	71	R2 773 864	R16 036 872	15	85	R693 466	R1 069 125
2006	31	85	27	73	R7 103 447	R28 554 167	20	80	R3 551 723	R1 586 343
2007	36	99	27	73	R8 915 802	R50 353 317	15	85	R810 527	R1 798 333
2008	38	108	26	74	R19 145 091	R69 693 460	22	78	R1 367 507	R2 403 223
2009	32	125	20	80	R8 328 182	R109 043 920	7	93	R757 107	R3 634 797
2010	54	133	29	71	R10 096 975	R139 770 149	7	93	R438 999	R4 110 887
2011	55	143	28	72	R9 553 846	R129 864 412	7	93	R329 443	R3 329 857
2012	67	155	30	70	R11 270 414	R91 070 144	11	89	R313 067	R2 117 910
2013	86	171	33	67	R14 662 567	R141 307 813	9	91	R366 564	R2 883 833
2014	98	166	37	63	R25 723 621	R162 200 859	14	86	R535 909	R3 451 082
2015	94	176	35	65	R13 895 614	R175 977 017	7	93	R421 079	R3 666 188
2016	92	192	32	68	R11 715 634	R185 384 017	6	94	R344 577	R3 310 429
2017	88	194	31	69	R17 848 598	R116 326 979	13	87	R594 953	R1 876 242
2018	83	177	32	68	R19 925 882	R110 341 901	15	85	R664 196	R2 006 216
2019	71	115	38	62	R19 927 275	R144 191 645	12	88	R905 785	R3 897 071
2020	46	93	33	67	R14 024 537	R107 318 902	12	88	R934 969	R3 577 297
Total	--	--	--	--	**R214 911 346**	**R1 777 435 574**	**11**	**89**	--	--

Table 15: Number of grant-holders and grants in Physics, and the total grant value, by organisation: 2005 – 2020

Organisation	Number of grant-holders	Number of grants	Total grant value
Stellenbosch University	44	145	R260 239 883
Nelson Mandela University	24	106	R201 911 512
University of Cape Town	63	221	R171 878 837
iThemba Laboratory for Accelerator-Based Sciences	37	157	R169 248 395
University of the Western Cape	34	124	R155 329 242
University of the Witwatersrand	71	212	R150 829 671
University of Pretoria	41	166	R120 991 322
South African Astronomical Observatory (SAAO)	39	141	R112 035 686
University of KwaZulu-Natal	51	190	R106 155 798
University of the Free State	30	106	R80 575 470
North-West University	30	110	R71 857 944
University of Johannesburg	42	145	R68 643 201
Hartebeeshoek Radio-Astronomical Observatory	9	32	R63 036 623
University of Limpopo	8	17	R47 811 799
South African National Space Agency (SANSA)	22	127	R44 508 266
Rhodes University	14	56	R43 243 103
Council for Scientific and Industrial Research (CSIR)	39	97	R36 412 517
University of South Africa	24	60	R21 577 993
University of Fort Hare	3	15	R20 154 657
Direct	7	8	R15 907 151
University of Zululand	10	30	R14 260 423
Tshwane University of Technology	4	8	R2 274 869
Mintek	2	2	R2 025 185
Cape Peninsula University of Technology	5	13	R1 900 977
Square Kilometre Array (South Africa)	4	4	R1 720 619
University of Venda	4	8	R1 517 587
Wits Commercial Enterprise (Pty) Ltd	1	4	R1 402 701
Durban University of Technology	3	6	R1 264 229
University of Limpopo	3	6	R1 239 541
Nuclear Energy Corporation of South Africa (NECSA)	6	14	R1 221 942
Sefako Makgatho Health Sciences University	2	2	R822 483
Walter Sisulu University	1	1	R800 000
National Metrology Institute of South Africa (NMISA)	4	5	R747 292
Vaal University of Technology	2	3	R369 520
Sol Plaatje University	1	1	R168 000
Mangosuthu University of Technology	1	2	R84 565
African Institute for Mathematical Sciences (AIMS)	1	1	R16 000
Stellenbosch University	44	145	R260 239 883

Table 16: Number of grant-holders and grants in Physics, and the total grant value, by funding category: 2005 – 2020

Funding category	Number of grant-holders	Number of grants	Total grant value
SA Research Chairs	59	32	R574 064 090
National Equipment	48	77	R439 961 417
National Institute for Theoretical Physics	4	3	R139 913 108
National Nanotechnology Grant	22	28	R87 814 786
Research and Innovation Reward Programme	12	47	R81 896 186
Incentive Funding for Rated Researchers	258	440	R74 966 507
Competitive Programme for Rated Researchers	101	124	R66 380 372
International Science and Technology Agreements	146	349	R66 319 481
Strategic Research Equipment	1	1	R34 686 173
SA National Antarctic Programme	16	31	R30 613 725
Innovation Fund Grants	5	5	R29 694 185
Research Infrastructure Support Programme	6	7	R25 666 155
Technology and Human Resources for Industry Programme (Thrip)	16	48	R25 211 872
South African Square Kilometer Array Project	31	32	R24 952 882
DST Grant for NASSP	4	4	R21 491 822
Human Capital Development for Multi-Wavelength Astronomy	32	36	R18 109 504
Economic Growth and International Competitiveness	24	35	R16 694 676
Nanotechnology Flagship Programme	8	8	R16 491 081
Unlocking the Future	44	65	R16 355 556
S&F - Scholarships & Fellowships Programme	35	38	R14 199 377
Thuthuka	41	53	R13 103 489
Knowledge Interchange and Collaboration	179	305	R12 360 372
Competitive Support for Unrated Researchers	32	32	R12 270 082
Grant Challenges - Infrastructure	1	1	R9 000 000
S&F - Scarce Skills Postdoctoral Fellowships	13	14	R8 659 645
S&F - Research Career Awards	4	4	R8 399 342
Institutional Research Development Programme	16	16	R8 108 647
Blue Skies Research Programme	15	23	R7 632 451
Research Equipment Programme	42	63	R6 540 057
Stellenbosch Institute for Advanced Study Fellowship Programme	1	1	R6 003 920
National Laser Centre	21	46	R5 738 064
IRG - BRICS Multilateral Joint Call	5	5	R5 359 648
S&F - DSI / NRF Innovation Postdoctoral Fellowships	9	9	R5 167 098
IEPD - Institutional Engagement and Partnership Development	3	3	R5 053 971
Astronomy Sub-Agency Funding Programme	13	16	R4 949 222
IRG - Italy / South Africa Research Cooperation Programme	5	5	R4 734 331
Distinct South African Research Opportunities	13	16	R3 923 981
S&F - Collaborative Postgraduate Training	3	3	R3 899 067
Rediba	20	23	R3 870 897
IRG - Sweden / South Africa Research Cooperation Programme	5	4	R3 384 757
Research Development Grants for Y-Rated Researchers	16	17	R3 196 424
Astronomy in Africa (Newton Fund)	1	1	R3 000 000

Funding category	Number of grant-holders	Number of grants	Total grant value
IRG - Flemish / South Africa Research Cooperation Programme	2	2	R2 298 972
S&F - NRF Free-standing Postdoctoral Fellowships	6	6	R2 215 950
S&F - NRF-TWAS Postdoctoral Fellowship Programme	3	3	R2 133 624
University Research Development Programme	7	8	R2 111 441
DST-NRF Conference Fund	3	3	R1 988 540
IRG - Switzerland / South Africa Research Cooperation Programme	1	1	R1 927 271
International Council of Scientific Unions	23	39	R1 827 190
IRG - UK / South Africa Researcher Links Grants for Travel	7	7	R1 809 790
IRG - National Natural Science Foundation of China / NRF Research Cooperation Programme	3	3	R1 800 000
NP - Support for Woman & Young Researchers	6	6	R1 800 000
Evaluation and Rating	45	45	R1 727 363
Researchers in Training	11	19	R1 669 433
IRG - Egypt / South Africa Research Cooperation Programme	4	4	R1 297 483
S&F - Manus and MatSci Grants	1	1	R1 216 000
P Y & L-Rated Researchers Under Thuthuka	1	1	R1 164 000
Regional Equipment	2	3	R1 120 000
Sustainable Livelihoods: The Eradication of Poverty	2	2	R1 050 669
Education and Challenges for Change	5	9	R1 032 957
Special Transformation Awards	7	7	R922 333
Women in Research	2	4	R863 700
IRG - South Africa-Joint Institute for Nuclear Research (SA-JINR)-Grants for JINR Student Practice	3	3	R848 660
Sabbatical Grants to Complete Doctoral Degrees	6	6	R842 457
IRG - France / South Africa Research Cooperation Programme	4	4	R799 387
IRG - South Korea / South Africa Research Cooperation Programme	2	3	R707 330
S&F - Renewable Energy Postdoctoral Fellowships	2	2	R686 991
African Origins Platform	1	2	R657 000
IRG - Russian Foundation for Basic Research / NRF Research Cooperation Programme	3	3	R630 612
IRG - South Africa-Joint Institute for Nuclear Research (SA-JINR)-Grants for JINR	14	16	R602 703
DST ERPG - Access Grants	1	1	R577 000
Development Grant for KFD	5	5	R563 456
IRG - Japan Society for the Promotion of Science / NRF Research Cooperation Programme	1	1	R485 417
International Liaison	14	17	R410 920
DST- NRF Fellowships for Early Career Researchers from the UK	2	2	R385 000
IRG - Poland / South Africa Research Cooperation Programme	1	1	R328 356
Innovation - National Competition Fund	1	1	R300 000
Renewable Energy Postdoctoral Fellowships	2	2	R300 000
S&F - Innovation Scholarships for Non-South African citizen	1	1	R279 871

Funding category	Number of grant-holders	Number of grants	Total grant value
IRG - Zambia / South Africa Research Cooperation Programme	2	2	R259 794
IRG - South Africa / Uganda Cooperation Bilateral Programme	1	1	R250 000
IRG - Romania / South Africa Research Cooperation Programme	1	1	R241 839
Ad Hoc Grants - ICD	2	2	R213 977
IRG - NRF/International Centre for Theoretical Physics Joint Collaboration for Science Advancement	3	3	R211 529
Technikon Research Development Programme	1	1	R200 560
NP - Improving Academic Qualifications	2	2	R200 000
NSTF/NRF Awards (Under Thuthuka)	2	2	R199 821
Black Academics Advancement Programme	1	1	R198 696
IRG - South Africa / Austria Joint Scientific and Technological Cooperation Programme	1	1	R197 000
Africa Interaction	1	1	R185 438
IRG - NRF/BELSPO Joint Science and Technology Collaboration	1	1	R172 526
Research Information Management System Implementation Grants	1	1	R150 000
IRG - South Africa / Wallonia-Brussels Federation Science and Technology Research Collaboration Programme	1	1	R109 824
IRG - Taiwan / South African Research Cooperation Programme	1	1	R63 568
Indigenous Knowledge Systems	1	1	R58 772
IRG - China / South Africa Research Cooperation Programme	1	1	R41 942
Drug Discovery Programme	1	1	R22 029

7. Staff capacity

Figure 7-1: Total number of staff in Physics by year: 2000 - 2020

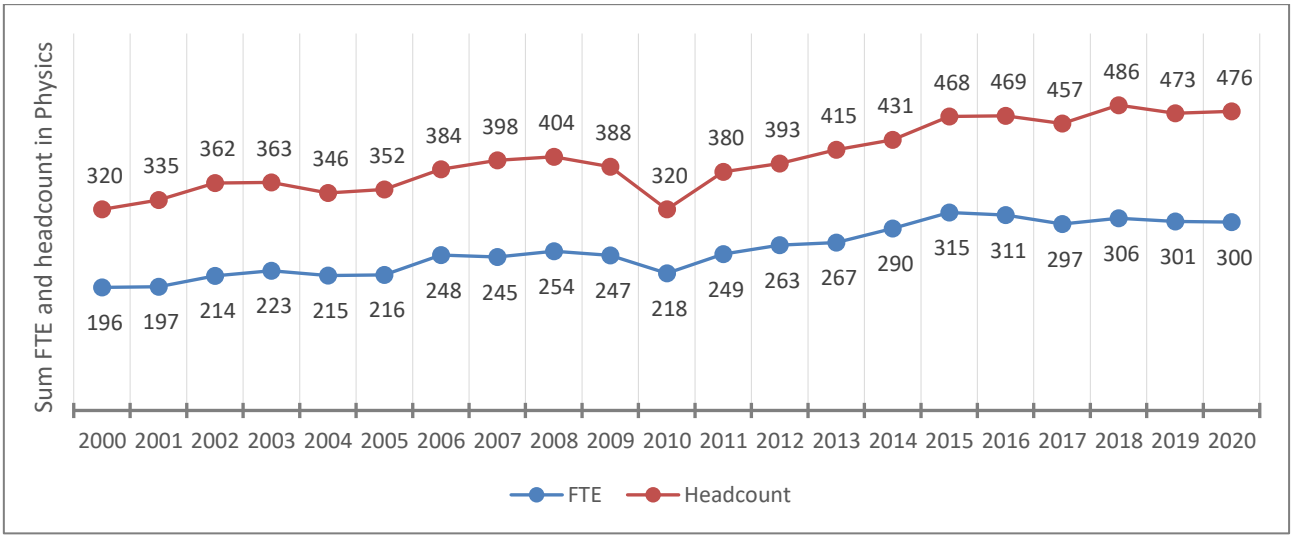


Figure 7-2:Percentage of staff with a Doctoral qualification in Physics by year: 2000 - 2020

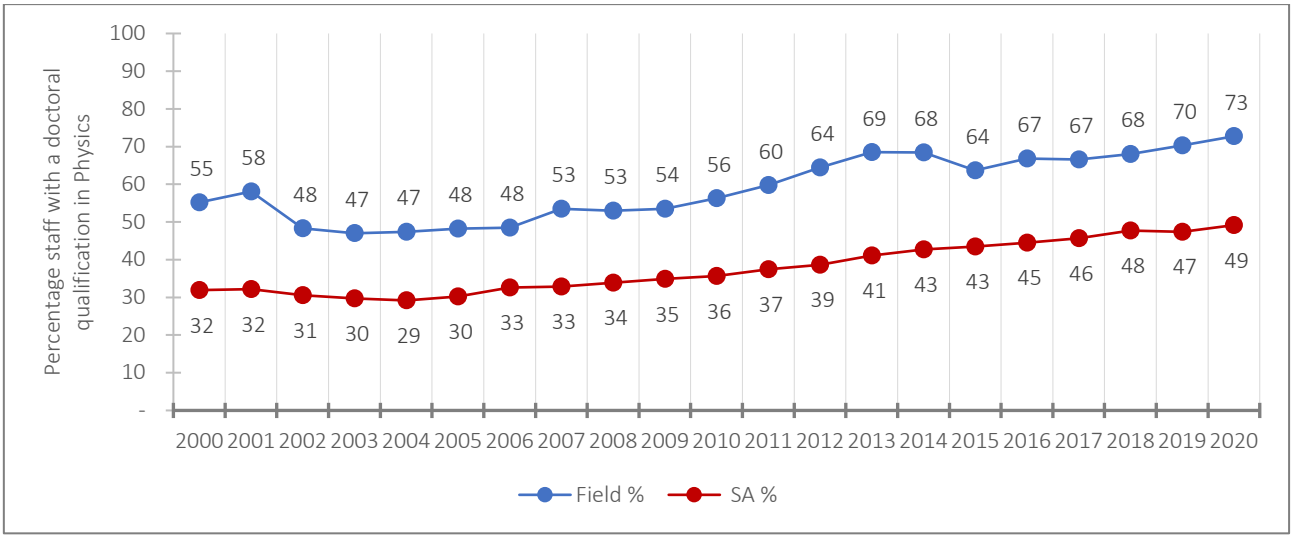


Figure 7-3: Percentage of staff in Physics by rank and year: 2000 - 2020

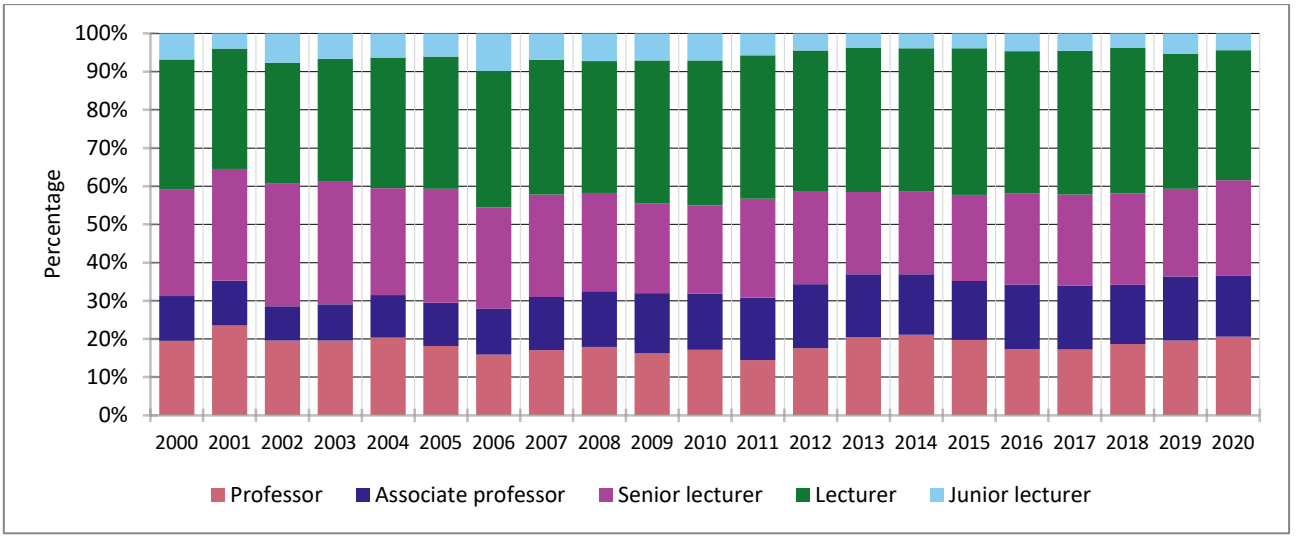


Table 12: Sum of staff FTE per university in Physics

University	Metric	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CPUT	Headcount	17	18	20	18	19	24	33	30	28	29	20	21	24	20	20	17	16	14	15	12	15
	FTE	6.0	5.0	4.9	9.1	8.1	10.5	13.2	10.2	9.5	9.4	8.3	8.9	11.0	8.3	10.7	9.7	8.6	8.0	7.7	8.4	8.3
CUT	Headcount	5	2	2	2	5	4	3	4	4	6	1	1	1	2	3	3	2	4	4	6	3
	FTE	2.0	0.9	1.1	0.6	1.8	0.9	1.5	2.2	1.8	2.0	0.8	0.7	0.7	0.8	1.4	1.4	0.9	1.5	2.1	2.4	0.7
DUT	Headcount	5	4	14	9	7	13	12	12	13	11	6	5	4	6	3	3	6	5	7	6	5
	FTE	2.7	2.1	6.0	5.0	5.8	5.5	5.5	6.1	6.0	7.2	1.1	2.1	1.9	2.7	0.9	1.0	0.9	2.5	1.0	0.9	2.1
MUT	Headcount	6	5	5	4	4	3	4	3	3	3				1	1	1	1	1	1	3	6
	FTE	1.6	0.9	2.8	1.2	1.0	0.6	0.8	0.7	0.5	0.5				0.2	0.2	0.2	0.3	0.3	0.3	1.0	1.6
NMU	Headcount	10	11	11	12	13	11	12	13	13	14	14	15	16	18	18	18	17	17	16	15	12
	FTE	5.6	5.3	6.7	6.0	8.9	8.3	9.4	8.3	8.6	9.6	10.8	11.9	11.9	14.2	13.3	14.2	14.2	13.8	13.4	12.2	9.0
NWU	Headcount	10	15	22	24	23	15	34	38	30	27	29	27	26	24	30	33	41	29	34	27	24
	FTE	8.5	13.6	18.7	15.8	15.3	9.6	28.1	19.1	20.2	17.7	18.1	15.3	18.4	13.1	19.3	20.3	26.6	17.4	18.2	16.1	16.2
RU	Headcount	7	7	6	6	6	6	7	8	6	6	7	8	7	7	9	8	8	8	10	8	8
	FTE	5.6	6.5	5.4	5.5	5.6	5.6	5.8	7.2	5.7	5.6	5.9	7.1	5.3	6.2	8.1	7.2	7.2	7.2	9.2	7.2	7.0
SMU	Headcount																33	8	8	13	13	14
	FTE																21.5	5.1	5.4	6.9	6.9	7.9
SPU	Headcount																	1	3	4	6	8
	FTE																	0.8	2.5	3.6	3.9	3.8
SU	Headcount		18	16	17	15	15	15	16	18	17	17	17	19	21	24	22	25	25	28	21	20
	FTE		13.4	10.3	12.7	11.8	11.4	12.7	13.2	11.4	14.8	15.4	15.6	16.3	16.8	19.9	19.8	19.2	18.9	16.7	15.4	15.3
TUT	Headcount	21	20	16	22	21	23	18	17	16	17	11	12	10	11	14	15	16	14	13	14	13
	FTE	5.7	6.6	4.7	7.7	7.8	9.0	7.4	5.9	5.2	5.8	6.2	5.7	4.3	5.3	7.6	9.1	10.9	9.6	9.0	10.3	9.0
UCT	Headcount	15	16	11	12	13	12	20	22	21	19	18	24	24	23	23	21	21	21	23	23	23
	FTE	12.7	11.8	9.4	10.0	10.2	9.1	16.6	16.5	15.8	14.8	13.8	17.8	18.9	19.6	20.2	18.1	17.9	18.0	19.6	19.1	20.0
UFH	Headcount	4	4	6	5	4	3	3	5	4	6	5	5	5	5	4	4	5	3	5	5	5
	FTE	2.8	2.8	3.8	3.4	3.3	2.4	2.2	4.4	2.9	4.9	4.5	4.5	4.5	3.8	3.6	3.6	3.8	2.7	4.5	4.7	4.7
UFS	Headcount	20	20	8	12		13	14	14	15	17	15	15	14	14	14	16	19	16	17	17	20
	FTE	16.0	8.4	5.8	7.0		8.8	8.8	11.1	11.1	12.0	11.7	12.8	10.9	11.9	11.2	11.5	14.4	10.0	8.4	8.8	10.4
UJ	Headcount	17	16	17	18	25	24	18	18	18	19	23	20	23	26	27	27	31	33	39	47	46
	FTE	9.0	8.5	10.3	10.4	16.9	16.5	10.1	10.4	11.9	13.6	16.2	14.5	17.2	16.3	17.9	18.6	20.8	23.5	27.7	33.8	34.1
UKZN	Headcount	36	36	38	39	32	24	25	45	62	43	28	26	23	25	25	22	34	34	32	27	28
	FTE	22.9	20.8	21.9	20.6	18.9	17.6	19.7	31.8	42.1	29.1	21.3	20.0	17.7	19.7	18.2	16.6	24.4	27.6	28.7	24.4	24.1
UL	Headcount	35	32	35	34	34	41	38	36	33	32	14	16	17	18	24	18	17	17	16	17	17
	FTE	20.1	20.4	20.6	21.1	22.3	25.7	25.8	21.6	25.0	22.8	11.0	12.3	13.7	14.4	17.8	14.2	13.6	12.9	12.5	13.0	13.2
UNISA	Headcount	11	8	12	13	13	11	13	10	12	15	14	17	15	14	15	13	13	16	17	19	13
	FTE	6.7	3.0	8.7	7.9	8.0	7.3	8.3	6.6	8.0	8.9	9.6	12.0	10.6	10.5	11.5	10.1	10.1	4.8	5.6	5.7	3.9
UNIVEN	Headcount	6	6	8	5	8	6	7	7	7	7	9	8	8	7	7	7	7	6	7	7	11
	FTE	4.4	4.5	5.8	4.6	6.2	5.2	5.2	5.3	6.1	4.2	7.2	7.0	7.0	6.2	6.2	6.2	6.3	5.6	6.5	6.5	8.7

University	Metric	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
UNIZULU	Headcount	3	3	6	4	2	5	10	7	8	9	7	7	9	8	8	10	9	10	7	7	7
	FTE	2.7	1.7	3.8	2.4	1.5	4.1	8.6	5.1	5.4	6.8	4.9	5.1	6.8	5.7	5.8	7.9	7.2	7.7	5.6	5.6	4.1
UP	Headcount	20	19	21	27	29	32	26	26	25	25	23	20	22	23	23	24	18	17	20	20	19
	FTE	13.8	13.0	13.6	18.5	17.6	18.3	16.2	15.9	12.7	15.6	16.0	15.9	14.6	16.6	18.1	17.2	14.0	13.0	14.2	13.5	15.1
UWC	Headcount	11	11	12	12	11	10	18	12	15	11		1	16	23	22	23	22	23	22	19	20
	FTE	7.3	7.3	8.6	10.2	9.1	8.3	9.2	9.9	11.7	9.7		0.6	13.9	14.5	17.6	18.7	16.6	16.9	17.7	13.9	14.1
Vista	Headcount	12	11	14	9																	
	FTE	8.3	6.4	6.9	6.8																	
VUT	Headcount	8	8	8	6	9	9	7	8	9	10	9	10	8	9	10	12	10	13	15	14	19
	FTE	4.9	5.5	4.5	4.0	4.3	4.0	4.1	4.4	5.2	5.9	6.4	8.0	7.0	7.9	8.5	9.6	7.4	7.8	9.6	9.9	9.5
WITS	Headcount	36	42	50	47	46	40	38	37	34	35	37	88	86	95	90	102	106	105	106	107	105
	FTE	22.7	27.3	28.4	28.6	27.1	23.2	22.7	23.1	21.3	20.7	22.1	41.5	40.8	42.9	43.1	50.0	51.7	51.5	51.0	51.7	50.4
WSU	Headcount	5	3	4	6	7	8	9	10	10	10	13	17	16	15	17	16	16	15	15	13	15
	FTE	3.9	1.4	1.7	3.6	3.6	4.2	5.6	5.6	5.5	5.5	6.8	9.7	9.7	10.0	8.4	8.4	8.4	7.9	6.4	6.0	7.1

In the table above we report on the data as submitted by the various institutions to the DHET. We see that for some institutions and some years we see some fluctuation. In the Technical Appendix we report on some of the problems with the HEMIS data and, especially the reclassification of the CESM framework which in some cases explain the fluctuations. We have tried as far as possible to correct any glaring errors in the data submitted and to explain fluctuations where explanations are evident, but verifying historical data has not been possible.

We see missing and incorrect data submitted by UWC for 2009 and 2010 which contributes to the sharp decrease in total staff FTE for Physics. At NWU we see a sharp increase for 2006.

8. Staff diversity

Here we look at the trends in staff diversity between 2000 and 2020.

Figure 8-1: Percentage of staff in Physics by gender and year: 2000 - 2020

Figure 8-2: Percentage of staff in Physics by race and year: 2000 - 2020

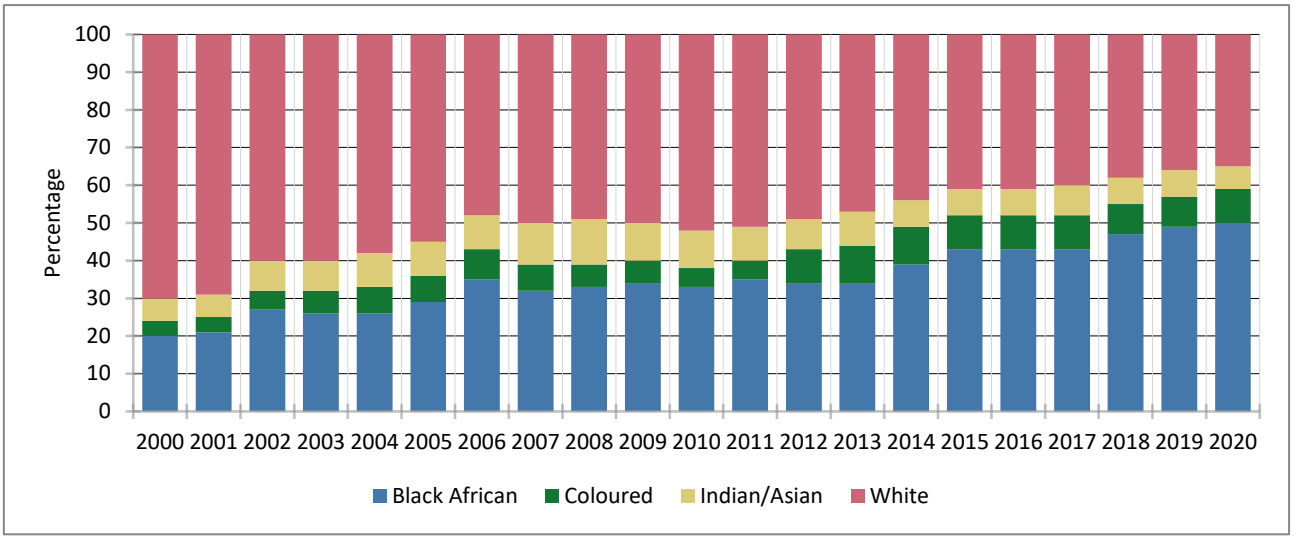


Figure 8-3: Percentage of staff in Physics by nationality and year: 2000 - 2020

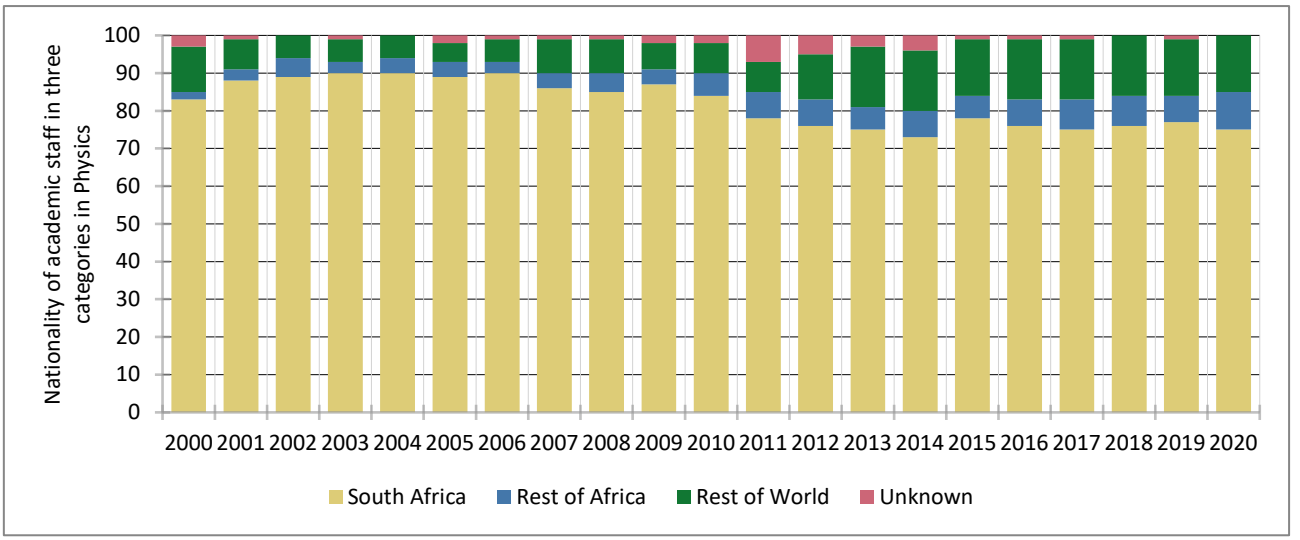


Figure 8-4: Percentage of staff in Physics by age (two categories) and year: 2000 - 2020

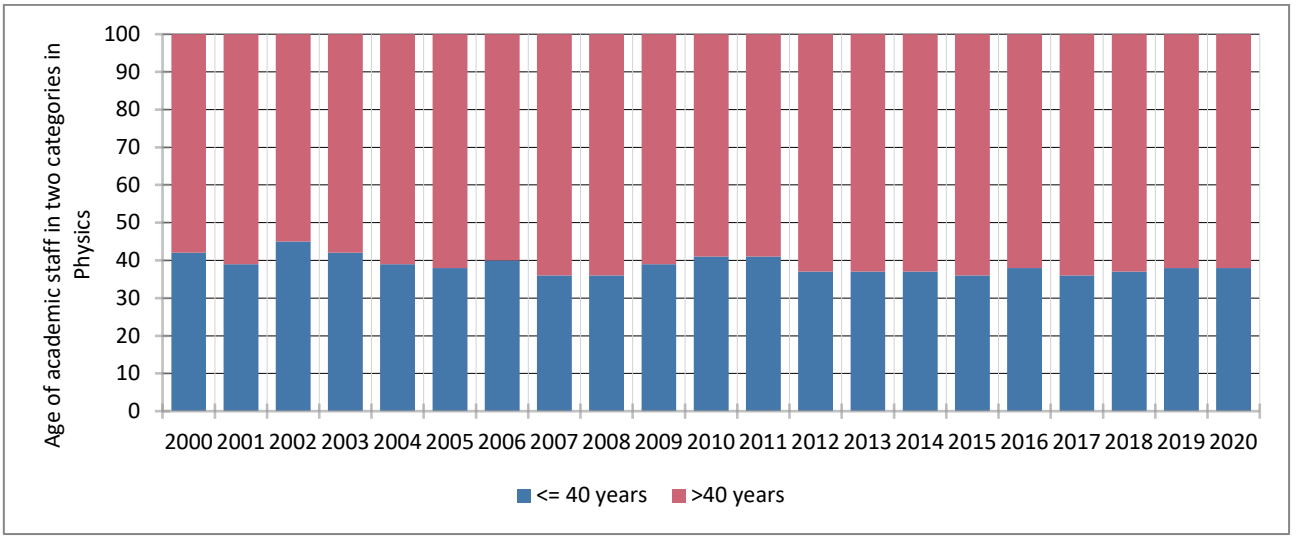
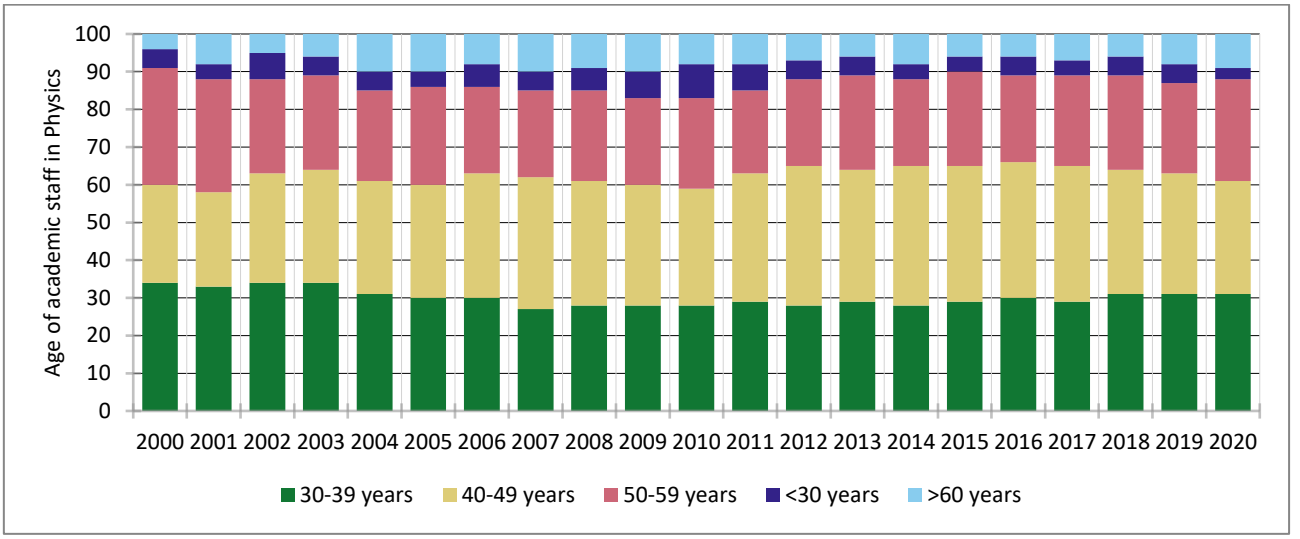


Figure 8-5: Percentage of staff in Physics by age (five categories) and year: 2000 - 2020



9. Academic pipeline

9.1. Honours students

9.1.1. Enrolments

Figure 9-1: Number of total Honours enrolments in Physics by year: 2000 - 2020

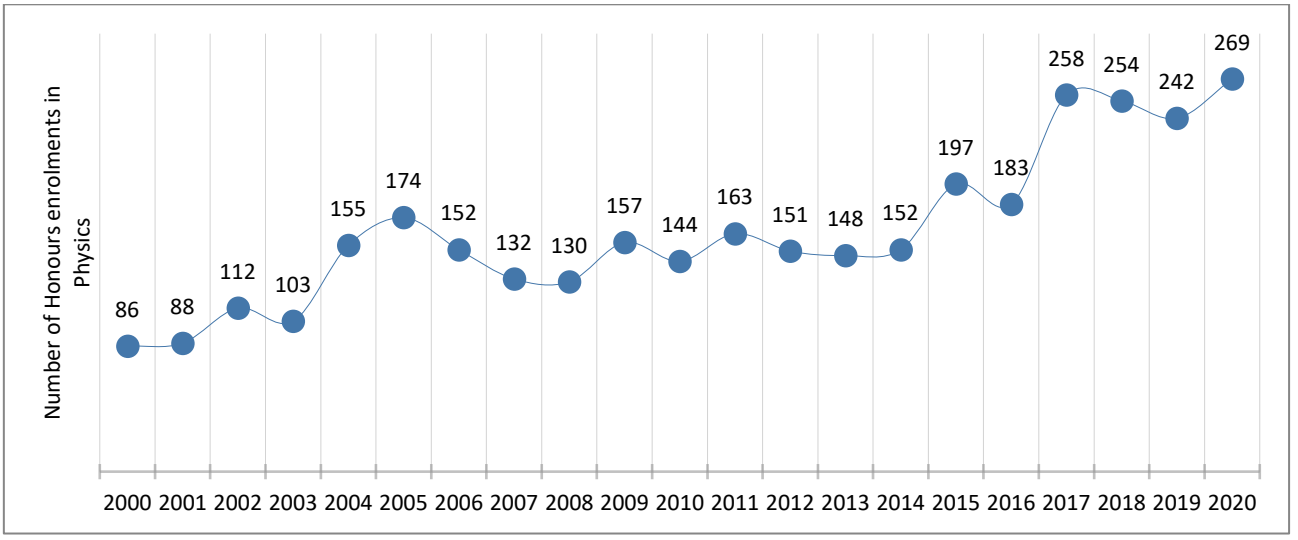
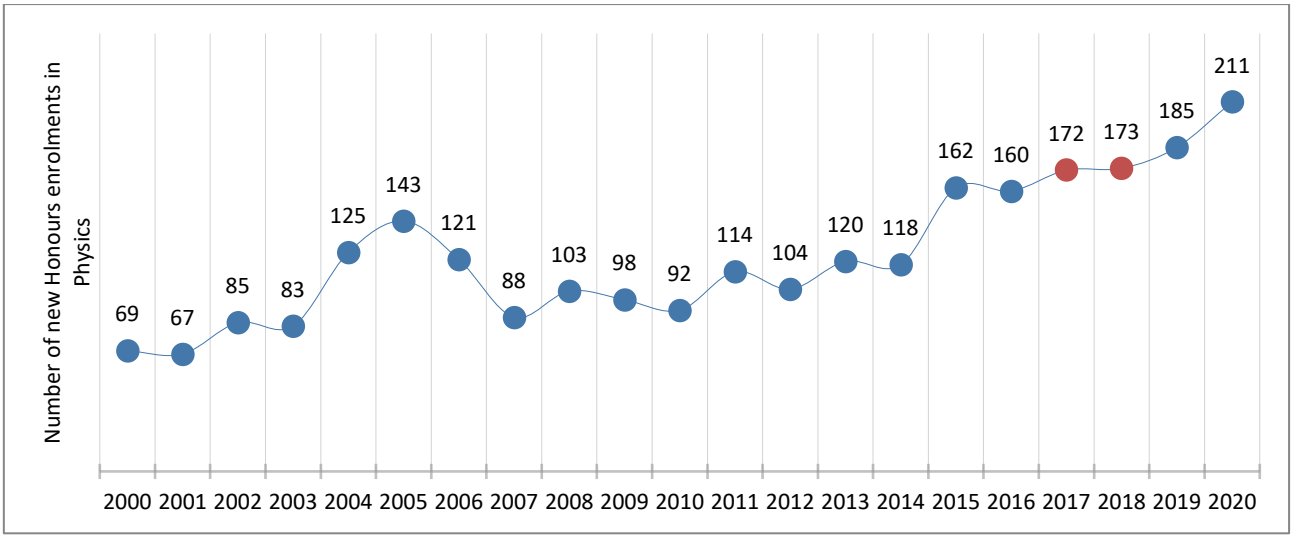


Figure 9-2: Number of new Honours enrolments in Physics by year: 2000 - 2020[2]



[2] Due to missing data reported for UNISA in 2017 and 2018 we have imputed data for these years for the entire system.

Figure 9-3: Percentage of total Honours enrolments in Physics by gender and year: 2000 - 2020

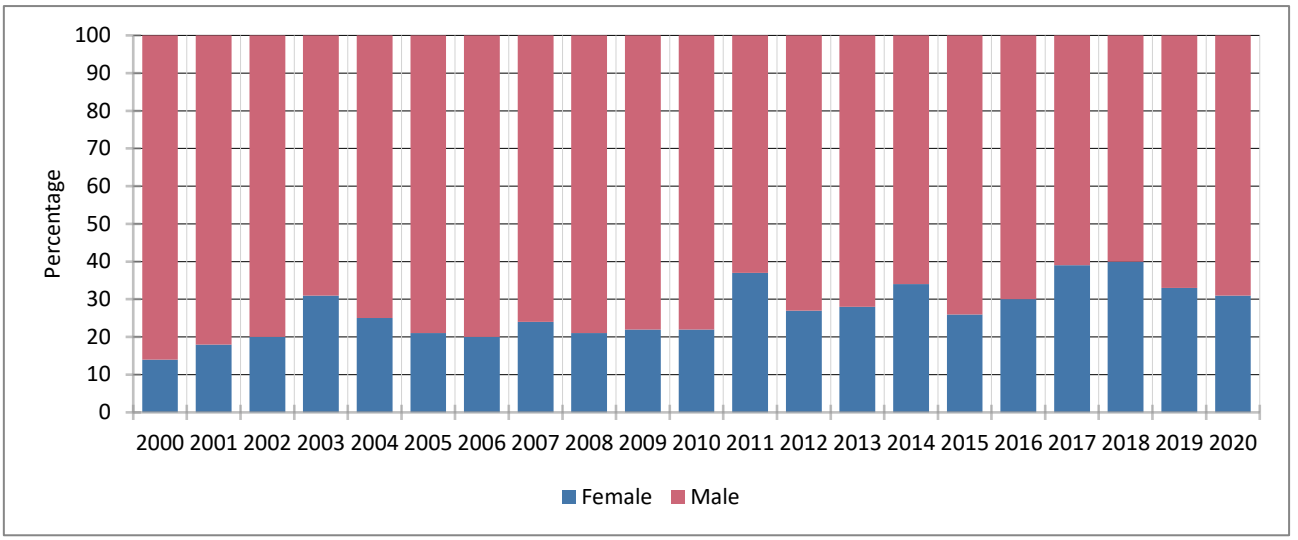


Figure 9-4: Percentage of total Honours enrolments in Physics by race and year: 2000 - 2020

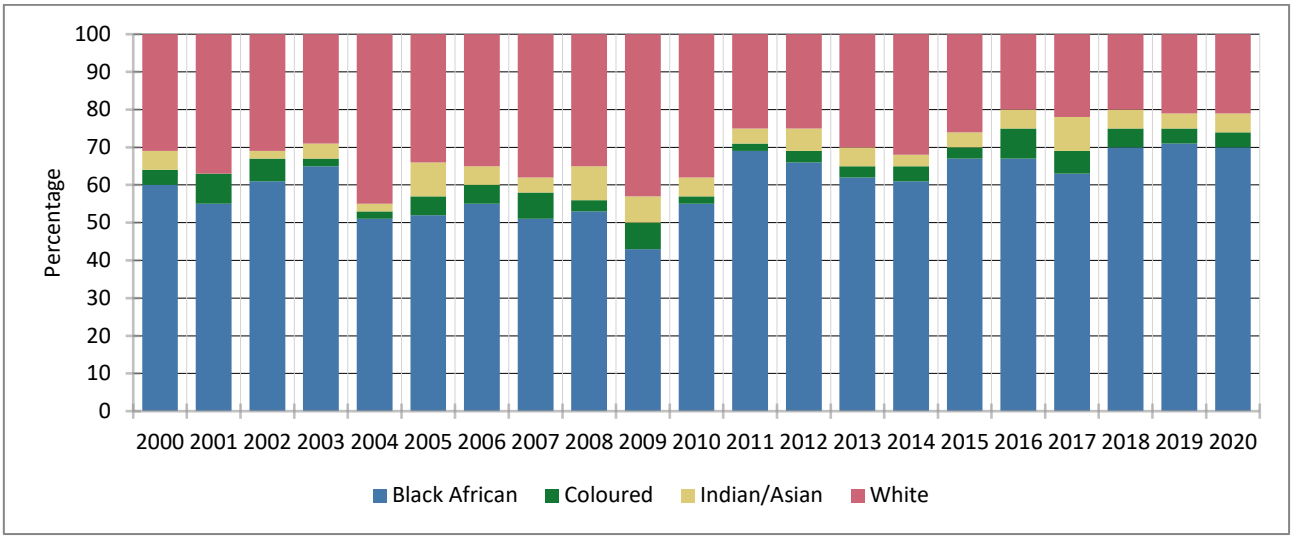


Figure 9-5: Percentage of total Honours enrolments in Physics by nationality and year: 2000 – 2020

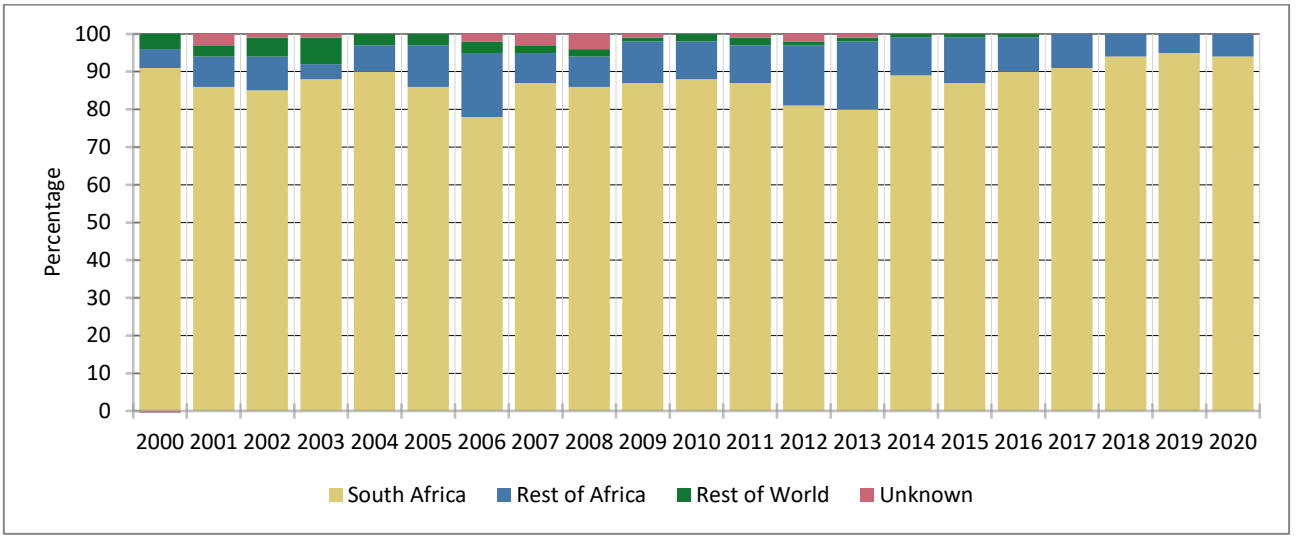
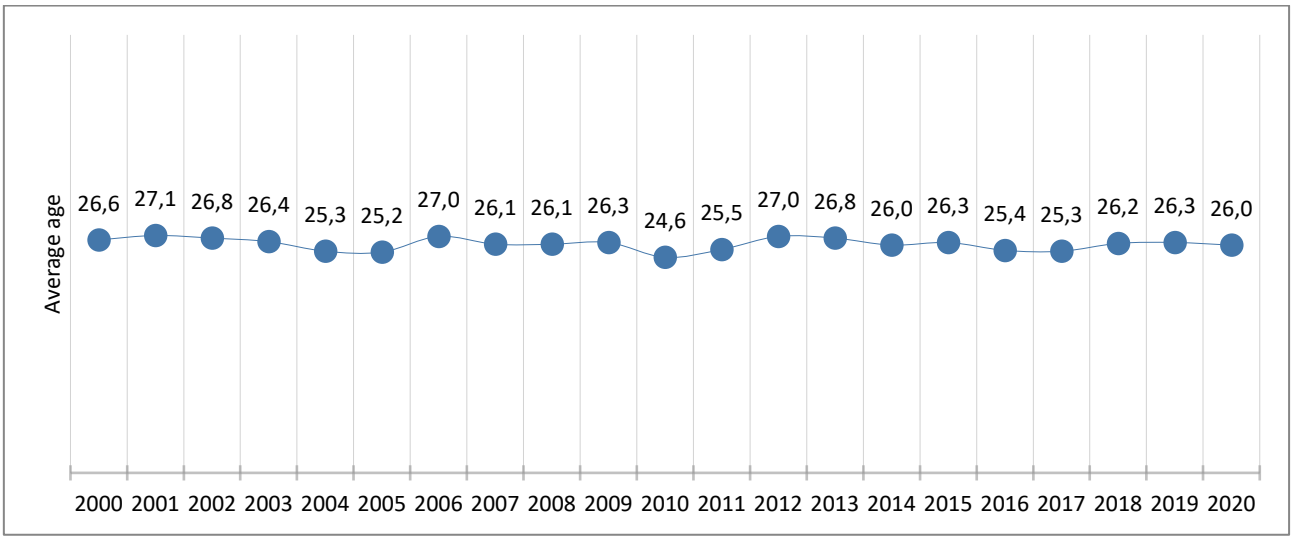


Figure 9-6: Average age of Honours students in Physics at commencement of studies by year: 2000 – 2020



In the box and whisker plot below, we show the distribution of the commencement age of Honours students. The thick, black horizontal line shows the median age while the mean age is depicted by the red dot. The median commencement age fluctuated slightly between 23 and 25 years old while the mean showed the same fluctuations between 25 and 27 years over the period analysed. In 2020 the median commencement age was 24 while the mean was slightly higher at 24 years. The range, as illustrated by the whiskers in the plot below shows that in 2020, Honours students were between the ages of 18 and 33 when enrolling for their Honours degrees in Physics.

Figure 9-7: Distribution of Honours enrolments' commencement age

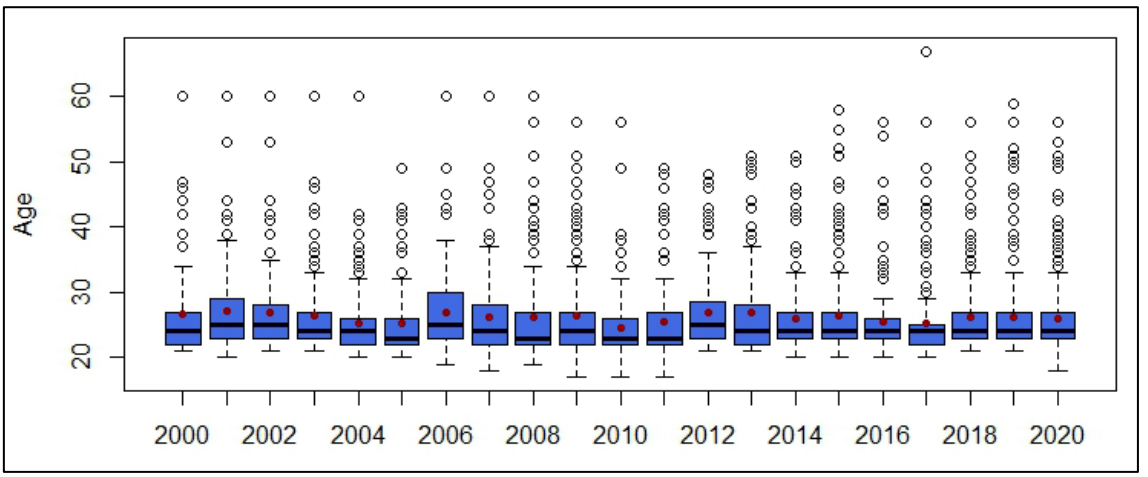


Table 18: Number of Honours enrolments per university in Physics

University	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NMU	4	7	4	8	4	7	6	3	4	5	5	5	6	3	2	4	1	1	3	2	3
NWU	11	10	10	10	13	13	10	15	12	11	12	17	21	7	14	10	14	20	9	10	
SU	4	3	5	5	10	11	12	10	10	13	4	7	9	8	11	6	9	14	11	12	12
UCT	5	6	14	13	26	19	26	22	21	26	26	25	22	21	24	21	21	34	32	26	35
UFH	1	3	2	1	2	1	4	3	4		7	10	9	4	4	11	2	8	47	37	21
UFS	1	9	8	10	15	21	3	9		11	14	7	10		1			1	1		4
UJ	5	2	11		8	5	3	3	6	3		5	5	2	2	5	11	15	11	8	16
UKZN	11	6	11	11	10	13	9	11	7	13	17	10	10	18	9	10	12	26	17	17	25
UL	10	2	8	9	9	11	11	7	6	8	11	12	10	22	18	13	14	15	8	15	16
UNISA	10	15	15	11	17	12	18	12	11	15	19	21	23	22	17	22	18	19	28	22	44
UNIVEN	3	2	1	3	3		2	3	5	7	2	3	4	8	6	7	9	11	12	12	9
UP	9	5	3	2	5	6	3	4	6	10	8	12	1	8	7	11	11	6	13	15	14
UWC	5	5	5		6	19	15	7	13	11			8	11	12	12	14	11	8	9	7
Vista	5		3	1																	
WITS	2	10	8	11	17	17	22	15	13	18	8	12	11	6	12	24	15	35	16	22	25
RU		2	1	1	3	1	1	1	4	4	1	3	1	5	1	3	1	3	2		1
UNIZULU		1	3	4	7	17	6	5	6	2	5	3	1	3	5	14	4	7	2	11	8
WSU				3		1	1	2	2		5	11			7	12	8	21	30	18	6
SMU																12	19	11	12	15	23

9.1.2. Graduates

Figure 9-8: Number of Honours graduates in Physics by year: 2000 - 2020

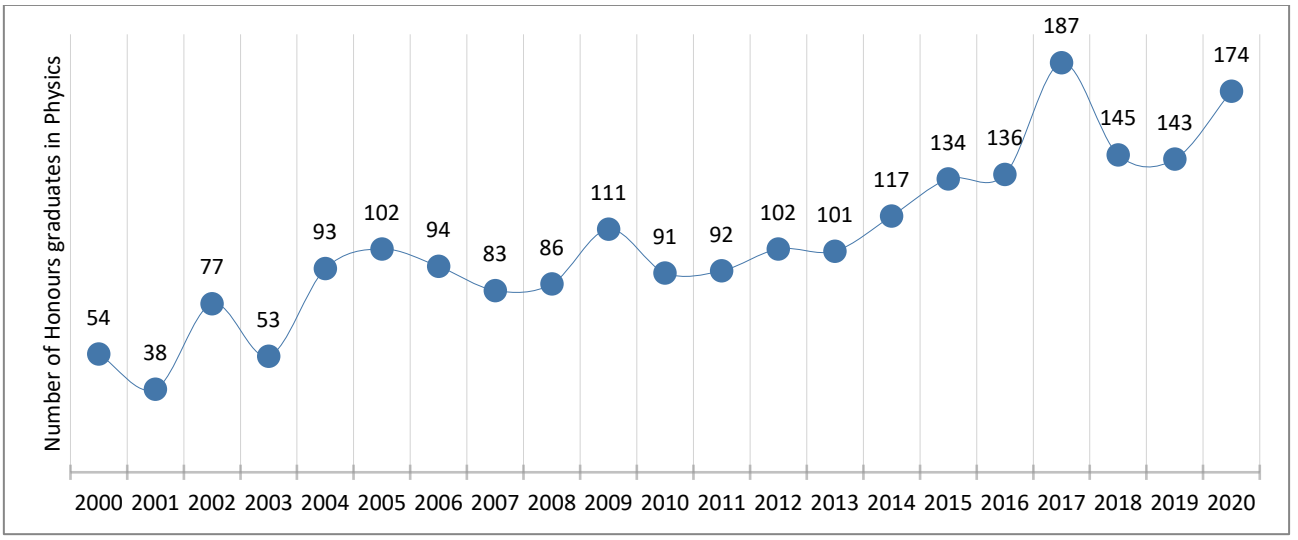


Figure 9-9: Percentage of Honours graduates in Physics by gender and year: 2000 - 2020

Figure 9-10: Percentage of Honours graduates in Physics by race and year: 2000 - 2020

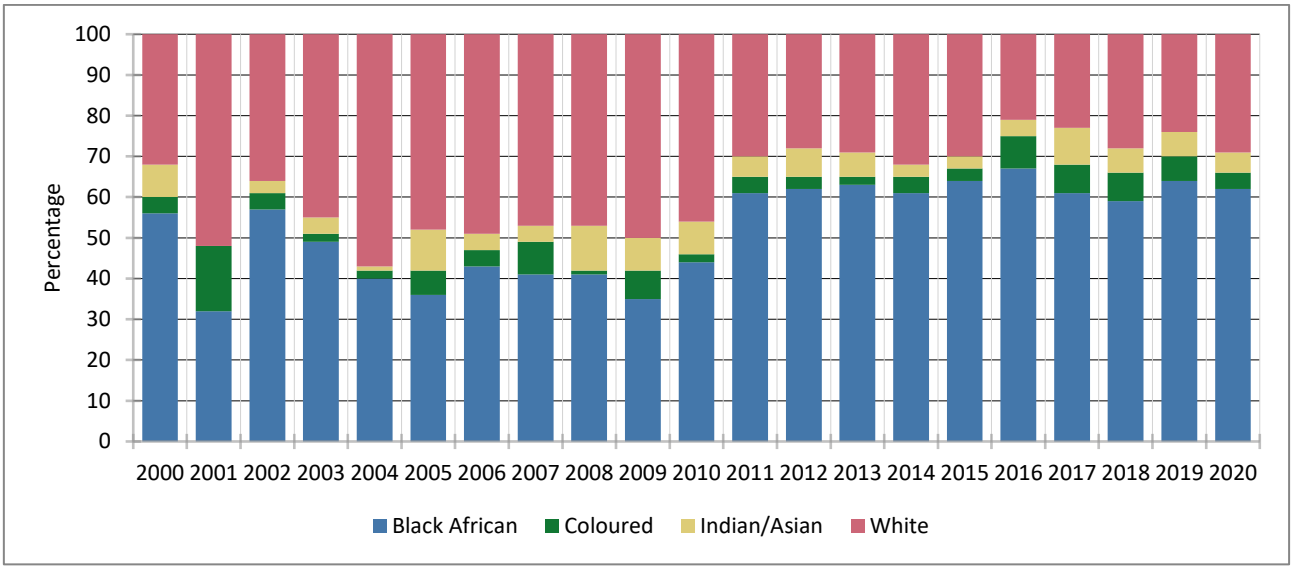


Figure 9-11: Percentage of Honours graduates in Physics by nationality and year: 2000 - 2020

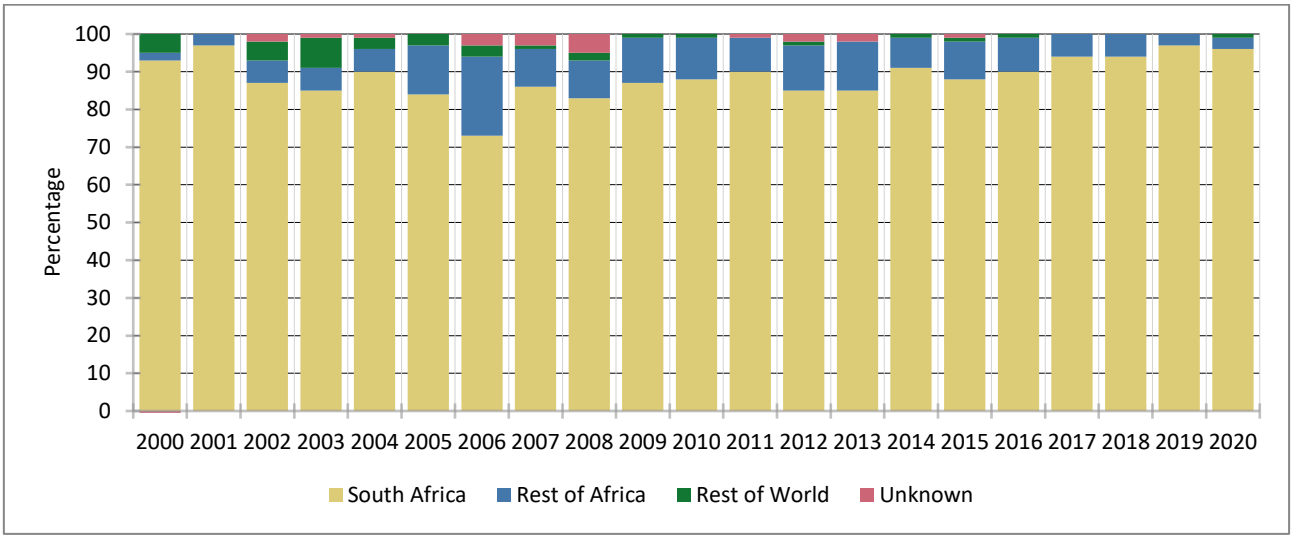
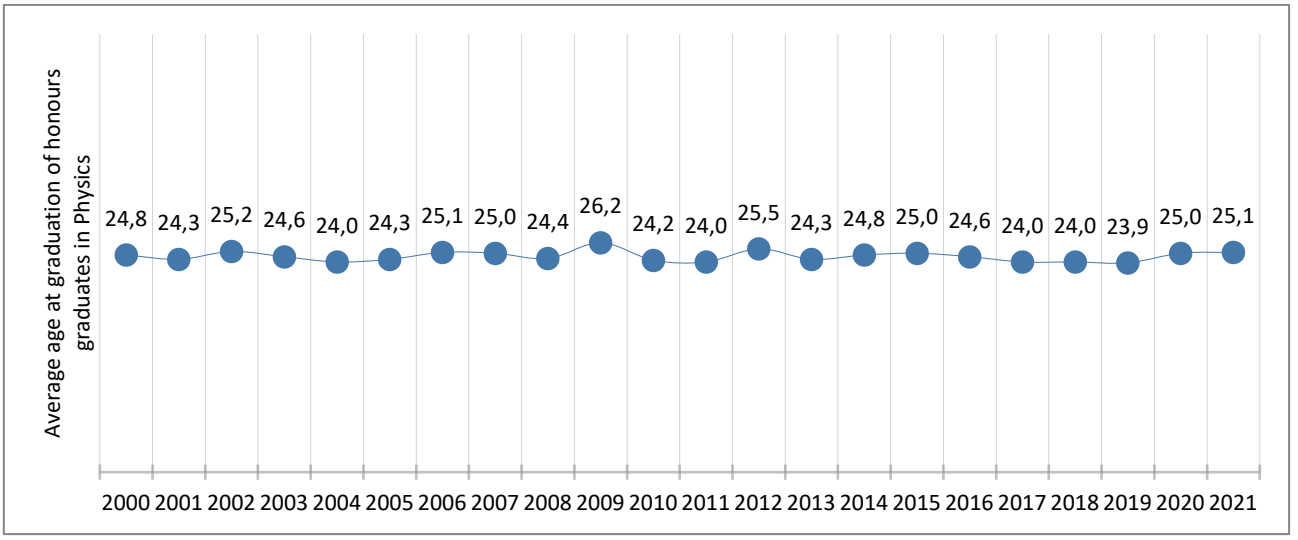


Figure 9-12: Average age at graduation of Honours students in Physics by year: 2000 - 2020



In the box and whisker plot below, we show the distribution of the graduation age of Honours students. The thick, black horizontal line shows the median age while the mean age is depicted by the red dot. The median graduation age remained consistent at 23/24 years while the mean fluctuated slightly between 24 and 26 years over the period analysed. In 2020 the median graduation age was 23 while the mean was slightly higher at 25 years. The range, as illustrated by the whiskers in the plot below, shows that in 2020, Honours students were typically between the ages of 18 and 30 when graduating with their Honours degrees in Physics.

Figure 9-13: Distribution of Honours students' graduation age

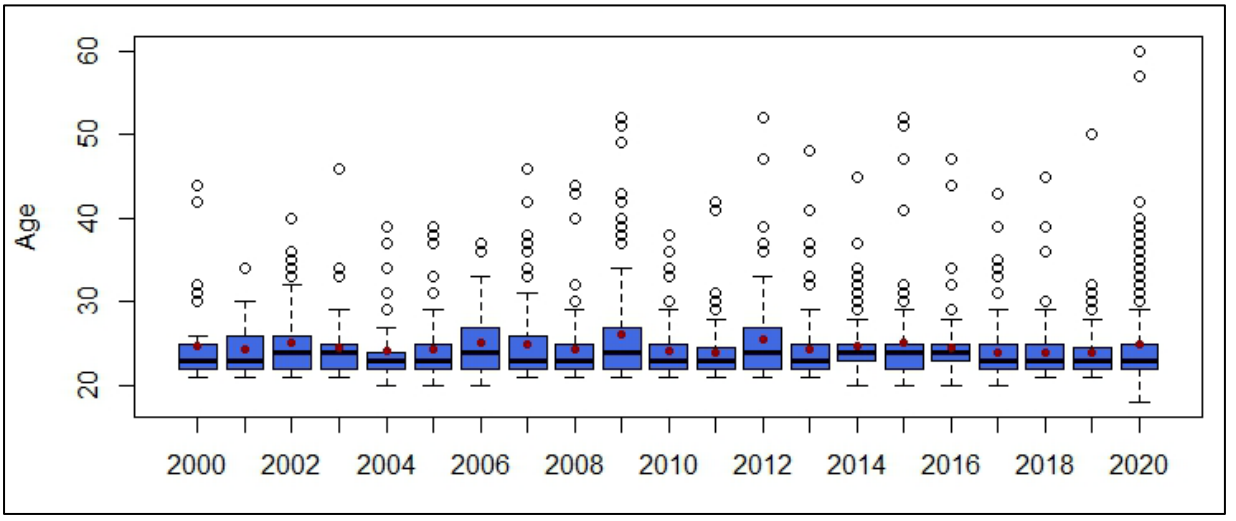
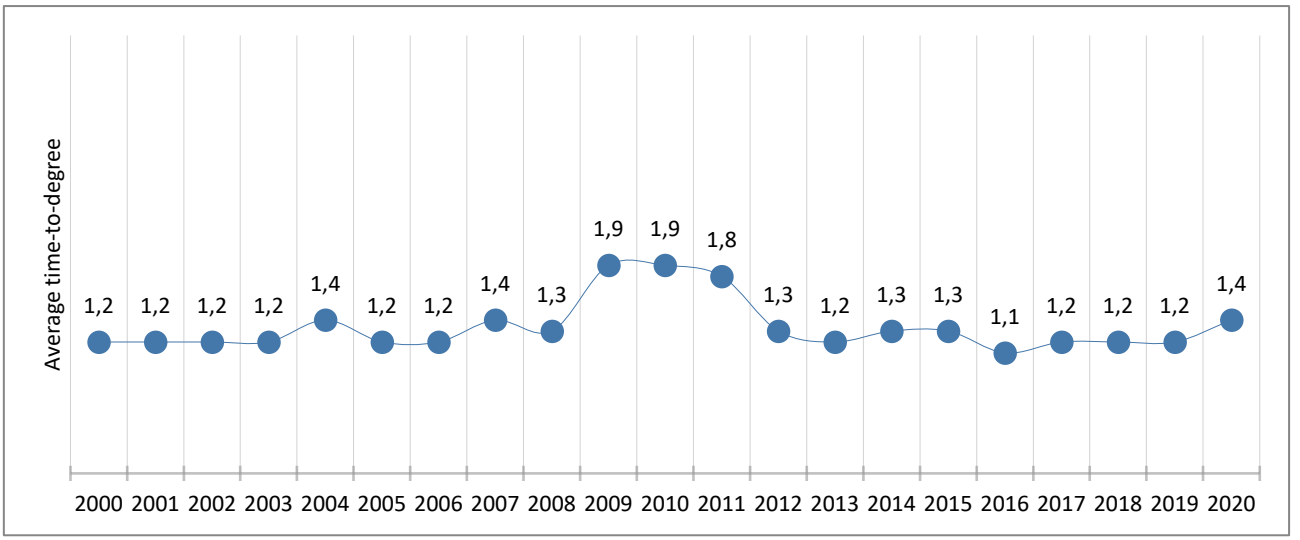


Table 3: Number of Honours graduates per university in Physics

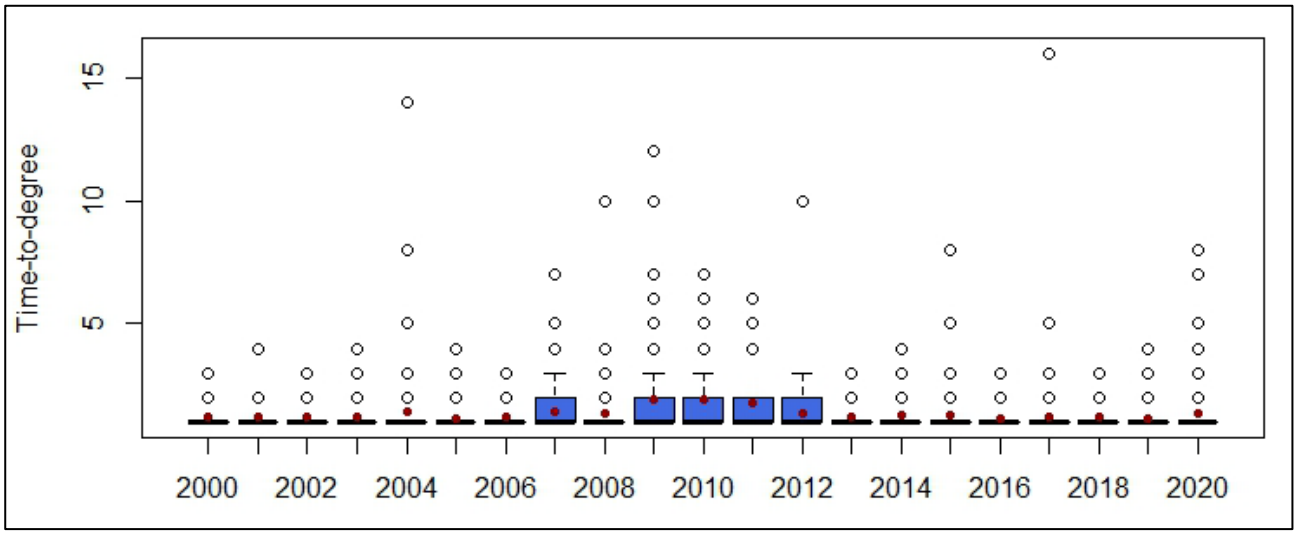
University	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NMU	3	3	2	4	2	4	6	1	2	3	3	1	3	1	1	3			1		1
NWU	8	1	5	2	7	8	2	8	7	7	6	5	14	3	5	3	9	17		1	
SU	3	3	5	4	7	9	10	9	10	13	2	7	8	5	10	4	7	11	9	8	10
UCT	5	4	14	13	22	18	25	22	21	24	22	23	20	21	23	20	20	33	30	23	25
UJ	4		8		6	5	2		2	1			4		1	1	4	11	8	3	7
UKZN	9	4	11	7	6	8	4	6	5	9	16	9	9	16	9	5	11	19	14	12	18
UL	8	2	6	2	5	4	6	4	4	7	9	8	10	18	14	12	13	15	6	13	16
UNIVEN	2	1	1	3	2			2	2	6	2	2		4	5	6	6	5	6	5	6
UP	5	1	2	1	3	1	3	1	5	10	6	10	1	8	7	10	11	6	13	15	13
UWC	4	4	3		6	17	10	6	7	6			8	7	11	10	13	8	8	7	7
Vista	3		2																		
RU		1	1	1	3	1	1	1	4	3		2	1	5	1	3	1	2	2		1
UFS		5	7	3	7	9	2	5		4	8	4	6		1			1	1		4
UNISA		2	1	2				3	1	1	5		2	1	2	4	3	2	3	1	10
WITS		7	5	7	11	16	16	10	10	15	8	12	10	6	12	24	12	28	13	20	19
UFH			2			1	3		3		4	5	5	3	3	9		6	7	7	8
UNIZULU			2	2	6	1	4	4	3	2		2	1	3	5	11	3	5	2	5	7
WSU				2				1				2			7	4	6	11	10	8	4
SMU																5	17	7	12	15	18

Figure 9-14: Average time-to-degree of Honours graduates in Physics by year: 2000 – 2020



In the box and whisker plot below, we show the distribution of the time-to-degree age of Honours students. The thick, black horizontal line shows the median while the mean time-to-degree is depicted by the red dot. The median and mean completion time remained consistent at 1 year. The range, as illustrated by the whiskers in the plot below, showed some variation between 2007 and 2012, but Honours students typically complete their Honours studies in Physics in one year.

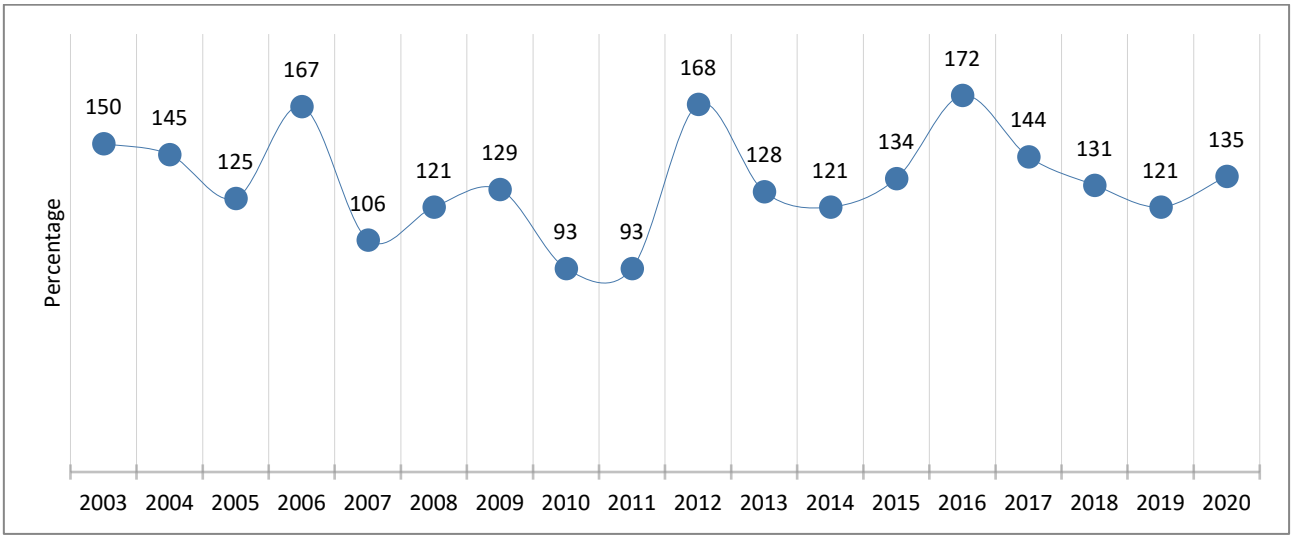
Figure 9-15: Distribution of Honours students' time-to-degree



A conversion rate is an indicator which measures the 'flow' of postgraduate students from one degree programme to another qualification. It is important to note that this indicator is not cohort-based. This is a simple measurement of the percentage new enrolments in a given year divided by the average number of graduates in the previous three years. In the figure below we report on the conversion rates of Honours studies to Masters studies in Physics: in other words, at what rate do Honours students convert to Masters studies in general and without tracking students specifically? Given the fluctuating (and often small) numbers of graduates and enrolments across years we report on at three-year average conversion rate (for details on the calculation of this indicator refer to Appendix 2).

In the figure below we see that in Physics, the conversion rate for 2003 was 150% and in 2020 this percentage was 135%. However, we see large fluctuations between years but generally the conversion rate to Masters studies in Physics is very high with a larger number of Masters students enrolling than who are graduating at an Honours level.

Figure 9-16: Conversion rates from Honours to Masters studies in Physics by year: 2000 - 2020[3]



[3] Due to errors in the data reported for UNISA in 2017 and 2018 we have excluded UNISA from our calculation of the conversion rate.

9.2. Masters students

9.2.1. Enrolments

Figure 9-17: Number of total Masters enrolments in Physics by year: 2000 - 2020

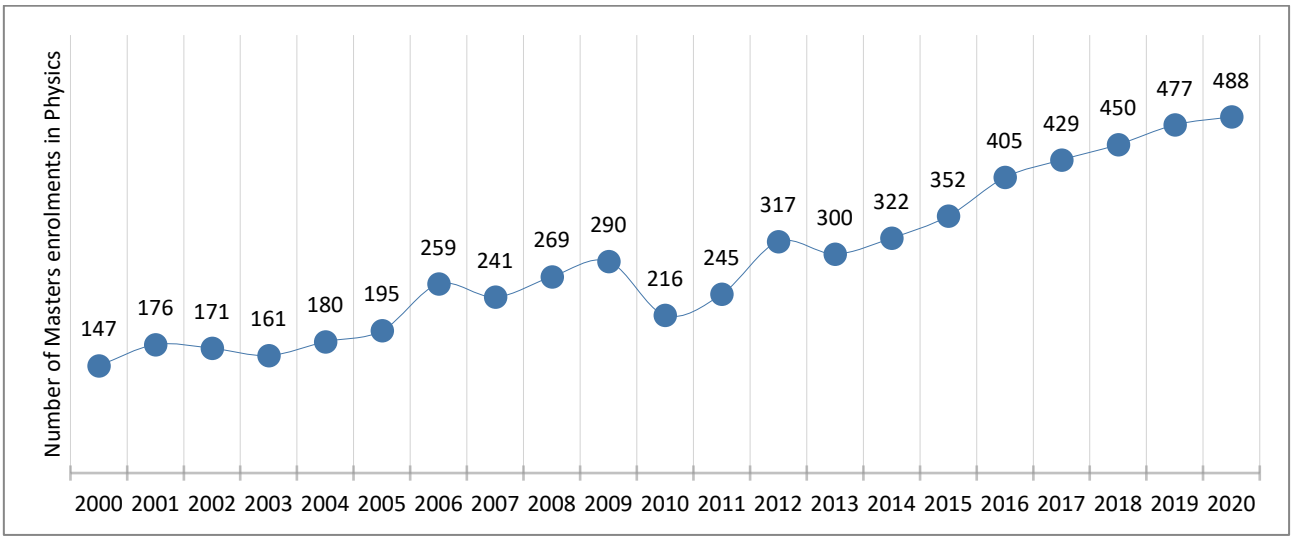
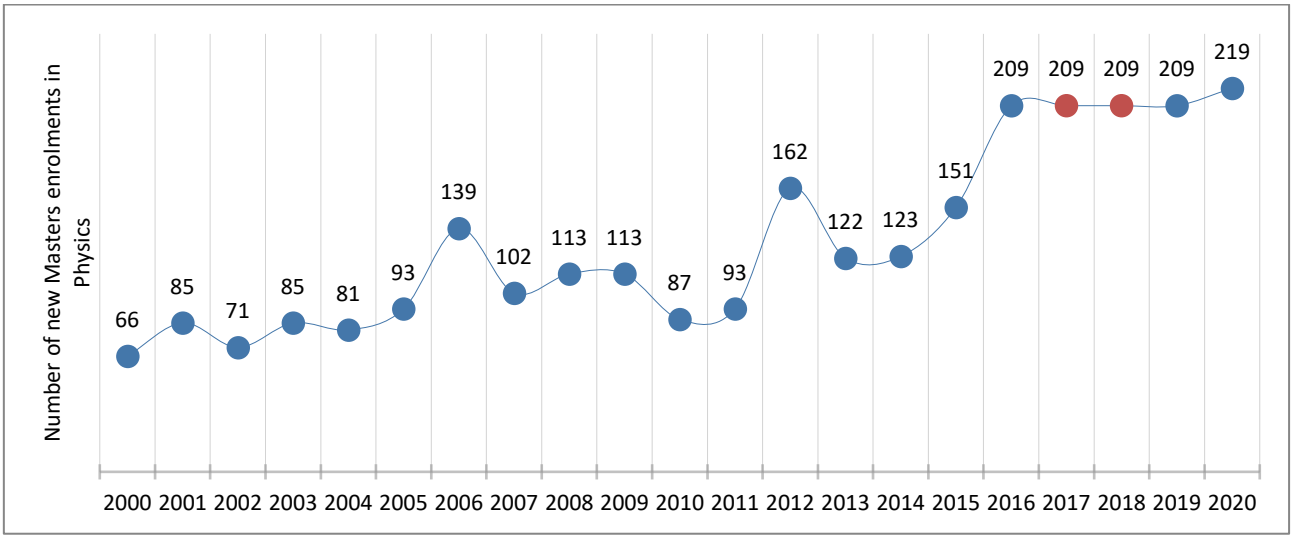


Figure 9-18: Number of new Masters enrolments in Physics by year: 2000 - 2020[4]



[4] Due to missing data reported for UNISA in 2017 and 2018 we have imputed data for these years for the entire system.

Figure 9-19: Percentage of total Masters enrolments in Physics by gender and year: 2000 - 2020

Figure 9-20: Percentage of total Masters enrolments in Physics by race and year: 2000 - 2020

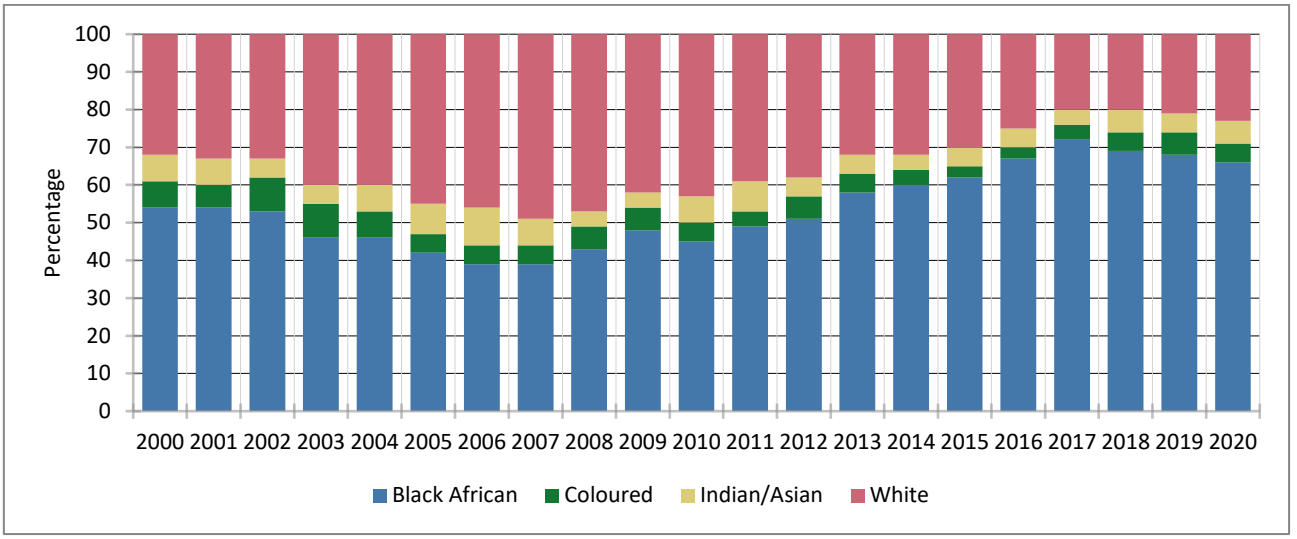


Figure 9-21: Percentage of total Masters enrolments in Physics by nationality and year: 2000 - 2020

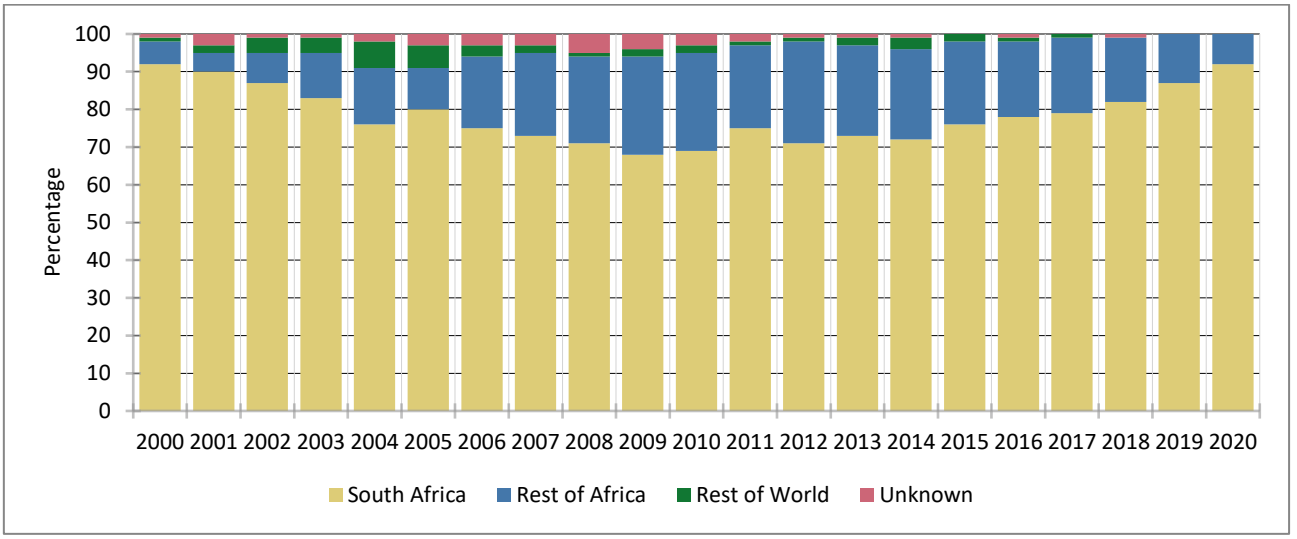
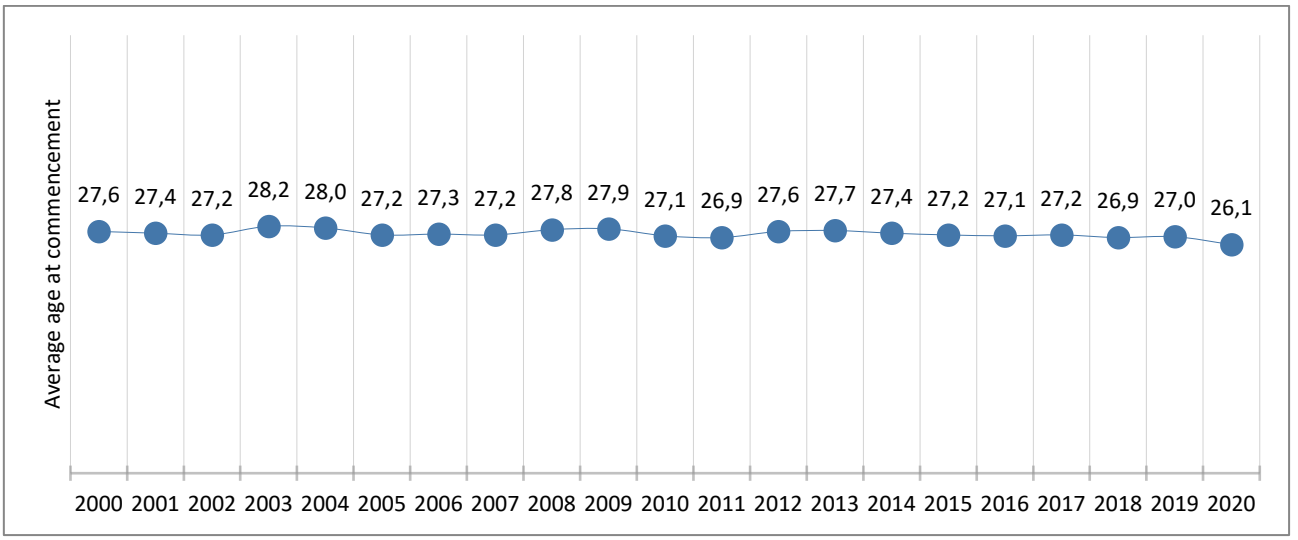


Figure 9-22: Average age of Masters students at commencement of studies in Physics by year: 2000 – 2020



In the box and whisker plot below, we show the distribution of the commencement age of Masters students. The thick, black horizontal line shows the median age while the mean age is depicted by the red dot. The median commencement age fluctuated slightly between 25 and 27 years while the mean showed the same fluctuations between 26 and 28 years over the period analysed. In 2020 the median commencement age was 25 while the mean was slightly higher at 26 years. The range, as illustrated by the whiskers in the plot below, has decreased over time and shows that in 2020, Masters students were between the ages of 21 and 28 when enrolling for their Masters degrees in Physics.

Figure 9-23: Distribution of Masters enrolments' commencement age

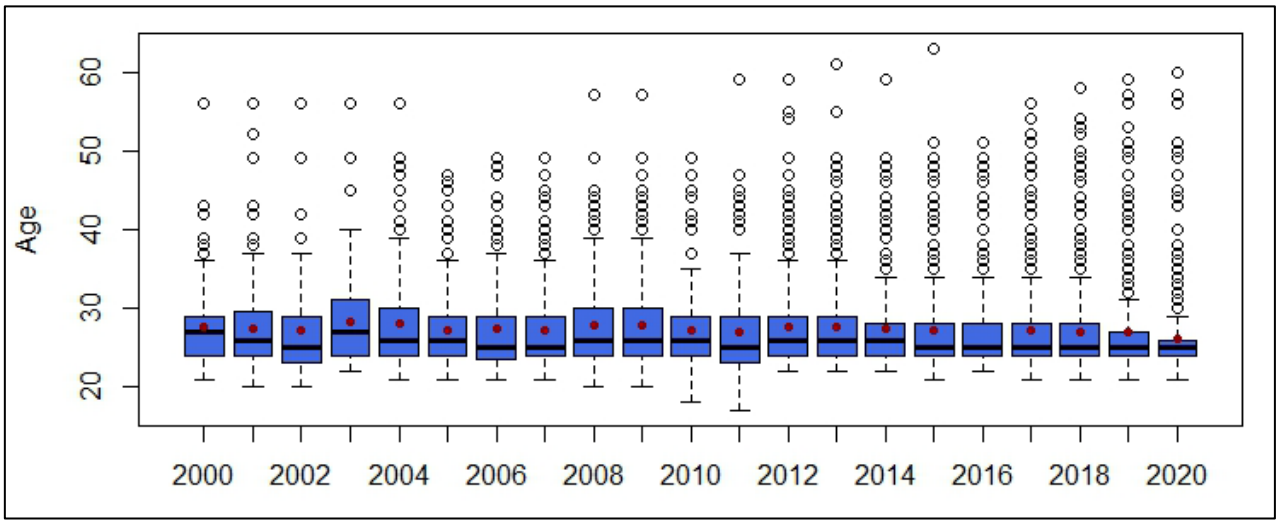


Table 20: Number of Masters enrolments per university in Physics

University	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NWU	22	33	38	8	12	25	19	11	14	12	13	18	17	17	18	16	14	20	27	26	30
SU	6	9	12	15	19	23	21	20	25	29	36	32	47	25	22	23	20	18	16	17	19
UCT	16	16	17	23	30	34	32	31	38	49	46	48	48	42	47	42	34	40	40	48	50
UFH	2	1	2	4	3	3	4	9	5	7	6	12	14	17	15	14	26	22	15	9	3
UFS	15	16	16	15	14	17	19	13	14	14	11	14	9				13	13	22	23	26
UJ	5	6	6	11	5	4	7	6	3	12	7	9	5	8	7	26	34	39	47	51	44
UKZN	17	21	11	11	16	21	22	25	34	31	36	41	40	39	40	41	38	41	45	38	39
UL	17	16	14	15	16	14	12	13	12	13	10	15	16	27	31	23	19	16	20	27	39
UNISA	2	2	4	5	5	7	4		4	4	4	9	8	4	13	11	11	20	15	25	13
UNIVEN	1	1	1	1	2	2	1		1	3	6	6	4	3	7	9	13	12	13	8	11
UNIZULU	2	2	1		3	8	16	7	11	10	4	7	5	7	5	6	15	14	11	10	12
UP	8	9	6	9	7	6	9	8	6	9	11	16	25	26	26	22	27	29	22	35	46
UWC	13	13	15	16	13	17	28	23	23	24			28	26	24	36	39	42	40	40	40
Vista	1																				
WITS	16	19	20	22	23		49	50	58	59	14	4	32	37	42	56	68	64	74	68	64
WSU	4							1	1	1	1	1	1					2	2		
NMU		6	5	4	7	8	7	12	9	5	7	7	9	11	10	10	17	15	18	15	16
RU		6	3	2	5	6	9	12	11	8	4	6	9	11	15	13	13	13	15	15	12
SMU																4	4	9	8	9	13
TUT																				13	11

9.2.2. Graduates

Figure 9-24: Number of Masters graduates in Physics by year: 2000 - 2020

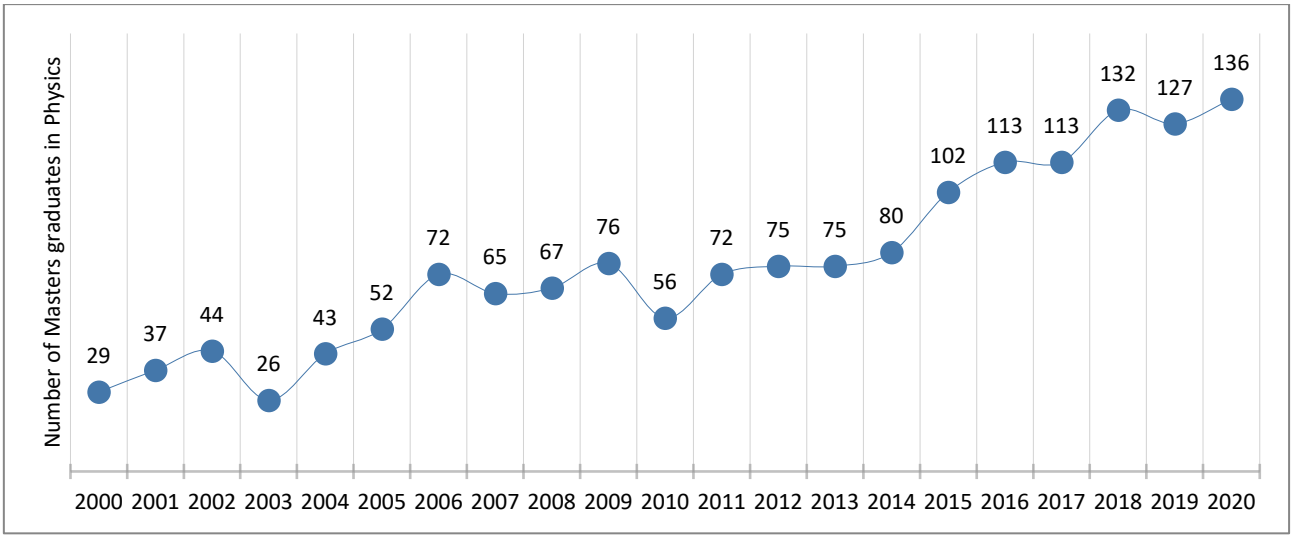


Figure 9-25: Percentage of Masters graduates in Physics by gender and year: 2000 - 2020

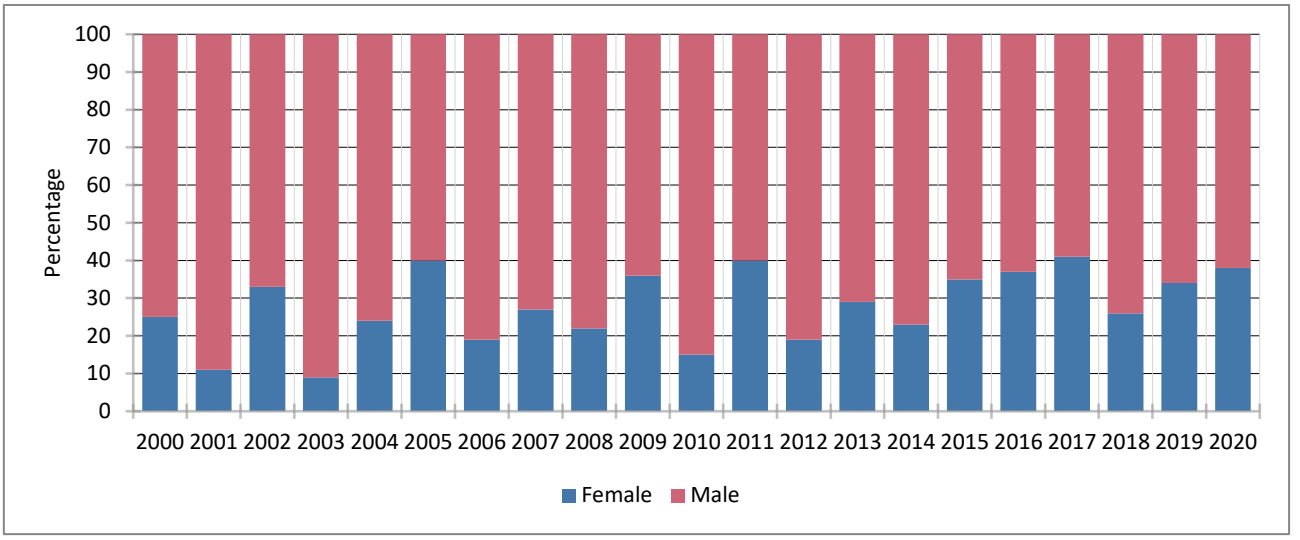


Figure 9-26: Percentage of Masters graduates in Physics by race and year: 2000 - 2020

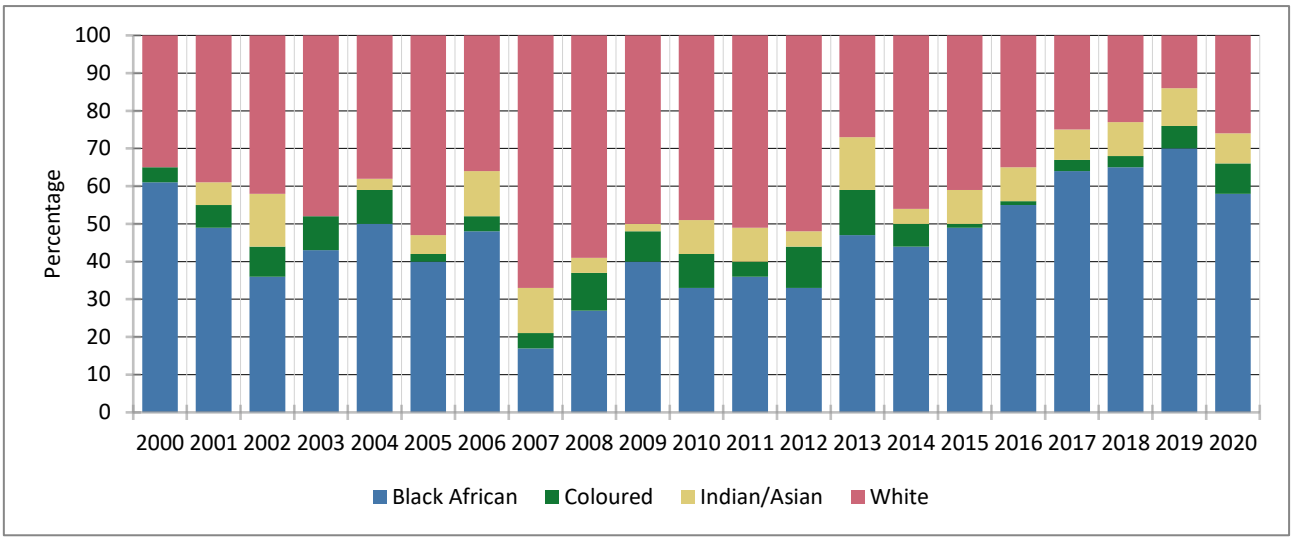


Figure 9-27: Percentage of Masters graduates in Physics by nationality and year: 2000 - 2020

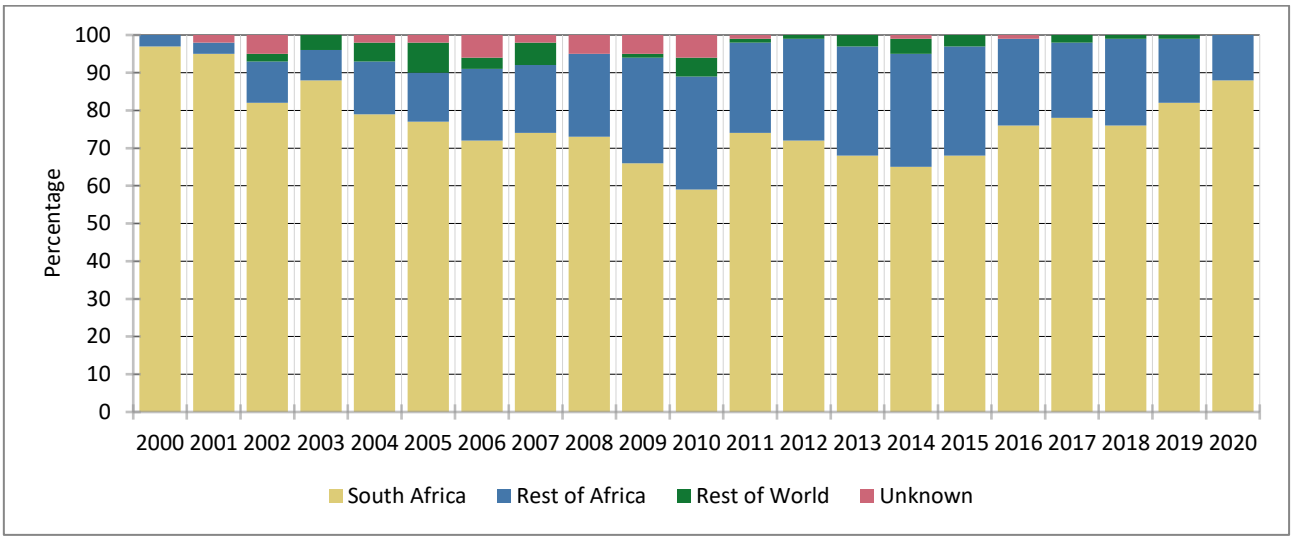
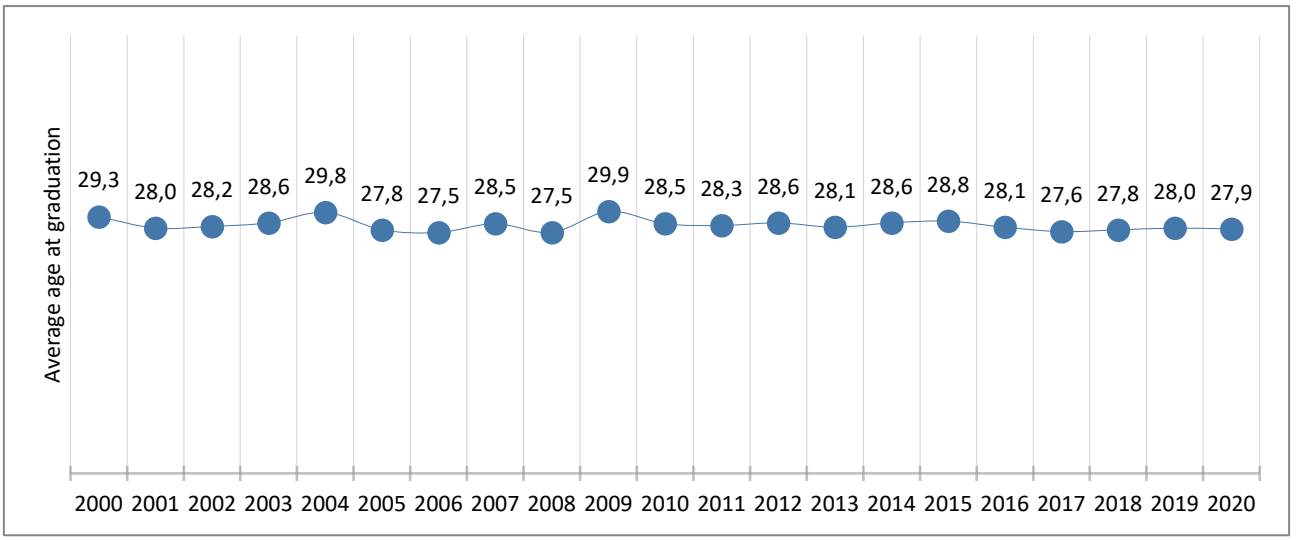


Figure 9-28: Average age at graduation of Masters students in Physics by year: 2000 - 2020



In the box and whisker plot below, we show the distribution of the graduation age of Masters students. The thick, black horizontal line shows the median age while the mean age is depicted by the red dot. The median graduation age remained consistent at 23/24 years old while the mean fluctuated slightly between 28 and 30 years over the period analysed. In 2020 the median graduation age was 23 while the mean was higher at 27.9 years. The range, as illustrated by the whiskers in the plot below shows that in 2020, Masters students were between the ages of 22 and 32 when completing their Masters degrees in Physics.

Figure 9-29: Distribution of Masters students' graduation age

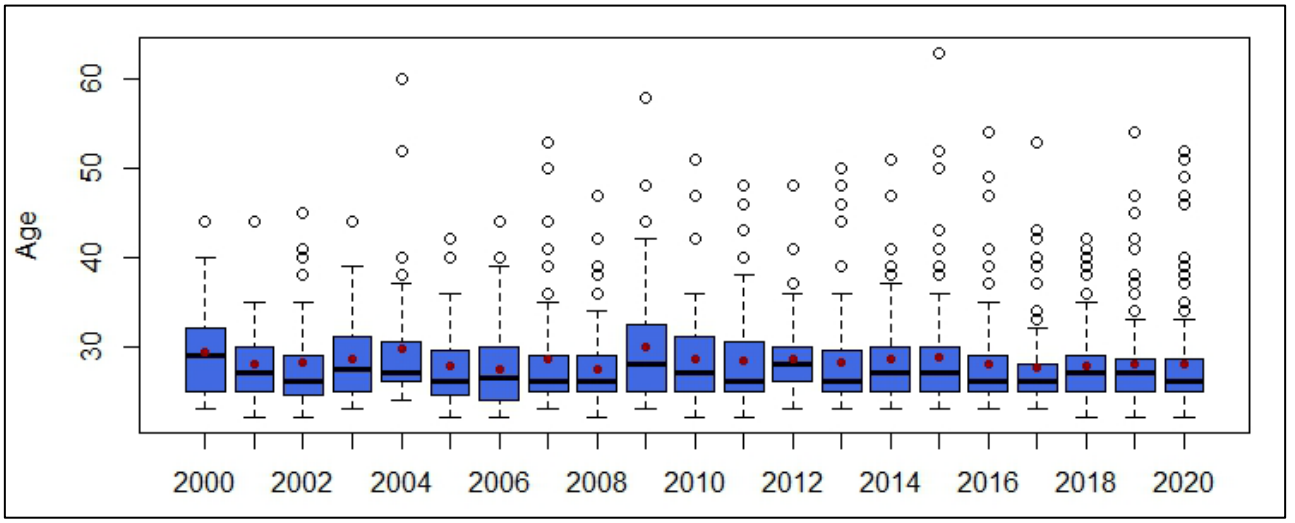
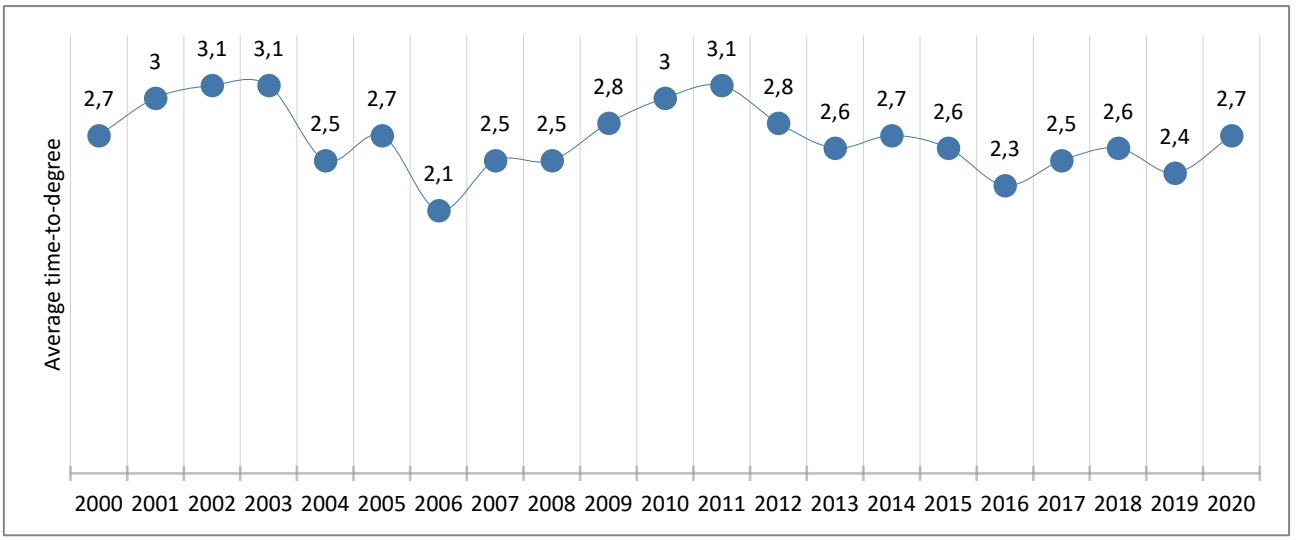


Table 41: Number of Masters graduates per university in Physics

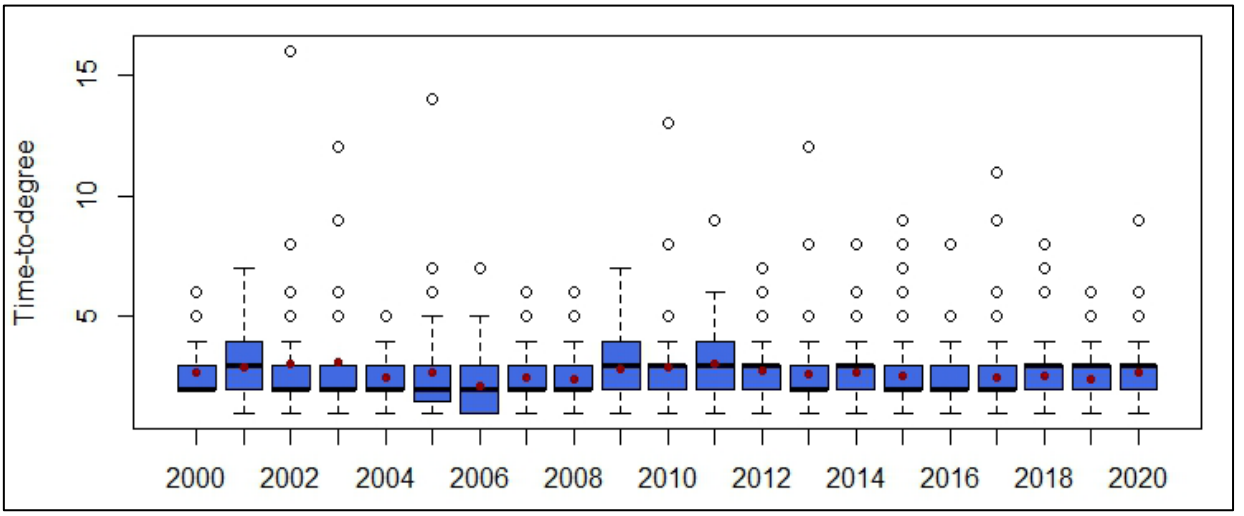
University	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NWU	9	4	9	3	3	4	5	2	4	5	1	5	7	2	3	6	5	3	6	11	8
SU	3	1	5	1	6	4	9	4	10	6	12	11	8	8	11	7	10	5	5	4	8
UCT	2	3	7	3	6	13	12	9	9	12	16	16	15	13	14	15	5	10	9	12	14
UFS	4	5	4	3	3	4	8	7	3	5	1	8	2				7	2	6	7	4
UJ	2	2	1	3	3	1	1	2		1		4	2	2		7	10	6	14	15	6
UKZN	1	5	6	1	1	6	6	5	7	11	10	11	9	13	9	17	19	19	19	16	19
UL	3	2	2	1	4	2		2	1	4			1		4	3	2	1	1		9
UP	1	4		3	1		1	2	1	4	2	1	4	6	7	7	7	9	5	8	8
WITS	3	3	4	2	6		4	11	11	9	9	2	9	8	11	13	16	23	19	16	27
WSU	1											1							1		
NMU		3	2	3	2	4	2	5	5		2	3	4	4	3	4	4	4	11	4	2
RU		2	2		1	2	3	6	4	6	1	3	2	4	7	6	5	3	4	4	6
UNIZULU		1			1	3	7	1	5	3	2	1	1	2	1		6	4	3	5	
UWC		2	1	3	4	4	11	9	7	9			8	12	3	7	9	8	15	12	12
UNISA			1		1	4	1			1		1	2		4	7	6	6	6	10	5
UNIVEN					1	1	1					1	1					1	2	1	2
UFH							1					4		1	3	1	2	7	5		1
SMU																2		2	1	2	3
TUT																					2

Figure 9-30: Average time-to-degree of Masters graduates in Physics by year: 2000 – 2020



In the box and whisker plot below, we show the distribution of the time-to-degree of Masters students. The thick, black horizontal line shows the median while the mean completion time is depicted by the red dot. The median time-to-degree fluctuated slightly between 2 and 3 years while the mean remained fairly consistent over the period analysed. In 2020 the median and mean time-to-degree was 3 years. The range, as illustrated by the whiskers in the plot below shows that in 2020, Masters students took between 1 and 4 years to complete their Masters studies in Physics.

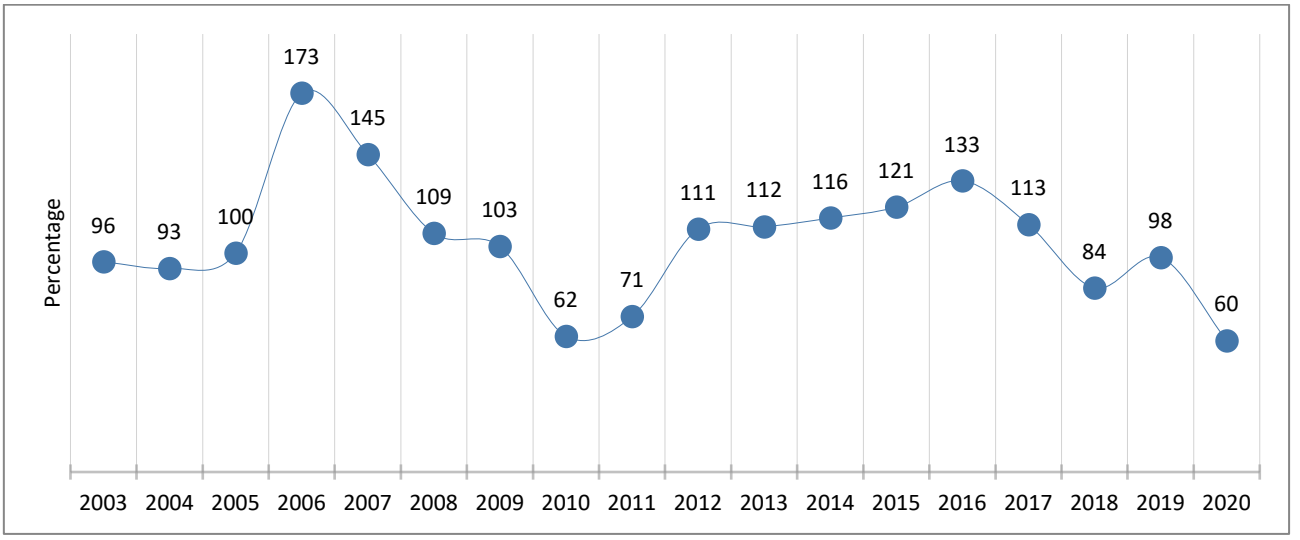
Figure 9-31: Distribution of Masters students' time-to-degree



A conversion rate is an indicator which measures the 'flow' of postgraduate students from one degree programme to another qualification. It is important to note that this indicator is not cohort-based. This is a simple measurement of the percentage new enrolments in a given year divided by the average number of graduates in the previous three years. In the figure below we report on the conversion rates of Masters' studies to Doctoral studies in Physics: in other words, at what rate do Masters' students convert to Doctoral studies in general and without tracking students specifically? Given the fluctuating (and often small) numbers of graduates and enrolments across years we report on at three-year average conversion rate (for details on the calculation of this indicator refer to Appendix 2).

In the figure below we see that in Physics, the conversion rate for 2003 was 96% and in 2020 this percentage was 60%. However, we see large fluctuations between years, especially in recent years where the conversion rate was lower, but generally the conversion rate to Doctoral studies in Physics is high with a higher number of Doctoral students enrolling than who are graduating at a Masters level.

Figure 9-32: Conversion rates from Masters to Doctoral studies in Physics by year: 2000 - 2020[5]



[5] Due to errors in the data reported for UNISA in 2017 and 2018 we have excluded UNISA from our calculation of the conversion rate.

9.3. Doctoral students

9.3.1. Enrolments

Figure 9-33: Number of total Doctoral enrolments in Physics by year: 2000 - 2020

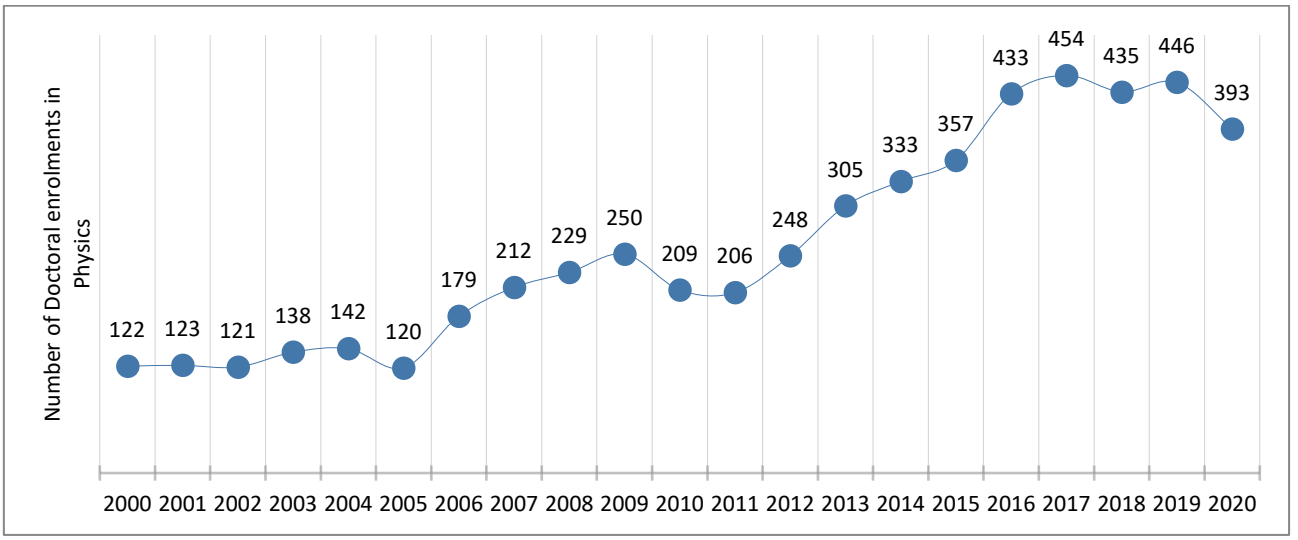
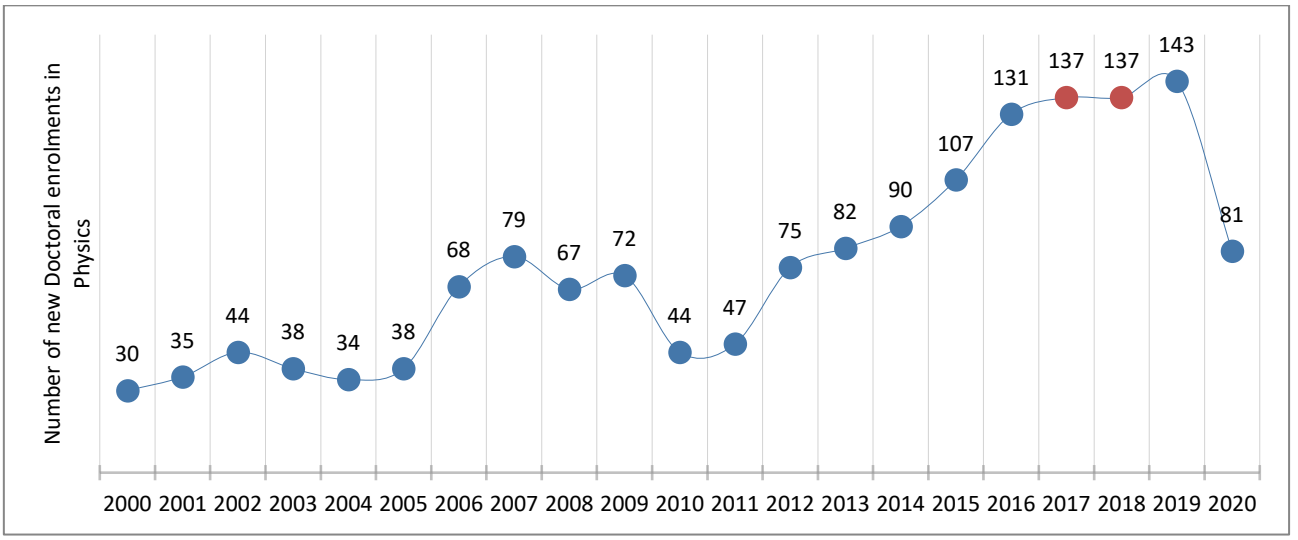


Figure 9-34: Number of new Doctoral enrolments in Physics by year: 2000 - 2020[6]



[6] Due to missing data reported for UNISA in 2017 and 2018 we have imputed data for these years for the entire system.

Figure 9-35: Percentage of total Doctoral enrolments in Physics by gender and year: 2000 - 2020

Figure 9-36: Percentage of total Doctoral enrolments in Physics by race and year: 2000 - 2020

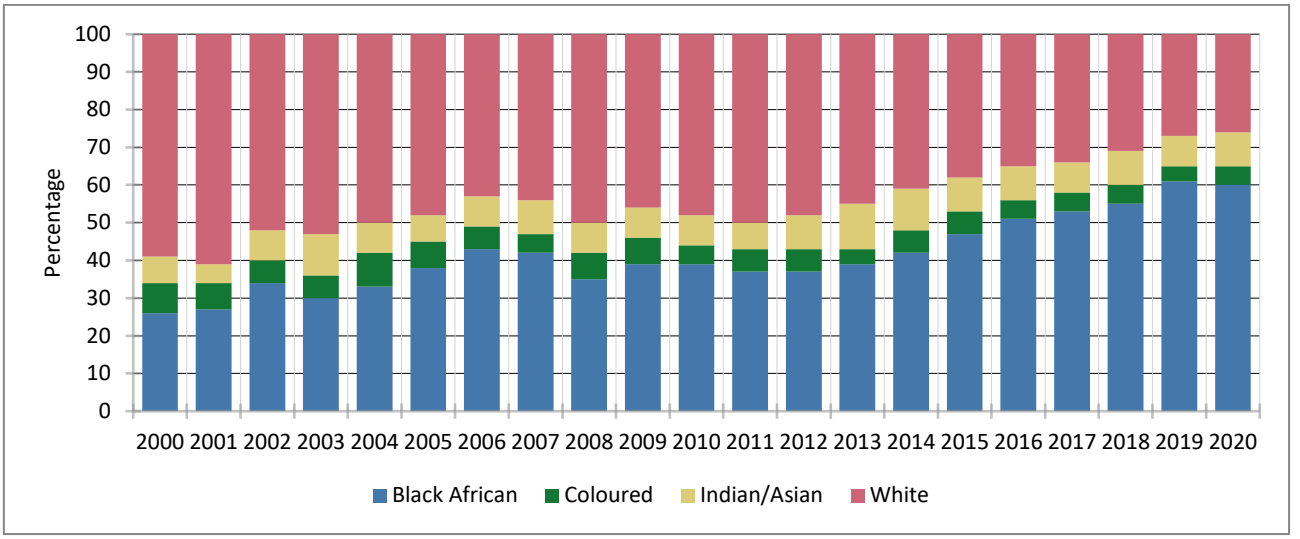


Figure 9-37: Percentage of total Doctoral enrolments in Physics by nationality and year: 2000 - 2020

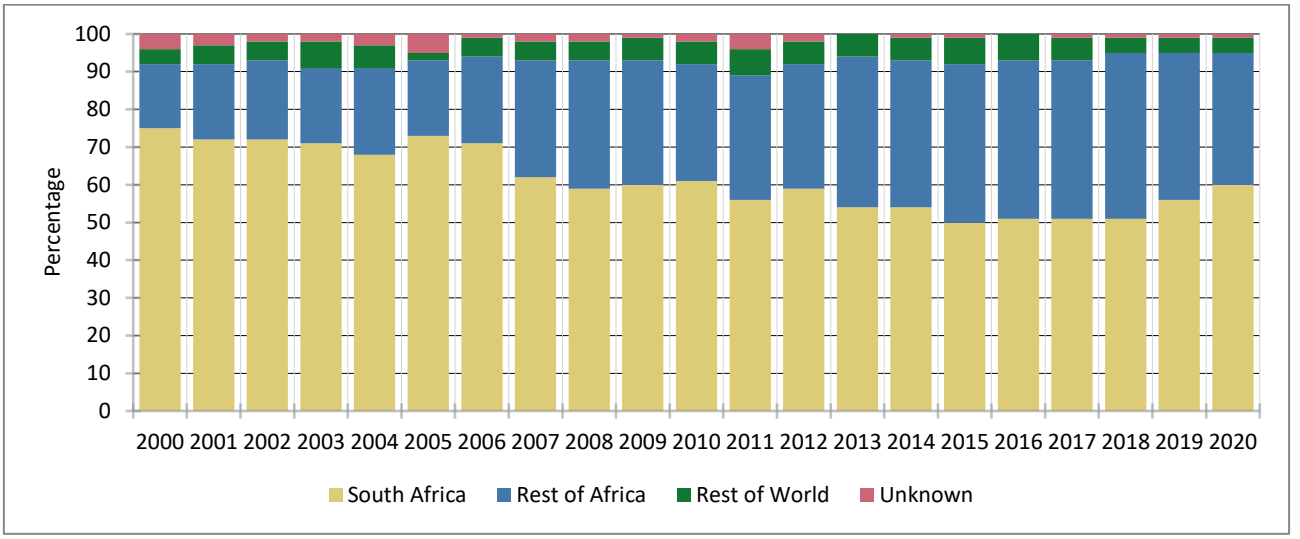
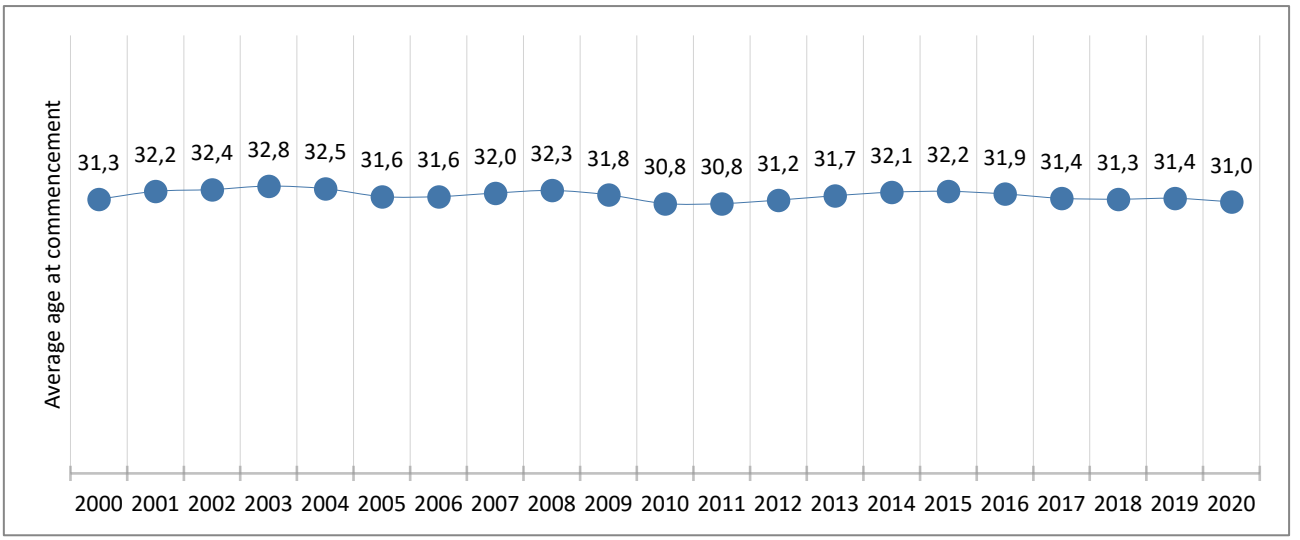


Figure 9-38: Average age of Doctoral students at commencement of studies in Physics by year: 2000 – 2020



In the box and whisker plot below, we show the distribution of the commencement age of Doctoral students. The thick, black horizontal line shows the median age while the mean age is depicted by the red dot. The median commencement age fluctuated slightly between 28 and 32 years where in 2020 the median commencement age was 29 while the mean was slightly higher at 31 years. The range, as illustrated by the whiskers in the plot below, has decreased over time and shows that in 2020, Doctoral students were between the ages of 24 and 42 when enrolling for their Masters degrees in Physics.

Figure 9-39: Distribution of Doctoral enrolments' commencement age

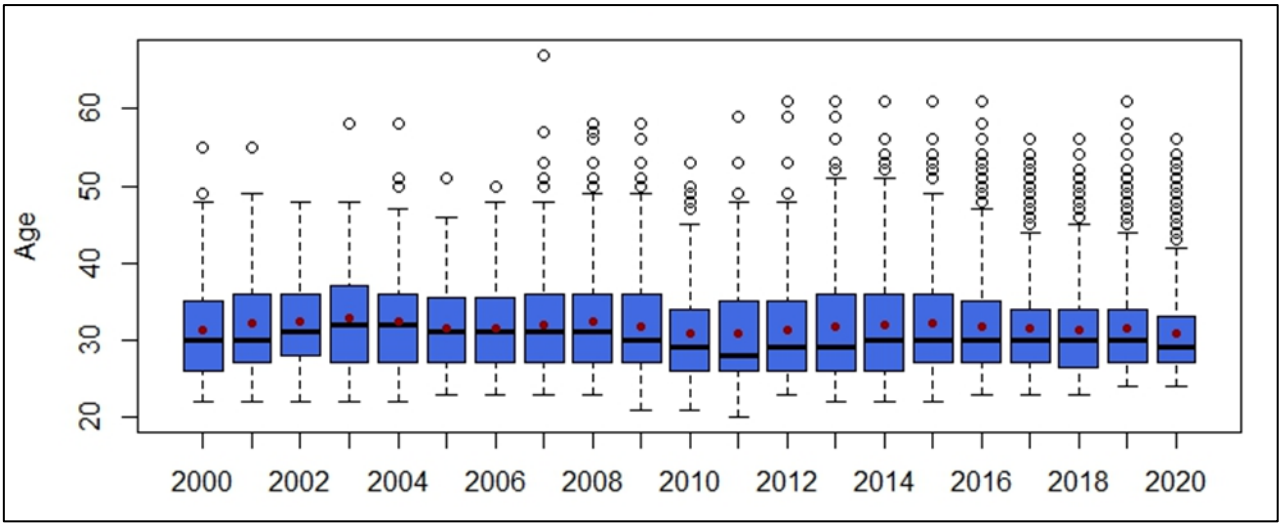


Table 22: Number of Doctoral enrolments per university in Physics

University	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NMU	7	7	8	9	10	9	12	15	18	22	19	15	20	17	17	15	16	19	18	19	17
NWU	4	7	8	11	11	7	10	9	12	12	13	12	18	23	28	28	31	29	26	24	23
SU	11	11	10	13	9	13	10	13	22	25	26	30	35	34	32	31	30	32	28	28	20
UCT	14	16	15	18	23	26	31	34	28	27	30	29	34	46	50	53	57	52	44	36	39
UFS	5	5	4	6	6	10	13	15	15	16	18	19	23				16	27	27	26	23
UJ	3	5	5	7	7	9	11	15	17	20	14	17	15	18	18	18	17	16	13	17	14
UKZN	12	7	9	18	19	16	19	20	22	25	29	34	44	51	50	51	54	54	64	59	63
UL	3	4	8	9	10	9	9	10	9	9	12	8	9	8	9	14	13	11	9	14	13
UNISA	4	4	4	5	5	5	2	4	7	7	7	5	3	7	5	17	22	25	16	33	23
UNIVEN	1								1	1	1		1	4	3	3	6	8	8	6	5
UNIZULU	1	1	1		1	2	1	5	2	3	4	1	3	1	3	2	5	4	3	3	4
UP	10	9	3	4	3	3	7	10	17	16	19	20	27	28	38	37	54	47	61	58	51
UWC	4	4	8	4	6	5	7	13	16	21			5	2	12	5	9	12	5	12	9
WITS	43	41	36	32	29		41	39	33	30			1	52	51	55	70	80	79	78	64
RU		2	2	2	3	3	3	4	4	8	7	7	3	5	8	15	20	24	21	24	19
UFH						3	3	6	6	8	10	9	7	9	9	12	11	11	11	7	4
SMU																1	2	3	2	2	2

9.3.2. Graduates

Figure 9-40: Number of Doctoral graduates in Physics by year: 2000 - 2020

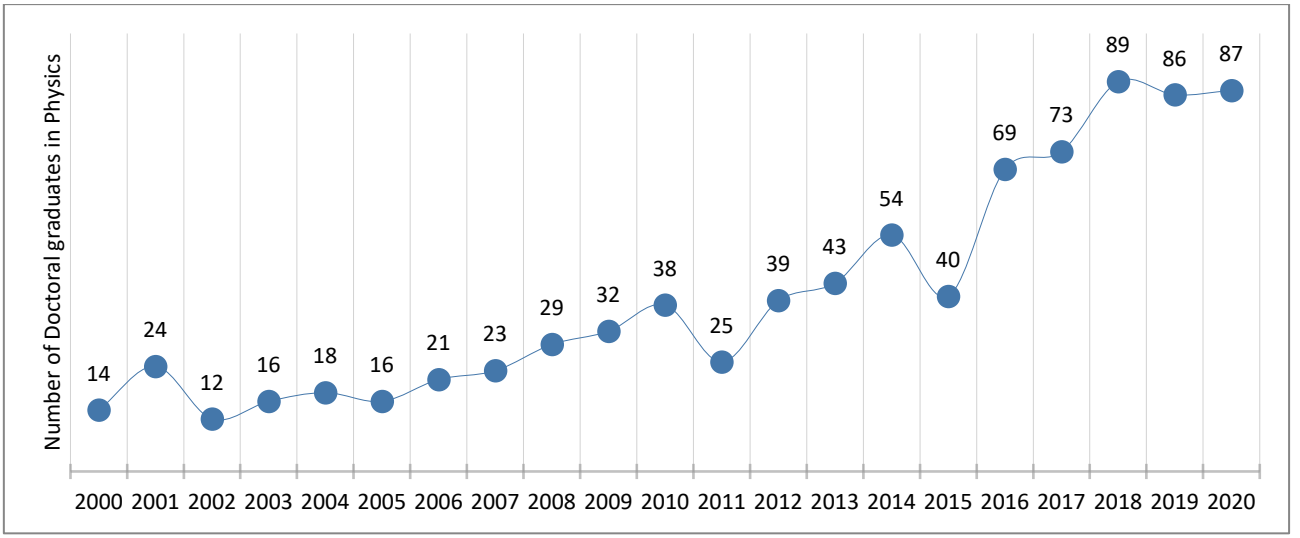


Figure 9-41: Percentage of Doctoral graduates in Physics by gender and year: 2000 - 2020

Figure 9-42: Percentage of Doctoral graduates in Physics by race and year: 2000 - 2020

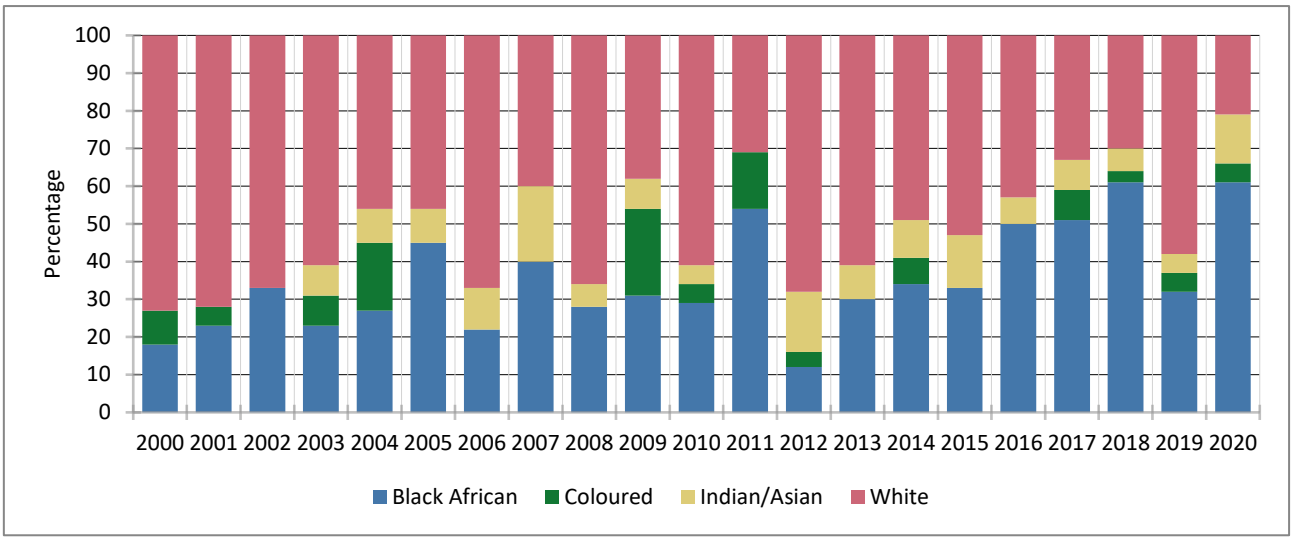


Figure 9-43: Percentage of Doctoral graduates in Physics by nationality and year: 2000 - 2020

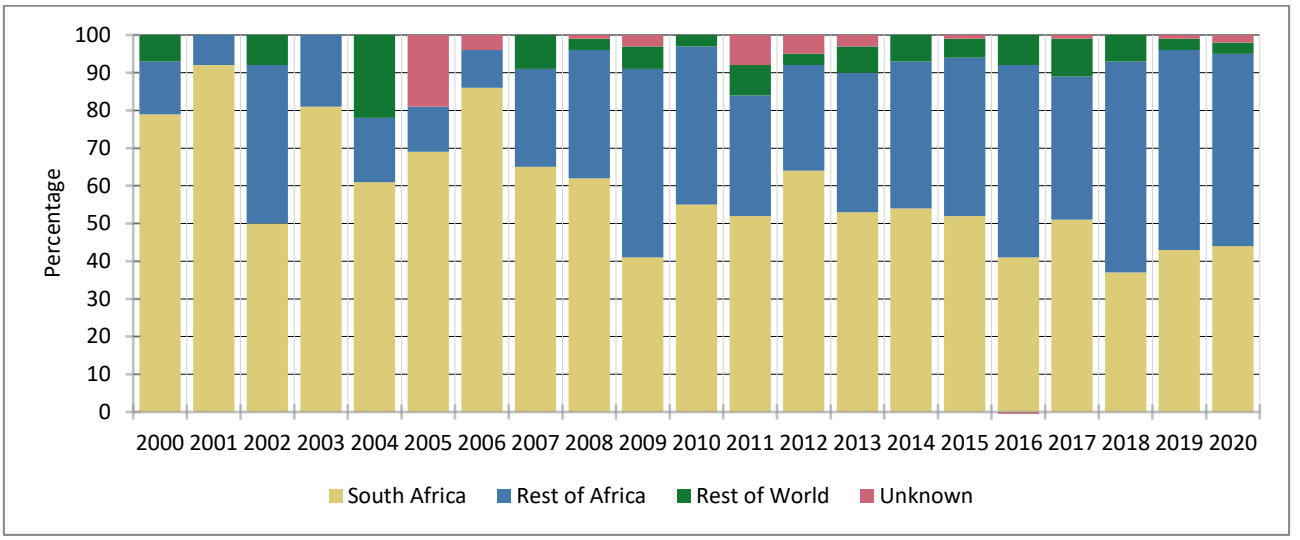
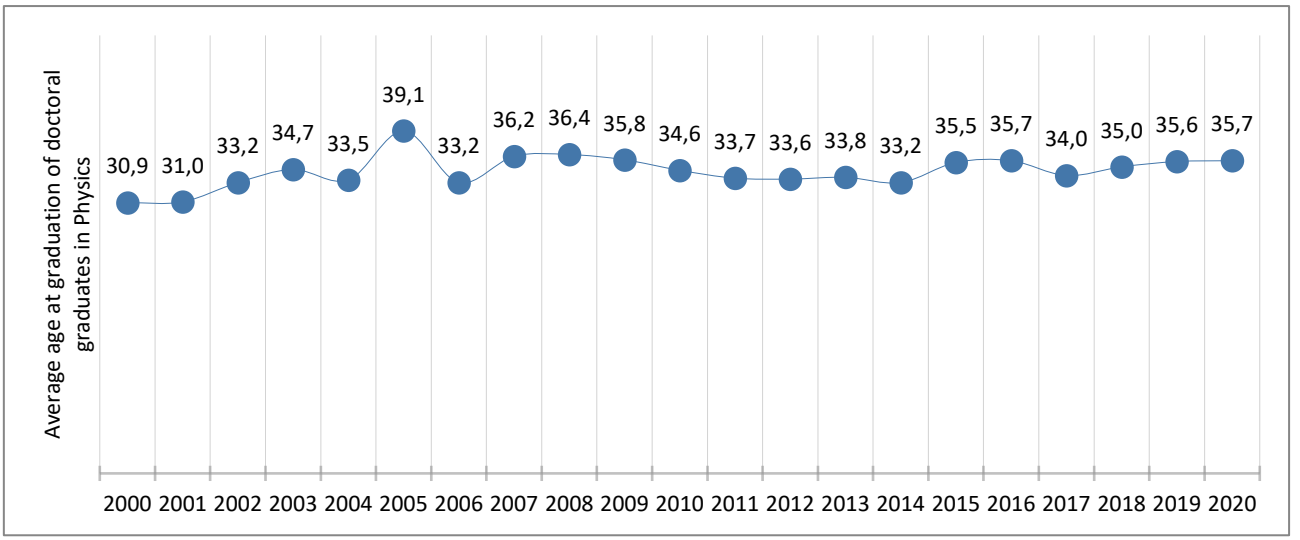


Figure 9-44: Average age at graduation of Doctoral students in Physics by year: 2000 – 2020



In the box and whisker plot below, we show the distribution of the graduation age of Doctoral students. The thick, black horizontal line shows the median age while the mean age is depicted by the red dot. The median graduation age fluctuated between 29 and 38 years over the period analysed where in 2020 the median and mean graduation age was 35 years. The range, as illustrated by the whiskers in the plot below shows that in 2020, Doctoral students were between the ages of 25 and 46 when completing their Doctoral degrees in Physics.

Figure 9-45: Distribution of Doctoral students' graduation age

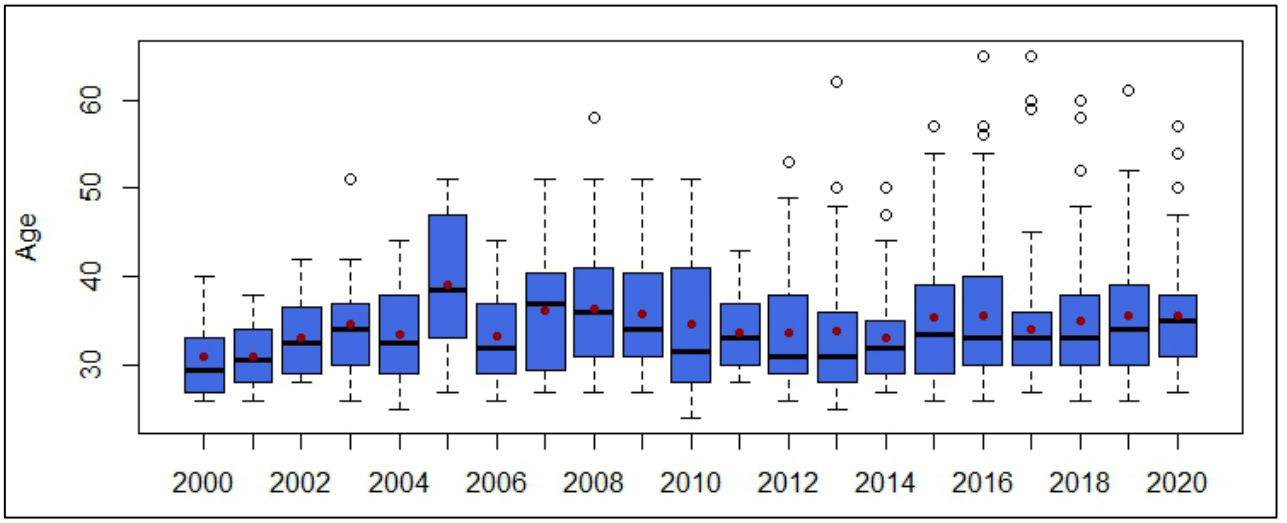
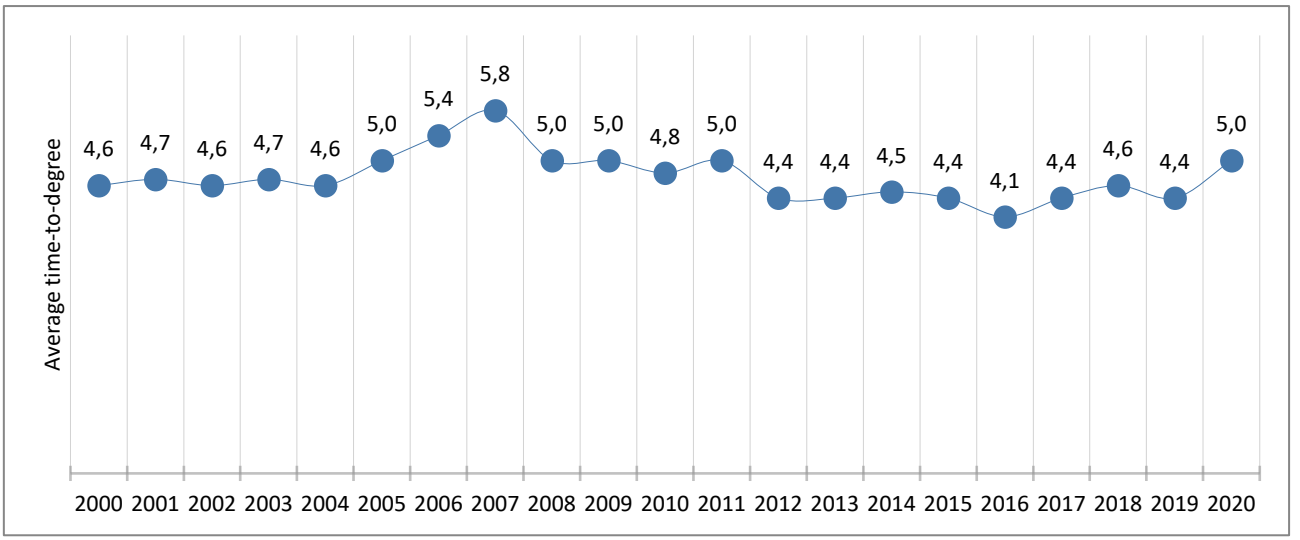


Table 23: Number of Doctoral graduates per university in Physics

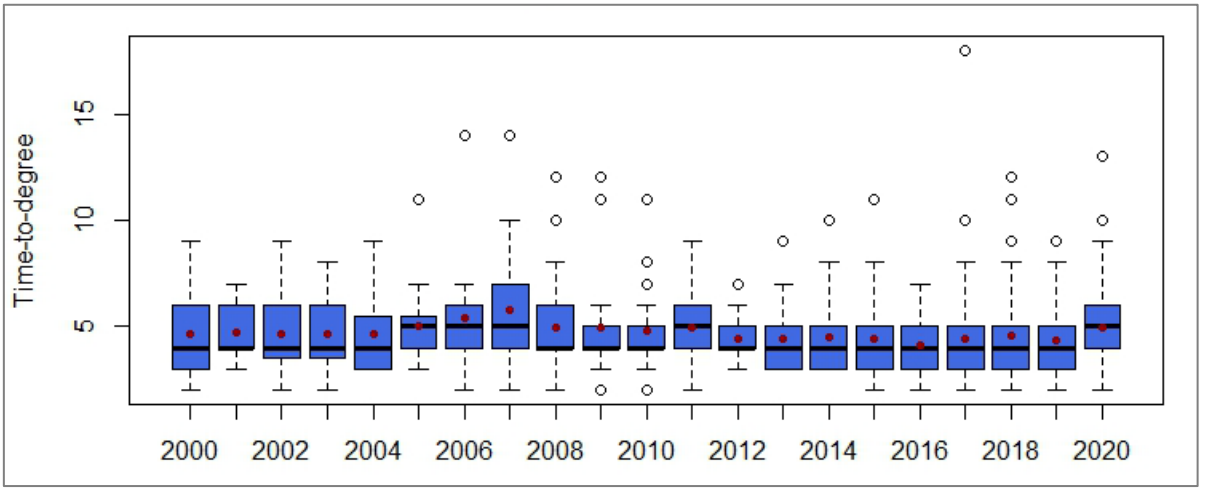
University	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NMU	1	3	1	1	4	1	4	1	4	3	6	2	6	3	5	2	2	4	5	2	4
NWU	1	2		2	1	1	1		1	2	2		3	2	1	2	10	5	5	6	5
SU	1	3		2		3	2		1	4	7	4	5	6	10	11	3	8	5	11	4
UFS	1	3		1		1	4		2	2	5	5	1				4	6	5	8	4
UKZN	1		1	1	2	2	3	3	3	3	2	3	7	8	8	9	9	7	11	6	12
UNISA	2		1		1	1					1	1	1			1	4	5	6	8	8
WITS	7	8	5	4	3		1	9	8	4			1	7	10	3	8	13	20	19	16
RU		1	1		1	1		2		1	1	4	1	1			2	6	3	5	3
UCT		2	2	2	1	3	3	5	5	5	7	3	7	7	8	4	11	9	10	3	8
UL		1			2	2	1	1	1				1	2		2	3	2	1	1	5
UP		1			1		1		1	3	3	1	3	2	8	5	7	4	11	11	17
UWC			1	1	2	1				3											
UJ				2				2	3		2		1	3	2	1	3	2	4	3	1
UFH							1			2		2		2	1		2	2	2	1	
UNIZULU											2		2		1		1				
UNIVEN																			1	1	
SMU																				1	

Figure 9-46: Average time-to-degree of Doctoral graduates in Physics: 2000 – 2020



In the box and whisker plot below, we show the distribution of the time-to-degree of Doctoral students. The thick, black horizontal line shows the median while the mean completion time is depicted by the red dot. The median time-to-degree remained consistent at 4/5 years over the period analysed. In 2020 the median and mean time-to-degree was 5 years. The range, as illustrated by the whiskers in the plot below shows that in 2020, Doctoral students took between 2 and 8 years to complete their Doctoral studies in Physics.

Figure 9-47: Distribution of Doctoral students' time-to-degree

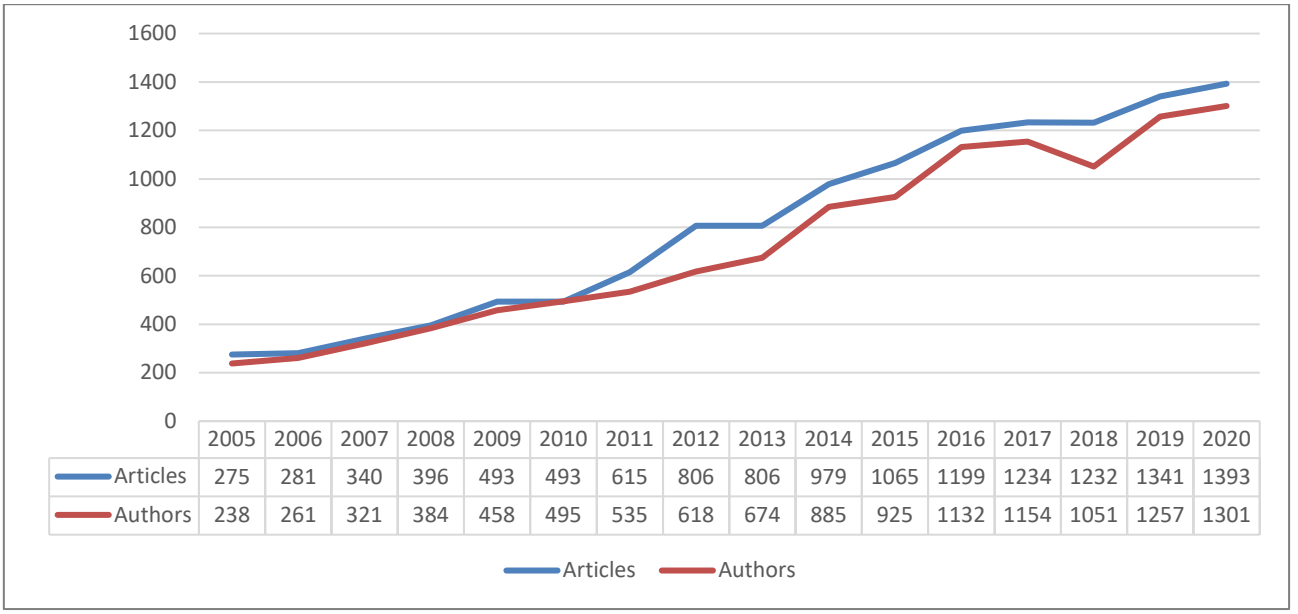


10. Research output

10.1. Physics

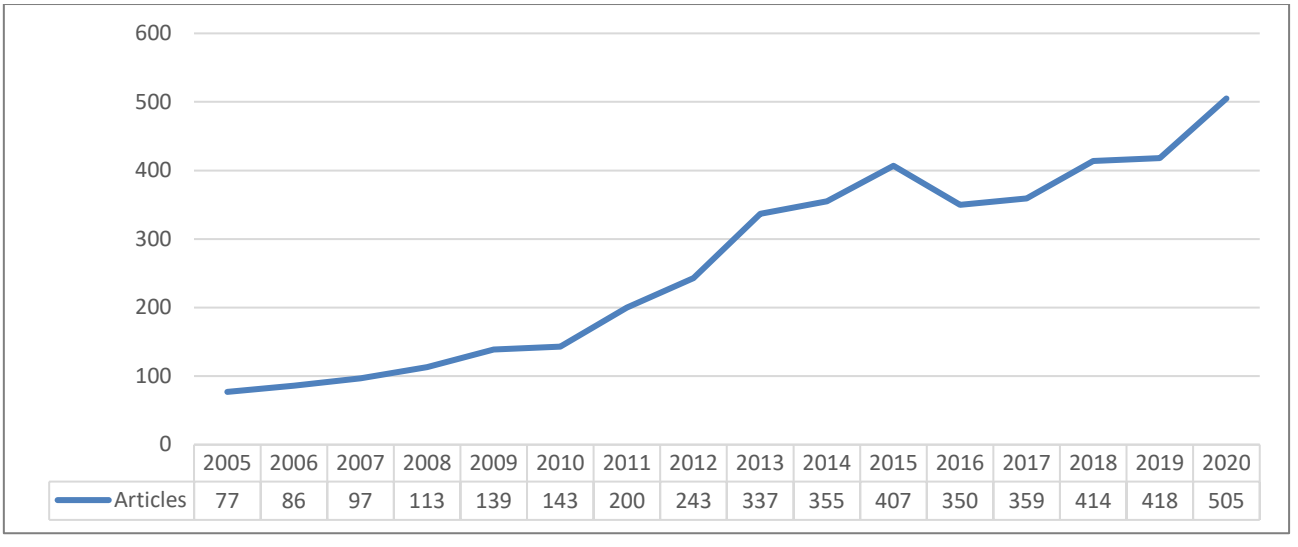
In the graphs below we present the trends of publications in the field of Physics as well as the trends of the demographics of the contributing authors.

Figure 10-1: Number of Physics articles in SAK and the authors who authored these



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Articles	275	281	340	396	493	493	615	806	806	979	1065	1199	1234	1232	1341	1393
Authors	238	261	321	384	458	495	535	618	674	885	925	1132	1154	1051	1257	1301

Figure 10-2: Number of Astronomy and Astrophysics articles in SAK



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Articles	77	86	97	113	139	143	200	243	337	355	407	350	359	414	418	505

Figure 10-3: Percentage of authors in Physics by gender and year: 2005 - 2020 (SAK)

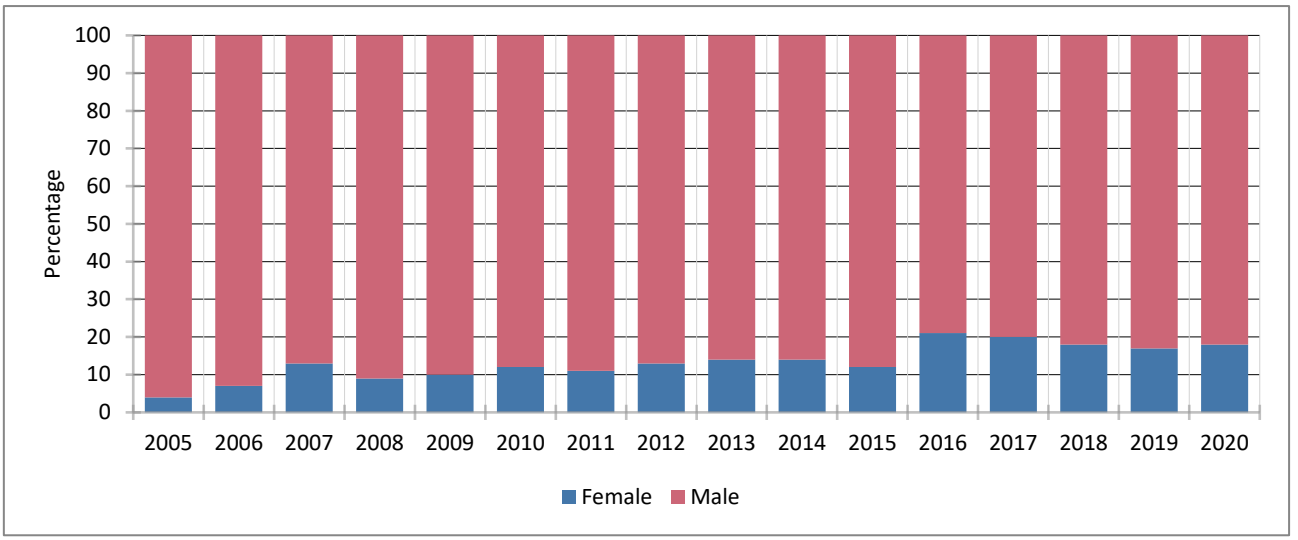


Figure 10-4: Percentage of authors in Astronomy and Astrophysics by gender and year: 2005 - 2020 (SAK)

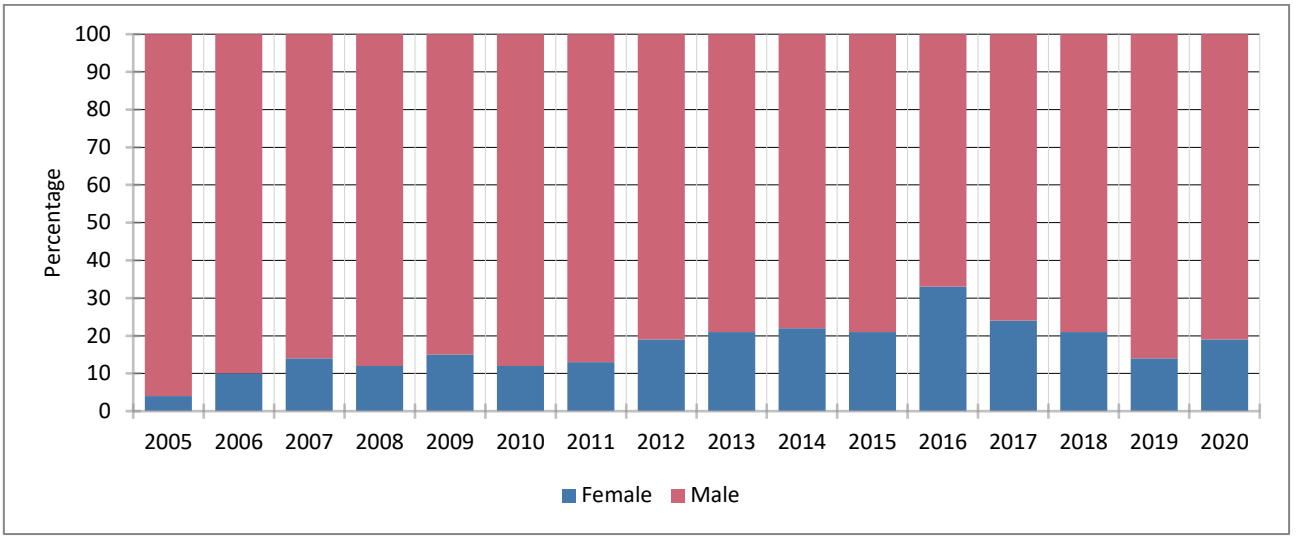


Figure 10-5: Percentage of authors in Physics by region and year: 2005 - 2020 (SAK)

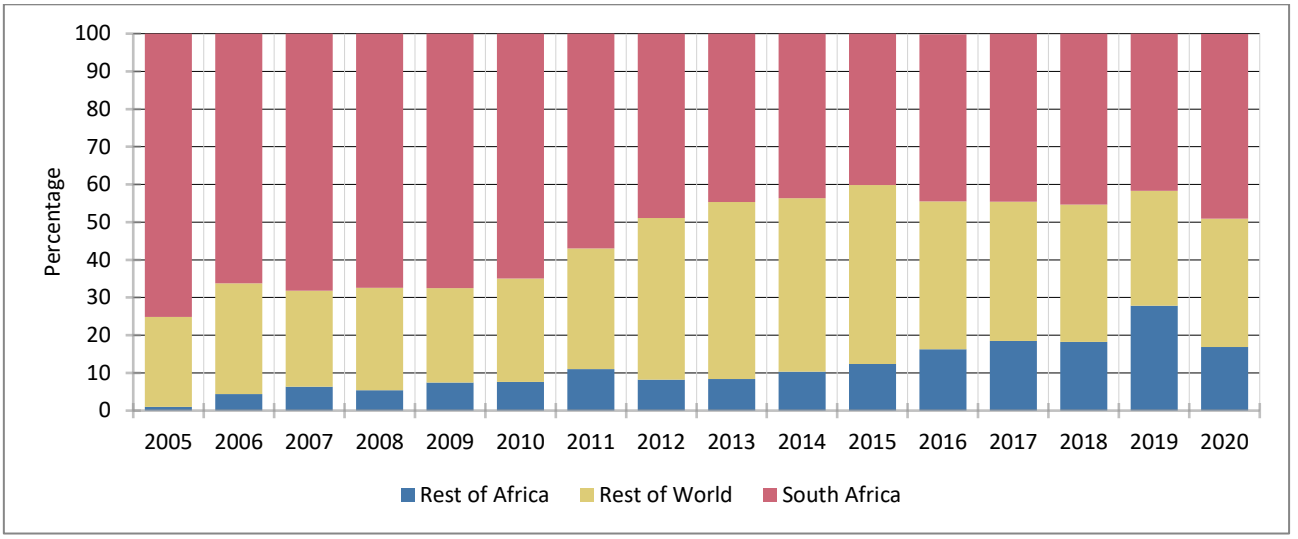


Figure 10-6: Percentage of authors in Astronomy and Astrophysics by region and year: 2005 - 2020 (SAK)

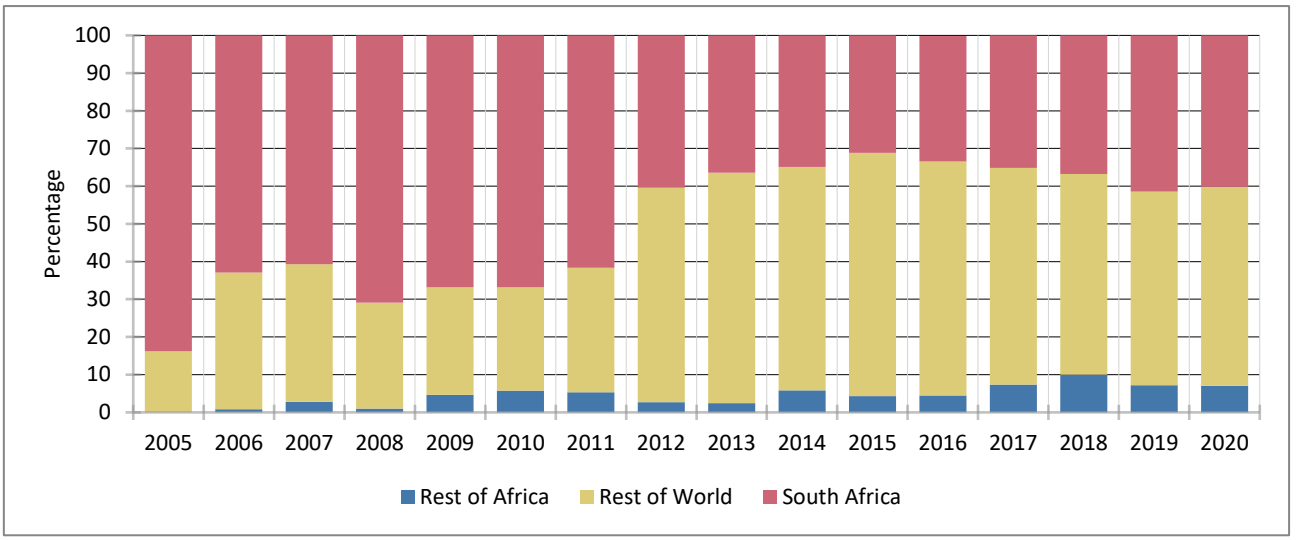


Figure 10-7: Percentage of authors in Physics by race and year: 2005 - 2020 (SAK)

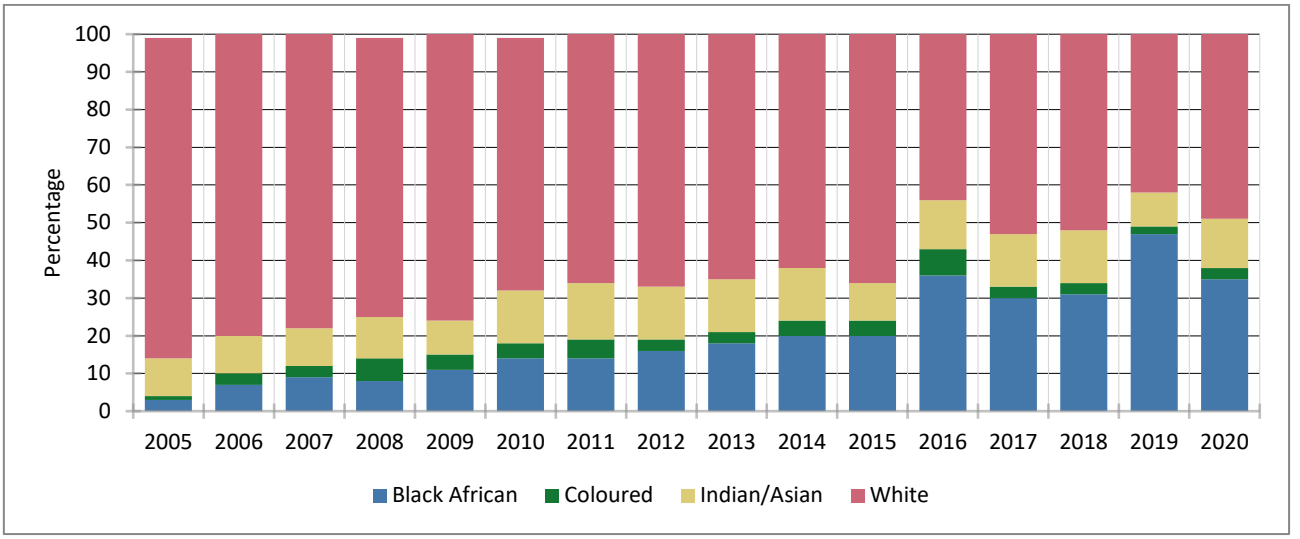


Figure 10-8: Percentage of authors in Astronomy and Astrophysics by race and year: 2005 - 2020 (SAK)

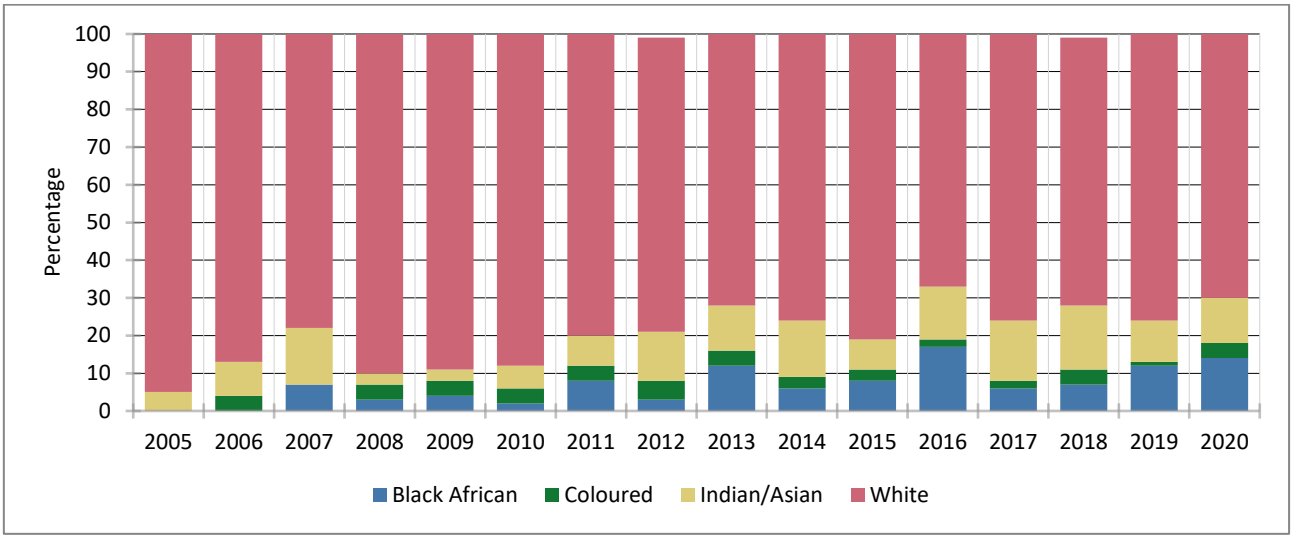


Figure 10-9: Percentage of authors in Physics by age and year: 2005 - 2020 (SAK)

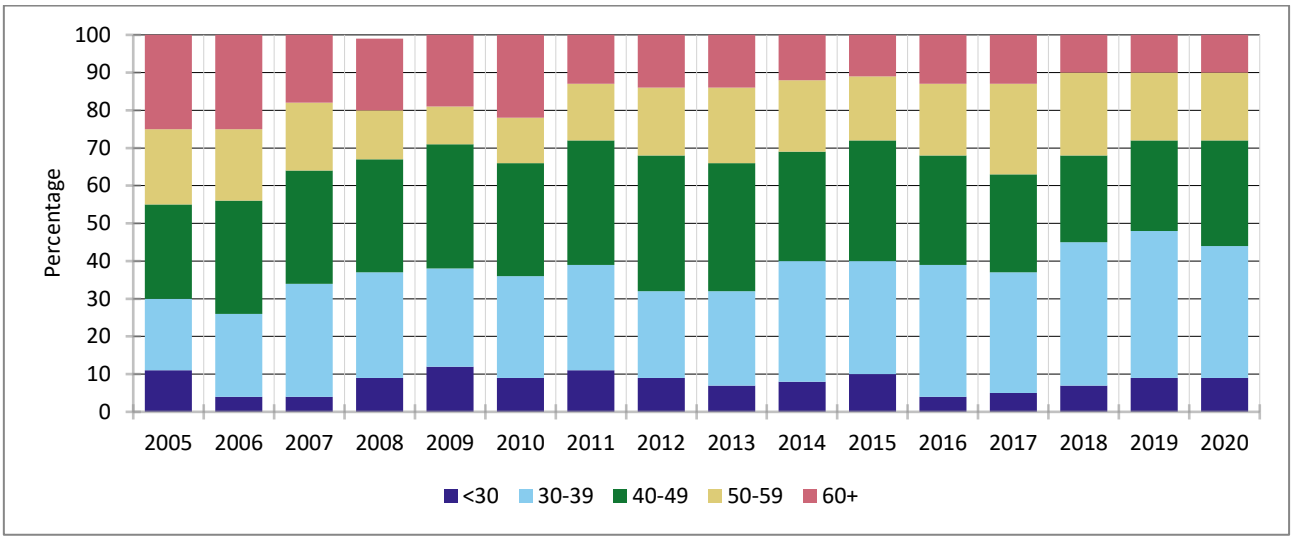
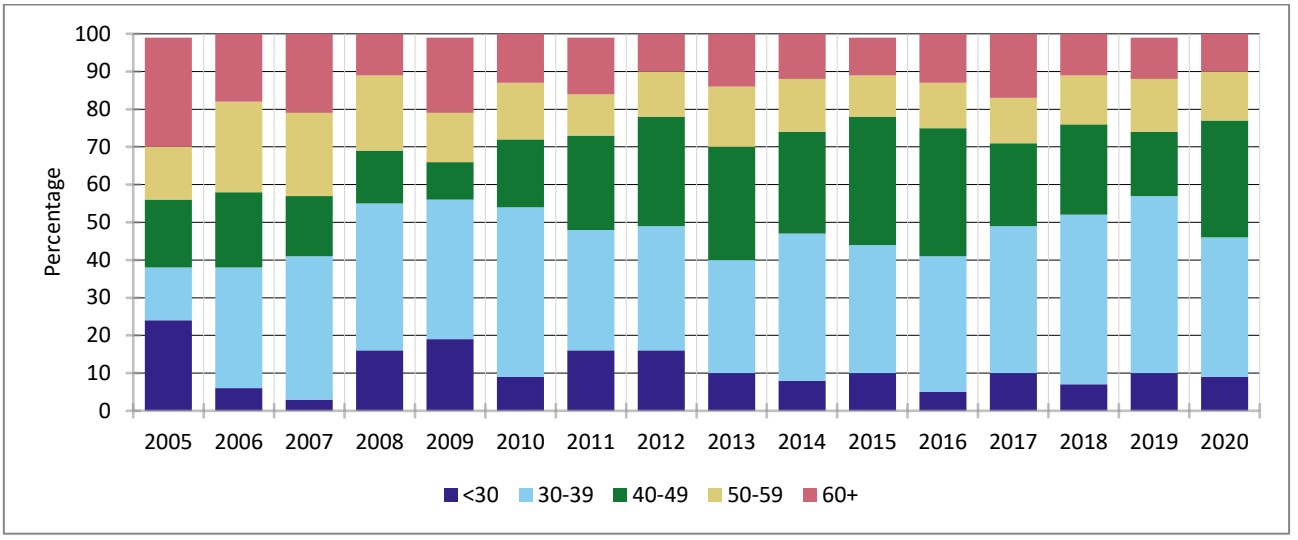


Figure 10-10: Percentage of authors in Astronomy and Astrophysics by age and year: 2005 - 2020 (SAK)



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The graphs below are based on publications from the [CA]**Web of Science** as classified in the subject category for Physics. The difference between these results and the data presented in the tables above (sourced from SA Knowledgebase) are because the graphs below only count articles published in journals indexed in the WoS. The advantage of these analyses is that they allow us to report on indicators and their values that (a) are often normalized; and (b) allow for comparison across countries. The first two graphs present the absolute number of articles and review articles authored by South African scientists for Physics (inclusive of Astronomy and Astrophysics) and Astronomy and Astrophysics separately.

*Figure 10-11: Number of publications in **Physics** by year: 2000 - 2020 (WoS)*

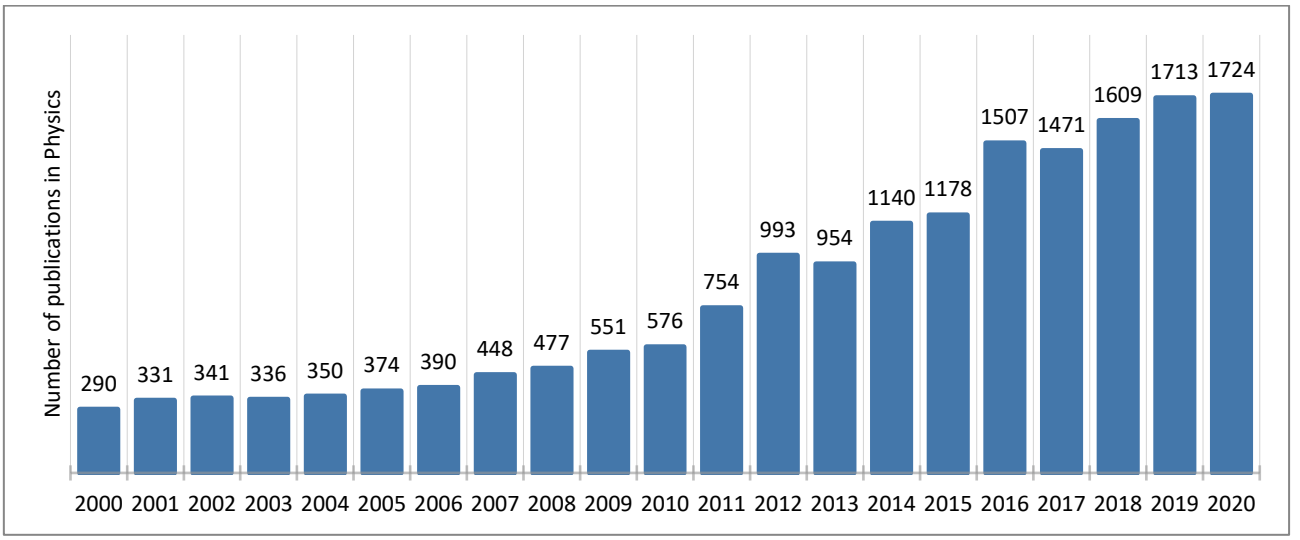
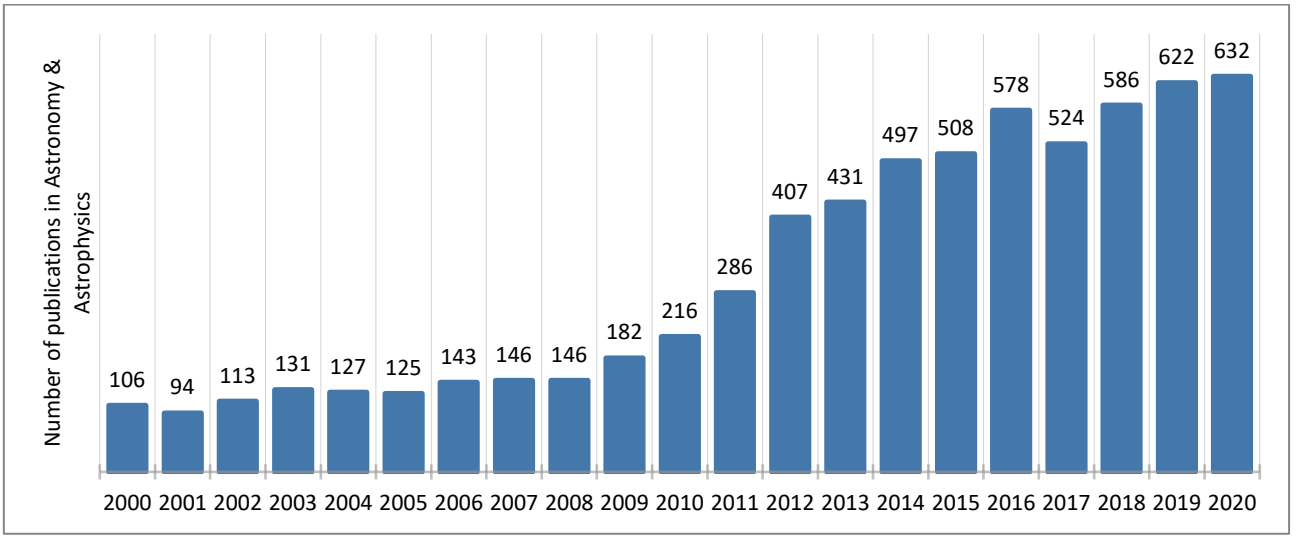


*Figure 10-12: Number of publications in **Astronomy and Astrophysics** by year: 2000 - 2020 (WoS)*



The trends in publication output over the past twenty-one years as shown in the two graphs are very similar.

CAGR (Physics = 9,322%) and Astronomy and Astrophysics (CAGR = 9,338%)

Figure 10-13: Number of publications per million of the population in Physics by year: 2000 - 2020 (WoS)

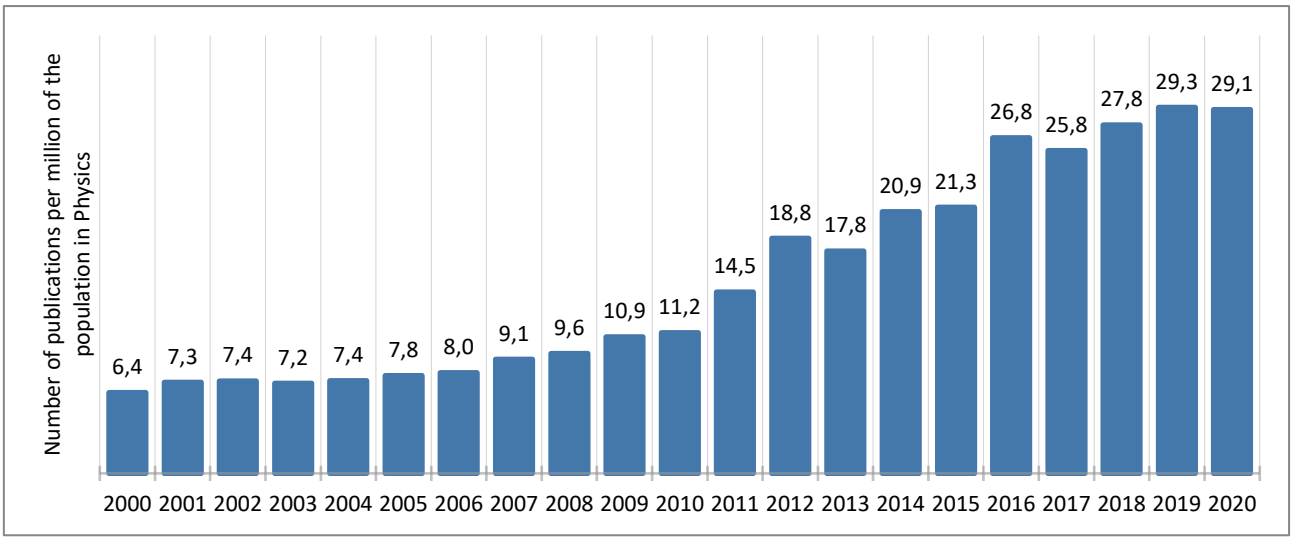


Figure 10-14: Number of publications per million of the population in Astronomy and Astrophysics by year: 2000 - 2020 (WoS)

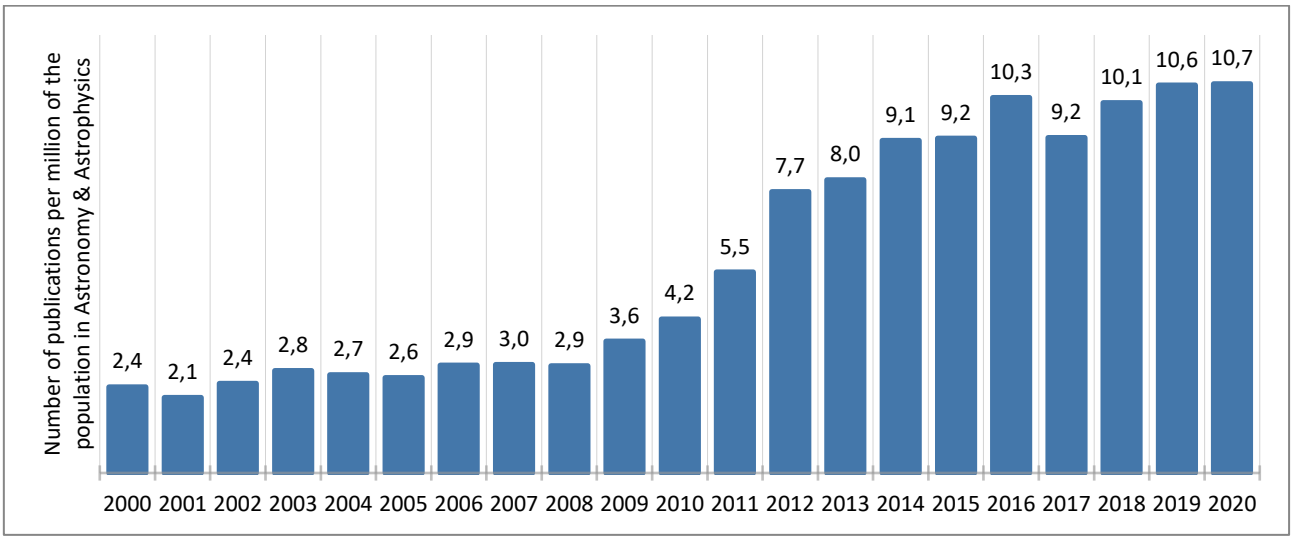


Figure 10-15: South Africa's world share of publication output in Physics by year: 2000 - 2020 (WoS)

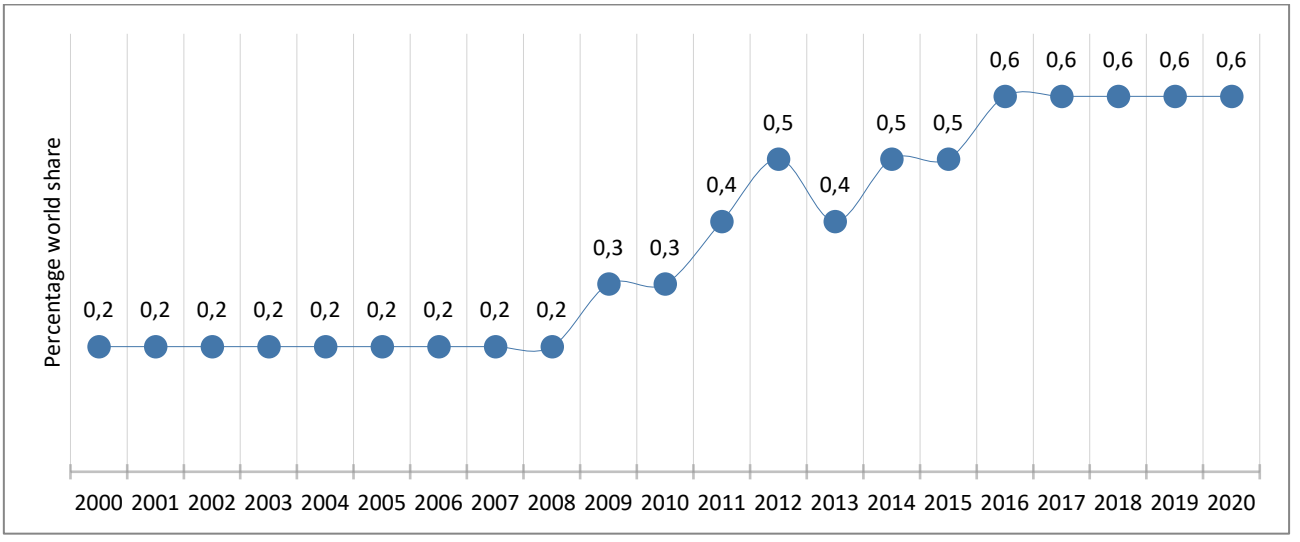


Figure 10-16: South Africa's world share of publication output in Astronomy and Astrophysics by year: 2000 - 2020 (WoS)

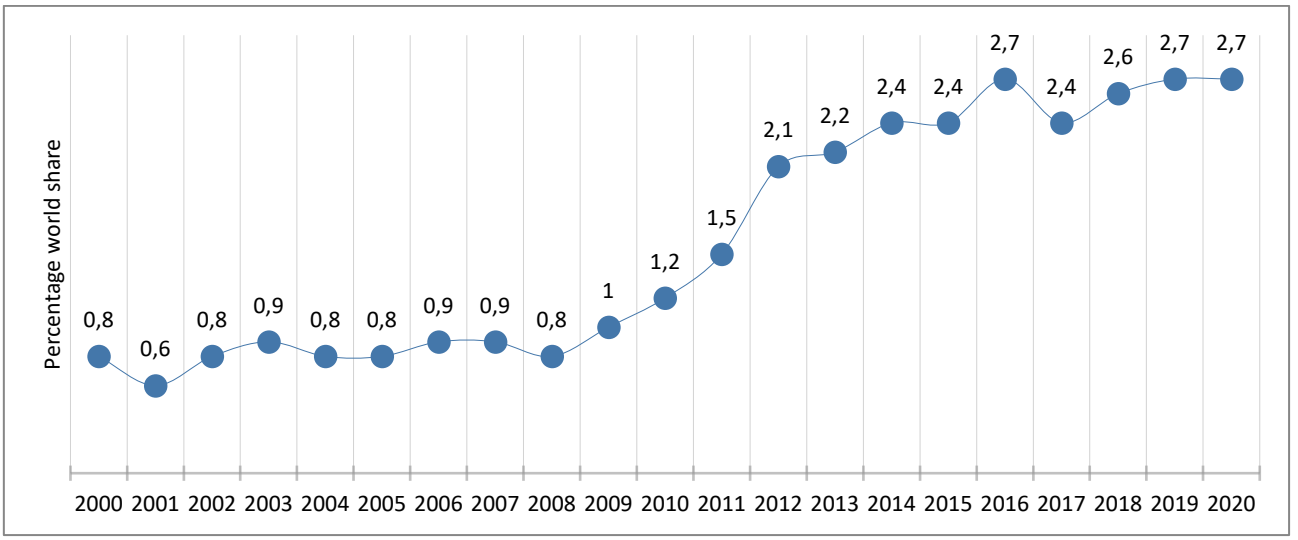


Figure 10-17: South Africa's rank among countries in terms of total output in Physics by year: 2000 - 2020 (WoS)

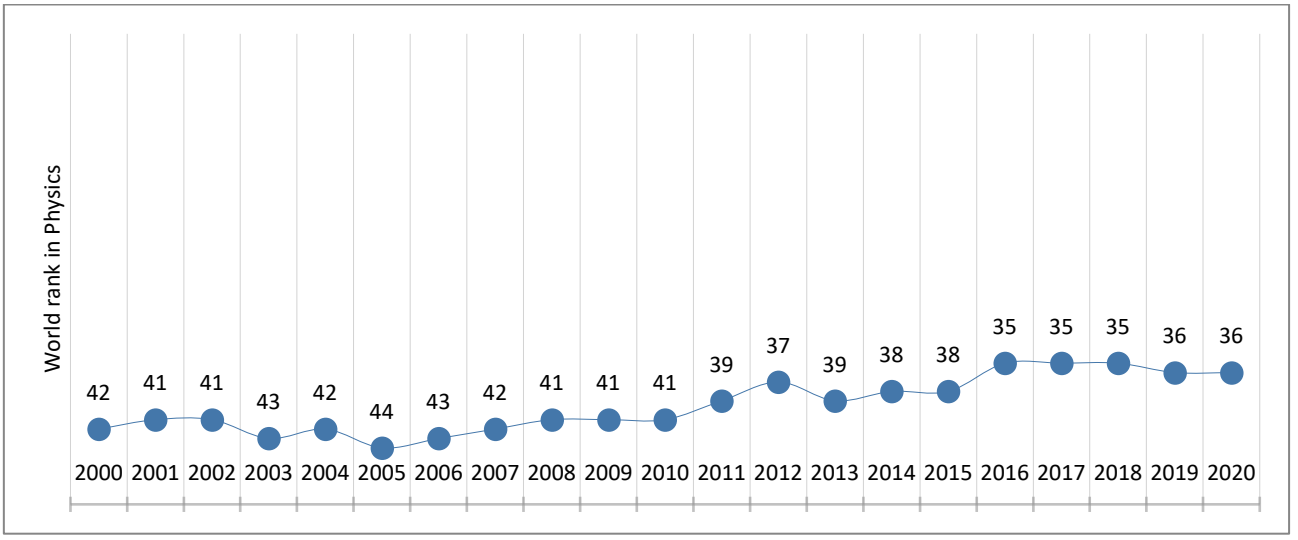


Figure 10-18: South Africa's rank among countries in terms of total output in Astronomy and Astrophysics by year: 2000 - 2020 (WoS)

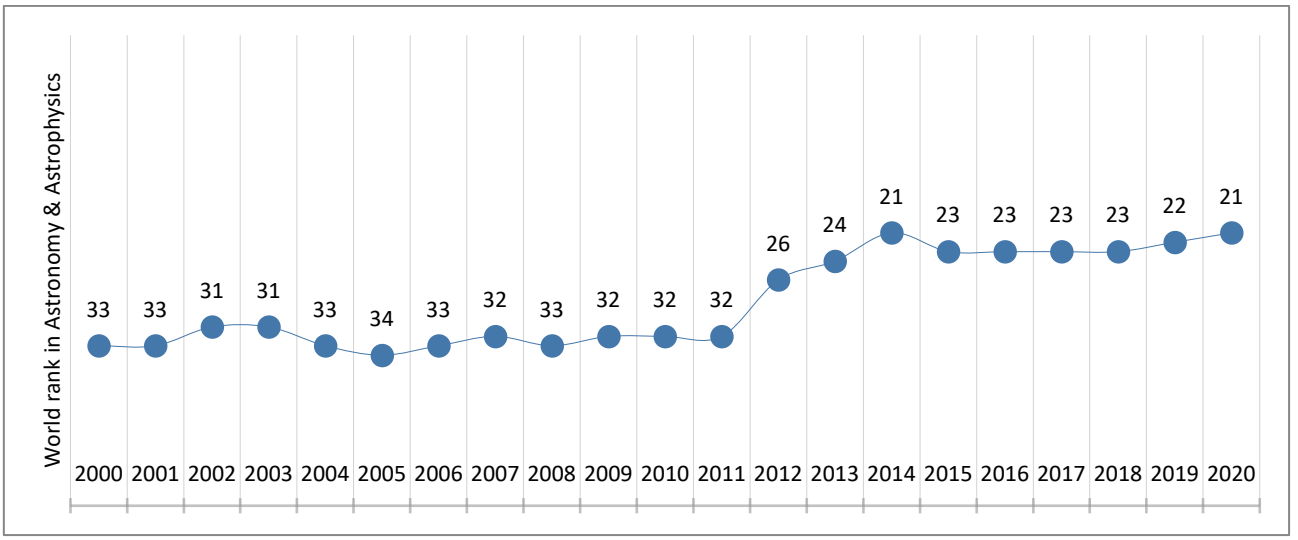


Figure 10-19: South Africa's relative field strength in Physics by year: 2000 - 2020 (WoS)

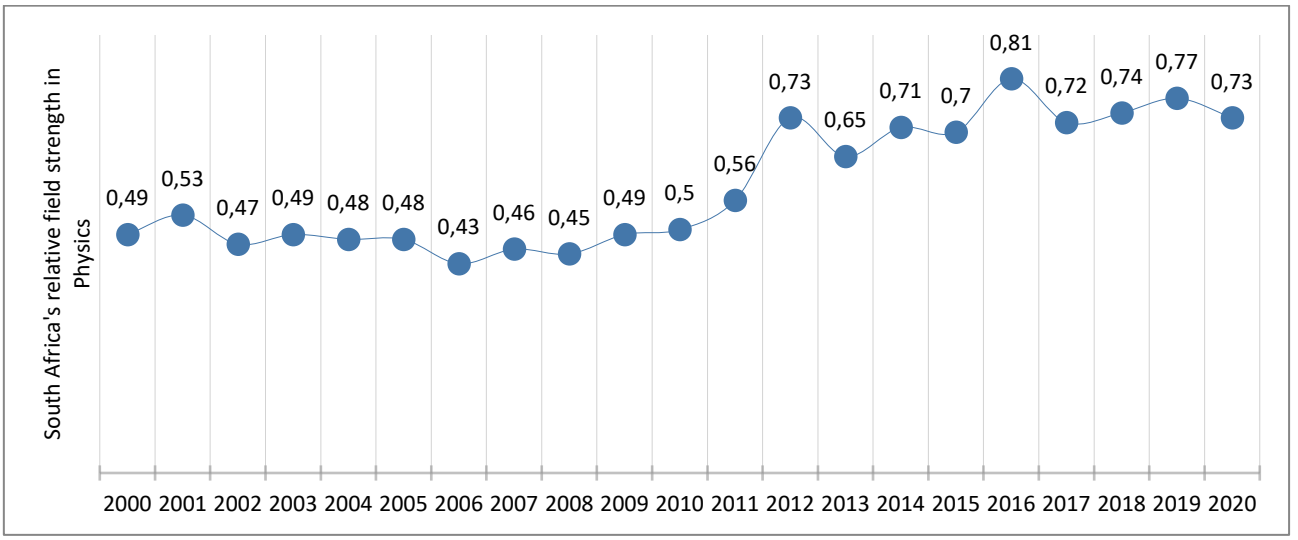


Figure 10-20: South Africa's relative field strength in Astronomy and Astrophysics by year: 2000 - 2020 (WoS)

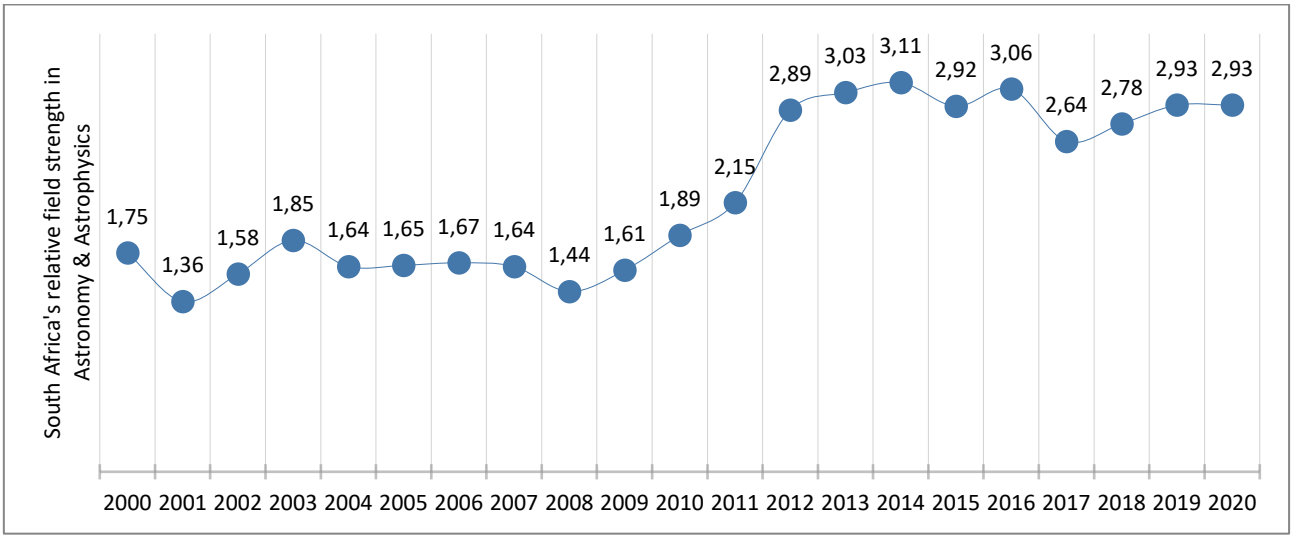


Figure 10-21: Percentage of South Africa's publications in the top citation percentile intervals in Physics by year: 2000 - 2020 (WoS)

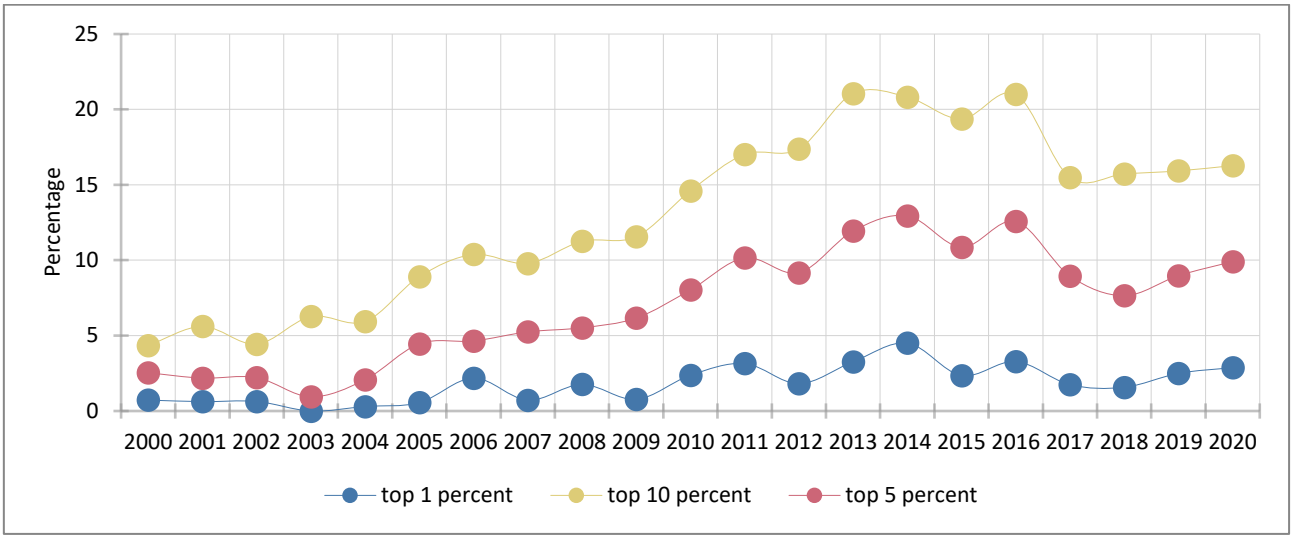


Figure 10-22: Percentage of South Africa's publications in the top citation percentile intervals in Astronomy and Astrophysics by year: 2000 - 2020 (WoS)

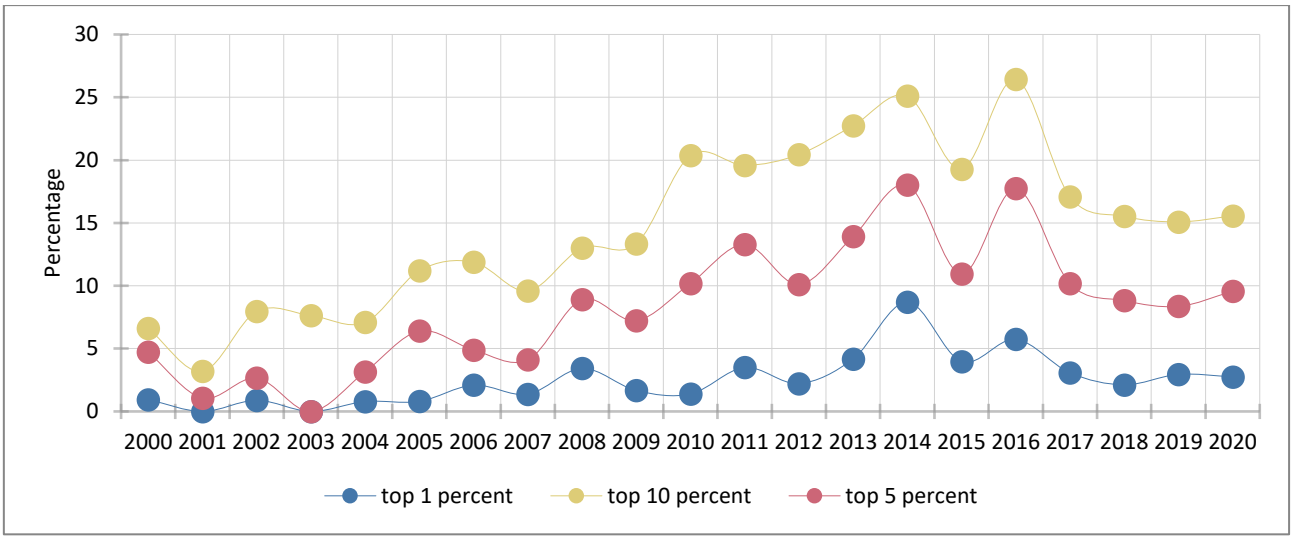


Figure 10-23: Percentage of Physics articles by quartile (according to JIF) by year: 2000 - 2020 (WoS)

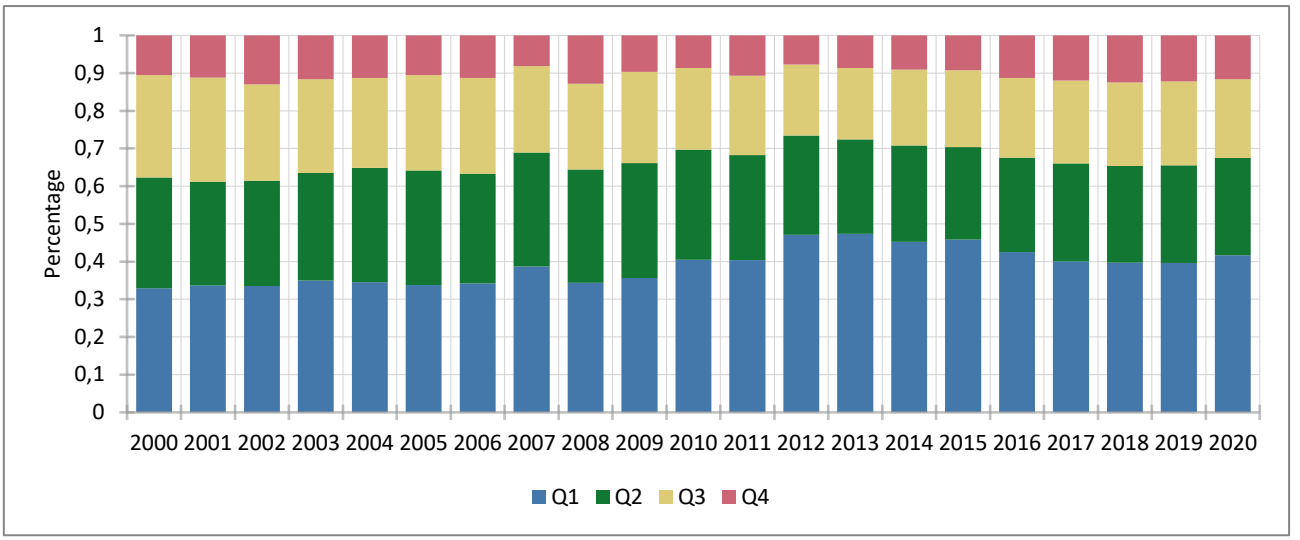


Figure 10-24: Percentage of Astronomy and Astrophysics articles by quartile (according to JIF) by year: 2000 - 2020 (WoS)

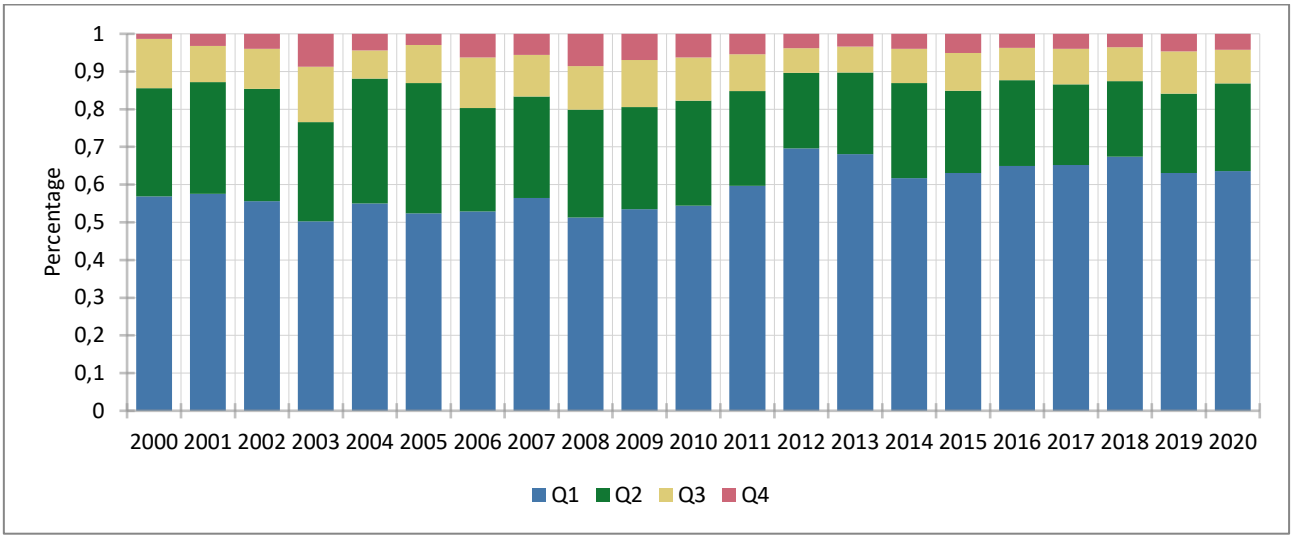


Figure 10-25: Trends in research collaboration in Physics by year: 2000 - 2020 (WoS)

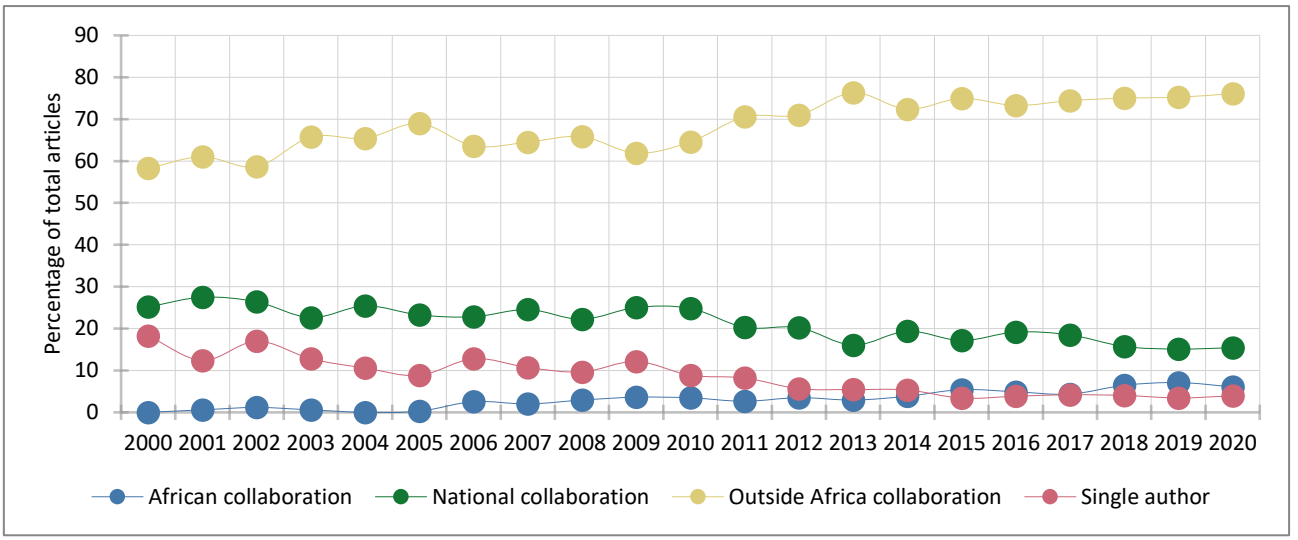


Figure 10-26: Trends in research collaboration in Astronomy and Astrophysics by year: 2000 - 2020 (WoS)

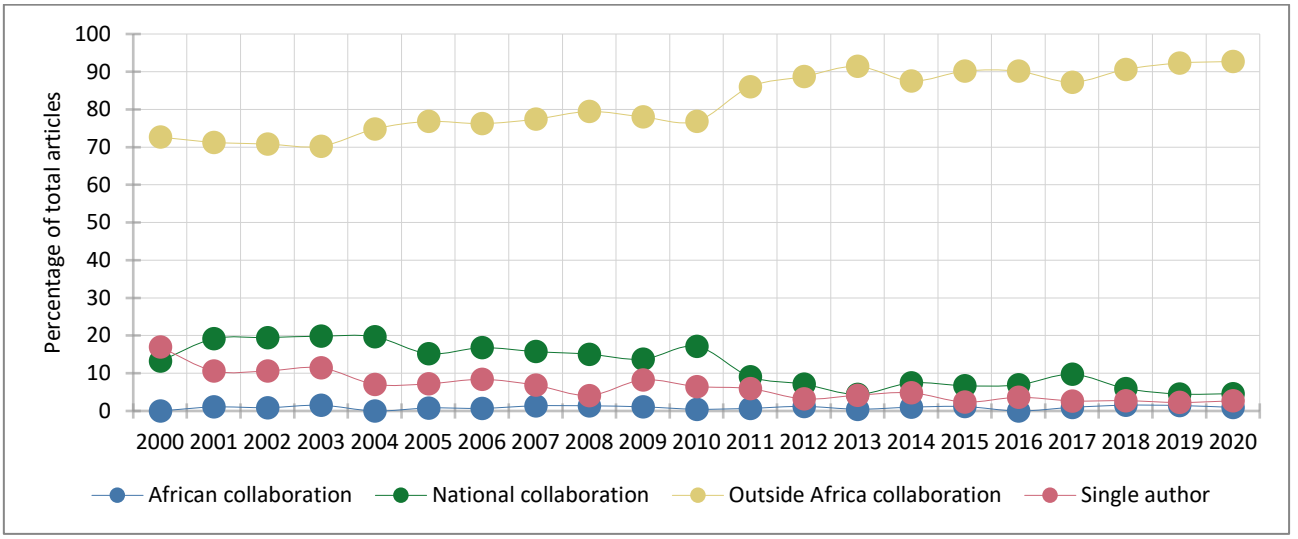


Figure 10-27: Trends in citation impact (5-year MNCS) for papers in Physics by year: 2000 - 2020 (WoS)

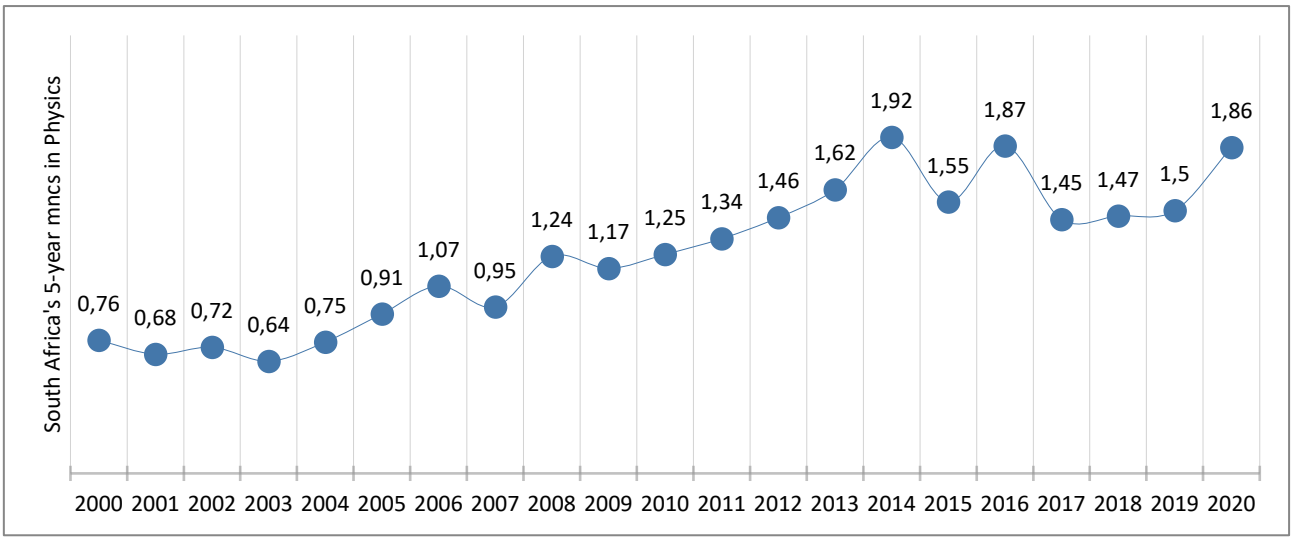


Figure 10-28: Trends in citation impact (5-year MNCS) for papers in Astronomy and Astrophysics by year: 2000 - 2020 (WoS)

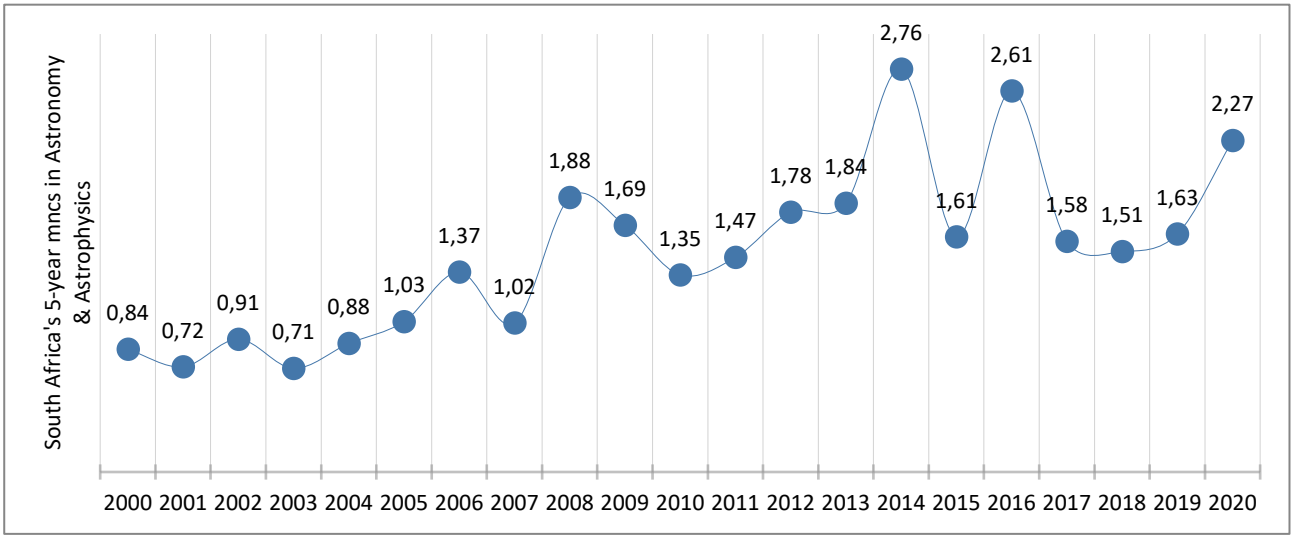


Figure 10-29: South Africa's research collaboration intensity in Physics between 2005 and 2012

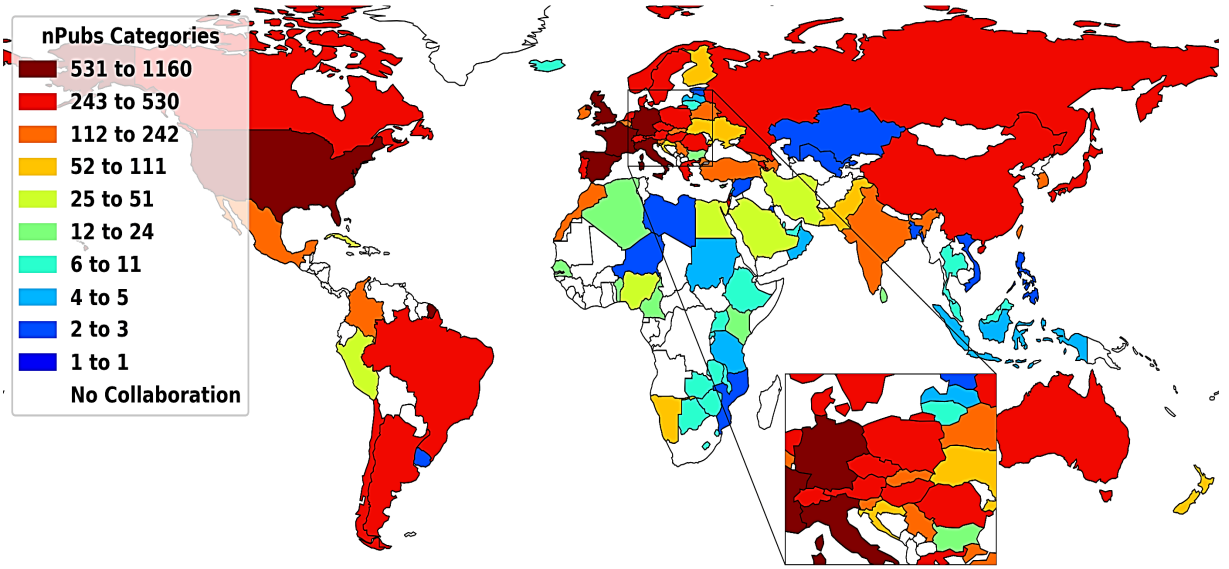


Figure 10-30: South Africa's research collaboration intensity in Astronomy and Astrophysics between 2005 and 2012

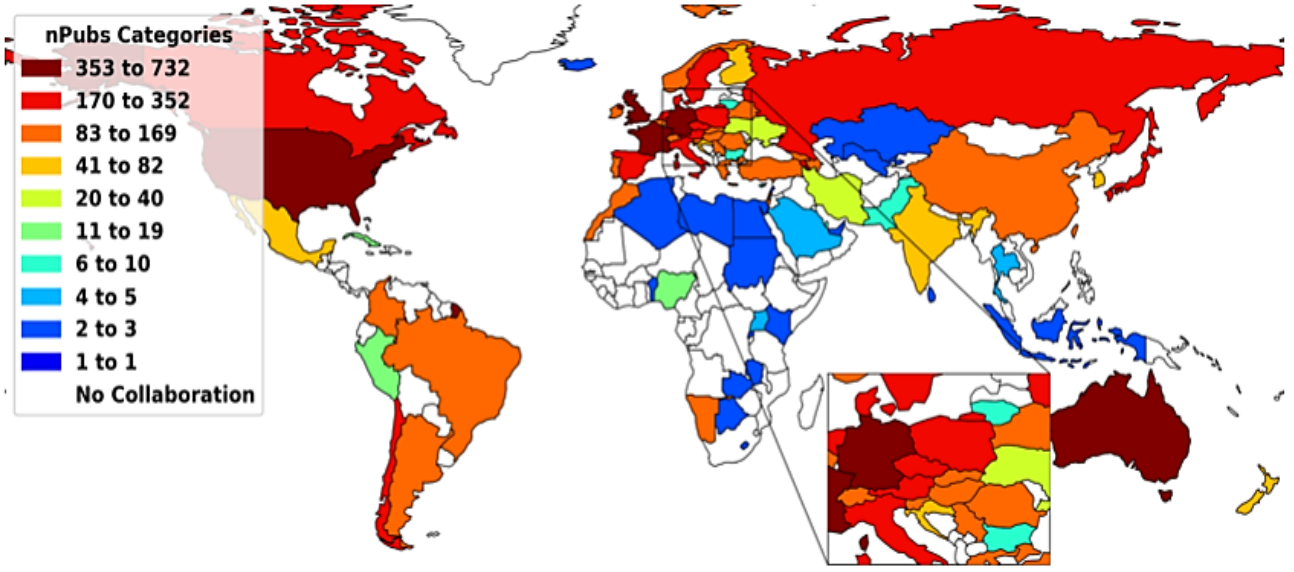


Figure 10-31: South Africa's research collaboration intensity in Physics between 2013 and 2020

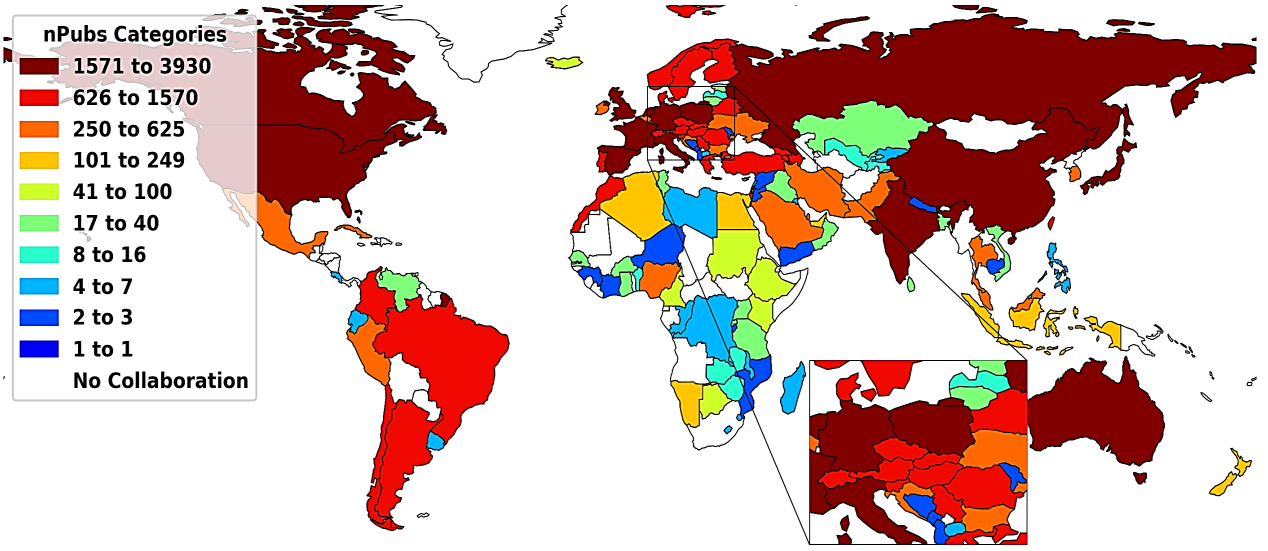
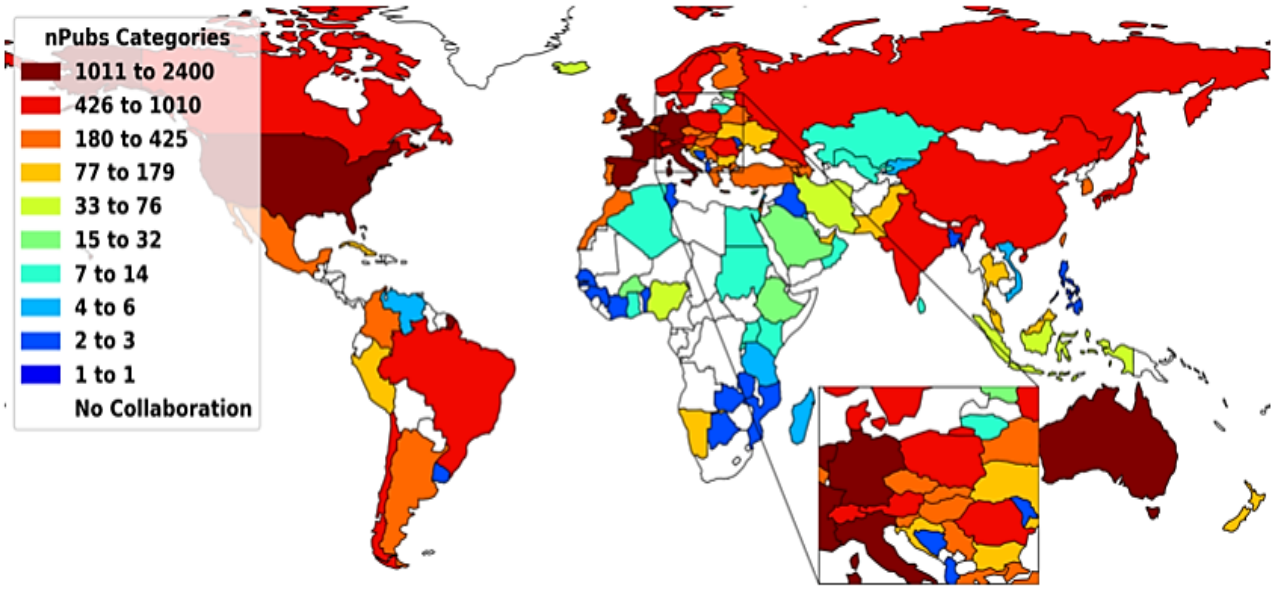


Figure 10-32: South Africa's research collaboration intensity in Astronomy and Astrophysics between 2013 and 2020



Appendix 1: Data and methodology

1.1 The construction of disciplines

For the purposes of this study, we used four different data sources to 'construct' the disciplines as required by the Terms of Reference of the study. We deliberately use the word 'construct' as the meaning attached to 'discipline' varies across different contexts and paradigms. One typical challenge is the boundaries between a 'discipline' (which most scholars would define in terms of its cognitive or theoretical core) and a department at a university. From an administrative point of view academic departments (e.g., the department of Sociology or Psychology) are generally equated with the 'disciplines' of 'sociology" and 'psychology". But academic departments – even when we use the same words, reflect very different cognitive and theoretical approaches and historical trajectories. What is meant by the 'discipline' of 'Physics' in one department may be very different from how the discipline of 'Physics' is understood at another department of Physics at another university. But the real challenge lies even deeper. As scholarship has become more specialised over the past 50 to 60 years, we have seen the development of increasing numbers of interdisciplinary 'spaces' such as gender studies, development studies, applied ethics, business ethics, monitoring and evaluation studies, science and technology studies, land reform studies, and so on. And these new 'inter-disciplines' are often not found in traditional academic departments. Some may be institutionalised as such (new names given to academic departments), but it is more often the case that they are found in research chairs, research centres and institutes.

In the context of this study, this problem manifested at different levels. Scholars from the same 'discipline' do not necessarily publish in the same set of scientific journals. There has also been a huge increase in inter-disciplinary and trans-disciplinary journals which cater for scholars from different disciplines. In fact, one could even argue that it is not particularly important where a scholar is housed academically (or in which discipline he or she was trained) when manuscripts are submitted to the journals. So, the distinction between the 'academic departmental affiliation' and 'disciplinary identity' of the author does not seem to matter.

The same point can be made when we look at the funding of research. In our studies we only had access to the NRF database on funding of SA academics. Besides the obvious constraint of this database – that it does not cover all academics in the country – there is no singular classification of the 'discipline' of the grant recipient (see elaboration below).

In the final analysis, we were faced with a number of different considerations and methodological choices, in constructing the set of academics or scholars that were included in our 11 disciplines in this study. We elaborate below on what these considerations and methodological choices were for the main categories of research assessment in the six reports.

1.1.1 Publications

A decision had to be made to follow an output-based (the journal article) perspective on a discipline as opposed to an (author) affiliation-based view on the discipline. In databases with collections of journal articles (e.g., Scopus or WoS), a journal is typically classified as belonging to one or more subject categories. The subject categories of a journal then also become the subject categories of the articles appearing in that journal. An output-based view of a discipline, therefore, means that a discipline is typically defined as the sum total of all articles in journals that are assigned to a selection of subject categories considered to be representative of that discipline. As far as the **Web of Science** database by Clarivate Analytics is concerned, an affiliation-based construction of a discipline was not possible. It would have required that we identify, clean, and standardise not only all the South African addresses in the six disciplines but all addresses in all countries in those disciplines. Hence, an output-based approach to the definition of a discipline was the only

feasible option for the WoS data, as each article (irrespective of where in the world it is published) appears in a journal with one or more subject categories. The relevant journal subject categories corresponding to a specific discipline were therefore identified and all articles in the world in those categories extracted to be used as a benchmark (in terms of both output volume and citations) for the South African set of articles in the WoS. In the case of the ***SAKnowledgebase*** (SAK) of CREST, an affiliation-based construction of a discipline was also followed, as the subject categories assigned to journals in the database are the same as those used by Clarivate Analytics in their Web of Science citation database. 'Interdisciplinarity is covered by both the SAK and the WoS data, in the sense that the authors who publish in a journal that belongs to a specific discipline could come from any center, unit or department outside that discipline.

1.1.1 Funding

In terms of the **NRF grant-holder** data, the datasets received from the NRF included a number a fields which contain subject related information that could have been used to define the 13 disciplines. However, these fields were not well-populated at all. Moreover, in some cases the field entries seem to reflect the research specialisation of an individual while in other cases the subject classification of a project, where the same project is often classified using different subject categories. As a result, apart from the many missing entries, there is very little consistency in the subject categories used for any specific grant-holder. We therefore decided to implement an affiliation-based definition of disciplines for the NRF data. Two existing variables in the database aided in the development of an affiliation-based field classification of NRF grant-holders. The first of these contains the centre and departmental affiliations of grant-holders at the time of their application ("NRF Department_Phoenix"). The second variable contains similar information for each grant-holder, but as provided by them when they report on their grants ("NRF Department_Submission_ProgressReport"). By considering information from both variables, the discipline reported on here was 'constructed'. In cases where the two variables contained missing information or provided conflicting information for a single grant-holder, alternative sources were consulted. These were the available address information for publication authors in SA Knowledgebase, and the websites of South African universities that list the names of academic staff in departments in the relevant discipline.

The process followed to construct the disciplines in the NRF funding database invariably led to omissions, as the focus was on identifying grant-holders with clear affiliations in the discipline in question. To use Economics as an example: some economists would not necessarily be housed at Economics departments but in departments or centres such as Development Studies or Labour Studies and the line. This again may have produced an under-estimate of the funding received by 'economic scholars' from the NRF.

It further needs to be mentioned that other NRF data sources, such as NRF rating data or postgraduate (masters and doctoral) scholarship data, had not been made available for this analysis. We recognise that analyses of other public, private, and international grants are equally important for reflecting on the state of a discipline.

1.1.2 Academic staff and postgraduate student data

In the case of the fourth data source, HEMIS data, the 13 disciplines were constructed in terms of the available CESM categories, as explained in Appendix 2. It must be emphasised that there is a huge difference between the CESM categories for a discipline and the university addresses corresponding to a discipline. These are not 100% correlated and it is very difficult, if not impossible, to map the CESM disciplinary information to the organisational departmental structures of universities.

1.2 Race as a construct

According to the South African Broad-Based Black Economic Empowerment (B-BBEE) Amendment Act, 2013 (Act No. 46 of 2013), "'black people' is a generic term which means Africans, Coloureds and Indians (a) who are citizens of the Republic of South Africa by birth or descent; or (b) who became citizens of the Republic of South Africa by naturalisation — (i) before 27 April 1994; or (ii) on or after 27 April 1994 and who would have been entitled to acquire citizenship by naturalisation prior to that date.''[7] This definition stipulates that the category 'black', for B-BBEE purposes, only applies to South African citizens.

The Statistics Act of 1999 also makes it clear that the classification in terms of 'population group' or 'race' into four categories (Black African, Indian/Asian, Coloured and White) only applies to South African nationals. This means that assigning any of the four 'categories' to a specific individual, we have to know whether this person is in fact a South African national. Unfortunately, this information is not readily available across all national databases.

- In the case of the **HEMIS** database (which contains data about **academic staff and students**) it is possible to identify the **'race' of South African nationals (by filtering on certain fields).**
- Although ***SAKnowledgebase*** (which contains data about **publications produced by universities**) does include a field called 'nationality', entries are missing. Where entries do occur, there is no clear distinction between 'country of birth', 'citizenship' and 'residency'. Because citizenship is not constant, but can vary, it is also impossible (in the case of individuals with different 'nationalities') to determine what outputs were produced as part of what 'nationality'. Thus, in the analyses involving *SAKnowledgebase*, the **race categories apply to all authors publishing with a South African university address and not only university authors who are South African citizens**.
- As far the **NRF grant-holder** data are concerned, **race is also reported for all grant-holders (and not only those who are South African citizens).** The reason is that the relationship between citizenship, country of birth and residency in the 'country' field in the NRF database is not clear.

In conclusion, then, the results of the analyses concerning race need to be interpreted with caution, as no credible data currently exist.

[7] https://www.gov.za/sites/default/files/gcis_document/201409/37271act46of2013.pdf

Appendix 2: Technical notes on the analysis of HEMIS (staff and student) data

2.1 Disciplines selected for HEMIS analysis

The analysis of human resources for the selected disciplines used the classification of disciplines as outlined by the HEMIS classifications. The HEMIS Classification of Educational Subject Matter (CESM) changed three times over the 20-year period of data analysed. In the table below, the disciplines and their corresponding CESM codes that were used in our analysis are shown. In some cases, the first and second order classifications were used.

2.1.1 CESM codes

	MATHEMATICAL SCIENCES			150100	MATHEMATICS
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	1601	160100	Mathematical Sciences, General Perspective	150101	Mathematics, General
	1602	160200	Logic, sets, and Foundations	150102	Algebra and Number Theory
	1603	160300	Arithmetic and Algebra	150103	Analysis and Functional Analysis
	1604	160400	Classical Analysis	150104	Geometry/Geometric Analysis
	1605	160500	Functional Analysis	150105	Topology and Foundations
	1606	160600	Geometry and Topology	150199	Mathematics, Other
	1607	160700	Probability	150200	Applied Mathematics
	1609	160900	Numerical Analysis and Approximation Theory	150201	Applied Mathematics, General
	1610	161000	Classical Applied Mathematics	150202	Computational Mathematics
	1611	161100	Applications of Mathematics	150299	Applied Mathematics, Other
	1612	161200	User-oriented Mathematics	159999	Mathematics and Statistics, Other
	1699	169900	Other Mathematical Sciences		

STATISTICS					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	1608	160800	Statistics	150300	Statistics
Descriptive Statistics				150301	Statistics, General
Applied Statistics				150302	Mathematical Statistics and Probability
Mathematical Statistics				150399	Statistics, Other
Parametric Inference					
Non-parametric Inference					
Linear Models					
Multivariate Analysis					

STATISTICS					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
Sample Surveys					
Decision Theory					
Time Series Analysis					
Reliability and Quality Control					
Other Statistics (Specify)					

	GEOLOGICAL SCIENCES			GEOLOGY AND EARTH SCIENCES/GEOSCIENCES	
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
Crystallography and Chrystal Chemistry	1505	150500	Geology	140600	Geology and Earth Sciences/Geosciences
Economic Geology				140601	Geology/Earth Science, General
Geomorphology				140602	Geochemistry
Geohydrology				140603	Geophysics and Seismology
Mineralogy				140606	Geochemistry and Petrology
Palaeontology				140699	Geology and Earth Sciences/Geosciences, Other
Petrology					
Sedimentology					
Seismology					
Stratigraphy					
Structural Geology					
Other Geology (Specify)					

	COMPUTER SCIENCE			COMPUTER AND INFORMATION SCIENCES	
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	0601	060100	Applications in Computer Science and Data Processing	060100	Computer and Information Sciences
	0602	060200	Computer Operations and Operations Control	060101	Computer and Information Sciences, General
	0603	060300	Computer Hardware Systems	060102	Artificial Intelligence and Robotics
	0604	060400	Computer Hardware	060103	Information Technology
	0605	060500	Information and Data Base Systems	060199	Computer and Information Sciences, Other
	0606	060600	Numerical Computations	060200	Computer Programming
	0607	060700	Programming Languages	060201	Computer Programming, General
	0608	060800	Programming Systems	060202	Computer Programming, Specific Applications
	0609	060900	Software Methodology	060299	Computer Programming, Other
	0610	061000	Theory of Computation	060300	Data Processing and Information Science
	0611	061100	Educational, Societal, and Cultural Considerations	060301	Data Processing and Data Processing Technology

	COMPUTER SCIENCE			COMPUTER AND INFORMATION SCIENCES	
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	0699	069900	Other Computer Science and Data Processing	060302	Information Science
				060399	Data Processing and Information Science, Other
				060400	Computer Business Systems Analysis
				060401	Computer Business Systems Analysis
				060500	Data Entry/Microcomputer Applications
				060501	Data Entry/Microcomputer Applications, General
				060502	Word Processing
				060599	Data Entry/Microcomputer Applications, Other
				060600	Computer Science
				060601	Computer Science
				060700	Computer Software and Media Applications
				060701	Web Page, Digital/Multimedia, and Information Resources Design
				060702	Data Modelling/Warehousing and Database Administration
				060703	Computer Graphics
				060799	Computer Software and Media Applications, Other
				060800	Computer Systems Networking and Telecommunications
				060801	Computer Systems Networking and Telecommunications
				060900	Computer/Information Technology Administration and Management
				060901	Systems Administration
				060902	Systems, Networking and LAN/WAN Management
				060903	Computer and Information Systems Security
				060904	Web/Multimedia Management
				060999	Computer/ Information Technology Administration and Management, Other
				061000	Management Information Systems and Services
				061001	Management Information Systems, General
				061002	Information Resources Management
				061003	Knowledge Management
				061099	Management Information Systems and Services, Other
				069999	Computer and Information Sciences, Other

CHEMISTRY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	1504	150400	Chemistry	140400	Chemistry
Analytical Chemistry				140401	Chemistry, General

CHEMISTRY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
Biochemistry				140402	Analytical Chemistry
Electrochemistry				140403	Inorganic Chemistry
Inorganic Chemistry				140404	Organic Chemistry
Macro-molecular Chemistry				140405	Physical and Theoretical Chemistry
Nuclear Chemistry and Radiochemistry				140406	Polymer Chemistry
Organic Chemistry				140407	Chemical Physics
Physical Chemistry				140499	Chemistry, Other
Surface Chemistry					
Specialised Areas of Chemistry					
Other Chemistry (Specify)					

	BIOLOGICAL SCIENCES			LIFE SCIENCES	
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	1503	150300	Biological Sciences	130100	Biology general
Biological Behaviour				130101	Biology/Biological Sciences, General
Cytology				130200	Biochemistry, Biophysics and Molecular Biochemistry
Developmental Biology				130201	Biochemistry
Ecology				130202	Biophysics
Embryology (See 09.01 05 - Embryology)				130203	Molecular Biology
Evolution				130204	Molecular Biochemistry
Genetics				130205	Molecular Biophysics
Histology (See 09.01 09 - Histology)				130206	Structural Biology
Limnology				130207	Photobiology
Marine Biology				130208	Radiation Biology/Radiobiology
Microbiology				130299	Biochemistry, Biophysics and Molecular Biochemistry, Other
Molecular Biology				130300	Botany/Plant Biology
Parasitology (See 09.01 14 03 - Parasitology)				130301	Botany/Plant Biology, General
Radio biology				130302	Plant Pathology/Phytopathology
Taxonomy and Systematics				130303	Plant Physiology
Mycology (See 09.01 14 02 - Mycology)				130304	Plant Molecular Biology
Phycology				130399	Biology/Plant Biology, Other
Plant Anatomy				130400	Cell/Cellular Biology and Anatomical Sciences
Plant Pathology				130401	Cell/Cellular Biology and Histology
Plant Physiology				130402	Anatomy
General Zoology				130403	Developmental Biology and Embryology
Animal Anatomy				130404	Neuroanatomy

	BIOLOGICAL SCIENCES			LIFE SCIENCES	
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
Animal Pathology				130405	Cell/Cellular Biology and Anatomy
Animal Physiology				130499	Cell/Cellular Biology and Anatomical Sciences, Other
Entomology				130501	Microbiology, General
Herpetology				130600	Zoology/Animal Biology
Ichthyology				130601	Zoology/Animal Biology, General
Mammalogy				130602	Entomology
Ornithology				130603	Animal Physiology
Other Biology (Specify)				130604	Animal Behaviour and Ethology
				130605	Wildlife Biology
				130699	Zoology/Animal Biology, Other
				130700	Genetics
				130701	Genetics, General
				130702	Molecular Genetics
				130703	Microbial and Eukaryotic Genetics
				130704	Animal Genetics
				130705	Plant Genetics
				130706	Human/Medical Genetics
				130799	Genetics, Other
				130805	Reproductive Biology
				131202	Marine Biology
				131204	Aquatic Biology
				131203	Evolutionary Biology
				131207	Conservation Biology

PHYSICS					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
Astronomy	1501	150100	Astronomy	140200	Astronomy and Astrophysics
				140201	Astronomy
				140202	Astrophysics
				140203	Planetary Astronomy and Science
				140204	Space Physics
				140299	Astronomy and Astrophysics, Other
Physics	1507	150700	Physics	140700	Physics
General Physics				140701	Physics, General

PHYSICS					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
Physics of Elementary Particles and Fields				140702	Atomic/Molecular Physics
Nuclear Physics				140703	Elementary Particle Physics
Atomic and Molecular Physics				140704	Plasma and High Temperature Physics
Classical Areas of Phenomenological Physics				140705	Nuclear Physics
Fluids, Plasmas and Electric Discharges				140706	Optics/Optical Sciences
Structure, and Thermal and Mechanical				140707	Solid State and Low Temperature Physics
Properties of Condensed Matter Electronic Structure and Electrical,				140708	Acoustics
Properties of Condensed Matter Magnetic and Optical				140709	Theoretical and Mathematical Physics
Cross-Disciplinary Physics				140799	Physics, Other
Materials Science					
Biophysics					
Astrophysics and Geophysics					
Other Physics (Specify)					

PHILOSOPHY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	1801	180100	Systematic Philosophy	170100	Philosophy
	1802	180200	History of Philosophy	170101	Philosophy, General
	1803	180300	Main Philosophical Currents and Trends	170102	Main Philosophical Currents and Trends
				170103	Logic
				170104	Ethics
				170199	Philosophy, Other

PSYCHOLOGY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	2001	200100	Foundations of Psychology	**180100**	**Psychology, General**

PSYCHOLOGY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	2002	200200	Biopsychology	180101	Psychology, General
	2003	200300	Environmental Psychology	**180200**	**Clinical Psychology**
	2004	200400	Experimental Psychology	180201	Clinical Psychology, General
	2005	200500	Psychology Applied to Health	180202	Clinical Child Psychology
	2006	200600	Psychology Applied to Education	180203	Clinical Psychology, Professional Studies
	2007	200700	Psychology Applied to Industry, Government, and other Organisations	180299	Clinical Psychology, Other
	2008	200800	Psychometrics	**180300**	**Cognitive Psychology and Psycholinguistics**
	2009	200900	Social Psychology	180301	Cognitive Psychology and Psycholinguistics
	2010	201000	Developmental Psychology	**180400**	**Community Psychology**
	2011	201100	Cognitive Psychology	180401	Community Psychology
	2099	209900	Other Psychology	**180500**	**Comparative Psychology**
				180501	Comparative Psychology
				180600	**Counselling Psychology**
				180601	Counselling Psychology
				180602	Family Psychology
				180603	Marriage and Family Therapy/Counselling
				180699	Counselling Psychology, Other
				180700	**Developmental and Child Psychology**
				180701	Developmental and Child Psychology
				180800	**Educational Psychology**
				180801	Educational Psychology
				180802	School Psychology
				180899	Educational Psychology, Other
				180900	**Environmental Psychology**
				180901	Environmental Psychology
				181000	**Research Methodology for Psychology**
				181001	Research Methodology for Psychology
				181100	**Forensic Psychology**
				181101	Forensic Psychology
				181200	**Geropsychology**
				181201	Geropsychology
				181300	**Health/Medical Psychology**
				181301	Health/Medical Psychology
				181302	Psychopharmacology
				181399	Health/Medical Psychology, Other
				181400	**Industrial and Organisational Psychology**
				181401	Industrial and Organisational Psychology, General
				181402	Occupational and Career Psychology
				181403	Organisational Psychology
				181404	Occupational Health, Well-being, and Performance Dysfunction in the Workplace
				181499	Industrial and Organisational Psychology, Other

PSYCHOLOGY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
				181500	**Personality Psychology**
				181501	Personality Psychology
				181600	**Physiological Psychology/Psychobiology**
				181601	Physiological Psychology/Psychobiology
				181602	Biopsychology
				181603	Neuropsychology
				181699	Physiological Psychology/Psychobiology, Other
				181700	**Psychometrics and Applied Psychological Assessment**
				181701	Psychometrics and Quantitative Psychology
				181702	Applied Psychological Assessment
				181799	Psychometrics and Applied Psychological Assessment, Other
				181800	**Social Psychology**
				181801	Social Psychology, General
				181802	Positive Psychology
				181899	Social Psychology, Other
				189999	**Psychology, Other**

SOCIOLOGY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	2206	220600	Sociology	**200700**	**Sociology**
Community Sociology				200701	Sociology
Criminology				200702	Demography and Population Studies
Demography and Human Ecology				200703	The Sociology of Developing Societies
Population Change				200799	Sociology, Other
Population Problems					
Population Theory					
Juvenile Delinquency					
Marriage and Family Counselling					
Sociology of Marriage					
Sociology of the Family					
Physics of Sociology					
Comparative Sociology					
History and Development of Sociology and Social Thought					
Theory of Social Conflict					
Theory of Social Structures					
Psychological Sociology					
Collective Behaviour Socialisation					
Rural Sociology					

SOCIOLOGY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
Quantitative and Qualitative Methods					
Social Control and Deviance					
Social Institutions					
Social Organisation and Change					
Social Stratification					
Futuristics					
Social Structure					
Social Movements					
Social Problems					
Urban Sociology					
Sociology of Groups					
Intergroup Relations					
Small Groups					
Women Studies					
Other Sociology (Specify)					

ECONOMICS					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	2202	220200	Economics	**40400**	**Economics**
Theory of Economics				40401	Economics, General
Micro-economic theory				40402	Applied Economics
History of Economic Thought				40403	Managerial Economics
Economic Policy				40404	Econometrics and Quantitative Economics
Monetary Economics				40405	Development Economics and International Development
National Income				40406	International Economics
Public Finance				40407	Natural Resource Economics
Economic Growth and Development				40499	Economics, Other
Consumer Economics					
Comparative Economic Systems					
Economics of Human Resources					
Labour and Manpower Economics					
Economics of Natural Resources					
Business and Industrial Economics					
Business Finance					
Industrial Organisation					
Industry Studies					
Economics of Industrial Change					
International Economics					

ECONOMICS					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
International Finance					
International Trade					
Social Economics					
Urban and Rural Economics					
Quantitative Economics					
Econometrics					
Economic Forecasting					
Other Economics (Specify)					

HISTORY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	2204	220400	History	**200300**	**History**
constitutional and Administrative History				200301	History, General
Diplomatic History				200302	African History
Economic History				200303	American (United States) History
Historiography				200304	Asian History
History of Science				200305	European History
Intellectual and Cultural History				200306	History and Physics of Science and Technology
Labour History				200307	South African History
Political History				200308	History of Ancient Cultures
Religious History				200399	History, Other
Social History					
Urban History					
African History					
American ·colonial History					
Antarctic History					
Asian History					
Australasian History					
British History					
Canadian History					
European History					
Latin American History					
Mediterranean History					
Oceanian History					
Russian History					
Southern African History					
United States History					
World History					
Ancient History					
Contemporary History					

HISTORY					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
Medieval History					
Modern History					
Minority Group History					
History of Women					
Other History (Specify)					

POLITICAL SCIENCE					
Fields included prior to 2010 – not disaggregated in CESM codes	**1999-2007**	**2008-2009**	**Description**	**2010-**	**Description**
	2205	220500	Political Science	**200600**	**Political Science and Government**
South African Political Systems				200601	Political Science and Government, General
Citizenship				200602	Comparative Political Systems
Comparative Political Systems				200603	Contemporary World Affairs
African Political Systems				200604	International Relations and Affairs
Asian Political Systems				200699	Political Science and Government, Other
Communistic Political Systems					
Latin American Political Systems					
Middle Eastern Political Systems					
Political Systems of the United States of America					
Western European Political Systems					
Contemporary World Affairs					
International Relations					
Political Behaviour					
Political Parties and Public Opinion					
Political Socialisation					
Political Structures					
Political Theory					
American Political Theory					
Provincial, Regional and Local Government					
Other Political Science (Specify)					

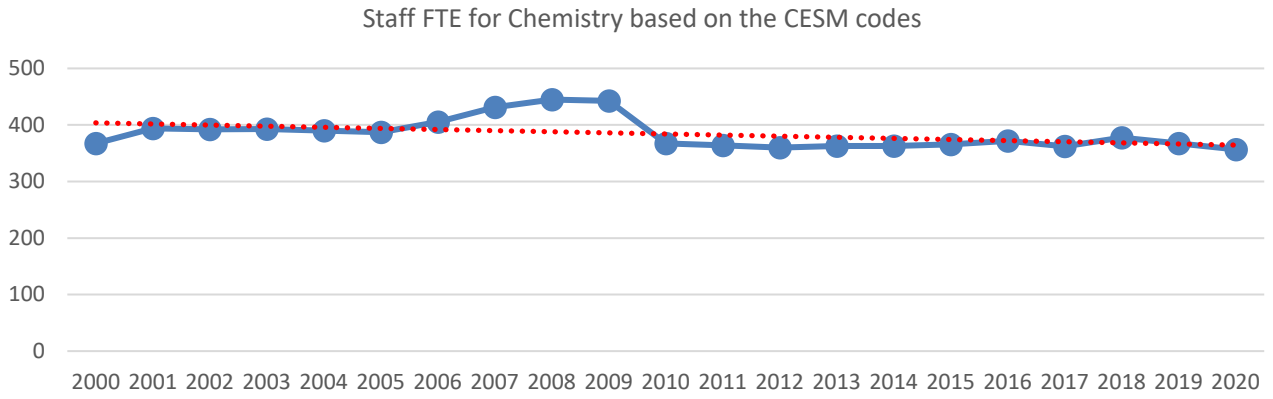
2.1.2. Implications of the CESM changes

We have shown in the tables above how the CESM disciplinary codes have changed over the last 21 years and how we have tried to align the three different classification frameworks. However, the changes in the CESM classification impacted on the HEMIS data in two ways.

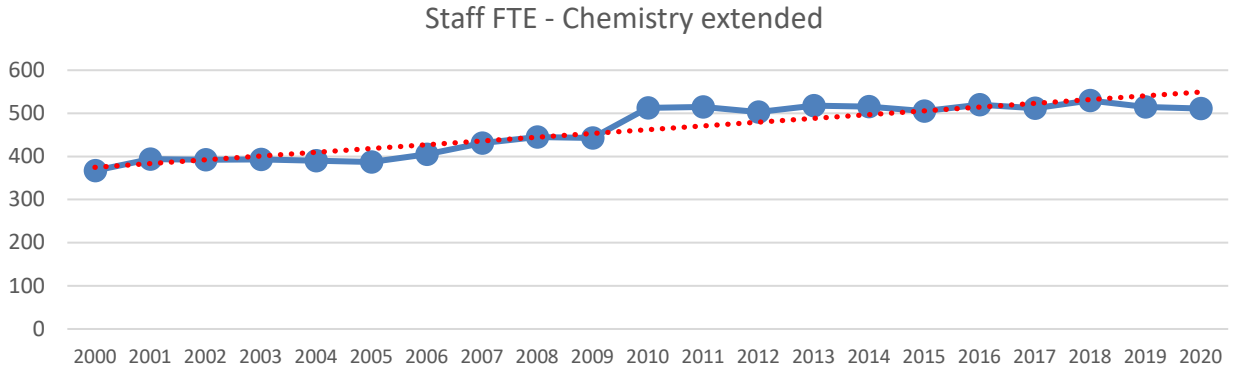
Firstly, many universities used the incorrect CESM codes (the new codes) in 2010 – where the old 2009 codes were used. This means that for some universities, in 2010, students and staff were assigned to incorrect disciplines. In these instances, we have tried where possible, to correct these errors and clean the HEMIS data.

Second, with the reclassification, some subfields were included and excluded. For some disciplines these changes had minor implications as the subfields were largely constant over the period. In other disciplines the subfields were not disaggregated at CESM level 2 which means that we could not align the inclusion and exclusion of the subfields to reconcile that data pre-2010 with that after the changes came into effect in 2010.

An illustrative example is provided below where we look at the field of Chemistry. Between 2000 and 2009 the only CESM code assigned to Chemistry was code 150400-Chemistry with no disaggregation at subfield level. From 2010 onwards, we see a breakdown of the subfields in Chemistry which each has an assigned CESM code in HEMIS. However, in the HEMIS documentation a list of subfields, which constitute the level 2 classification between 2000 and 2009, is given. We have provided these subfields, where available, in the tables above. When we look at the total staff FTE for Chemistry, using purely the CESM codes assigned to Chemistry for the three periods (1504, 150400 and 140400), as illustrated in the figure below, we find that there is a substantial decrease in the total FTE in Chemistry between 2009 and 2010 (from 442 to 367).



When we then align the subfields which were previously included in the classification of Chemistry (2000 to 2009), which mainly include fields related to biochemistry, and subsequently excluded in the 2010 onwards classification (as shown in the figure below) we see an expected linear growth for the period.



In the presentation of the trend data for staff and students, based on the HEMIS data, we report on the results of the given CESM classifications as given for the three periods. In many cases we will therefore see a decrease in the number of staff and students between 2009 and 2010 for the reasons explained above.

2.2. Data cleaning

In our analysis of staff and student data, which is based on the HEMIS data a number of challenges are reported. In the previous section we reported on two challenges which concerns the changes in the CESM classification framework. A third challenge pertains to the incorrect submission of data from the respective universities as well as cases where there are missing data – or no data submitted for certain years. In some cases, we have imputed missing data where there are obvious omissions, but in most cases, we report on the data as captured in the HEMIS database. One such an example is UNISA in 2017 and 2018, where all students recorded the same commencement date. This affects the calculation of new enrolments and well as conversion rates. In our reporting of new enrolments, we have thus imputed data for 2017 and 2018 as the average number of new enrolments for 2016 and 2019. We have also excluded UNISA in our calculation of conversion rates.

2.2.1 Students

The HEMIS microdata received from the DHET were used in the analysis of Honours, Masters, and Doctoral students of selected disciplines. From here, all Honours, Masters and Doctoral students in each discipline were selected. The fields used from the microdata to select students are outlined below.

Code	Description	
529	Reporting year	Data from 2000 to 2020 were selected
005	Qualification type	The qualifications selected are as follows: **Honours:** 06: Honours Degree 47: HEQF Postgraduate Diploma 48: HEQF Bachelor Honours Degree 69: HEQSF Postgraduate Diploma 70: HEQSF Bachelor Honours Degree **Masters:** 07: Masters Degree 28: Magister Technologiae Degree 49: HEQF Masters Degree Doctoral 72: HEQSF Masters Degree 73: HEQSF Prof Masters Degree **Doctoral:** 08: Doctoral Degree; 30: Doctor Technologiae Degree 50: HEQF Doctoral Degree 74: HEQSF Doctoral Degree 75: HEQSF Prof Doctoral Degree
007	Commencement date	The date on which a student first commenced the qualification at the reporting institution. This was recoded to 'commencement year'
011	Date of birth	Each student's year of birth is recorded from which students' ages were determined.
012	Gender	Male; female and unknown
013	Race	Black 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 refers 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

2.2.2 Staff

The micro staff FTE data from the DHET were used. The codes used to extract data and their descriptions are outlined below.

Code	Description	
529	Reporting year	Data from 2000 to 2020 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 merged institutions after 2005
National Staff Register ID	A code which uniquely identifies a staff member at an institution.	This was used to identify staff members uniquely
012	Gender	Male, female and unknown
013	Race	African, Coloured, white, Indian/Asian and 'no information'
014	Nationality	Students' nationalities were recoded into three regional categories: Rest of World (ROW) Rest of Africa (ROA) South African (RSA) Nationality refers 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 members 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 members 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 are: 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 of FTEs (across all specialisations) was 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	This refers to a person's age (in years) in a recording year.
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.
040	Rank of staff member	A code indicating the rank of a staff member (if Instructional/Research professionals).

2.3 Indicators

2.3.1 Student analysis

The results presented in this report, are based on an analysis of individual records which were specific to students registered for an Honours, Masters, or Doctoral degree between 2000 and 2020. The database included biographical information which allowed for an in-depth analysis of students by gender, race, nationality (categorised into three broad geographical locations) and age. Below the definition and calculation of each indicator is explained.

Indicator	Working Definition	Calculation
Enrolments	All students registered for a selected degree (H, M, PhD) in the recording year, regardless of entrance category	
New enrolments	These are first-time entering students	We did not use the 'entrance category' classification of HEMIS. Rather, we define these students as those where 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	

2.3.1.2. Conversion rates

This indicator is a measure of the 'flow' of postgraduate students from undergraduate to Doctoral graduation. We calculate the conversion rate by dividing the number of new enrolments (i.e., Doctoral) in a particular year (year x+3) by the average number of graduates at the previous degree level (i.e., masters) over the preceding three years [(year x) + (year x+1) + (year x+2) / 3). It is important to note that this indicator is not cohort-based. This is a simple measurement of the percentage new enrolments in a given year divided by the average number of graduates in the previous three years. In other words, at what rate do masters students convert to Doctoral studies in general and without tracking students specifically?

$$Conversion\ rates\ (\%) = \frac{PhD\ new\ enrolments\ (\text{year x} + 3)}{Master's\ graduates\ (year\ x + year\ x + 1 + year\ x + 2)/3}$$

2.3.1.3. Time-to-degree

This indicator refers to the total 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). In the calculation of Doctoral time-to-degree, all cases less than two years were excluded given the prescribed minimum registration time for a Doctoral student in South Africa.

2.3.1.4. Age at commencement

This indicator refers to the average age of a student at the time of registration (enrolments only). It is calculated as 'reporting year' minus 'year of birth'. The mean and median of all enrolments in each reporting year is calculated. Outliers were not excluded in the calculations.

2.3.1.5. Age at graduation

This indicator refers to the average age of a student at the year of graduation (graduates only). It is calculated as 'reporting year' minus 'year of birth'. The mean and median of all enrolments in each reporting year is calculated. Outliers were not excluded in the calculations.

2.3.2 Staff analysis

The criteria discussed in the section above were used to select individual records for the analysis of staff FTE. Personnel can have FTE time in more than one CESM specialisation. We determined the staff capacity in each disciplinary field by summing the FTE values for research or instructional staff who have an FTE in the specified CESM classification within a given year. We therefore report on the total FTE value for the respective disciplinary field, per year and per demographic group.

In calculating **supervisory capacity**, we used a simple calculation in determining the number of PhD enrolments per permanent instructional and research staff member who holds a PhD. The number of Doctoral (total) enrolments is then divided by the number of staff to determine a student-to-supervisor ratio. This ratio then serves as an indicator of supervisory capacity at the Doctoral level. However, it should be noted that supervisory capacity is a less robust indicator and should be interpreted within context as the distribution of students varies significantly across institutions. This indicator does therefore not take into consideration the unequal distribution of students across universities.

2.3.3. Compound Annual Growth Rate (CAGR)

Throughout the report, we indicated rates of change through the use of the CAGR which is a measure of growth over multiple time periods. The calculation of the CAGR is as follows:

(End Value/Start Value)^(1/Periods) – 1 written as:

$$r_{CAGR} = \left(\frac{X_f}{X_0}\right)^{\frac{1}{n}} - 1$$

which is derived from the compound growth formula (that defines the geometric growth series):

$$X_f = X_0(1 + r)^n$$

where X_f is the end value, X_0 is the start value and n = the number of periods.

Appendix 3: Technical notes on bibliometric analyses

3.1. Web of Science indicators

3.1.1. Percentage World Share

Percentage of the publications in the world that can be attributed to a single entity, $\%\, WS = \frac{n_f}{N_f} \times 100\%$

Where n_f is the number of publications produced by the entity in field f and N_f is number of publications produced by the whole world in field f.

3.1.2. Mean Normalised Citation Score (MNCS)

The calculation of the *MNCS* starts with a calculation of the expected number of citations for any publication in a specific field. Since publications are often associated with more than one field, each publication, and all citations it receives are attributed in equal fractions to all the fields associated with it.

$$e_i = \frac{\sum_{j=1}^{N_i} \frac{c_j}{f_j}}{\sum_{j=1}^{N_i} \frac{1}{f_j}}$$

where e_i is the expected number of citations for any publication in field i, N_i is the number of publications in field i, c_j is the number of citations received by publication j and f_j is the number of fields associated with publication j. Now the normalised citation score for publication j is given by

$$ncs_j = \sum_{i=1}^{f_j} \frac{c_j}{e_i f_j} = \frac{c_j}{f_j} \sum_{i=1}^{f_j} \frac{1}{e_i}$$

Finally, we can calculate $MNCS$ for any set of n publications:

$$mncs = \frac{1}{n} \sum_{j=1}^{n} ncs_j$$

It should be noted that in our citation-based calculations, self-citations are not counted. A self-citation happens when one publication cites another, but one of the authors of the citing article is also an author of the cited article. Furthermore, for this study, we use a 2-year citation window so only citations received up until the second year after publication are counted.

3.1.3. Relative field strength (RFS)

The relative field strength (RFS), or activity index, of an entity in field f is the ratio of two ratios, calculated as:

$$rfs_f = \frac{\frac{n_f}{n_t}}{\frac{N_f}{N_t}}$$

where n_f is the number of publications produced by the entity in field f, n_t is the number of publications produced by the entity across all fields, N_f is the number of publications produced by the world in field f and N_t is the total number of publications produced by the world. The rfs can be interpreted as

$$rfs = \frac{\text{field share of publications by entity}}{\text{field share of publications by world}}$$

3.2. SAK indicators

SAKnowledgebase by CREST, Stellenbosch University, is a comprehensive database of research output produced by the South African universities from 2005 onwards, and specifically research outputs (articles, books, book chapters and conference proceedings) that were submitted to the DHET for subsidy. It includes the demographics of authors (gender, race, age, and institution) as well as specialised journal information. Relevant authors in each field were identified based on the available departmental affiliations of authors in SAKnowledgebase, as well as by sourcing the names of academic staff in the field from the university websites and incorporating that information into SAKnowledgebase.