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Racial Disparities in Human Capital: Numeracy in South Africa, 1850-1980

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Abstract.

South Africa represents a paradigmatic case in international literature on racial discrimination, illustrating a deeply institutionalised system that affected all aspects of daily life. Black, Coloured, and Asian populations were systematically relegated to a subordinate status compared to the dominant White minority. Drawing on direct statistical sources such as censuses and national budgets—despite certain limitations—this study explores long-term disparities through the lens of numeracy, a proxy for basic arithmetic skills. We analyse numeracy levels by race across cohorts born between the 1850s and the 1980s, with a particular focus on the Black population, given its demographic predominance. A key contribution of this research is the inclusion of province of residence as a control variable, alongside gender, birth decade, and literacy. Our results show clear and persistent gaps in numeracy by race and gender, with Black individuals and women consistently disadvantaged. Notably, numeracy levels indicative of full numerical literacy were not attained by the Black population until the 1960s cohort, more than a century after White individuals had reached that threshold. Strikingly, we also find unexpectedly high numeracy levels in the "homelands", suggesting a strong valuation of education by Black communities in these self-governed areas, a dynamic we refer to as "African Agency".

Keywords.

South Africa, Human Capital, Numeracy, Discrimination, Race.

JEL Codes

I24, I25, N37, N97.

1. Introduction

Human capital is widely recognized as a critical factor in modern economic growth and development theories, and it is crucial for achieving success in both industrial and agricultural economic contexts (Lucas, 1988; Romer, 1989; Mankiw et al., 1992; Jones, 1995; Glaeser et al., 2004; Galor, 2011). Common indicators for assessing human capital in contemporary periods include years of schooling, educational expenditure (Barro and Lee 1996, 2001), productivity gains through education (Wößmann, 2003), and schooling rates (Mankiw et al., 1992; Becker and Woessman, 2009).

Since the establishment of the Republic in 1910, historical South African censuses have offered useful information on the progression of literacy levels. In contrast, assessing changes in numeracy remains more difficult—a challenge that this study aims to tackle. We define numeracy as the ability to perform basic mathematical operations—skills essential for processing, understanding, and communicating numerical information. Basic arithmetic skills are essential for any profession that requires the use of numbers, weights, and measurements, such as those in various crafts or construction trades. This study contributes to the literature on numeracy skills in Sub-Saharan Africa by measuring these skills through the age heaping approach, quantified using the ABCC index (Nagi et al., 1973; Baten and, Fourie 2015; Cappelli and Baten, 2017; De Haas and Frankema, 2018; Ferber and Baten, 2025). It has been suggested that the British colonial education system—extensively utilizing African teachers and local languages—fostered more rapid numeracy development than other educational systems in Africa (Cappelli and Baten, 2021). In South Africa, the influence of the British educational system became particularly evident starting in the 1910s.

Drawing for the first time on the full South African censuses (birth cohorts 1850s–1980s), we present new evidence on numeracy levels in South Africa, disaggregating by race, sex

and residence. We also take into account the *Bantu Educational Act (1953)*, which was the most important South African educational segregation law during apartheid. This approach will enable a more in-depth understanding of the historical evolution of South Africa's educational system and its impact on society by birth cohort.

This paper continues as follows: the next section summarizes the most important milestones in educational changes in South Africa; Section 3 details the data and methodology used; in Section 4, the descriptive results are presented and explained, and Section 5 the econometric results are covered. Finally, in Section 6, some discussions and elements for the conclusion are offered.

2. Evolution of education in South Africa

Since its roots as a Dutch East India Company victualling station and then expansion into Boer Republics and British Colonies and later a British dominion, education in South Africa has been provided with varying degrees of access and quality. Because of the initial focus on Company business and productivity in the Cape Colony and with low rates of immigration, by 1700 there were only three schools (Clarke, 1904). This does not imply a low level of human capital, as a significant proportion of the settlers who arrived by sea were literate, often bringing Bibles with them, and in some cases, personal diaries from the early centuries of colonization have even been preserved (Hunt, 2005; Stanley, 2019). The type of education did, however, vary drastically depending on the point in the country's history that it was offered, to whom it was offered (race, gender, geographical area, etc.), who that education was offered by and at what cost. Jansen (1990) divided the history of Black education into five periods: 1. *Traditional African education* led by traditional leaders and based on oral traditions in the pre-colonial period; 2. *Slave education* in the early colonial period from 1652 onwards, entailing basic instruction

related to the Christian faith; 3. *Mission education* from the nineteenth century, which saw the introduction of European standards of education through mission organisations; 4. *Native education* from the 1920s, which was marked by the decline of schools for Black people because of state introduced curricula segregated by race; and 5. *Bantu education,* which saw the first state formulated and enforced education system for people of all races, ushered in by the 1953 Bantu Education Act. For the sake of brevity, three dates are crucial to gaining an overview of the education landscape in South Africa: 1910, 1948 and 1994.

Before 1910, the year of the Union of South Africa, the area known as South Africa today consisted of two British Colonies and two Boer Republics, and education was conducted independently in each region. Within the Cape Colony and beyond, from the eighteenth century, missionary stations educated small groups of indigenous peoples (with high levels of education), while schools were started for the children of European settlers, usually linked to churches. The out migration of farmers with a Dutch heritage from the Cape from the 1835 onwards saw an initial decrease in education levels for this section of the population, but these migrants went on to establish two republics and their own schools within these (Russel, 1889).

In 1910 the colonies and republics were united to form the Union of South Africa, a British dominion. The National Party came into power in 1948 and education, including mission schools, came to be fully controlled by the Government. Although apartheid is associated with the National Party and its policies, talks of special education for "natives" had been prevalent since the late nineteenth century (Paterson, 2005). Some argue that the National Party just formalised existing ideas of segregation that permeated colonial society since the Dutch East India established their station at the Cape (Cross and Chisholm, 1990).

The quality of the post-1948 state-provided education depended on the racial group it was being offered to. The concept of Bantu Education was introduced to limit employment opportunities for Black people in order to maintain a cheap and unskilled labour force (Wills, 2011). This education system emphasised teaching only basic numeracy and literacy. Of the 7 000 schools in South Africa attended by Black students in 1953, 5 000 were missionary run, typically under severe economic constraints. The Bantu Education Act of 1953 moved control of those schools to the so-called Native Affairs Department (Christie and Collins, 1984). 1994 heralded the first democratic elections in South Africa, after which the first democratic education system was introduced, and which continues to be riddled with challenges (Chisholm, 2017). Education in South Africa in the twentieth century has been characterised as dysfunctional (Fedderke et al., 2000) and outcomes continue to be divided along racial lines in the twenty first century (Van der Berg, 2008). The Bantu Education Act of 1953 is particularly significant in understanding the systemic educational discrimination against the Black population during Apartheid, as it represented a legislative cornerstone that institutionalized the racist and exclusionary ideologies of the ruling elite. It enforced racially segregated educational systems. It was the most important South African educational segregation law during apartheid. The Act aimed to control and limit the education provided to Black South Africans, emphasizing a curriculum that prepared them for labour and subordinate roles within society. Hendrik Verwoerd, the Minister of Native Affairs in 1953, stated: “What is the use of teaching the Bantu child mathematics when it cannot use it in practice? This is quite absurd.” The Soweto Students Representative Council responded to the Act with a clear understanding of its implications: “We shall reject the whole system of Bantu Education whose aim is to reduce us, mentally and physically, into ‘hewers of wood and drawers of water’” (Kraak, 2002).

Under this Act the government centralized control over schools and dictated curricula that promoted the apartheid ideology, asserting that Black South Africans did not need advanced education because they were destined to occupy lower-level jobs. By restricting access to quality education, the Bantu Education Act entrenched socioeconomic inequalities, hindering the economic and social mobility of the Black population (Christie and Collins, 1984).

This Act not only downgraded the resources allocated to schools for Black students but also minimized their access to subjects that could provide upward mobility, such as mathematics and sciences. It is often argued that the policy of African education was aimed to direct Black or non-white youth to the unskilled labour market (Byrnes, 1996). As a consequence of this law, in the 1960s, while the schools reserved for Whites were of Western standards, 30% of the Black schools did not have electricity, 25% no running water and less than half had plumbing. In the 1970s, the per capita governmental spending on Black education was one-tenth of that of the spending on White education, with the understanding that the White population represented a demographic minority (Byrnes, 1996).

Resistance to Bantu Education was widespread, including protests led by students and teachers. One prominent protest in Soweto in 1976, known as the Soweto Uprising, became a pivotal event in the anti-apartheid movement, marking a strong opposition to the educational and societal injustices imposed by apartheid policies (Hyslop, 1990). The introduction of the new education law was accompanied by the mandatory signing of a commitment by teachers to work in alignment with the ruling nationalist government (Soudien, 2002).

3. Methods and data

To estimate historical numeracy values as a proxy for human capital, the calculation of age heaping is used (Mokyr, 1985). Age heaping refers to the tendency of individuals to round their ages to numbers ending in zero or five when they do not know their exact age. For example, a person might declare in official records that they were 45 years old when they were actually 43. To measure this, A'Hearn et al. (2009) proposed an index called the ABCC index, which is a straightforward linear modification of the Whipple index (equation 1). The ABCC index (equation 2) allows for the estimation of the proportion of people who accurately report their age. The calculation is based on predefined age intervals that start with ages ending in the digit 3 and end with ages ending in the digit 2, typically beginning in the 23–32 age group and often extending to the 63–72 age group. It ranges from 0 to 100, where a score of 100 indicates that everyone reports their age correctly.

$$(1)\ Wh = \left(\frac{(Age25 + Age30 + Age35 + \cdots + Age60)}{\frac{1}{5} \times (Age23 + Age24 + Age25 + \cdots + Age62)} \right)$$

$$(2)\ ABCC = \left(1 - \frac{(Wh - 100)}{400}\right) \times 100\ if\ Wh \geq 100\ ;\ else\ ABCC = 100$$

Although there is some debate regarding this proxy, as some scholars argue that it could indicate institutional and cultural modernization, in general, age heaping is generally considered a good proxy for arithmetic capacity (Spenneman, 2017; A'Hearn et al., 2016). Recent studies have examined numeracy and its progress over the life course individually, demonstrating that there is a correlation between age heaping and the accuracy of individual declarations (Baten and Nalle, 2022; Blum and Krauss, 2018; Pujadas-Mora and Pérez-Artés, 2023).

We utilize the South African censuses from 1911, 1921, 1936, 1946, 1951, 1960, 1970, 1980, 1991, 2001, and 2011, which provide detailed population distributions by age, race, and sex. This implies that we will examine cohorts born in the 1850s and the early 21st century. Each census includes a "single ages" section that categorizes the total South African population by sex, race, and specific reported age, enabling us to detect any age heaping, or over-reporting of ages ending in 0 and 5. Table 1 presents the total number of observations by census year and race and sex for individuals aged between 23 and 73 years. As seen in Table 1, the Black population consistently represented the largest demographic, accounting for 74% of the total population in 1936, 70% in 1970, and 80% in 2011. This was followed by the White population, comprising 17% in 1921, 17% in 1970, and 9% in 2011, and the Coloured population,[1] which represented 6% in 1921, 9% in 1970, and 9% in 2011. The Asian population experienced significant fluctuations due to its dependence on population movements from other British colonies (Bhana and Brain, 1990).

Table 1 Number of observations (aged 23–72 years)

	Asian		White		Coloured		Black	
Census	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
1921	49,654	24,307	378,975	341,090	115,578	109,675	.	.
1936	48,208	32,861	526,824	509,867	160,791	153,866	1,417,365	1,384,809
1946	188,471	181,803	644,021	630,657	188,471	181,903	1,785,181	1,630,022
1951	70,490	59,334	688,671	700,935	218,135	216,726	1,946,587	1,785,221
1960	90,687	85,582	775,245	797,022	288,578	291,780	2,365,732	2,244,048
1970	127,076	125,273	964,602	978,791	366,541	386,079	2,978,129	3,093,026
1980	185,460	190,328	1,300,140	1,316,020	518,220	548,740	3,689,080	3,297,280
1991	250,318	261,517	1,500,676	1,505,506	742,533	805,334	4,848,056	4,774,632
1996	275,731	298,019	1,291,688	1,367,876	839,101	937,776	6,390,414	7,312,235
2001	308,486	335,872	1,284,978	1,386,979	932,534	1,066,463	7,272,755	8,512,768
2011	.	.	.	.	.	.	9,371,606	10,348,341

Source: South African Censuses.

[1] The word "Coloured" is interpreted negatively in some contexts, such as the United States. In South Africa it is currently the preferred and self-affirmed term used by people with mixed racial ancestry, whose heritage can often be traced to early colonial encounters between settlers and indigenous peoples or slaves.

Consistently classifying South Africa's population by race has been challenging given the Country's diverse cultural and ethno-linguistic composition, and changing administrations (Christopher, 2002). Traditionally, four racial groups have been used: White/European, Black/Native, Coloured/mixed, and Asian/Indian/Malay. The classifications of White, Black, and Coloured have remained relatively stable over time, with some exceptions, but the classification of Asians has been inconsistent. In the late nineteenth century, Cape Colony censuses introduced the category "Malay" for people of Southeast Asian origin, but more recent censuses tend to focus on "Indian", including Malays in the "Coloured" group. Most Indian immigrants arrived in the Cape in the late nineteenth and early twentieth centuries. The changing classification of "Asian" reflects not only evolving demographics but also different patterns of behaviour, especially in political contexts (Ferree, 2006). We include the Asian/Indian/Malay group in our study, acknowledging potential biases and inaccuracies over time.

The 1911 census, the first for the Union of South Africa, is a milestone in South African documentation. Completed in just 14 months, it collected extensive individual data on demographics, the economy, religion, and more. Despite its breadth, it contains errors that are common to South African censuses throughout the twentieth century (Christopher, 2010, 2011). For instance, the 1951 census recorded 1,226,982 black children aged 0–4, while the 1960 census, following the same cohort, recorded 1,287,998 (aged 9–13 in 1960). This suggests that not only did no children die, but 61,016 new children appeared, indicating significant under-reporting in 1951. Some children must have died, exacerbating the under-reporting. Official immigration data do not account for this discrepancy. Similar inconsistencies appear in earlier censuses, such as the disappearance of 24,484 black children aged 0–4 between 1936 and 1946, and 167,904 black children aged 0–4 between 1946 and 1951. Such variations over short periods raise

serious concerns about census accuracy. However, these errors should not impact our analysis of age heaping.

The nineteenth-century Cape Colony censuses also suffer from under-reporting issues, partly due to changing borders. Although we only use the last two Cape Colony censuses, which included most of the territories that later became the Cape Province in the Union of South Africa, we considered that newly incorporated areas might have poorer record-keeping and data quality than established districts.

Despite these shortcomings, the censuses remain valuable information sources (Moultrie and Timæus, 2003; Christopher, 2011). To avoid idiosyncrasies, we focused on long-term trends across the century rather than short-term variations. Our large samples helped mitigate bias from outliers. We also conducted separate analyses for each South African province over shorter periods and found similar results, indicating no geographical bias affecting our findings.

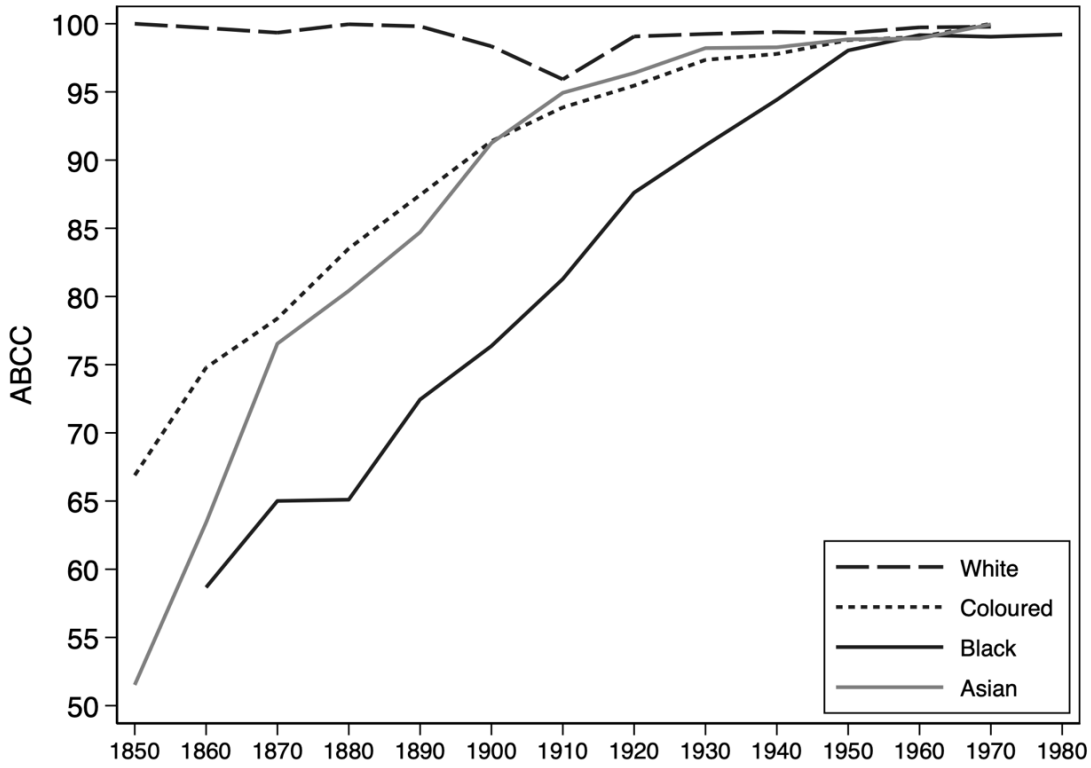
4. Descriptive analysis

Figure 1 illustrates the numeracy trend by race for birth cohorts from 1850 to 1980. Consistent with existing literature, White individuals display numeracy levels comparable to those found in the metropole (Juif et al., 2014; Baten and Fourie, 2015). The Coloured and Asian populations follow with gradual increases in numeracy levels, while Black individuals are the last to reach parity with the other three groups, doing so by 1960. This trend reflects the dominant system of racial discrimination in South Africa (Dubow, 2014), extending beyond the globally recognized apartheid laws to include earlier colonial policies. The low numeracy levels among those born in the latter half of the nineteenth century reflect the limited efforts of both British and Boer colonial systems (descendants of Dutch settlers) to provide academic training to non-White populations.

This was the case despite the fact that Black individuals commonly held artisanal roles, where basic arithmetic skills could have significantly enhanced their work (Funtowicz et al., 1990). As for the Asian population, the results should be interpreted with caution, as they encompass the entire group, some of whom arrived as adults from other British colonies, such as India.

Figures A.1 and A.2 in the Appendix replicate the analysis from Figure 1, disaggregated by gender: men in Figure A.1 and women in Figure A.2. Our findings indicate very similar trends by racial group, regardless of gender. Even the baseline values for 1850 and 1860 are comparable for both sexes across all racial groups. However, the rate of numeracy improvement differs by gender: men tended to converge more quickly within White populations (who exhibit near-perfect numeracy levels) than women. Consequently, although both genders started from similar levels, women reached full numeracy literacy at a slower pace. That girls faced a disadvantaged educational situation should not come as a surprise. There are numerous historical accounts in South Africa that reinforce this discrimination. For example, the Abbot of Mariannhill in 1889 expressed support for educating native boys in literacy and numeracy, but unequivocally opposed providing the same education to girls (Morrell and Moletsane, 2002: 229).

Figure 1. ABCC index by races (birth decades 1850-1980)

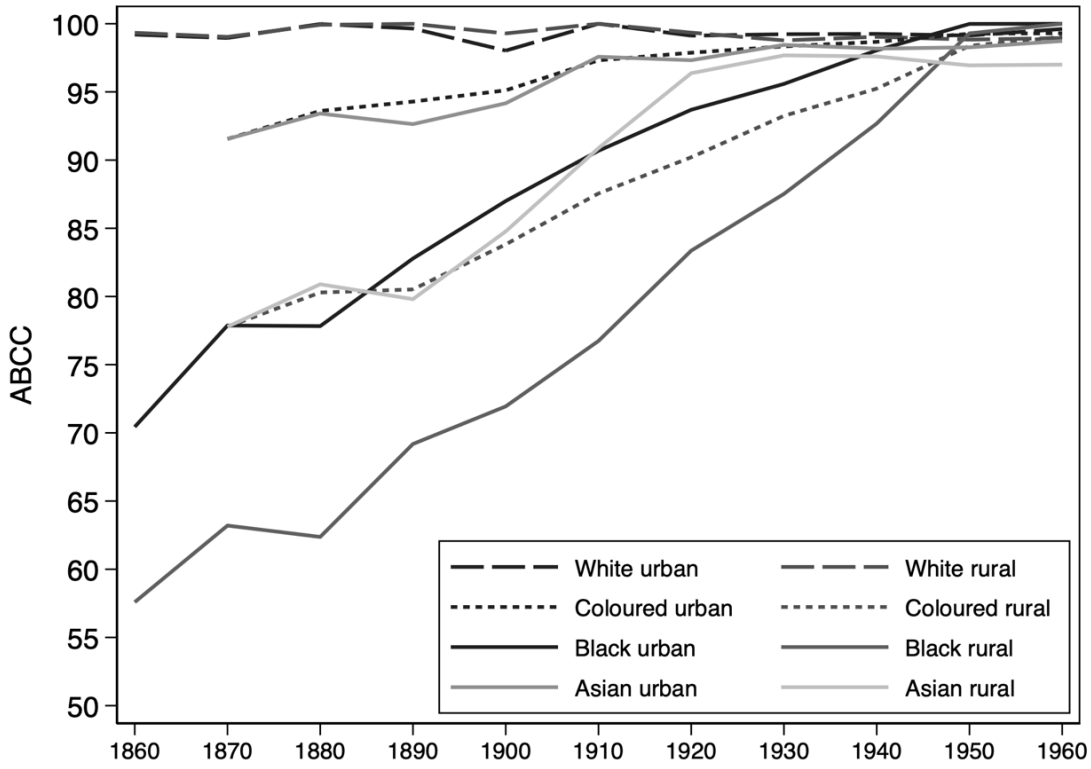


Source: South African Censuses.

In Figure 2, we extend our analysis of numeracy levels to investigate the influence of geographic context, distinguishing between urban and rural residency based on census classifications. The White and Asian populations were predominantly urban (65.3% and 86.7% of urban population in 1970, respectively), whereas the Black population was mainly rural (67% of rural population in 1970), with the Coloured population occupying an intermediate position (Marco-Gracia and Fourie, 2021, 2022). It is also important to note that apartheid policies registered Black individuals as rural residents—when they resided temporarily in urban areas for employment as workers and domestic servants—but families were generally not allowed to reside in urban areas. The Group Areas Acts, 1955 and 1960, saw the reorganisation of South African cities, removing

people of colour from areas that were earmarked for White use (Lemon, 2021). To move into so-called White areas, people of colour were required to use a pass (Savage, 1986).

Figure 2. ABCC index by races and rural-urban (birth decades 1850-1980)



Source: South African Censuses.

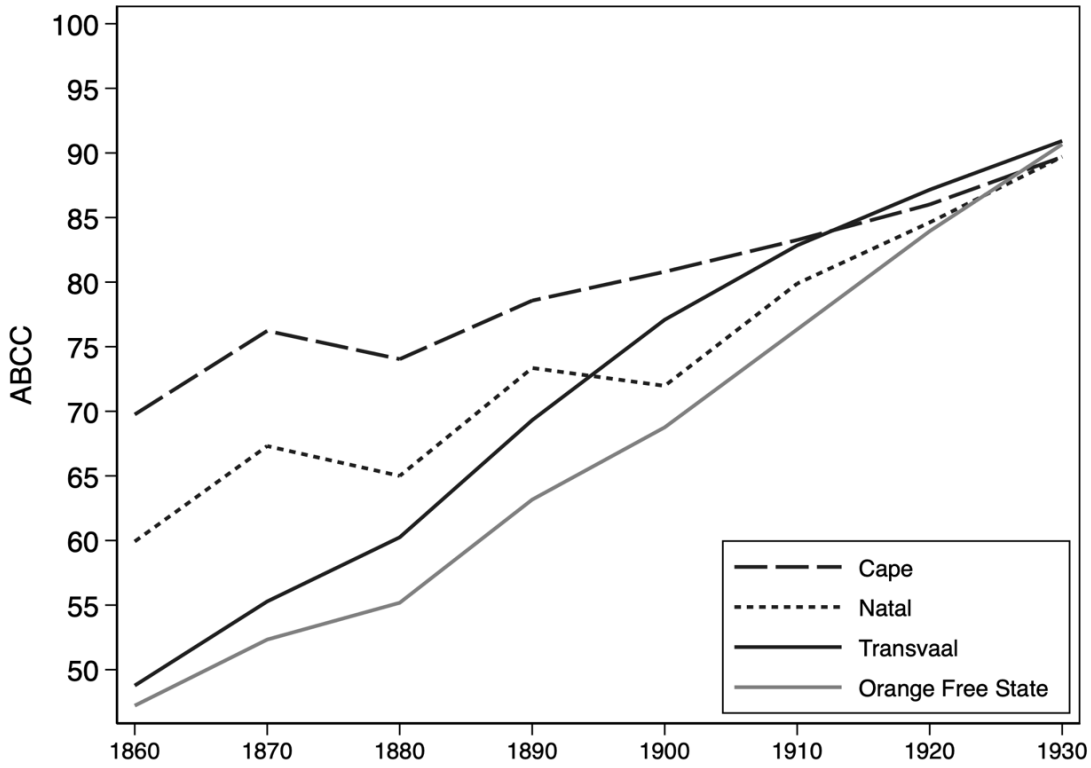
The results in Figure 2 clearly reveal distinctions not only by race but also, in an innovative way, by place of residence. First, we focus on the White population, which demonstrates near-perfect numeracy levels in both rural and urban areas. Only the cohort born around 1900 shows a slight decline in these nearly perfect numeracy levels, particularly in rural areas. This drop may reflect the challenges and crises linked to the South African War (1899–1902), the unification of South Africa in the early 1910s, the impact of World War I, and the post-war gold crisis (South Africa being a major gold exporter) as it returned to the gold standard (Thompson, 2001).

More intriguing are the differences in rural versus urban residency, particularly among Black individuals. The rural Black populations exhibit very low numeracy levels, even by historical standards of developed nations (Cappelli and Baten, 2021). Early cohorts studied display numeracy levels barely exceeding 55, in stark contrast to the maximum levels seen in Whites (100) and the intermediate levels in Coloured and Asian populations (around 70). Nevertheless, the numeracy levels of Coloured and Asian individuals remain unsatisfactory within the context of a developed South African society, which sought living standards similar to Western nations (Sharp, 2018).

Thus, Figure 2 demonstrates that rural residency represents a disadvantage, or "penalty", but only for racially discriminated groups; it has no significant impact on the basic numeracy literacy levels of Whites. The pervasive discrimination against Blacks, as the most impacted group (Dubow, 2014), resulted in urban Blacks showing numeracy levels similar to rural Coloured and Asian individuals, all notably lower than those of the broader urban population.

Figures A.3 and A.4 in the Appendix replicate the analysis of Figure 2, disaggregating by gender: men in Figure A.3 and women in Figure A.4. The findings from Figure 2 are consistent across genders, with very similar results. The primary difference is that women, from the outset, show slightly lower numeracy levels than men, following the same trend but with an added degree of disadvantage. Therefore, Black women (and even Coloured and Asian women) faced a "double penalty" in achieving numeracy: first due to race and second due to gender.

Figure 3. ABCC index by provinces, only black population (birth decades 1860-1930)



Source: South African Censuses.

In Figure 3, we take our geographic analysis further by comparing populations not only by locality type but also by former South African provinces (pre-1990s), as well as by the so-called "Bantu Homelands". The Apartheid government designated these homelands to segregate the Black population into limited territories. This analysis has two main objectives. First, it seeks to determine whether the colonial authority governing each province influenced educational attainment. Were certain colonial powers more invested in developing human capital among native populations than others? Did Boers or the British make a greater effort to promote numeracy? Second, examining differences between the "Bantu homelands" (officially governed by Black leaders in collaboration with the South African government) and White-dominated provinces may help clarify

whether the low arithmetic literacy among Black individuals stemmed from a lack of desire to educate their children in basic numeracy.

The trends reveal three distinct, converging scenarios. Individuals registered in the Bantu territories exhibit the highest literacy levels. Following them is the Cape Province, while Transvaal, the Orange Free State, and Natal show the lowest literacy levels, with fairly similar values among them (Fourie and Swanepoel, 2015).

Until 1902, the British governed the Cape and Natal and the Boers held authority over Transvaal and the Orange Free State. From 1902 onwards, the British also gained control of the Boer Republics, with the end of the South African War. This observation might suggest that the British made greater educational efforts in their colonies compared to the Boers, as only one of the two British-controlled areas displayed low numeracy levels, in contrast to both Boer-controlled areas displaying low levels.

However, the Cape's evolution is complex and cannot be attributed solely to British institutions. Originally founded by the Dutch (from whom the Boers descend) in the 16th century, the Cape remained under Dutch control, including its education system, until it was taken over by the British in the early nineteenth century (Thompson, 2001). This was also the first part of the colony to expand and develop within the area known as South Africa today, establishing the largest number of educational institutions, notably through missionary stations (Links, 2021). Therefore, attributing the Cape's development purely to British influence overlooks the possible impact of its inherited Dutch legacy, as recognized in the literature (Dubow, 2009; Oostindie, 2008). In fact, if we consider that Natal was established by the British around the same time that the Boers founded Transvaal and the Orange Free State, it becomes challenging to definitively assert that one colonial system was more conducive to numeracy than the other.

The second, and perhaps more significant, finding from Figure 3 is the stark contrast in numeracy between Black populations in the "Bantu Homelands" and those in the rest of the provinces. The differences are striking: while Blacks registered in the "Bantu Homelands" tended to report near-perfect ages, those in other regions were still converging. This phenomenon can be interpreted in two ways. If we trust the data, it may reflect an African/Indigenous agency (Fourie and Swanepoel, 2015; Carlos et al., 2024); if we question the data's accuracy, this discrepancy could result from registration issues (Christopher, 2002, 2010, 2011). Assuming the results are valid, it appears that leaders in these Black-administered territories made a concerted effort to provide basic education for all residents. Recognizing the importance of arithmetic skills in the labour market, they likely sought to raise educational standards. As noted by Fourie and Swanepoel (2015), this might be due to the persistence of mission education, which had a more inclusive reach across all social strata compared to government-provided education. Thus, this may indicate an African agency where Black leaders, when given autonomy, prioritized educational development for their children, enhancing human capital with potential economic implications. However, we must exercise caution with these assertions, as there remained an ongoing debate among the indigenous population in the 1950s regarding whether Western-style education was beneficial or detrimental for Black individuals (Soudien and Nekhwevha, 2002).

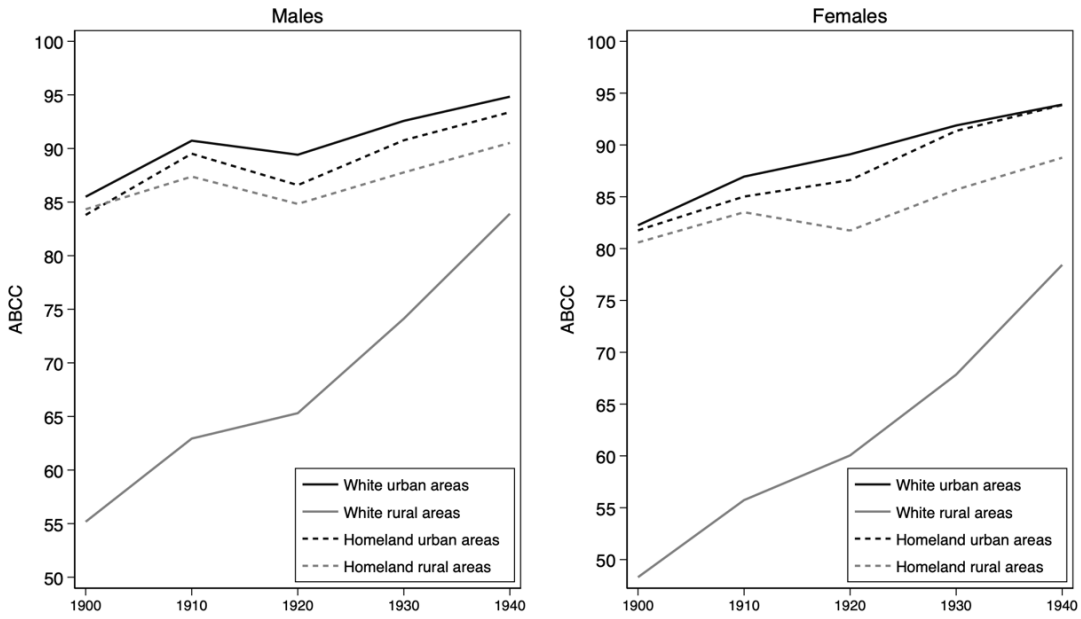
Alternatively, these results could reflect data collection biases. It is possible that the census data disproportionately represented the more educated segments of the local population, or that census officials, observing an unbalanced age distribution, adjusted data to present a more regular age distribution in this subgroup.

Given these unexpected results and the open debate on African agency, Figure 4 takes the analysis further by examining the Black population based on place of residence in two

categories: 1) Urban vs. Rural, and 2) “Bantu Homelands” vs. the rest of the country. The findings are illuminating. Educational levels in the “Bantu Homelands”, whether urban or rural, closely align with intermediate results for urban Black populations across most of South Africa. These levels are also notably higher than those observed in rural Black populations. This suggests that in both urban areas and the “Bantu Homelands”, there was indeed an effort to promote arithmetic education among the predominantly rural Black population, even if this investment was far from the levels seen among the White population. By contrast, such efforts seem to have reached rural Black populations to a much lesser degree. There was perhaps an educational push within the “Homelands” (Kallaway, 2002).

The values by gender presented in Table A.1 of the Appendix undoubtedly reinforce the observations discussed in relation to the trends in Figure 4. The numeracy levels of the Black population exhibited substantial variation based on factors such as place of residence and gender. For gender-specific values, we observe minimal differences between the “Homelands” and the rest of the country. Although men consistently show slightly higher values on average, these differences are minimal for this period. It is possible that these discrepancies arise from the greater emphasis placed on training girls in household tasks, while boys received reinforced instruction in mathematics (Shilling, 1991).

Figure 4. ABCC index by sex and rural-urban, only black population (birth decades 1900-1940)



Source: South African Censuses.

5. Results

To analyse the determinants of numeracy, we estimate a series of Linear Probability Models (LPM) specified as follows:

$$ABCC_i = \beta_0 + \beta_1 race\_ABCC_i + \beta_2 bdec_i + \beta_3 bantu\_act_i + \beta_4 urban\_rural_i + \epsilon_i$$

where $ABCC_i$ represents numeracy levels. The independent variables include $race\_ABCC_i$, which captures the racial classification of the individual, with "Blacks" as the reference category; $bdec_i$, an indicator variable for the decade of observation, with the 1860s serving as the reference decade; $bantu\_act_i$, a binary variable indicating whether the observation falls within the period of enforcement of the Bantu Education Act (1954–1994, based on census data from this period); and $urban\_rural_i$, a binary variable distinguishing between urban and rural settings, with "rural" as the reference category. The intercept (β_0) reflects the expected level of ABCC for individuals in the reference categories of all independent variables, while ϵ_i captures unobserved

factors. This specification allows us to disentangle the effects of race, time period, legislative changes, and urbanisation on numerical literacy outcomes.

In Tables 2 and 3, for each dependent variable, three models were estimated: Models 1, 2, and 3 for the total population; Models 4, 5, and 6 for men; and Models 7, 8, and 9 for women.

The results in Table 2 provide valuable insight into the evolution of numeracy levels by race. Using the numeracy levels of the Black population as a reference point, all other racial groups in every model show significantly higher positive values, highlighting the racial structure of South African society and the levels of discrimination throughout the twentieth century. While the Asian and Coloured populations exhibit numeracy levels, on average, between 6.3 and 7.1 points higher than the Black population in models (1) to (3), the White population's scores are roughly double, ranging from 13.6 to 14.6 points above those of the Black population. Even when controlling for decade of birth, the results remain remarkably stable. As demonstrated by the descriptive statistics, the disparities are even more pronounced for women. The gap between White women and Black women (the reference category) ranges from 14.5 to 15.6 points (2 to 3 points higher than the gap for men), and for Coloured women, the difference increases to between 7.3 and 8.1 points (approximately 2 points higher than for men). The only exception is found among Asian women, who show a smaller gap, just one point less than the difference observed for Asian men compared to Black men. This may be due to a portion of Asian men residing in rural areas, where educational levels, including numeracy, were lower compared to the more feminized urban settings for Asian women. Race emerges as a key factor in explaining numeracy levels in twentieth-century South Africa.

Table 2. The impact of race, time period, urbanisation, and Bantu education act on numeracy levels.

	(1) ABCC	(2) ABCC	(3) ABCC	(4) ABCC Males	(5) ABCC Males	(6) ABCC Males	(7) ABCC Females	(8) ABCC Females	(9) ABCC Females
Asian	6.34***	6.88***	7.05***	6.64***	7.14***	7.31***	5.58***	6.17***	6.35***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)
Coloured	6.41***	6.95***	7.12***	5.51***	6.01***	6.18***	7.32***	7.91***	8.09***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
White	13.60***	14.61***	14.64***	12.73***	13.68***	13.71***	14.51***	15.60***	15.63***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
bdec==1870		4.67	4.21		4.50	4.03		5.06	4.57
		(0.339)	(0.369)		(0.347)	(0.380)		(0.326)	(0.358)
bdec==1880		7.14	6.51		6.91	6.27		7.63	6.97
		(0.119)	(0.140)		(0.126)	(0.146)		(0.114)	(0.137)
bdec==1890		10.25**	9.47**		9.86**	9.07**		11.06**	10.24**
		(0.020)	(0.026)		(0.023)	(0.029)		(0.017)	(0.023)
bdec==1900		12.67***	11.67***		12.15***	11.14***		13.71***	12.66***
		(0.004)	(0.006)		(0.005)	(0.007)		(0.003)	(0.005)
bdec==1910		15.04***	14.11***		14.53***	13.58***		16.16***	15.18***
		(0.001)	(0.001)		(0.001)	(0.001)		(0.000)	(0.001)
bdec==1920		17.94***	17.15***		17.15***	16.35***		19.43***	18.59***
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
bdec==1930		19.85***	19.28***		18.97***	18.39***		21.45***	20.85***
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
bdec==1940		20.83***	20.50***		19.85***	19.50***		22.53***	22.17***
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
bdec==1950		21.91***	21.92***		20.91***	20.91***		23.59***	23.60***
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
bdec==1960		22.17***	22.06***		21.13***	21.02***		23.87***	23.75***
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
bdec==1970		23.30***	24.09***		22.13***	22.93***		25.08***	25.92***
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
bdec==1980		28.63***	29.49***		27.12***	28.00***		30.70***	31.61***
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
Bantu_Act		-1.76**	-1.49**		-1.28*	-1.01		-2.34***	-2.06***
		(0.011)	(0.020)		(0.055)	(0.107)		(0.001)	(0.002)
urban_rural==unknown			1.20			0.99			1.22
			(0.248)			(0.326)			(0.275)
urban_rural==urban			5.89***			5.55***			6.14***
			(0.000)			(0.000)			(0.000)
Constant	85.52***	70.58***	68.52***	86.40***	71.95***	70.08***	84.60***	68.65***	66.52***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	307	307	307	307	307	307	307	307	307
Adjusted R-squared	0.24	0.58	0.65	0.23	0.56	0.63	0.25	0.58	0.65

Notes: Robust p-values are given in parentheses *** p<0.01, ** p<0.05, * p<0.1 The constant refers to ABCC index for black individuals.
Source: South African Censuses.

Another highly relevant variable in Table 2 is the one examining the impact of the Bantu Education Act. In all models, it shows a negative impact of the introduction of this law, with an average decrease ranging from 1.3 to 2.3 points (which, as expected, had a greater impact on the Black population). This effect of the Bantu Act is statistically significant in all models except for Model 6. Moreover, it is particularly noteworthy that the impact in terms of points was nearly double for women (over 2 points) compared to men (around 1 point or slightly higher), once again highlighting the dual disadvantage faced by Black South African women in the educational system throughout the twentieth century.

The decade of birth, as expected, tends to show increasingly higher and statistically significant values. In other words, as the twentieth century progressed, arithmetic levels improved across the population, as clearly demonstrated by the descriptive statistics in Figures 1, 2, 3, and 4. Regarding the differences between urban and rural residence, the models (3), (6), and (9) show that living in an urban area was associated with higher numeracy levels, with differences of approximately 6 points, and a larger advantage for women compared to men. This suggests that female education in urban areas may have been more comprehensive than in rural areas (more focused on agricultural production).

In Table 3, we have replicated the models from Table 2, but instead of studying the impact of the Bantu Education Act and whether the residence was rural or urban, we focus on the province of residence (according to historical categorizations), restricting the analysis to the population born until the 1940s. This group represents those with the most significant racial differences in numeracy levels. As previously mentioned, the province of birth and residence could be crucial for understanding the evolution of educational levels, as the provinces had different recent colonial histories. While the Cape and Natal were dominated by the British from the early nineteenth century, Orange Free State and

Transvaal were the Boers Republics, controlled independently by Dutch settlers who had moved out of the Cape from the 1830s.

Table 3 The impact of race, time period, and provinces on numeracy levels.

	(1) ABCC	(2) ABCC	(3) ABCC	(4) ABCC Males	(5) ABCC Males	(6) ABCC Males	(7) ABCC Females	(8) ABCC Females	(9) ABCC Females
Asian	21.79***	19.15***	18.32***	20.07***	17.69***	17.01***	21.77***	19.00***	18.25***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Coloured	20.07***	18.09***	18.17***	17.92***	16.10***	16.29***	21.89***	19.84***	20.19***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Whites	25.96***	24.97***	25.05***	23.30***	22.42***	22.60***	28.48***	27.45***	27.78***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
bdec==1870		2.72	2.70		3.16	3.11		2.32	2.24
		(0.546)	(0.532)		(0.478)	(0.469)		(0.611)	(0.595)
bdec==1880		4.44	4.40		4.40	4.34		4.33	4.23
		(0.304)	(0.289)		(0.308)	(0.298)		(0.320)	(0.294)
bdec==1890		7.20*	7.16*		6.91*	6.85*		7.47*	7.37*
		(0.082)	(0.071)		(0.095)	(0.087)		(0.072)	(0.055)
bdec==1900		9.91**	9.97**		8.90**	9.05**		10.82***	11.11***
		(0.016)	(0.012)		(0.031)	(0.024)		(0.008)	(0.004)
bdec==1910		12.01***	12.07***		12.27***	12.42***		11.28***	11.57***
		(0.004)	(0.003)		(0.003)	(0.002)		(0.009)	(0.004)
bdec==1920		13.83***	13.98***		12.58***	12.87***		14.05***	14.57***
		(0.001)	(0.001)		(0.003)	(0.002)		(0.001)	(0.000)
bdec==1930		15.30***	15.44***		14.03***	14.31***		16.51***	17.02***
		(0.001)	(0.000)		(0.001)	(0.001)		(0.000)	(0.000)
bdec==1940		12.61***	12.79***		11.71***	12.05***		12.96***	13.58***
		(0.002)	(0.002)		(0.005)	(0.003)		(0.002)	(0.001)
province = 1, Bantu Homelands			-2.75*			-3.16*			-6.10**
			(0.071)			(0.055)			(0.027)
province = 3, Natal			-0.94			-0.32			-1.53
			(0.364)			(0.754)			(0.178)
province = 4, Orange Free State			-4.94***			-4.14**			-6.14***
			(0.003)			(0.014)			(0.000)
province = 5, Transvaal			-1.79			-0.93			-3.11**
			(0.172)			(0.455)			(0.032)
Constant	73.11***	64.93***	66.81***	75.65***	67.87***	69.13***	70.48***	62.13***	64.66***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	135	135	135	135	135	135	135	135	135
Adjusted R-squared	0.67	0.80	0.81	0.64	0.77	0.78	0.65	0.77	0.80

Notes: Robust p-values are given in parentheses *** p<0.01, ** p<0.05, * p<0.1 The constant refers to ABCC index for black individuals in Cape province. Source: South African Censuses.

As we have restricted the sample in Table 3 to individuals born between the 1870s and 1940s, the differences in numeracy values by race become more pronounced. Overall, White individuals exhibit around 25 additional points of numeracy compared to the Black population, while Coloured and Asian groups show a difference of 19 points. These represent significant disparities, the result of structural discrimination in Black education. As in the previous analysis, Black women experienced a double disadvantage because of race and gender, presenting even more extreme differences (up to 28.5 points compared to White women). The decade of birth again shows a trend towards a general improvement in educational levels, particularly from the founding of the Republic of South Africa in 1910, although these improvements did not reach the higher levels enjoyed by those born in the second half of the twentieth century, especially the advancements linked to the arrival of democracy at the end of the century.

In Table 3, the variable of most interest in this analysis, due to its novelty, is the province of residence. Cappelli and Baten (2017) argued that British colonies in Africa began to improve their numeracy levels earlier than other colonies did. South Africa allows us to compare British-dominated provinces for over a century with those under Afrikaner control. Furthermore, we can compare these provinces with the "Bantu Homelands" (a term used by the Apartheid regime), which were partially self-governed by the Black population, potentially offering a form of Black agency (Fourie and Swanepoel, 2015). The results confirm that the Cape (the reference province) had the highest numeracy levels in the country. Natal (the other British colony) showed small differences, none of which were statistically significant. In contrast, the areas that had been the Boer Republics exhibited much lower numeracy levels, particularly in the Orange Free State. It seems that the premise of Cappelli and Baten (2017) holds true, at least partially, in the South

African context. The Bantu Homelands also showed a disadvantage compared to the Cape.

Table 4 The impact of areas, time period, urbanisation and ethnics on numeracy levels (only blacks).

	(1) ABCC	(2) ABCC	(3) ABCC	(4) ABCC	(5) ABCC Males	(6) ABCC Males	(7) ABCC Males	(8) ABCC Males	(9) ABCC Females	(10) ABCC Females	(11) ABCC Females	(12) ABCC Females
bdec=1910	6.76*	6.52**	6.32***	6.24***	7.14**	6.93**	6.74***	6.66***	5.90	5.64*	5.41**	5.32**
	(0.065)	(0.029)	(0.005)	(0.005)	(0.043)	(0.018)	(0.003)	(0.003)	(0.127)	(0.079)	(0.021)	(0.020)
bdec=1920	7.22**	6.34**	5.60***	5.62***	6.26**	5.47**	4.79**	4.83**	8.04**	7.10**	6.25***	6.23***
	(0.032)	(0.019)	(0.008)	(0.006)	(0.050)	(0.036)	(0.020)	(0.018)	(0.026)	(0.015)	(0.004)	(0.003)
bdec=1930	12.40***	11.52***	10.78***	10.80***	11.56***	10.78***	10.09***	10.14***	13.21***	12.27***	11.41***	11.39***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
bdec=1940	17.32***	16.24***	15.34***	15.47***	16.32***	15.36***	14.53***	14.66***	18.30***	17.15***	16.10***	16.23***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
urban		15.01***	15.78***	15.56***		13.38***	14.09***	13.88***		16.04***	16.93***	16.68***
		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
areas=whites			-11.87***	-11.65***			-10.97***	-10.76***			-13.77***	-13.52***
			(0.000)	(0.000)			(0.000)	(0.000)			(0.000)	(0.000)
ethnic=Sepedi				0.53				0.79				0.14
				(0.842)				(0.776)				(0.958)
ethnic=Seshoeshe				4.71*				4.76*				4.86*
				(0.095)				(0.099)				(0.089)
ethnic=Shangaan				0.41				1.53				-1.24
				(0.876)				(0.563)				(0.639)
ethnic=South Ndebele				1.01				0.41				1.78
				(0.732)				(0.893)				(0.549)
ethnic=Swazi				1.00				0.81				1.19
				(0.724)				(0.784)				(0.672)
ethnic=Tswana				6.33**				5.45**				7.03***
				(0.018)				(0.044)				(0.009)
ethnic=Venda				-2.45				-1.76				-4.14
				(0.427)				(0.565)				(0.202)
ethnic=Xhosa				2.49				2.51				2.28
				(0.360)				(0.367)				(0.407)
ethnic=Zulu				1.46				1.09				1.89
				(0.569)				(0.680)				(0.461)
Constant	72.14***	65.71***	72.16***	70.48***	74.34***	68.61***	74.57***	72.88***	70.00***	63.12***	70.61***	69.10***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	189	189	189	189	189	189	189	189	189	189	189	189
Adjusted R-squared	0.17	0.48	0.67	0.68	0.17	0.45	0.64	0.65	0.16	0.46	0.68	0.71

Notes: Robust p-values are given in parentheses *** p<0.01, ** p<0.05, * p<0.1 The constant refers to ABCC index for black individuals in black areas.

Source: South African Censuses.

We are particularly interested in the Black population, as they were (and are) the largest racial group in South Africa. However, this population was not homogeneous; rather, it was divided into various ethnic groups. Therefore, in Table 4, we have taken a further step by focusing exclusively on the Black population living in urban areas (since the censuses do not provide ethnic group data) and comparing it with the rural population across the nine most prominent Bantu ethnic groups, as well as with those residing in areas classified as White according to Apartheid laws. In this case, due to data availability in the South African censuses, we focus on birth cohorts from the 1910s to the 1940s, a period of particular interest due to the persistence of disparities, the unification of the country, and the demographic groups that were subjected to the Apartheid laws. Once again, the variable of birth decade indicates improvements in the educational system over the decades studied, both for men and women (although with clearer and more satisfactory results in the first half of the twentieth century for men).

Regarding the ethnic group variable, we have taken the Black population in urban areas classified as White under Apartheid laws as the reference category. The results show that Black people in urban areas who associated with their own communities exhibit much higher educational levels (even partially in rural areas, as we will discuss further below). Urban Black areas present a numeracy premium of approximately 15 points, with 13.5 for men and 16 for women. Thus, the existence of a potential African Agency cannot be ruled out (Fourie and Swanepoel, 2015) and could even be considered a plausible hypothesis given the results. In areas where the Black population was self-managed, greater efforts were made to achieve reasonable arithmetic levels for everyday use.

In all ethnic groups studied in Table 4, we observe positive values. That is, the level of numeracy in rural Black areas was higher than in urban areas. Negative values (though not statistically significant) were found only among the Venda. Their isolation in the northern part of the country may have hindered the development of a strong educational system. On the other hand, the ethnic groups showing strongly positive and statistically significant values were the Seshoeshe (with an additional 4.7 points of numeracy) and the Tswana (with an additional 6.3 points of numeracy). Both ethnic groups are concentrated in the central-northern part of the country, near the border with Botswana.

Regarding differences between men and women within each ethnic group, we observe fairly similar values across most ethnic groups. The greatest difference is seen among the Tswana, where women show a 7-point advantage (compared to 4.5 points for men), indicating that in their region of residence, educational efforts clearly extended to women, reducing their traditional disadvantage.

Table 5. The impact of Literacy rate and languages on numeracy levels (only Blacks).

	(1) ABCC Males	(2) ABCC Males	(3) ABCC Males	(4) ABCC Females	(5) ABCC Females	(6) ABCC Females
Literacy rate	0.28**	0.27**	0.93***	0.34***	0.33***	0.69***
	(0.012)	(0.019)	(0.000)	(0.001)	(0.001)	(0.000)
census51		2.20	1.11		2.55	1.86
		(0.641)	(0.715)		(0.576)	(0.473)
language = 1, afrikaans			6.27			6.74*
			(0.180)			(0.091)
language = 3, native			-18.21***			-13.17***
			(0.001)			(0.001)
Constant	77.18***	76.17***	69.70***	72.61***	71.43***	66.52***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	12	12	12	12	12	12
Adjusted R-squared	0.15	0.08	0.62	0.35	0.31	0.78

Notes: Robust p-values are given in parentheses *** p<0.01, ** p<0.05, * p<0.1 The constant refers to ABCC index for black individuals in census 1946. The literacy rate for the reference language is English.

Source: South African Censuses.

As mentioned previously, literacy and numeracy are two forms of measuring human capital that may be interconnected. Similarly, the language in which the learning process takes place can be crucial for understanding differences in educational outcomes. For this reason, in Table 5, we have taken a further step by focusing on the 1946 and 1951 censuses (which allow us to include these new variables). We analyzed the impact of literacy levels (the percentage of the same population cohorts who could read and write) and the predominant language in which their education was conducted, which may or may not correspond to the language spoken at home (especially if they were forced to study in Afrikaans).

The results in Table 5 show a statistically significant positive correlation between literacy and numeracy. A 1% increase in the literacy rate corresponds to a rise of at least 0.3 points in numeracy levels. This is not surprising, given that it reflects the functioning of the educational system. If the system is effective and focuses on ensuring students learn and acquire knowledge, it is more likely that this knowledge will encompass both literacy and basic arithmetic skills. The variable census 51 again shows slight improvements between 1946 and 1951, although these are small and not statistically significant, given the brief span of just five years.

More interesting are the results in Table 5 regarding the language of instruction. Higher literacy in native languages is associated with lower numeracy levels compared to English (which serves as the reference category). Education in native languages was likely provided by less qualified teachers and in classrooms with a higher concentration of native students (due to the discrimination faced by Black individuals, particularly if their education was not intended to serve White populations). Therefore, learning in native languages may have been penalized. In contrast, instruction in Afrikaans was associated with a premium in numeracy levels (although this effect is only statistically significant

for women). Afrikaans was the language of the South African elite until the late twentieth century and was likely the most protected and promoted form of education, especially concentrated in the elite classes. Women of color who accessed education in this language likely represented or aspired to represent the future elite, and their education was of a high level, with both literacy and numeracy capabilities being notably strong.

In any case, the results from Table 5 show that the language in which education was received had a substantial impact on the educational outputs developed. Once again, the culture associated with the Black population was penalized in comparison to the culture developed by the White population in South Africa.

6. Discussion and conclusions

The foundations of basic education are built upon literacy and numeracy skills (Hanushek and Woessmann, 2008), both essential for participation in the labor market. While historical population statistics have typically recorded literacy levels, they have not systematically documented levels of numeracy. However, assessing numeracy provides key insights into the effectiveness of the educational system and the potential existence of discriminatory policies based on gender or race (Ferber and Baten, 2025). Accordingly, this article seeks to examine historical numeracy levels in South Africa by analysing age heaping in population censuses for the entire country.

The primary contribution of this study is its demonstration of racially discriminatory patterns in basic arithmetic education, even when numeracy was essential for Black populations to carry out designated artisanal or construction tasks within the system (Kallaway, 2016). Our findings reveal that Black populations exhibited the lowest levels of numeracy, a result not unexpected given the dominant racial discrimination system that prevailed until the 1990s (Dubow, 2014). White populations had nearly perfect levels of

numeracy, while Coloured and Asian populations maintained intermediate levels. According to our statistical regressions, the White population exhibited average numeracy levels up to nearly 20 points higher than the Black population throughout most of the twentieth century.

Race, however, was not the only factor influencing numeracy levels; gender also shaped the degree of educational discrimination. Black women experienced a "double penalty" in their arithmetic knowledge due to both their race and gender. In fact, according to our regression models in Table 2, being a Black woman entailed an additional penalty of 2 points compared to Black men. In other words, the average penalty for Black women compared to White women was 15.6 points, compared to 13.7 points for men. The marginalization of women in education is not a new phenomenon (Stromquist, 1990; Morojele, 2011); however, in South Africa, this additional disadvantage was not experienced by White women during the twentieth century. Thus, the intersection of race and gender is key to understanding numeracy attainment levels, aligning with recent intersectional approaches to discrimination studies in the United States (Crenshaw, 2013).

Place of residence/origin also impacted numeracy levels. Unfortunately, the twentieth-century South African censuses do not disaggregate data by individuals' place of origin, but rather by their place of residence. We assume a certain correlation between these two factors, despite the presence of internal migration, acknowledging this as a limitation of our study. However, the place of residence provides valuable insights into understanding the evolution of numeracy levels, with the most plausible explanation (included in this study) being the differences in the educational systems of the respective areas.

With the exception of the White population, rural residents generally showed lower numeracy levels than their urban counterparts, likely a result of reduced investment in rural South African schools (Spaull, 2013). In his 1981 report, De Lange considered that

a rural child: “does not have a sufficient background of concrete experiences to develop the concepts needed for the development of science and mathematics” (Kraak, 2002: 76). Provincially, only the former Cape Province stands out for consistently higher numeracy levels. Caution is warranted in interpreting these findings, as colonial structures in the Cape developed as early as the seventeenth century, including mission stations. In contrast, the rest of South Africa was colonized throughout the nineteenth century.

A previous study claimed that the British colonial system was necessarily more favourable to numeracy development than alternative systems (Capelli and Baten, 2021). The results of the regression models in Table 3 of our analysis also seem to suggest an advantage in numeracy levels for provinces with prolonged British dominance, particularly in the Cape. Or, to put this differently, there was a disadvantage for the areas that were the Boer Republics, especially the Orange Free State, with average numeracy gaps of between 4 and 6 points. However, these results must be interpreted with caution, as the prolonged British rule in the Cape facilitated the establishment of more educational missions, in addition to the limited efforts to create a widespread educational system until the twentieth century in South Africa. In any case, our findings do not contradict the previous results found by Capelli and Baten (2021).

One of this study’s most striking findings is the high numeracy levels within the “homelands”—territories formally governed by Black populations. Here, numeracy levels approach those of White populations and far exceed those of Black or Coloured populations in White-controlled territories. This finding raises questions about whether data collection in these areas was conducted accurately and, if so, whether Black populations in these territories placed a particularly high value on education to achieve such strong basic arithmetic skills—a phenomenon we term “African Agency” (Fourie and Swanepoel, 2015). The debate remains open, and further sources and microdata are

needed to address these questions fully. Regardless, our findings indicate the importance of focusing on areas and periods where Black populations had greater control over their future to understand the country's true educational landscape and the gap between educational goals and their actual implementation.

The Black population of South Africa is not a homogeneous group but is divided culturally and linguistically into ethnic groups. The numeracy levels by ethnic group have been addressed in the regressions in Table 4. The results did not show vast differences between the various ethnic groups but did highlight two as particularly advantaged: the Seshoeshe (Northern Sothos) and the Tswana. In contrast, although not statistically significant, the Venda seem to have the lowest results. This leads us to consider that the geographical location of the ethnic group and its cultural values may have influenced the level of educational attainment in arithmetic.

Other factors that may have influenced numeracy levels include the individuals' broader education and the language in which they were educated. The regressions in Table 5 of this study address these issues through the literacy rate and the primary language of instruction. The results show a correlation between literacy and numeracy. A 1% increase in the literacy rate corresponds to, at a minimum, a 0.3-point increase in numeracy levels. This is likely linked to the fact that in areas with good education, instruction was provided across all subjects, including both reading and writing as well as basic arithmetic. In terms of the language of instruction, native languages show a strong penalty, with a deficit of up to 18 points in numeracy compared to English. In contrast, Afrikaans generally presents an advantage. This is closely related to the argument in this article. The local elite, particularly those aligned with the dominant National Party, were strongly connected to the use of Afrikaans, which was the preferred and most advantageous language, likely receiving the greatest funding allocation. English speakers had the ability

to communicate with the rest of the world in an international language and were often White and associated with British colonialism. Meanwhile, those educated in native languages were Black, receiving much lower educational funding, larger classes, and less qualified teachers. All of this resulted in racial discrimination being especially pronounced depending on the dominant language of instruction.

We cannot overlook that the study presents several limitations, primarily related to the use of censuses and methodology. The use of censuses allows us to study the population classified by categories, but we lack the microdata to recreate categories, expand the time period if a result was not published in the census (even if it was collected), and, especially, it does not allow us to track individuals throughout their lives to control for migration, immigration, etc. Regarding the methodology, this requires working with aggregated data, and while it highlights trends of great interest, it may not be perfect, as there could be additional motivations for modifying age that we are not capturing. However, the large sample size of the study (with tens of millions of observations for each year), the critical analysis of the source conducted beforehand, and the still limited knowledge about numeracy in South Africa throughout the past centuries of significant transformation make this an exceptionally valuable study.

In sum, this study offers critical insights into the impact of educational discrimination on arithmetic knowledge among generations born in the late nineteenth and twentieth centuries. This research reaffirms that South Africa's systematic racial discrimination extended into education, despite its utility, and also varied by gender and place of residence.

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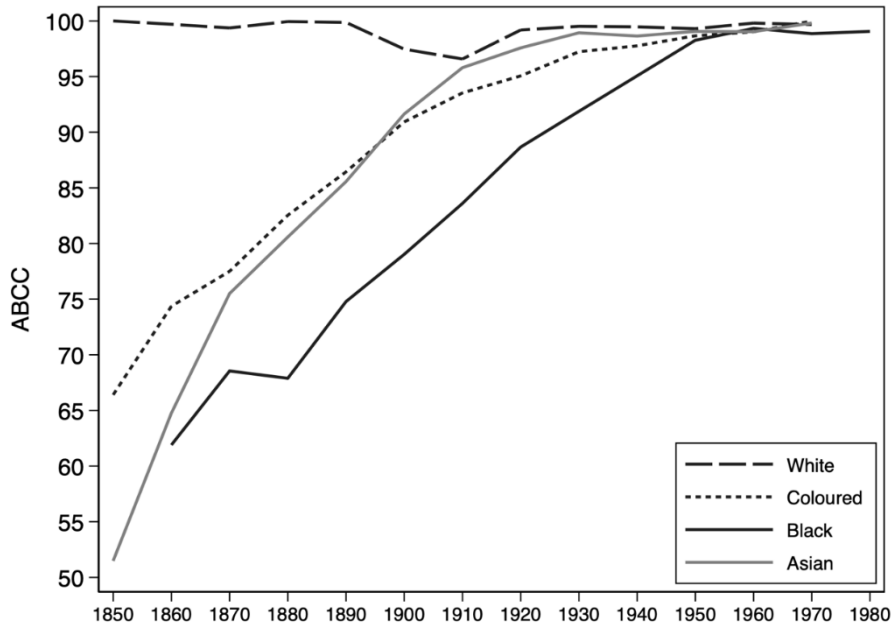
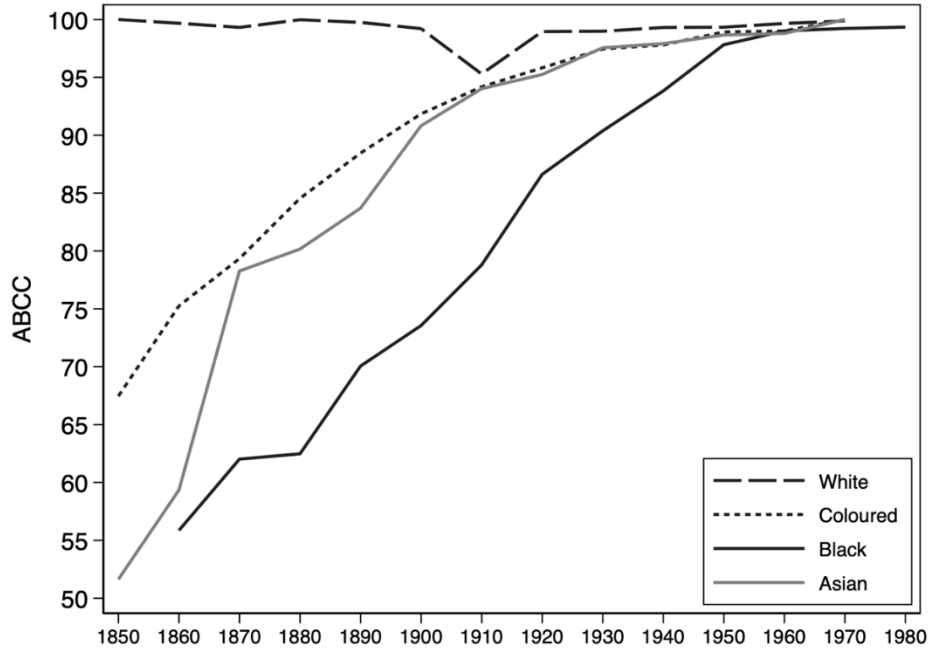
Appendix

Figure A.1. Males ABCC index by races (birth decades 1850-1980)



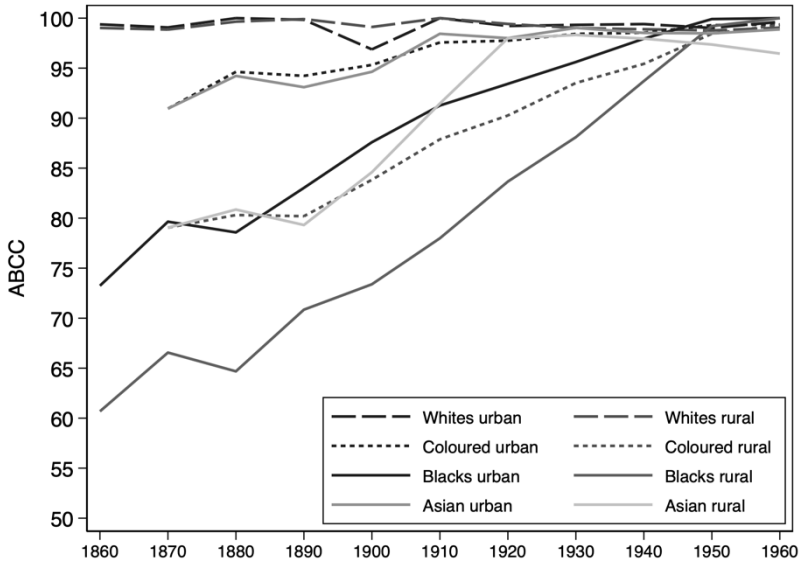
Source: South African Censuses.

Figure A.2. Females ABCC index by races (birth decades 1850-1980)



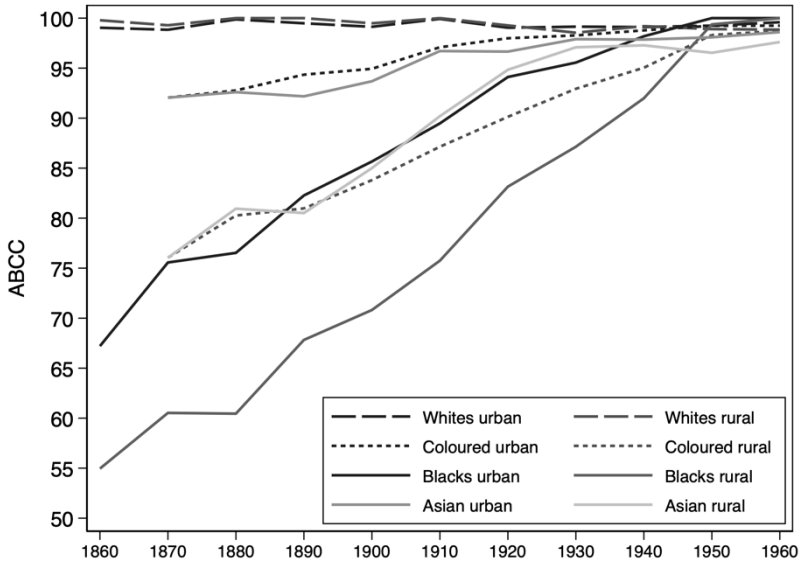
Source: South African Censuses.

Figure A.3. Males ABCC index by races and rural-urban (birth decades 1850-1980)



Source: South African Censuses.

Figure A.4. Females ABCC index by races and rural-urban (birth decades 1850-1980)



Source: South African Censuses.

Table A.1. ABCC index by sex and rural-urban, only black population (birth decades 1900-1940)

	Whites areas				Bantu areas			
	Urban		Rural		Urban		Rural	
	Males	Females	Males	Females	Males	Females	Males	Females
1900	85	82	55	48	84	82	84	81
1910	91	87	63	56	90	85	87	84
1920	89	89	65	60	87	87	85	82
1930	93	92	74	68	91	91	88	86
1940	95	94	84	78	93	94	91	89

Source: South African Censuses.