Expanding Opportunities for South African Youth through Math & Science:

The Impact of the Dinaledi Program

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ABSTRACT

The strengthening of secondary school education in mathematics and science poses a significant challenge for South Africa, where few students study for and pass the certificate examinations for these subjects. The Dinaledi program was established in 2001 to expand math and science education by offering secondary schools resources based on need, and thus reducing the historical resource gap between former Bantustan and House of Assembly schools. This paper estimates the impact of the Dinaledi program during its expansion in 2005. By building a panel data set from administrative, test score, and infrastructure data for the years 2005–2007, a matching and difference-in-difference strategy is used to estimate program impact. The analysis finds that the program was effective in expanding enrolment and passing rates in math and science: the Dinaledi program nearly doubled the number of students who entered and wrote Higher Grade (HG) physical sciences exams, and by 2007, 35 students on average had selected HG physical sciences in Dinaledi schools, compared to 18 students in matched non-Dinaledi schools. In addition, 60 percent more students passed the HG physical sciences exam in Dinaledi schools. The program was most effective in formerly disadvantaged Bantustan schools and schools in KwaZulu Natal and Limpopo that had the greatest need and the greatest ability to take advantage of the additional resources. Dinaledi thus helped narrow the racial and geographical gap in the quality of education.

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'Special attention will need to be given to the compelling evidence that the country has a critical shortage of mathematics, science, and language teachers, and to the demands of the new information and communication technologies.'

President Thabo Mbeki, State of the Nation Address, 2000

EXECUTIVE SUMMARY

The Dinaledi program

The strengthening of secondary school education in mathematics and science poses a significant challenge for South Africa. Few students study math and science and fewer still pass the Senior Certificate examinations needed to qualify for university admission into technical fields like engineering, accounting, and science, particularly among traditionally disadvantaged youth. In 2004, in former (African) Bantustan schools, only 2 percent of students enrolled in Higher Grade physical sciences compared to 14 percent in former (white) House of Assembly (HoA) Schools. Only 43 percent passed in Bantustan schools compared to 86 percent in HoA schools.

Yet, professionals with these skills are in high and increasing demand in the labor market. Therefore, the task of expanding youth access to technical professions, particularly for traditionally disadvantaged youth, is of great importance for the South African Government.

The Dinaledi program aims to expand the number of students in secondary schools studying and passing math and science certificate examinations. Launched by the Government of South Africa in 2001, the Dinaledi program offers secondary schools resources to improve math and science education based on need in an attempt to close the historical resource gap between former Bantustan schools and HoA schools. Resources are used to provide teachers, enhance teachers' skills, and supply textbooks and calculators, while targeting and monitoring by the Department of Education helps schools stay on track.

Impact evaluation

The National Department of Education has been collaborating with the World Bank since 2008 to answer the question: did and can a program like Dinaledi significantly contribute to this agenda? The team assembled test score, infrastructure, and program data to understand the evolution of the program and develop a strategy to evaluate its impact. This report summarizes the findings of a retrospective impact evaluation covering the program's second phase of expansion in 2004 across 350 schools, and presents the estimated program effect between 2005 and 2007.

The study used a matching and difference-in-difference (DID) strategy to measure student math and science uptake and passing rates in Dinaledi schools, relative to student behavior and achievements in similar non-Dinaledi schools. The study was also able to separately identify the impact of the Dinaledi program among former Bantustan schools.

Impact evaluation results

The results are positive. The Dinaledi program made an important contribution to reducing inequalities and expanding math and science education in 2005–2007.

Enrolment and passing rates in HG physical sciences increased as a result of the program: every year, Dinaledi schools had 5 to 7 percent higher enrolment than control schools. More importantly, the Dinaledi program increased the number of students passing the Senior Certificate examination in Higher Grade (HG) math and physical sciences by 55 percent, compared to control schools.

The Dinaledi program was very effective in schools with the greatest need. In former Bantustan and Department of Education and Training (DoET) schools, the program increased the number of HG physical sciences passes sevenfold (from two in control schools to 16 in former Bantustan schools and from five to 11 in former DoET schools). By contrast, the Dinaledi program had little measurable effect in former HoA schools.

Regional differences confirm these results. The Dinaledi program was very effective in the provinces of Kwazulu Natal and Limpopo where a large share of former Bantustan schools are located. There, the program increased the number of HG physical sciences passes fivefold. The effects are smaller in other provinces, such as Free State, Gauteng, North West, and Western Cape.

Policy recommendations

The results provide support for scaling up the Dinaledi program and targeting schools that have fewer resources and that service disadvantaged populations. However, many questions remain unanswered: What are the mechanisms through which the Dinaledi program delivered these results? Why was the Dinaledi program particularly effective in former Bantustan schools? Will the program be equally effective in the remaining schools? Are these short-term effects or will they be sustained over time? What features of the program could be improved to strengthen program effectiveness?

Effective targeting. This study clearly indicates that targeting of the Dinaledi program to former Bantustan schools could increase program effectiveness, at least in the short run. Former Bantustan schools had less qualified teachers, less equipment, and fewer inputs, and could gain more from any additional resources than resource-rich schools. However, they must have received more inputs from Dinaledi, so targeting former Bantustan schools may or may not increase cost-effectiveness. In addition, these schools host a greater proportion of students from poorer socioeconomic backgrounds. Going forward, it would be important to understand how school characteristics influence the effectiveness of the program and target the program accordingly.

External validity and sustainability. Eligibility criteria for access to the program gave priority to schools with outstanding performance in mathematics and physical sciences education. Whether the impact measures are representative of the rest of the schools in South Africa is not clear. The validity of the impact measures depends on how similar the remaining schools are to the schools initially targeted by the Dinaledi program. Since schools with a good track record were chosen, expanding the program to schools with worse track records might change program effectiveness. This suggests that the effectiveness of expansion should continue to be measured. In addition, to really understand the effectiveness of the program, its longer-term impact should be tracked.

Fine-tuning. This study measured the average effect of schools' assignment to the Dinaledi program. To improve program effectiveness, it would be important to understand which factors are causally linked to the results. Is it the fact that these schools received implicit recognition for their performance that made them perform better, or is it because principals and teachers knew that there was interest in their performance and that results were being monitored that they were motivated to do more? Furthermore, is schools' performance indeed the result of the fact that they faced constraints in their access to skills, equipment, and educational inputs? If so, which input combination is most effective at improving performance? Answering these questions would help to fine-tune interventions and increase the program's cost-effectiveness in the future.

In order to obtain answers to these questions, it is necessary to incorporate a learning strategy in the design of the next phase of the Dinaledi program—first, to continue measuring program impact and second, to test some of the program features to understand which elements of the program should be strengthened. This would provide the evidence base for improving secondary education policies on an ongoing basis.

INTRODUCTION

Policies aimed at increasing labor skills in mathematics and science are of paramount importance for a country's growth in the global economy. Yet, very little rigorous evidence exists on the impact of these policies. This study makes an initial attempt to measure the impact of a flagship program in South Africa aimed at expanding the body of students in secondary schools that enter and successfully complete math and science coursework, while providing equal access to traditionally disadvantaged schools and populations. The program offers a supply-side intervention package to selected schools, which includes teacher training and provision of learning materials. This retrospective study adopts a non-experimental strategy to measure the impact of this program on math and science learning outcomes. Its purpose is to provide the Government of South Africa with a measure of the program's effectiveness in meeting its objectives and with an understanding of the distribution of estimated effects across school types and regions that could guide program expansion in the future.

The Government of South Africa launched the Dinaledi program in 2001 as part of its National Strategy for Mathematics, Science, and Technology Education (MSTE) to address ethnic imbalances and severe shortages of skilled labor in math and science. Dinaledi, which means "the stars," targets secondary schools to expand the supply of students moving into science and technology at the university level. South Africa's share of university graduates with natural science and engineering degrees compares poorly to countries with similar GDP levels—according to the National Department of Education (NdoE), in 2004 it was less than half as high as in Chile, Cuba, and Brazil.[2] The number of high school graduates in these subjects is particularly low among African and Indian students. In the early 2000s, only 1.6 percent of South Africa's chartered accountants, 2.4 percent of engineers, 1.6 percent of dentists, 7.5 percent of medical doctors, and 2.4 percent of actuaries were African.[3]

The Dinaledi program seeks to improve mathematics and physical sciences education outcomes and reduce ethnic and gender imbalances through supply-side interventions in selected schools. The program provides schools with a needs-based combination of supplementary inputs, including additional teachers, in-service teacher training, textbooks, scientific calculators, computers and other learning support materials. Dinaledi schools are monitored through school surveys, on-site school visits, and phone interviews. The program also creates school-level incentives, such as performance awards, for improving mathematics and physical sciences learning outcomes. In order to enhance its cost-effectiveness, the program targets only selected public high schools based on a combination of needs and minimum capacity criteria.

This evaluation exploits administrative panel data to estimate the effect of enrolment in the Dinaledi program for about 350 schools added to the program in 2004. The data originates from two sources. Information on school characteristics is drawn from South Africa's Education Management Information Systems (EMIS) for the baseline year 2004, while the National

[2] Department of Education (2004), "National Strategy for Mathematics, Science and Technology Education (NSMSTE)", presented to Portfolio Committee on Education on February 3, 2004, http://www.pmg.org.za/docs/2004/appendices/040203strategymst.ppt.
[3] Ibidem.

Department of Education provided information on student test scores, performance, and enrolment in science and mathematics for the school-leaving exam for the period 2004–2007.

The identification strategy employed for estimating the effect of the Dinaledi program on physical sciences learning outcomes combines a difference-in-difference (DID) method with propensity score matching as suggested by Heckman et al. (1997). This combined strategy serves to distinguish the program's effect from those arising from pre-existing differences observed between Dinaledi and non-Dinaledi schools since such differences could bias estimation results. First, propensity score matching minimizes *observable* differences by matching each Dinaledi school with a control school that had similar observed characteristics in 2004, based on an aggregate indicator of similarity (the propensity score). Second, the DID component seeks to eliminate bias from *unobserved* pre-existing differences (such as teaching capacity) by comparing Dinaledi and non-Dinaledi schools (the first DID "difference") with respect to the *change* (the second DID "difference") in learning outcomes over time. The DID approach eliminates bias from unobserved differences if the assumption holds that outcomes in Dinaledi and non-Dinaledi schools would have pursued parallel trends, had Dinaledi schools not received the program. Owing to a lack of reliable baseline data, in the case of the mathematics learning outcomes analysis a simple propensity score matching method is employed, which requires stronger identification assumptions.

The study's main finding is that the Dinaledi program has substantially improved Senior Certificate (SC) examination results in Higher Grade (HG) physical sciences and mathematics. In the 2004–2007 period, the Dinaledi program doubled enrolment rates of grade 12 students from 6 percent to 12 percent in HG physical sciences and from 5.5 percent to 11 percent in HG mathematics. On average, 17 more students entered and wrote the HG physical sciences exam and six more students passed in Dinaledi schools than in similar non-Dinaledi schools. For math, 12 more students entered and 5 more students passed the HG mathematics exam in Dinaledi than in similar non-Dinaledi schools. Dinaledi schools had better passing rates for HG mathematics in 2005 and 2006 (14 percent and 8 percent more respectively), but not significantly different passing rates in 2007 for either HG mathematics or physical sciences.[4]

The Dinaledi program had no effect on the absolute number of students passing Standard Grade (SG) physical sciences at statistically significant levels in 2006 and 2007, but had a significant effect on the number of students passing SG mathematics. In 2007, 56 students passed SG mathematics in the average Dinaledi school, compared to 47 students in the comparison school (see Table 19).

Effects vary over time. For example, the number of students entering HG physical sciences in the average Dinaledi school relative to the average comparison school increased from 11 to 14 to 17 students in 2005, 2006 and 2007 respectively. The number of students passing HG physical sciences hovered around 6 to 8 more students in the same period.

The analysis finds strongly heterogeneous effects in different types of schools and across provinces. On average, the program had no statistically significant effect on the number of students passing

[4] This study employs two distinct definitions of (mean) passing rates. In both definitions, the term "passing rate" refers to the number of students passing the Senior Certificate examination (p_n) in a given subject divided by the number of the students entering (e_n), not writing, the respective subject examination in school *n*. While the first definition refers only to a restricted sample of schools with at least one student entering the respective subject, the second definition also covers schools with no students entering the respective subject, setting the passing rate to zero for these schools. The first rate is referred to simply as the "passing rate" and the second as the "entry-corrected passing rate" (EC PR). Analogously, a writing-corrected passing rate (WC PR) definition is used for the share of students who pass out of the number of students who write the SC examination, setting the passing rate to zero in schools where no student *writes* the SC examination in the respective subject.

the HG physical sciences exam in five out of nine provinces—Free State, Gauteng, Mpumalanga, North West and Western Cape—and strong positive effects in Limpopo, KwaZulu Natal, and Eastern Cape.[5] In Limpopo and KwaZulu Natal, students passing HG physical sciences increased about fivefold from 4 to 22 students. These are the provinces with a large proportion of formerly Bantustan schools.

Indeed, geographical heterogeneity is driven by the fact that the Dinaledi program was very effective in former Bantustan schools, which were semi-autonomous black homeland schools that were severely disadvantaged during the apartheid era. As they started with a low resource base, these schools were been able to take full advantage of the Dinaledi program. In contrast, no statistically significant effects were observed in former House of Assembly schools (formerly for white students) for which the supply of school inputs was not a constraint. In terms of geographical distribution, KwaZulu Natal and Limpopo host a large share of the former Bantustan schools, while Free State, Gauteng, North West, and Western Cape do not.

This is one of the most important findings of this study, suggesting that the Dinaledi program might be an effective mechanism for narrowing the gap in resources and the quality of education between former Bantustan and HoA schools. In so doing, the program may be an essential policy instrument to equalize opportunities for South African youth. Overall, the results suggest that the Dinaledi program had a positive impact on enrolment and passing rates in math and science and that it particularly benefited the most needy schools.

Methodological qualifications. Because of the methodological limitations of retrospective analysis, and although the authors went to great lengths to control for selection bias in the assignment of the Dinaledi program, some unobserved factors in the selection of Dinaledi schools may not have been captured. For this reason, the results are indicative but not definitive. Unobserved characteristics, such as the quality of the headmaster and teacher body, may influence take-up of the program as well as the ability of the school to benefit from the program. In this case, for example, the schools with more motivated headmasters may participate in the program and the schools with less motivated headmasters may not. When we estimate program effects, the estimated effects would include both program effects and headmaster motivation effects and tend to overstate the true impact of the program were it to be extended to the rest of the school population across the country.

In the case of this study, propensity score matching was used to minimize observed differences in initial characteristics, and the difference-in-difference strategy to control for time-invariable differences in unobserved characteristics. [6] The combined strategy is based on the assumption that in the absence of the program, comparisons between Dinaledi schools and matched schools would have followed the same trends in the outcomes of interest. The study uses prior data to test this assumption, but this is constrained by the lack of good data prior to the intervention. Even with sound prior data, the tests are informative but not conclusive. Technical details are fully addressed in Technical Appendix I.

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[5] Estimation of the effect of the Dinaledi program for Northern Cape is impossible owing to a lack of sufficient observations.

[6] The difference-in-difference method employed in this study serves to eliminate bias due to differences in outcomes (e.g., passing rates) that existed *prior* to the Dinaledi intervention between Dinaledi and comparison schools. Eliminating such bias is only possible under the (identification) assumption that these differences would have *remained constant over time* in the absence of the Dinaledi program, that is, that Dinaledi and comparison schools would have pursued parallel trends.

Furthermore, this study cannot compare the program's cost-effectiveness between different types of target schools. Such comparisons are bound to be skewed because different Dinaledi schools received different input packages at different costs, based on need. Comparing schools with great need that receive a large transfer to low-need schools with low levels of transfers could erroneously suggest that low transfers are more effective than high transfers. The analysis cannot control for the endogenous decision to provide more to more needy schools; the analysis only estimates the average effect of *assignment to the Dinaledi program* on the sample of current Dinaledi schools, ignoring the specific input package received by each school. Its findings thus may be poor predictors of the effect of a specific input package on any individual school.

Caution is also warranted in extrapolating the results to the rest of the school population. The study shows that schools selected into the Dinaledi program were outperforming other schools *before* the introduction of the program. It is very likely that a school's qualities prior to treatment interact with the Dinaledi program to secure different results from those that would be secured across the whole school population. For this reason, a first phase of a future expansion of the program would need to be rigorously evaluated.

While this analysis was conducted using the best available methods given the time and data constraints, the positive results presented should be taken with restrained optimism. The remainder of this paper is organized as follows: The Background section describes the Dinaledi program; Data described the administrative data used for thr study; the Identification Strategy section explains the choice of the DID-matching identification strategy for estimating the Dinaledi program's effect and discusses the plausibility of underlying assumptions; and the Results section presents the estimated program effects. A final section presents the main conclusions and policy implementations. Four technical appendices discuss methodological questions in further detail: Technical Appendix I discusses major threats to the internal and external validity of the estimated program effects; Technical Appendix II discusses the plausibility of the identification strategy; Technical Appendix III conducts sensitivity checks for different sets of matching criteria and algorithms as well as for OLS regression as the standard alternative method for selection on observables; and Technical Appendix IV summarizes different methodologies employed for estimating heterogeneous effects.

BACKGROUND

The Government of South Africa (GoSA) adopted the Dinaledi program with the goal of improving the performance of secondary school students in the mathematics and science Senior Certificate examinations, with a particular interest in the performance of African and female learners. The target was to increase the number of students passing HG mathematics from about 24,000 in 2004 to 50,000 by 2009.

MATHEMATICS AND SCIENCE EDUCATION IN SOUTH AFRICA

Policies aimed at improving mathematics and science education in South Africa serve two overarching objectives—they help overcome the legacy of ethnic inequality in access to quality education created by the apartheid era and develop critical human capital for achieving economic growth.

Under apartheid, unequal access to education for different ethnic groups was the rule. The National Party government established parallel, separately administered education systems for white, colored, Indian and African students, with very unequal teaching resources (for details, see Kallaway, 2002). For example, according to Case and Deaton (1999), per student funding in House of Assembly (HoA) schools for white students was 1.85 times higher than in Department of Education and Training (DoET) schools—that is, schools for African students managed by the Department of Education—and 2.5 times higher than in Bantustan schools, which were semi-autonomous schools for African students. Training institutions preparing teachers for African schools often did not offer mathematics as a specialization. As a consequence, non-white and particularly African students were systematically underexposed to mathematics and science education (OECD, 2008).

Since 1994, the GoSA replaced racially segregated schools with a single national education system and actively promoted equity in access to education (see Fiske et al., 2004). Despite these efforts, African students continue to face unequal access to mathematics and physical sciences education. As Khan (2004) shows, while the average passing rate for students of all ethnicities enrolled in HG mathematics in 2001 was 55.9 percent, only 20.0 percent of African students passed, according to the "language proxy method."[7] While narrowing, the gap in enrolment and passing rates in HG mathematics and physical sciences between African and white/non-African students is far from closed.

This ethnic imbalance in access to education in mathematics and sciences has consequences. For example, it restricts access to tertiary education in engineering and actuarial sciences, as most universities require an HG passing grade for these subjects (OECD, 2008). Such inequity must also be a major contributing factor to the underrepresentation of Africans in professions requiring quantitative skills. According to labor statistics for 2000, only about 9 percent of employed South Africans aged 15 to 65 were in occupations that require some mathematical competence, such as technicians and accountants (OECD, 2008).

International benchmarks rank South Africa poorly in mathematics and science education compared to other African countries at similar economic and human development levels. According to the Trends in International Mathematics and Science Survey (TIMSS), South African eighth-graders performed poorly compared to their peers from Tunisia, Egypt, Morocco, Botswana and Ghana (2003, Table 1).[8] At the same time, the shortage of human capital is identified as a binding constraint to enhancing South Africa's growth and reducing unemployment (Hausmann et al., 2008).

THE DINALEDI PROGRAM

The Dinaledi program is part of a broad set of policies aimed at improving mathematics and physical sciences learning outcomes. In secondary education, it is complemented by increased schooling funding, teacher recruitment, and schooling infrastructure investments on the supply side.[9] On the demand side, the mathematics Olympiads held by the African Institute for

[7] The language proxy method served to identify the ethnicity of exam candidates, which was not explicitly recorded from 1991 to 2002. It identifies candidates as "African" if they take an African language as an examination subject (Kahn, 2004).
[8] The TIMSS 2003 provides the latest available international benchmark of South African learners' performance in mathematics and sciences. South Africa did not participate in the TIMSS 2007.
[9] *Source*: National Department of Education, Technical Report National Senior Certificate Results, 2008.

Mathematical Sciences, for instance, seek to strengthen students' incentives for learning in mathematics. In 2008, the National Senior Certificate examination system was redesigned so that it no longer differentiates between Higher and Standard Grade exams, but only offers a single examination level, largely corresponding to the HG. In primary education, the Dinaledi program is complemented by programs such as the Minister of Education's Foundation for Learning Initiative, which seeks to strengthen fundamental numeracy skills.

The GoSA designed the Dinaledi program primarily as a supply-side intervention. It identified the lack of qualified mathematics and physical sciences teachers as well as other crucial teaching inputs such as textbooks, computers, calculators, and laboratory equipment as the major constraint to the students successfully passing the Senior Certificate examination in these subjects. In 1997, a report found that only 85 percent of mathematics and science teachers were professionally qualified as educators and only 50 percent and 42 percent were qualified in their respective subjects (Arnott and Kubeka, 1997). The difficulty of attracting qualified mathematics and science graduates to the teaching profession is seen as a major bottleneck aggravating this situation. Given their scarcity on the labor market, qualified graduates find more attractive opportunities, for instance, in private sector jobs. Because of the lack of qualified teachers, many South African secondary schools do not offer classes in mathematics and physical sciences at all.

The Dinaledi program also comprised a demand-side component. In particular, it provided students with career guides in Grade 9, potentially reducing systematic undervaluation of the expected returns to passing mathematics and physical sciences matriculation exams.

Schools included in the Dinaledi program received, based on need, a combination of the following treatments:

1. Teacher training focused on improving teachers' knowledge in mathematics and sciences;
2. Recruitment of additional teachers;
3. Provision of textbooks in mathematics and physical sciences;
4. Provision of scientific calculators and/or computer resources;
5. Provision of Learning Support Materials (LSM), including Grade 9 career guidance guides, exemplar question papers to support assessment of the curriculum (past Higher Grade mathematics and science question papers with marking memorandum), and audio-visual cassettes; and
6. Monitoring in the form of school surveys, on-site school visits, and phone interviews.

In addition, a number of Dinaledi schools received financial and in-kind support from private companies. Data on the allocation of Dinaledi treatments indicates that different Dinaledi schools received very different input packages. Some inputs, such as calculators (86 percent of Dinaledi schools), higher education guides (67 percent), sample exam papers (41 percent) and textbooks (18 percent to 54 percent of Dinaledi-schools) were allocated to a substantial share of schools, but in very different quantities. Other program components only benefitted a smaller number of schools, in particular "adoptions" (24 percent) or financial support (9 percent) by private companies; however, data on the amount of teacher training and additional teaching staff provided to schools is lacking. Table 2 provides an overview of the distribution across schools of the above-mentioned inputs.

The Dinaledi program was rolled out in several phases. At its start in 2001, 102 schools were selected. In 2005, the program was expanded to 400 schools, but in 2007, 29 of the 400 schools were de-listed and 117 new schools were added, resulting in a total of 488 Dinaledi schools. This study estimates the effect of the Dinaledi program's expansion on these 488 schools for the 2005–2007 period.[10] The number then grew to 500 schools in 2008. Table 3 shows a breakdown of the number of Dinaledi schools by province; the last column provides the number of schools included in this study.

During the program's major expansion in 2005, the GoSA defined guiding principles for Dinaledi eligibility in order to target resources cost-effectively to selected schools. Measurable eligibility criteria comprised a minimum of 35 African Senior Certificate mathematics learners, and a minimum Senior Certificate passing rate of 50 percent in mathematics and physical sciences. In addition, schools were required to "display basic levels of functionality" and to have "potential to improve both participation and performance in SC mathematics and physical science." In view of these criteria, each provincial government preselected schools for final approval by the central government. However, an ex-post comparison between Dinaledi and non-Dinaledi schools shows that these criteria were only loosely applied and that different provincial governments weighted needs and capacity criteria differently.

DATA

DATA SOURCES AND MEASUREMENT QUALITY

The administrative panel data for this study comes from two sources. Information on school characteristics in the year 2004 is drawn from South Africa's Education Management Information Systems (EMIS). This data serves to match Dinaledi schools with control schools that had similar observed baseline characteristics prior to the expansion of the Dinaledi program in 2005. Information on the number and performance of students taking Secondary Certificate exams for the pre-intervention year (2004) and the three subsequent years (2005–2007) was provided by the National Department of Education. The two datasets were merged based on national school identification numbers and exam center numbers.

The data covers nearly all 3,347 secondary schools in the nation, including data for 447 out of a total of 488 Dinaledi schools in 2007. To ensure basic comparability between Dinaledi and other schools, the sample used in the study is restricted to public secondary, combined, and intermediate schools with selected specializations.[11] The resulting data includes 3,135 schools, with 440 Dinaledi schools and 2,695 non-Dinaledi schools. Of the 440 Dinaledi schools, 72 were admitted to the initial program in 2001.

The quality and completeness of data on school characteristics, which varied significantly between provinces, presented an obstacle during this study. The EMIS provides detailed data on the number of students per school by grade, such as ethnicity and gender, but has less information on key determinants of mathematics and physical sciences learning outcomes, such as the number of mathematics and physical sciences teachers per school, class sizes, or the availability of computers and other relevant teaching inputs. These challenges may result in the exclusion of variable bias in

[10] These 488 schools are referred to as "Dinaledi 2005 schools."

[11] The sample was restricted to schools with the following specializations: "COMPREHENSIVE", "COMPUTER; MATHS SCIENCE AND TECHNOLOGY", "DANCE; MATHS SCIENCE AND TECHNOLOGY", MATHS SCIENCE AND TECHNOLOGY", "ORDINARY", "ORDINARY & TECHNICAL" and "TECHNICAL".

the estimates. Data on student or household characteristics is lacking, and proxy indicators, such as school fees or whether the school is in an urban or rural setting, are not available.

Outcome data from the NDoE on student test participation and performance is detailed and comprehensive for physical sciences, whereas for mathematics, pre-treatment data (for 2004) appears to be unreliable.[12] Without pre-treatment data, estimates of the Dinaledi program's effects on mathematics learning outcomes could be biased. Therefore, while the study estimates effects of the program on both physical sciences and mathematics, the results are more reliable for physical sciences learning outcomes.

DESCRIPTIVE STATISTICS: OBSERVED DIFFERENCES BETWEEN DINALEDI AND NON-DINALEDI SCHOOLS

Schools admitted to the Dinaledi program differed significantly from non-selected schools before the start of the intervention in 2004. Dinaledi schools comprised most schools with a specialization in mathematics and sciences (see Table 4). On average, they were about 1.5 times larger than other schools (see Table 6). Dinaledi schools outperformed others in terms of their students' success in Secondary Certificate examinations in mathematics and physical sciences (see Table 8). Both in HG and SG physical sciences, the average number of students from Dinaledi schools participating in, writing, and passing matriculation exams was about twice as high as in other schools. While this does to some extent simply reflect the fact that Dinaledi schools have a larger number of students on average, their enrolment and passing rates are also significantly higher, especially for HG physical sciences (see Table 8). For example, with a mean of 50 percent, the entry-corrected passing rate for HG physical sciences is nearly twice as high as in other schools (28 percent).

These differences reflect the targeting of the Dinaledi program toward schools that were performing comparatively well in mathematics and physical sciences. In addition, a majority of schools that benefitted from the first Dinaledi intervention in 2001 were readmitted to the 2004 program. Of the 72 Dinaledi schools in the sample for this study, 57 were reselected as Dinaledi schools in 2004. The implications of this overrepresentation of Dinaledi 2001 schools for the identification strategy are further discussed below.

Targeting of the Dinaledi program to African and female students does not translate into major differences in the ethnic or gender composition of the student body between Dinaledi and non-Dinaledi schools. In Dinaledi schools, on average, 86 percent of students are African; in non-Dinaledi schools, 84 percent. In Dinaledi schools, there were on average 100 female to 90 male African students, compared to a nearly balanced gender-ratio in other schools (100 female to 97 male students) (see Table 7).

[12]Mathematics outcome data for 2004 is frequently miscoded as zero when it is, in fact, missing. For 2004, over 93 percent of all schools in the dataset report that no students were enrolled in SG mathematics, whereas for the subsequent years this share declined to less than 2 percent. The respective values for HG mathematics are 96 percent for 2004 and less than 40 percent in all subsequent years. Thus, both in absolute terms and compared to subsequent years, the mathematics data for 2004 is inaccurate.

DISPARITIES IN MATHEMATICS AND PHYSICAL SCIENCES LEARNING OUTCOMES

South Africa's legacy of apartheid, in combination with its geographic and socioeconomic diversity, is responsible for a great variance in mathematics and physical sciences learning outcomes and in access to quality schooling. This section briefly highlights these disparities along two dimensions—by provinces, which bear part of the administrative responsibility for the post-apartheid education system, and by schools' former attribution to the different racially segregated education administrations under apartheid.

BY PROVINCE

As shown in Table 9, the distribution of Dinaledi schools across provinces in the sample is equitable based on population. While the absolute number of Dinaledi schools per province ranges from 17 schools in Northern Cape to 101 schools in Gauteng, the number of Dinaledi schools per capita only varies slightly and favors less populous and sparse provinces, for example, Free State, Mpumalanga, Northern Cape, and North West Province.

Pre-treatment outcomes, in particular for grade 12 students that enter HG and SG physical sciences Senior Certificate exams, varied across provinces at the baseline. In Free State, Gauteng, Mpumalanga, Northern Cape, North West Province, and Western Cape in 2004, at least one in 10 students on average entered SG and about one in 20 entered HG physical sciences (see Table 10 and Table 11).[13] Eastern Cape had the highest average enrolment rate for SG physical sciences (20 percent), but a relatively low enrolment rate for HG physical sciences (2 percent). By contrast, in Kwazulu Natal and Limpopo, average entry rates for HG and SG physical sciences were zero. Inter-provincial discrepancies regarding the passing rate in physical sciences existed in 2004, but were less pronounced. They were highest in Western Cape with 89 percent on average for SG and 78 percent for HG and lowest in Mpumalanga, with 67 percent and 41 percent respectively.

BY APARTHEID ADMINISTRATION

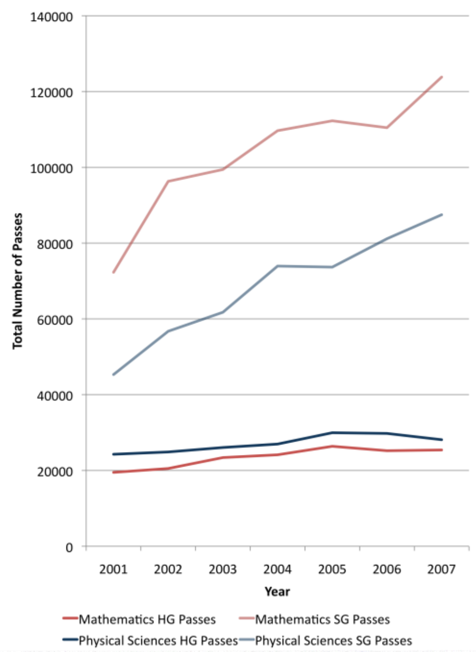
Categorizing schools according to their administration under apartheid shows that strong discrepancies prevail in particular between former House of Assembly schools for white students and Bantustan schools for Africans living in the homelands. While Bantustan schools are attended almost exclusively by African students, Africans remain a minority in former HoA schools (see Table 12). As shown in Table 13, enrolment rates (14 percent vs. 2 percent) and passing rates (86 percent versus 43 percent) in HG physical sciences were still many times higher in 2004 in former HoA schools than in former Bantustan schools included in this study's sample.

[13] All Figures reported comprise both Dinaledi and non-Dinaledi schools in the respective province.

TRENDS

How has the number and passing rate of mathematics and physical sciences for Senior Certificate examination takers evolved before and after the 2004 baseline year? Aggregate data for the entire population of schools under the Ministry of Education (NDoE) shows that the number of Standard Grade (SG) passes grew continuously and at a relatively rapid pace from 2001 to 2007—by 71 percent for SG mathematics and by 93 percent for SG physical sciences. By contrast, the number of HG passes only grew by 30 percent and 16 percent respectively (see Figure 1) over the same period. These trends mostly reflect a general growth in the number of graduates, not a major increase in the proportion of grade 12 students who take and pass the Senior Certificate in mathematics and physical sciences. As shown in Figure 2 and Figure 3, the total share of students writing and passing the mathematics exam (including HG and SG) nearly stagnated since 2001—it only grew from 58.2 percent to 61.5 percent in 2007 and from 38.1 percent to 40.2 percent respectively.

FIGURE 1. GROWTH OF THE ABSOLUTE NUMBER OF MATHEMATICS AND SCIENCE PASSES 2001-2007



Source: NDoE report, 2007

What has been the contribution of Dinaledi 2005 schools to this trend? A breakdown (see Figure 4) based on a sample of 1,571 schools[14] suggests different trends for SG and HG physical sciences, in both of which Dinaledi schools outperformed other schools on the growth of enrolment rates during 2004-2006. Whereas this growth differential was modest for SG physical sciences, it was strikingly high for HG physical sciences. From 4 to 5 percent in 2004, Dinaledi schools nearly doubled their average HG enrolment rate to 8 percent in 2006. This growth differential is consistent with the study's finding that the Dinaledi program considerably affected HG physical science enrolment rates.

Trends in aggregate passing rates also differed considerably. In SG physical sciences, Dinaledi and non-Dinaledi schools followed similar trends. Average SG physical science passing rates more or less stagnated above the 70 percent mark between 2004 and 2007 and remained about 7–10 percentage points higher in Dinaledi schools than in other schools. HG passing rates fell from 72 percent in 2004 to 58 percent in 2007. Passing rates in Dinaledi schools dropped even more perhaps due to larger enrolment of less prepared students and/or pre-existing differences between Dinaledi and other schools.

[14] The sample comprises schools for which complete data were available for all years between 2004 and 2007. It is not necessarily representative of South Africa's secondary school population.

IDENTIFICATION STRATEGY

OVERVIEW

It is difficult to estimate the Dinaledi program's effect because major differences between Dinaledi and other schools clearly existed *before* the inception of the program, and were—at least in part—*unobserved*. Dinaledi schools may have outperformed their peers simply because they had a considerable head start or because they had more motivated headmasters and teachers. To estimate program effects accurately, Dinaledi recipient schools should be compared to schools that started from a similar point, but which did not take up the program. For example, comparable schools should, on average, have as many and as well-qualified mathematics and physical sciences teachers per student, have students from similar socioeconomic backgrounds, possess similar quality textbooks and other teaching materials before the program, and have equally motivated headmasters. By comparing schools with similar baseline characteristics, the claim that learning outcome differences between Dinaledi and non-Dinaledi schools in 2007 resulted from the Dinaledi program—and not to a head start or other pre-existing differences—is more plausible. However, data on such key determinants of mathematics and physical sciences learning outcomes is very limited, and indicators such as the quality of staff are not observed. In order to estimate the Dinaledi program effect (on physical sciences learning outcomes) despite this lack of data, this study employs a twin identification strategy.

First, the study seeks to *minimize observed differences between Dinaledi and comparison schools*. Since data *is* available on pre-treatment *outcomes,* Dinaledi and non-Dinaledi schools can be matched based on the share of their students entering and passing the Secondary Certificate in physical sciences. In addition, *observed* school characteristics that do *not directly determine* school performance are sometimes *correlated* with unobserved performance determinants and thus serve as *indirect proxies*. This, however, cannot be ascertained. The Identification Strategy section provides further details on the method employed in order to minimize observed differences (propensity score matching), and Technical Appendix II contains a technical discussion.

Second, this study seeks to eliminate bias from *unobserved differences*—provided these differences remain constant over time. This is done by comparing Dinaledi and non-Dinaledi schools based on the *change* in mathematics and physical sciences learning outcomes over time to cancel out differences in levels. This is possible thanks to the availability of time series data on learning outcomes. For example, rather than comparing Dinaledi physical sciences passing rates in 2007 to passing rates in comparison schools in 2007, the study compares the *growth in passing rates* from 2004 to 2007 between treated and comparison schools. Even if Dinaledi schools had a head start, that is, higher passing rates, than non-Dinaledi schools in 2004, this approach would correctly identify the Dinaledi program effect, provided passing rates would have evolved in parallel in both groups of schools had none of them taken up the Dinaledi program. Identification Strategy section discusses the plausibility of this parallel trends assumption, which is crucial for the difference-in-difference (DID) estimation. Appendix II adds technical details.

For mathematics learning outcomes, it was not possible to use the second DID component of this identification strategy owing to the lack of reliable time-series outcome data, which is not available for mathematics in 2004. The estimation of Dinaledi program effects on mathematics learning outcomes thus relies on stronger identification assumptions and is more likely to provide biased estimates. The implications of this lack of data on the reliability of mathematics estimates are further discussed below.

PROPENSITY SCORE MATCHING

This study seeks to reduce *bias due to observable differences* by matching Dinaledi schools with similar non-Dinaledi schools. In principle, for each Dinaledi-school, a comparison school is identified that has similar baseline characteristics. This method requires both matching characteristics (how to measure school similarity) and a matching algorithm (given a measure of similarity, how to identify matches) be chosen for selecting or weighting comparison schools. This section briefly describes these two choices.

MATCHING CRITERIA

Prior to matching comparison schools to Dinaledi schools, the sample of non-Dinaledi schools is restricted to plausible matches by excluding schools that do not belong to the same categories as Dinaledi schools. Since nearly all Dinaledi schools are public secondary, combined, and intermediate schools with certain specializations, only schools that belong to these categories are used as comparison schools. For example, private, elementary, or high schools specializing in arts and music are omitted as they are likely to offer poor comparisons. Second, all schools that benefitted from the Dinaledi program in 2001 were excluded from the sample. If these schools had been included, estimates of the Dinaledi expansion's effects in 2005 risked partly capturing the effects of the program's first phase. It seems unlikely that 2001 Dinaledi schools would have evolved in parallel with non-Dinaledi schools had the program not been expanded. Finally, schools that lacked data on relevant baseline characteristics were also excluded. Imposing these restrictions reduced the sample of Dinaledi schools from 447 schools to about 350 schools (see Technical Appendix II for further details).[15]

The guiding criterion for the choice of matching characteristics (covariates) is whether they may cause bias if omitted because they *both* influence learning outcomes *and* are correlated with Dinaledi school status. Ideally, matching covariates should, for example, include indicators of the quantity and quality of mathematics & physical sciences teachers and of other school inputs, as well as child and household characteristics. However, as mentioned above, these key determinants of students' learning outcomes are *not observed* in existing data sources. Failing to control for these characteristics is particularly apt to cause bias because the Dinaledi program was explicitly targeted to schools that differed significantly from other schools in their ability to teach mathematics and physical sciences. In order to mitigate the risk of bias to the extent possible in the absence of such data, the covariates of this study's main specification have been selected according to the following three criteria (see Technical Appendix II for details):

1. *Their suitability as proxy indicators of school quality and student socioeconomic backgrounds*, based on theory and evidence from the empirical education literature. In particular, schools are

[15] The sample slightly varies in size for each post-treatment year (between 346 schools in 2006 and 353 schools in 2005), as outcome data is not available for all post-treatment years (2005–2007) for all schools. For the estimation of the Dinaledi program effect in 2007, 88 Dinaledi schools were excluded from the original sample of 440 Dinaledi schools (i) because they already were Dinaledi schools in 2001 (57 observations dropped), (ii) because they lacked data on characteristics used for estimating the PS (18 observations dropped), (iii) because they lacked outcome data for 2007 (6 observations dropped) or (iv) because of a lack of comparison schools to meet the common support condition (7 observations dropped). For the 2006 and 2005 estimations, similar numbers apply.

matched based on their students' performance in physical sciences before the Dinaledi program in 2004—assuming that schools of similar size that produced similar numbers of students entering and passing physical sciences, have, on average, comparable teaching capacity (see Technical Appendix II for details);

2. *Their suitability for predicting Dinaledi eligibility.* The choice of school characteristics controlled for in this study's main specification is driven by information about the Dinaledi program's design and targeting, the latter of which is reflected in the inclusion of the number of African and female students. School size matters in particular because the Dinaledi effect on learning outcomes—for example, the number of students entering and writing physical sciences matriculation exams—is measured in absolute numbers, rather than in shares of students enrolled in the final grade 12. To make outcomes comparable, Dinaledi and non-Dinaledi schools thus need to be of similar size. School size also matters because large schools are likely to differ from small schools in unobserved ways. For example, large schools may be found more often in urban areas with students from different socioeconomic backgrounds, have more specialized teachers due to scale effects, and may be more or less likely to be eligible for the Dinaledi program. Finally, the number of students with English as the language of instruction is an important control as it is a proxy indicator of the student bodies' ethnic composition. These qualitative considerations are backed by testable criteria as suggested by Heckman et al. (1997) (see Technical Appendix II for details); and

3. *Their suitability for balancing baseline characteristics among Dinaledi and control schools*. The choice of matching characteristics should ideally lead to balanced baseline characteristics between treated and matched control schools after matching, lending credibility to the assumption that—at least for observable characteristics—Dinaledi schools and selected matched schools are comparable. Tables 6 to 8 in the Technical Appendices show that the main specification successfully balances most observed baseline characteristics for the DID matching results for the years 2006 and 2007 (see Technical Appendix II for details).

BOX 1:
MAIN SPECIFICATION MATCHING COVARIATES

A. School characteristics: size, ethnic and gender composition, language of instruction

- Total male enrolments
- Total female enrolments
- Number of African learners in the school
- Enrolments in grade 10
- Enrolments in grade 11
- Male enrolments in grade 12
- Female enrolments in grade 12
- Number of African learners in grades 10 to 12
- Number of learners with English as medium of instruction

B. Learning outcome measures

- Total number of students writing SG physical sciences
- Total number of students writing HG physical sciences
- Total number of students passing SG physical sciences
- Total number of students passing HG physical sciences
- Entry-corrected passing rate out of those writing SG physical sciences
- Writing-corrected passing rate out of those writing HG physical sciences

C. Province dummies

Box 1 lists the pre-treatment covariates that have been selected based on these criteria for this study's main specification. They comprise selected baseline characteristics, pre-treatment Secondary Certificate examination outcome measures, and province dummies. Baseline characteristics include size, ethnic, and gender characteristics as well as the language of instruction.

Outcome measures include the number of students writing and passing HG and SG physical sciences and the respective passing rates (see Technical Appendix II for details).[16]

MATCHING ALGORITHM

Choosing the matching algorithm essentially involves choosing the number of comparison schools used for constructing the counterfactual as well as the weights attributed to these schools. At one extreme, single nearest neighbor matching identifies only a single match for each Dinaledi school. At the other extreme, algorithms include all non-Dinaledi schools in the counterfactual, but give more weight to good matches than to poor matches (e.g., Kernel matching). Between these extremes, the choice of a matching algorithm needs to be guided by two competing objectives: on the upside, using only a few, precise matches reduces bias by ensuring that control schools are very similar to Dinaledi schools; however, using few matches limits the sample size and thus increases the ability to detect the smallest program effect at standard significance levels. Inversely, using many matches allows smaller program effects to be detected, but risks introducing bias by including poorer matches.

This study's main specification one-sidedly seeks to minimize bias by using a single nearest neighbor matching algorithm, accepting that small program effects cannot be detected at statistically significant levels. Opting for bias-minimization in this way is possible as a result of the large sample of schools available for this study, comprising the majority of South Africa's high school population. With about 350 Dinaledi and 350 control schools, the resulting sample is still large enough to detect sufficiently small program effects.

Accordingly, a single match is identified for each Dinaledi school. Given the large number of selected matching covariates, matches are identified based on an aggregate indicator of their observed characteristics, the propensity score. The propensity score estimates the likelihood of being selected for the Dinaledi program, given a school's covariates. Rosenbaum and Rubin (1983) show that in principle, controlling for the propensity score provides the same estimates of program effects as controlling for the covariates used for estimating the propensity score. Matches are used multiple times if they are the closest match for several Dinaledi schools (see Technical Appendix II for further details on the matching algorithm).

DIFFERENCE-IN-DIFFERENCE

Besides reducing bias due to observable differences via matching, this study seeks to *make unobserved differences between Dinaledi and matched non-Dinaledi schools negligible*—provided these differences would have remained constant over time in the absence of the Dinaledi program (difference-in-difference (DID) component).

How plausible is this parallel trends assumption? In 2004, for example, the number of students entering and writing the HG physical sciences exam was on average six students *lower* in Dinaledi schools than in matched control schools (20 versus 26 students).[17] If this difference had remained constant until 2007 in the absence of the Dinaledi program, the DID approach would provide an unbiased estimate of its effect on the number of students entering and writing HG physical sciences

[16] Pre-treatment mathematics learning outcomes are not used as matching covariates owing to the lack of reliable data.
[17] For the sample of schools with outcomes data availability from 2004-2007 (see Appendix Table 2, row 4).

exams. By contrast, this assumption would fail if for example overall grade 12 enrolment had grown between 2004 and 2007, as it did, *and* if Dinaledi schools on average had students with stronger preferences for taking HG physical sciences (an unobserved characteristic). In this case, the enrolment growth would translate into a higher number of students taking HG physical sciences in Dinaledi than in non-Dinaledi schools. Consequently, the initial gap in HG physical sciences enrolment would have narrowed *without the Dinaledi program*, and the DID strategy would overestimate the Dinaledi program effect.

While the parallel trends assumption is not directly testable for the treatment period (2005–2007), it *is* testable for the pre-treatment period (2004 and prior). If it can be shown that physical sciences learning outcomes in Dinaledi and matched control schools pursued parallel trends prior to 2004, this would lend strong support to the assumption that they would have continued to evolve in parallel after 2004 in the absence of the Dinaledi program (see Technical Appendix II for details).

IDENTIFICATION STRATEGY FOR MATHEMATICS LEARNING OUTCOMES

The DID component of the identification strategy cannot be employed for estimating the Dinaledi program effect on mathematics learning outcomes. It requires reliable pre-treatment (2004 or prior) learning outcome data, which is available for physical sciences, but lacking for mathematics. Accordingly, stronger identification assumptions underlie the reported preliminary estimates of the Dinaledi program effect on mathematics outcomes. These estimates would only hold if, in 2004, matched control schools had not differed from Dinaledi schools in observable and unobservable characteristics that influence mathematics learning outcomes. Given the lack of data on key determinants of mathematics learning outcomes, this is a strong assumption. For example, if HG mathematics enrolment had differed between Dinaledi and control schools prior to the Dinaledi program (as is the case for HG physical sciences), and if this difference were constant over time, it would erroneously be attributed to the Dinaledi program. Pre-treatment mathematics outcome data would be needed to secure more precise estimates of the Dinaledi program effects on mathematics learning outcomes.

RESULTS

AVERAGE TREATMENT EFFECTS ON TREATED (DINALEDI) SCHOOLS (ATET)[18]

PHYSICAL SCIENCES

Under the parallel trends identification assumption, this study finds that assignment to the Dinaledi program doubled the enrolment rate of grade 12 students in HG physical sciences (see Table 14). Compared to an average enrolment rate of 6% for matched control schools, Dinaledi schools had enrolment rates between 11 and 14 % in each of the program years of 2005, 2006 and 2007.

The effect of the Dinaledi on the HG physical sciences passing *rate* is also positive (see Table 14): Dinaledi increased passing rates by 15 percentage points in 2005 and 10 percentage points in 2006, although this effect levels off in 2007. The passing rate definition we use here, and throughout the

[18] All results reported at 1% statistical significance level.

results section, is the ratio of passes over total enrolment in that subject.

Assignment into Dinaledi greatly increased the *number* of students entering, writing, and passing *HG physical sciences* examinations. For instance, in 2007, on average, 35 students *entered* HG physical sciences in Dinaledi schools compared to only 18 students in matched control schools, and 16 students *passed* HG physical sciences in Dinaledi schools, compared to 10 students in control schools (see Table 15).

No statistically significant effect is detected on the number of students passing *SG physical sciences*. In 2007, an average of 35 students passed SG physical sciences both in Dinaledi and comparison schools (see Table 15).

These estimates are robust to a bias-corrected estimation algorithm as suggested by Abadie and Imbens (2002) (see Table 16 - Table 17 or Technical Appendix II for details). However, estimates of the Dinaledi program effects on physical sciences outcomes vary considerably for the three post-treatment years (2005–2007). The sequencing of Dinaledi's implementation and the overall enrolment trends may be affecting these results. Extending the analysis to 2008 matriculation results could help corroborate the findings from previous years.

MATHEMATICS

Estimates of the Dinaledi program effect on mathematics learning outcomes are likely to be biased as they are based on strong assumptions due to lack of baseline controls. Hence, the following results are not conclusive.

The Dinaledi program had positive and statistically significant effects on the number of students entering, writing, and passing the Senior Certificate examinations in HG mathematics. In 2007, 25 students on average entered and wrote HG mathematics in Dinaledi schools, compared to only 13 students in matched control schools (see Table 19). In the same year, an average of 14 students passed HG mathematics in Dinaledi schools, compared to only 9 students in matched control schools. Dinaledi doubled the HG mathematics enrolment rate from an average of 5.5 percent to 11 percent (see Table 18) in 2006 and 2007. The Dinaledi program also increased passing rates[19] by 15-17 percentage points in each of the program years (see columns 4 and 6, Table 18). These results hold at the 1 percent significance level and are robust to bias-correction (see Table 20 and Table 21).

HETEROGENEOUS TREATMENT EFFECTS

BY FORMER DEPARTMENT UNDER APARTHEID[20]

Persistent inequalities in access to quality education in today's South Africa can be traced back to segregated, parallel education systems for different ethnic groups under the apartheid system. This section presents estimates of Dinaledi program effects on three types of schools that belonged to separate apartheid-era education systems: House of Assembly (HoA) schools (formerly for white

[19] Passing rates of students entering HG mathematics.

[20] The discussion of heterogeneous treatment effects does not cover mathematics learning outcomes for the time being, hampered by a lack of reliable pre-treatment data.

students), Department of Education and Training schools (DoET) (formerly for black students) and schools in nine out of ten[21] of the semi-autonomous black homelands or Bantustan schools.[22]

The Dinaledi program had strikingly different effects on these three groups of schools (see Table 22 to Table 25). On average, Dinaledi had no statistically significant effect on former House of Assembly schools. In former Department of Education and Training schools, the Dinaledi program doubled enrolment rates. It also increased the number of students entering and passing HG Physical Sciences: 10 more students entered and 4 more students passed HG physical sciences in Dinaledi schools than in control schools. In Bantustan schools, Dinaledi tripled the number of students enrolled in HG physical sciences and doubled passing rates compared to control schools. More students entered and passed: on average, 43 students entered and 15 students passed HG physical sciences in Dinaledi Bantustan schools, compared to only 11 entering and 2 passing in matched schools. These heterogeneous effects are robust to controlling for pre-treatment (propensity score) matching criteria and in particular for pre-treatment HG physical sciences enrolment rates (TabTable 33).

In short, assignment to the Dinaledi program led to stronger improvements in learning outcomes in former Bantustan schools than in former HoA schools. This suggests that Dinaledi is a potentially powerful policy instrument to address past inequalities in access and outcomes. The mechanisms through which more disadvantaged schools benefited more grants further investigation to understand whether higher effects are due to a larger transfers of resources or to the schools' greater needs and higher returns to the resources provided.

First, as the program components were tailored to individual school needs, former HoA schools may have received fewer resources than Bantustan schools. Second, decreasing marginal returns may explain that the Dinaledi program was less effective in HoA schools. For example, the impact of providing training in physical sciences education to teachers on HG physical sciences enrolment in a school that has no qualified teachers may be higher than in a school that already has qualified teachers. Third, the classification as an HoA or Bantustan school may proxy for other (observed and unobserved) school characteristics that make the school more or less able to take advantage of the Dinaledi program. Proxy measures for students' socioeconomic background, such as household survey data, could be used to investigate these issues further.

BY PROVINCE

Estimation of treatment effects by province is constrained by the number of observations available in each province. For South Africa's four northern provinces—Northern Cape, North West, Limpopo, and Mpumalanga—the sample is too small to provide reliable within-province matching estimates. For the five southern provinces—Western Cape, Eastern Cape, Kwazulu Natal, Free State, and Gauteng—there are sufficient observations for estimating separate Dinaledi program effects, but matching results are poor because there are few valid comparison schools within each province. Consequently, significant baseline differences remain between Dinaledi schools and matched controls from the same province which risk causing bias.

[21] Former Qwaqwa schools are not included because no observations are available.
[22] Heterogeneous effects for House of Representative schools and House of Delegates schools are not estimated owing to a lack of observations. Regrouping all Bantustan schools may hide heterogeneous effects between Bantustans, which merit further inquiry.

In order to enlarge the pool of available matches and to improve the quality of matching results, this study reports separate treatment effects for three sets of provinces (see Table 26 to Table 29). The first set comprises Free State, Gauteng, Mpumalanga, North West and Western Cape; the second, Kwazulu Natal and Limpopo; and the third, Eastern Cape. The Dinaledi effect for Northern Cape is not estimated for lack of observations.[23]

Dinaledi had different effects on HG physical sciences *enrolment rates* in different sets of provinces. In Free State, Gauteng, Mpumalanga, North West, and Western Cape, the program increased enrolment rates only moderately from an average of about 9 percent in control schools to 12 percent in Dinaledi schools (5 percent significance level). In KwaZulu Natal and Limpopo, the program more than doubled HG enrolment rates from about 9 percent in control schools to 22 percent in Dinaledi schools (1 percent significance level). In Eastern Cape, it doubled HG enrolment rates from 5 percent to 11 percent (5 percent significance level).

The effect on the absolute *number of students passing* HG physical sciences also varied (see Table 26 to Table 29). By 2007, Gauteng, Free State, Mpumalanga, North West, and Western Cape experienced no statistically significant effect on the number of students passing HG physical sciences. In KwaZulu Natal and Limpopo, the program on average increased the number of students passing HG physical sciences by a factor of five (an average of 22 students versus 4 in control schools). In Eastern Cape, the Dinaledi program more than doubled the number of students passing HG (an average of 6.1 students versus 2.4 in control schools).

Contrary to HG physical sciences, the Dinaledi program had no statistically significant effect on the number of students passing SG physical sciences in any province subset in 2007. This is the case despite some statistically significant Dinaledi effects on SG enrolment or passing rates. In Gauteng, Free State, Mpumalanga, North West, and Western Cape, the Dinaledi program increased SG passing rates by 8 percentage points (to 79 percent compared to about 71 percent in control schools). In Kwazulu Natal and Limpopo, the Dinaledi program slowed the growth of SG enrolment rates by about 6 percentage points.

The Dinaledi program's heterogeneous effects across provinces and across former departments under apartheid are closely correlated. The two provinces where the Dinaledi program was most effective in increasing the number of students passing HG physical sciences—Kwazulu Natal and Limpopo—also comprise a large population of former Bantustan schools. In the Kwazulu Natal province, 62 percent of Dinaledi schools of the analyzed sample formerly belonged to the Kwazulu Natal Bantustan (see Table 30). In Limpopo, 92 percent of Dinaledi schools are former Bantustan schools, with 14 percent formerly belonging to Gazankulu, 38 percent to Lebowa, and 40 percent to Venda. By contrast, Free State, Gauteng, and Western Cape, where the program showed no significant effect, also did not comprise a single Dinaledi school from a Bantustan. Only Mpumalanga and North West Province do not fit this pattern. Here, the Dinaledi program had no significant effect, although about 41 percent of Dinaledi schools were former Bantustan schools in Mpumalanga (from Kangwane (28 percent), Kwandebele (6 percent), and Transvaal (6 percent)), and 32 percent in North West Province (from Bophuthatswana).

[23] There are only three Dinaledi schools in Northern Cape with sufficient baseline information that meet selection criteria.

HETEROGENITY BY BASELINE CHARACTERISTIC: PRE-TREATMENT HG PHYSICAL SCIENCES ENROLMENT RATES

The Dinaledi program effect also varies depending on observed baseline school characteristics. For example, the Dinaledi effect on HG physical sciences enrolment rates rapidly decreases with increasing pre-treatment enrolment rates. While the Dinaledi program increased HG physical sciences enrolment rates on average by over 6 percentage points in schools with pre-treatment enrolment rates in the 0 percent to about 5 percent range, it had no statistically significant effect in schools with initial enrolment rates greater than 20 percent (see Figure 5 to Figure 7), holding constant the pre-treatment characteristics used for matching (see Box 1). This finding is robust to different techniques for estimating heterogeneous effects (see Technical Appendix IV for details).

CONCLUSIONS

In 2004, South Africa continued to experience severe regional and ethnic imbalances in mathematics and physical sciences learning outcomes. This study's main findings are that:

1. The Dinaledi program substantially increased the number of students entering, writing, and passing the Senior Certificate examinations in HG physical sciences and in HG mathematics in the 350 Dinaledi schools under observation.

2. The impact of Dinaledi was driven by program effects in historically discriminated and currently more disadvantaged schools where the effects were large and significant.

The results provide support for scaling up the Dinaledi program and targeting schools that have fewer resources and that service disadvantaged populations.

However, many questions remain unanswered:

- What are the mechanisms through which the Dinaledi program delivered these results?
- Why was the Dinaledi program particularly effective in former Bantustan schools?
- Will the program be equally effective in the remaining schools?
- Are these short-term effects or will they be sustained over time?
- What features of the program could be improved to strengthen program effectiveness?

Effective targeting. This study clearly indicates that targeting of the Dinaledi program to former Bantustan schools could increase program effectiveness, at least in the short run. Former Bantustan schools had less qualified teachers, less equipment, and fewer inputs, and could gain more from any additional resources than resource-rich schools. However, they must have received more inputs from Dinaledi, so targeting former Bantustan schools may or may not increase cost-effectiveness. In addition, these schools host a greater proportion of students from poorer socioeconomic backgrounds. Going forward, it would be important to understand how school characteristics influence the effectiveness of the program and target the program accordingly.

External validity and sustainability. Eligibility criteria for access to the program gave priority to schools with outstanding performance in mathematics and physical sciences education. Whether the impact measures are representative of the rest of the schools in South Africa is not clear. The validity of the impact measures depends on how similar the remaining schools are to the schools initially targeted by the Dinaledi program. Since schools with a good track record were chosen, expanding the program to schools with worse track records might change program effectiveness. This suggests that the effectiveness of expansion should continue to be measured. In addition, to really understand the effectiveness of the program, its longer-term impact should be tracked.

Fine-tuning. This study measured the average effect of schools' assignment to the Dinaledi program. To improve program effectiveness, it would be important to understand which factors are causally linked to the results. Is it the fact that these schools received implicit recognition for their performance that made them perform better, or is it because principals and teachers knew that there was interest in their performance and that results were being monitored that they were motivated to do more? Furthermore, is schools' performance indeed the result of the fact that they faced constraints in their access to skills, equipment, and educational inputs? If so, which input combination is most effective at improving performance? Answering these questions would help to fine-tune interventions and increase the program's cost-effectiveness in the future.

In order to obtain answers to these questions, it is necessary to incorporate a learning strategy in the design of the next phase of the Dinaledi program—first, to continue measuring program impact and second, to test some of the program features to understand which elements of the program should be strengthened. This would provide the evidence base for improving secondary education policies on an ongoing basis.

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TABLE 1. SCALE SCORES AND KEY INDICATORS OF AFRICAN COUNTRY PARTICIPANTS IN TIMSS 2003

County	Average mathematics score (SE)	Average science score (SE)	Popul ation	Life expectan cy	Net enrolment (primary)	Net enrolment (secondary)	GNI per capita in US$
Tunisia	410 (2.2)	404 (2.1)	9.8	73	97	68	1990
Egypt	406 (3.5)	421 (3.9)	66.4	69	90	78	1470
Morocco	387 (2.5)	396 (2.5)	29.6	68	88	31	1170
Botswana	366 (2.6)	365 (2.8)	1.7	38	81	55	3010
Ghana	276 (4.7)	255 (5.9)	20.3	55	60	30	270
South Africa	264 (5.5)	244 6.7)	45.3	46	90	62	2500

Source: UNDP (2003)
See Reddy (2006) for a differential analysis of South Africa's TIMSS performance by province and school types.

TABLE 2. DISTRIBUTION OF DINALEDI PROGRAM TREATMENT COMPONENTS ACROSS SCHOOLS

Input category	Input	No. of schools that received input	No. of schools with no record of reception[1]	Percentage of schools that received input	Minimum input (>0)	Maximum input	Input unit
1. / 2.	Teacher training and additional teachers	No data available					
3.	Received Grade 11 mathematics textbooks	95	325	22.6%	5	539	textbooks
	Received Grade 11 physical sciences textbooks	65	355	15.5%	3	435	textbooks
	Received Grade 12 mathematics textbooks	227	193	54.0%	1	279	textbooks
	Received Grade 12 physical sciences textbooks	76	344	18.1%	5	181	textbooks
4.	Received calculators in 2007	359	61	85.5%	50	390	calculators
5.	Received higher education guides in 2006-2007	280	140	66.7%	60	180	guides
	Received exam papers math	171	249	40.7%	1	360	papers
	Received exam papers physical science	171	249	40.7%	1	360	papers
6.	Received at least one monitoring visit in 2006-2007	169	251	40.2%	1	2	visits
7.	Were adopted by private companies	99	321	23.6%	-	-	-
	Received financial support from private companies	36	384	8.6%	100000	150000	Rand (ZAR)
Other	Received Department of Education rewards	37	383	8.8%	10000	40000	Rand (ZAR)
	Received Tutor Finance	6	414	1.4%	8000	12000	Rand (ZAR)

Source: Department of Education (2007)
[1]This table reports data for 420 Dinaledi schools from the sample used in this study for which detailed input data are available. Schools with missing values or no reported inputs are grouped in this column.

TABLE 3. PHASES OF DINALEDI EXPANSION

Province	2001	2005	2007	Number of Dinaledi schools in the sample
Eastern Cape	15	60	60	55
Free State	6	30	35	34
Gauteng	11	70	101	93
KZN	23	70	84	76
Limpopo	23	50	51	46
Mpumalanga	7	30	44	39
Northern Cape	4	10	17	11
North West	7	40	51	42
Western Cape	6	40	45	44
Total	102	400	488	440

Source: NDoE, Government of South Africa, 2007.

TABLE 4. DESCRIPTIVE STATISTICS. CATEGORICAL SCHOOL CHARACTERISTICS

Category	**Dinaledi 2004**	**Non-Dinaledi 2004**	**Percentage of Dinaledi 2004 schools in category**
Dinaledi 2001 schools	57	15	79.2%
Combined schools	13	237	5.2%
Intermediate schools	1	10	9.1%
Secondary schools	426	2,448	14.8%
Public schools	440	2,695	14.0%
Schools by specialization			
Comprehensive	59	346	14.6%
Computer, math, science and technology	2	0	100.0%
Dance, math, science and technology	1	0	100.0%
Math, science and technology	40	8	83.3%
Ordinary	318	2,283	12.2%
Ordinary & technical	14	31	31.1%
Technical	6	27	18.2%
N	440	2,695	14.0%

TABLE 5. DESCRIPTIVE STATISTICS. DINALEDI SCHOOLS BY FORMER DEPARTMENT UNDER APARTHEID

Department under Apartheid	Dinaledi 2004	Non-Dinaledi 2004	Percentage of Dinaledi 2004 in category
BOPHUTATSWANA (BOP)	18	110	16.4%
CAPE EDUCATION DEPARTMENT (CED)	12	153	7.8%
CISKEI	4	160	2.5%
DEPARTMENT OF EDUCATION AND TRAINING (DoET)	148	693	21.4%
FREE STATE EDUCATION DEPARTMENT	1	3	33.3%
GAZANKULU	7	87	8.0%
HOUSE OF ASSEMBLY (HOA)	56	184	30.4%
HOUSE OF DELEGATES (HOD)	6	43	14.0%
HOUSE OF REPRESENTATIVES (HOR)	34	168	20.2%
KANGWANE	12	65	18.5%
KWANDEBELE	2	54	3.7%
KWAZULU NATAL EDUCATION DEPARTMENT	49	134	36.6%
LEBOWA	19	196	9.7%
NEW EDUCATION DEPARTMENT	21	242	8.7%
TRANSKEI	26	269	9.7%
TRANSVAAL EDUCATION DEPARTMENT (TED)	2	5	40.0%
VENDA	15	65	23.1%
WESTERN CAPE EDUCATION DEPARTMENT	2	18	11.1%
INDEPENDENT	1	0	-
TO BE UPDATED	5	46	10.9%
N	440	2,695	14.0%

TABLE 6. DESCRIPTIVE STATISTICS. PRE-TREATMENT LEARNER, ENROLMENT AND LANGUAGE CHARACTERISTICS

Baseline characteristics (2004)	Dinaledi 2004		Non-Dinaledi 2004			Difference-in-difference means Dummy for 488 Dinaledi schools (2005)	SE
	N	Mean (SD)	N	Mean	SD		
Total number of learners	440[4]	5475.63 (3037.40)	2695[4]	3747.46	(2950.07)	1,728.169***	(155.446)
Number of African learners in the school	420	4928.82 (3201.53)	2580	3127.37	(2893.51)	1,801.453***	(166.158)
Number of male African learners	420	1341.71 (890.97)	2580	859.48	(736.81	482.227***	(45.796)
Number of female African learners	420	1518.40 (918.08)	2580	937.51	(1299.50)	580.885***	(51.557)
Learners in grades 10, 11 and 12	440	921.93 (451.59)	2695	568.66	(367.07)	353.274***	(22.644)
Number of African learners in grades 10 through 12	440	807.39 (519.75)	2695	480.51	(387.47)	326.876***	(25.859)
Total enrolment	440	3142.05 (1580.78)	2695	2088.75	(1486.39)	1,053.308***	(80.56)
Total male enrolments	427	1503.70 (810.26)	2610	1030.80	(735.65)	472.900***	(41.741)
Total female enrolments	427	1734.01 (855.43)	2610	1125.97	(785.53)	608.043***	(44.129)
Enrolments in grade 10	427	443.46 (208.26)	2610	279.07	(180.87)	164.390***	(10.674)
Enrolments in grade 11	427	346.37 (151.77)	2610	213.42	(132.20)	132.950***	(7.782)
Enrolments in grade 12	427	221.78 (101.06)	2610	128.09	(91.18)	93.690***	(5.202)
Male enrolments in grade 10	427	141.00 (71.83)	2610	89.02	(59.53)	51.984***	(3.664)
Male enrolments in grade 11	427	105.49 (52.01)	2610	65.15	(42.66)	40.338***	(2.65)
Male enrolments in grade 12	427	66.87 (34.58)	2610	39.06	(28.68)	27.816***	(1.764)
Female enrolments in grade 10	427	157.69 (75.46)	2610	97.41	(64.52)	60.277***	(3.861)
Female enrolments in grade 11	427	128.82 (59.20)	2610	77.52	(49.16)	51.306***	(3.02)
Female enrolments in grade 12	427	82.89 (42.74)	2610	47.05	(37.75)	35.845***	(2.195)
Number of learners with English as medium of instruction	428	537.60 (271.28)	2615	299.63	(223.95)	237.972***	(13.814)

TABLE 7. DESCRIPTIVE STATISTICS. RATIO MEASURES

Ratio measure	Dinaledi 2004					Non-Dinaledi 2004					Difference-in-difference means (SE)
	N1	Mean	SD	Min	Max	N0	Mean	SD	Min	Max	
Proportion of African learners in total learners	416	0.86	0.30	0.00	1.00	2561	0.84	0.33	0.00	1.00	0.016 (0.016)
Proportion of African learners in grades 10 to 12	416	0.86	0.30	0.00	1.00	2542	0.84	0.34	0.00	1.00	0.014 (0.016)
*Male to female ratio among African learners	406	0.90	0.49	0.00	6.50	2489	0.97	0.70	0.00	18.00	-0.075*** (0.028)
*Male to female enrolment ratio in grades 10 through 12	420	0.88	0.42	0.00	5.60	2590	2.18	43.48	0.00	1576.00	-1.299 (0.855)
*Male to female enrolment ratio in grades 10 to 12	420	0.86	0.40	0.00	5.27	2565	1.01	4.76	0.00	237.00	-0.145 (0.096)
*Share of learners with English as medium of instruction out of total number of learners	416	0.15	0.92	0.00	18.92	2550	0.09	0.13	0.00	5.66	0.053 (0.045)

*Values >1 are data to data errors.

TABLE 8. DESCRIPTIVE STATISTICS. OUTCOMES MEASURES

Outcomes measure	Dinaledi 2004			Non-Dinaledi 2004			Difference-in-difference means (SE)
	N1	Mean	SD	N0	Mean	SD	
Total number of students entering SG physical science	440	29.69	(30.50)	2695	16.66	(20.73)	13.033*** (1.507)
Total number of students entering HG physical science	440	13.95	(20.31)	2695	5.57	(13.44)	8.380*** (1.002)
Total number of students writing SG physical science	440	29.61	(30.39)	2695	16.57	(20.60)	13.041*** (1.501)
Total number of students writing HG physical science	440	13.93	(20.27)	2695	5.56	(13.41)	8.367*** (1.000)
Total number of students passing SG physical science	440	24.88	(24.91)	2695	11.90	(15.41)	12.973*** (1.223)
Total number of students passing HG physical science	440	9.66	(16.20)	2695	3.73	(11.57)	5.927*** (0.803)
Passing rate out of those entering SG physical science[1]	440	0.64	(0.41)	2695	0.57	(0.39)	0.072*** (0.021)
Passing rate out of those entering HG physical science[1]	440	0.50	(0.40)	2695	0.28	(0.39)	0.223*** (0.02)
Passing rate out of those writing SG physical science[1]	440	0.64	(0.41)	2695	0.57	(0.39)	0.071*** (0.021)
Passing rate out of those writing HG physical science[1]	440	0.50	(0.40)	2695	0.28	(0.39)	0.224*** (0.02)
Proportion entering SG physical science of students enrolled in grade 12	426	0.14	(0.13)	2573	0.13	(0.13)	0.069 (0.07)
Proportion entering HG physical science of students enrolled in grade 12	426	0.06	(0.09)	2573	0.04	(0.09)	0.027*** (0.005)

[1]The passing rate is set as zero for schools with no students entering the respective subject (entry-corrected passing rate).

TABLE 9. DESCRIPTIVE STATISTICS. OBSERVATIONS BY PROVINCE

Province	Number of Dinaledi schools in the population (2007–2008)[3]	No. of Dinaledi 2004 schools in sample[1]	No. of Non-Dinaledi 2004 in sample	Total no. of schools per province in sample	Share of Dinaledi 2004 schools per province	Population in m (mid-2007 estimate)[2]	Dinaledi schools per m population [4]
Eastern Cape (EC)	60	55	735	790	12.50%	6.9	8.7
Free State (FS)	35	34	249	283	7.70%	2.9	12.1
Gauteng (GT)	101	93	305	398	21.10%	9.6	10.5
Kwazulu Natal (KZ)	84	76	189	265	17.30%	10	8.4
Limpopo (LP)	51	46	417	463	10.50%	5.4	9.4
Mpumalanga (MP)	44	39	261	300	8.90%	3.5	12.6
Northern Cape (NC)	17	11	48	59	2.50%	1.1	15.5
North West Province (NW)	51	42	235	277	9.60%	3.4	15.0
Western Cape (WC)	45	44	256	300	10.00%	4.8	9.4
Total	**488**	**440**	**2695**	**3135**	**100%**	**47.6**	**10.3**

[1]These figures are based on the restricted sample of 3,135 schools included in this study.
[2]Source: http://www.southafrica.info/about/people/popprov.htm
[3]Source: MoE Report, 2007
[4]Based on the population number of Dinaledi schools as in column one.

TABLE 10. DESCRIPTIVE STATISTICS BY PROVINCE. BASELINE AND PHYSICAL SCIENCES OUTCOMES MEASURES (RATIO AND ABSOLUTE MEASURES)

	Eastern Cape			Free State			Gauteng			Kwazulu Natal			Limpopo		
Variable	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Baseline characteristics (2004)															
Learners	790	2656.94	2421.88	283	4426.46	2571.38	398	6130.87	2884.11	265	4337.56	2539.7	463	3351.29	1901.94
African learners	759	2350.83	2189.46	280	3841.01	2794.83	384	4776.81	3341.07	255	4367.31	2462.07	450	3417.11	1837.71
Male African learners	759	637.83	581.86	280	1067.64	759.35	384	1346.81	947.83	255	1204.35	696.4	450	940.34	506.04
Female African learners	759	739.09	626.25	280	1113.87	794.62	384	1394.24	961.2	255	1276.37	671.16	450	1008.32	566.08
Learners 10 to 12	790	503.11	349.94	283	642.07	374.21	398	904.87	427.9	265	644.49	362.58	463	528.19	302.31
African learners 10 to 12	790	457.75	355.62	283	581.61	412.67	398	688.48	536.28	265	623.6	368.88	463	523.58	302.68
Enrolment	790	1486.99	1304.53	283	2434.53	1355.93	398	3428.75	1573.34	265	2570.25	1398.37	463	1848.62	1055
Male enrolment	772	706.15	661.2	281	1189.96	686.34	386	1706.89	788.08	263	1234.34	733.06	453	898.96	495.57
Female enrolment	772	815.51	727.98	281	1261.89	721.54	386	1828.45	832.99	263	1355.45	782.98	453	990.47	558.55
Enrolment 10	772	254.31	182.04	281	331.66	200.61	386	436.87	197.04	263	302.79	158.85	453	211.56	121.42
Enrolment 11	772	179.66	123.68	281	213.72	134.27	386	325.61	146.25	263	259.22	129.01	453	234.26	140.33
Enrolment 12	772	112.59	82.56	281	123.86	78.94	386	214.03	105.52	263	152.81	81.48	453	109.16	78.15
Male enrolment 10	772	76.2	55.41	281	109.74	68.59	386	145.12	68.06	263	99.77	59.07	453	67.3	39.63
Male enrolment 11	772	52.09	37.22	281	66.96	45.05	386	102.53	50.2	263	81.07	46.59	453	72.25	43.66
Male enrolment 12	772	33.18	25.49	281	39.25	26.75	386	66	37.59	263	47.68	29.21	453	33.48	24.57
Female enrolment 10	772	93.31	68.93	281	112.46	69.57	386	148.58	71.27	263	102.68	53.68	453	74.35	43.3
Female enrolment 11	772	68.16	49.21	281	76.01	48.38	386	116.83	56.65	263	92.98	47.27	453	84.72	52.64
Female enrolment 12	772	42.84	34.31	281	43.58	30.94	386	78.18	41.14	263	56.22	36.24	453	39.6	29.24
English instruction	782	224.34	173.8	275	352.08	223.88	387	473.6	316.92	263	447.4	213.37	452	330.24	186.52
Outcomes measure															
SG EC PR of entering[1]	790	0.66	0.31	283	0.76	0.32	398	0.75	0.25	265	0.18	0.38	463	0.15	0.35
HG EC PR of entering[1]	790	0.18	0.35	283	0.48	0.41	398	0.59	0.35	265	0.08	0.26	463	0.13	0.32
SG EC PR of writing[1]	790	0.67	0.32	283	0.76	0.32	398	0.76	0.25	265	0.18	0.38	463	0.15	0.35
HG EC PR of writing[1]	790	0.18	0.35	283	0.48	0.41	398	0.59	0.35	265	0.08	0.26	463	0.13	0.32
SG passing rate of entering	711	0.74	0.24	255	0.84	0.2	391	0.77	0.23	54	0.87	0.34	84	0.81	0.38
HG passing rate of entering	259	0.55	0.4	211	0.64	0.34	367	0.64	0.32	43	0.47	0.48	148	0.4	0.46
SG passing rate of writing	711	0.74	0.24	255	0.84	0.2	391	0.77	0.23	52	0.9	0.3	84	0.81	0.38
HG passing rate of writing	258	0.55	0.4	211	0.64	0.34	367	0.64	0.32	42	0.49	0.49	148	0.4	0.47
SG enrolment rates	748	0.2	0.14	276	0.14	0.12	383	0.17	0.12	263	0	0.01	449	0	0.01
HG enrolment rates	750	0.02	0.07	276	0.06	0.08	383	0.09	0.1	263	0	0.01	449	0	0.01
Students entering SG	790	24.17	23.81	283	16.61	16.27	398	34.41	25.14	265	0.32	0.79	463	0.25	0.59
Students entering HG	790	2.65	7.26	283	8.98	14.84	398	20.8	26.43	265	0.21	0.53	463	0.45	0.8
Students writing SG	790	24.04	23.7	283	16.57	16.24	398	34.27	25.03	265	0.31	0.78	463	0.25	0.59
Students writing HG	790	2.64	7.24	283	8.96	14.83	398	20.76	26.38	265	0.2	0.52	463	0.45	0.79
Students passing SG	790	17.68	18.38	283	13.45	13.15	398	25.71	20.12	265	0.29	0.78	463	0.2	0.54
Students passing HG	790	1.86	6.46	283	5.9	12.56	398	15.15	23.68	265	0.09	0.33	463	0.19	0.52

[1]The passing rate is set as zero for schools with no students entering the respective subject (entry-corrected).

TABLE 11. DESCRIPTIVE STATISTICS BY PROVINCE. BASELINE AND PHYSICAL SCIENCES OUTCOMES MEASURES (RATIO AND ABSOLUTE MEASURES)

	Mpumalanga			Northern Cape			North West			Western Cape		
Variable	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Baseline characteristics (2004)												
Learners	300	4882.33	3454.75	59	2232.27	3042.36	277	3239.57	4126.01	300	5073.52	2725.01
African learners	291	4932.58	3390.45	29	1661.79	2172.63	255	3299.41	4126.91	297	1576.99	2910.35
Male African learners	291	1351.33	904.75	29	459.76	599.57	255	864.96	611.51	297	415.33	781.35
Female African learners	291	1418.2	924.91	29	465.62	624.75	255	1125.65	3419.97	297	524.6	920.84
Learners 10 to 12	300	686.8	393.34	59	245.86	396.29	277	612.35	432.42	300	644.59	408.7
African learners 10 to 12	300	680.18	398.09	59	135.03	344.7	277	593.94	440.49	300	219.28	417.66
Enrolment	300	2663.75	1830.18	59	1302.03	1680.24	277	1714.32	1283.81	300	2985	1298.89
Male enrolment	292	1310.33	888.45	30	1248.67	770.81	263	865.99	612.17	297	1395.25	656.6
Female enrolment	292	1426.4	930.46	30	1312	769.22	263	939.59	678.79	297	1619.91	747.31
Enrolment 10	292	319.46	187.97	30	242.3	204.22	263	320.28	217.08	297	334.45	197.44
Enrolment 11	292	256.33	146.74	30	173.13	144.66	263	223.7	149.69	297	226.6	126.27
Enrolment 12	292	152.22	85.59	30	100.97	84.91	263	144.68	95.63	297	166.65	132.46
Male enrolment 10	292	101.98	60.22	30	80.4	67.73	263	104.66	70.53	297	102.4	62.05
Male enrolment 11	292	78.83	47.44	30	57.53	55.37	263	69.46	46.51	297	65.35	37.84
Male enrolment 12	292	46.47	26.95	30	33.4	29.86	263	44.63	29.44	297	48.32	36.22
Female enrolment 10	292	111.24	67.01	30	80.93	69.5	263	108.68	76.72	297	122.61	74.69
Female enrolment 11	292	91.62	53.24	30	61.83	48.52	263	79.2	54.82	297	87.44	51.96
Female enrolment 12	292	55.12	31.23	30	34.63	29.62	263	52.14	36.28	297	64.39	65.63
English instruction	292	440.68	227.54	29	133.98	206.21	266	300.1	224.7	297	265.2	281.1
Outcomes measure												
SG EC PR of entering[1]	300	0.64	0.27	59	0.78	0.33	277	0.66	0.29	300	0.81	0.3
HG EC PR of entering[1]	300	0.33	0.36	59	0.51	0.47	277	0.31	0.38	300	0.57	0.43
SG EC PR of writing[1]	300	0.64	0.27	59	0.78	0.33	277	0.66	0.29	300	0.81	0.3
HG EC PR of writing[1]	300	0.33	0.36	59	0.51	0.47	277	0.31	0.38	300	0.57	0.43
SG passing rate of entering	287	0.67	0.24	52	0.88	0.17	257	0.71	0.23	272	0.89	0.15
HG passing rate of entering	241	0.41	0.36	37	0.82	0.32	167	0.51	0.37	220	0.78	0.29
SG passing rate of writing	285	0.67	0.24	52	0.88	0.17	256	0.72	0.23	272	0.89	0.15
HG passing rate of writing	239	0.41	0.36	37	0.82	0.32	167	0.51	0.37	220	0.78	0.29
SG enrolment rates	291	0.16	0.1	30	0.11	0.09	257	0.18	0.13	297	0.11	0.08
HG enrolment rates	292	0.05	0.07	30	0.05	0.06	258	0.04	0.07	297	0.07	0.09
Students entering SG	300	22.22	16.21	59	12.85	13.62	277	25.07	24.15	300	19.68	27.08
Students entering HG	300	8.05	11.1	59	5.53	9.19	277	6.39	11.69	300	11.56	18.58
Students writing SG	300	22.05	16.13	59	12.81	13.53	277	24.99	24.08	300	19.58	26.73
Students writing HG	300	8.03	11.08	59	5.53	9.19	277	6.38	11.68	300	11.52	18.49
Students passing SG	300	14.2	10.44	59	10.86	11.3	277	17.6	18.99	300	16.9	22.42
Students passing HG	300	2.83	4.69	59	4.58	7.87	277	3.31	6.71	300	9.96	17.5

[1]The passing rate is set as zero for schools with no students entering the respective subject (entry-corrected).

TABLE 12. DIFFERENCES IN BASELINE CHARACTERISTICS BETWEEN FORMER HOUSE OF ASSEMBLY AND FORMER BANTUSTAN SCHOOLS.
PRE-TREATMENT LEARNER, ENROLMENT AND LANGUAGE CHARACTERISTICS

Baseline characteristics (2004)	Former House of Assembly schools			Former Bantustan schools			Difference-in-difference means	SE
	N	Mean	SD	N	Mean	SD		
Total number of learners	240	4634.54	2498.06	1292	3038.58	2161.07	1596***	(171.9)
Number of African learners in the school	226	1721.79	2126.28	1249	3127.93	2104.66	-1406***	(153.3)
Number of male African learners	226	467.14	574.79	1249	862.99	576.09	-395.8***	(41.51)
Number of female African learners	226	554.81	676.59	1249	935.27	603.98	-380.5***	(48.08)
Learners in grades 10, 11 and 12	240	603.21	367.1	1292	578.01	359.07	25.20	(25.69)
Number of African learners in grades 10 through 12	240	197.53	247.09	1292	577.21	359.3	-379.7***	(18.81)
Total enrolment	240	2740.07	1371.64	1292	1686.31	1164.37	1054***	(94.16)
Total male enrolments	226	1389	761.53	1268	812.41	564.26	576.6***	(53.00)
Total female enrolments	226	1520.8	804.72	1268	905.82	616.88	615.0***	(56.19)
Enrolments in grade 10	226	261.52	135.84	1268	263.35	172.55	-1.828	(10.24)
Enrolments in grade 11	226	226.03	121.58	1268	223.45	139.57	2.579	(8.976)
Enrolments in grade 12	226	193.82	115.33	1268	126.82	84.25	67.00***	(8.017)
Male enrolments in grade 10	226	87.16	54.2	1268	82.88	55.45	4.287	(3.923)
Male enrolments in grade 11	226	72.34	48.65	1268	67.81	43.83	4.532	(3.458)
Male enrolments in grade 12	226	61.42	45.57	1268	38.38	26.09	23.04***	(3.114)
Female enrolments in grade 10	226	92.62	56.51	1268	92.43	62.28	0.189	(4.141)
Female enrolments in grade 11	226	83.23	53.22	1268	81.5	52.48	1.726	(3.829)
Female enrolments in grade 12	226	71.89	48.84	1268	46.73	33.44	25.17***	(3.377)
Number of learners with English as language of instruction	224	246.94	263.8	1275	312.29	199.95	-65.34***	(18.47)

TABLE 13. DIFFERENCES IN BASELINE CHARACTERISTICS BETWEEN FORMER HOUSE OF ASSEMBLY AND FORMER BANTUSTAN SCHOOLS.
PRE-TREATMENT MEASURES OF LEARNING OUTCOMES

Pre-Treatment outcomes measures (2004)	Former House of Assembly schools			Former Bantustan schools			Difference–in-difference means	SE
	N	Mean	SD	N	Mean	SD		
Passing rate out of those entering SG physical science	217	0.93	0.13	762	0.71	0.26	0.219***	(0.0130)
Passing rate out of those entering HG physical science	205	0.86	0.19	485	0.43	0.4	0.429***	(0.0228)
Passing rate out of those writing SG physical science	217	0.93	0.13	759	0.72	0.26	0.216***	(0.0128)
Passing rate out of those writing HG physical science	205	0.86	0.19	482	0.43	0.4	0.429***	(0.0228)
Proportion entering SG Physical Sciences of students enrolled in grade 12	226	0.14	0.15	1247	0.11	0.14	0.0313***	(0.0105)
Proportion entering HG Physical of students enrolled in grade 12	226	0.14	0.12	1250	0.02	0.04	0.122***	(0.00814)
Total number of students entering SG physical science	240	23.05	25.18	1292	14.61	22.55	8.436***	(1.740)
Total number of students entering HG physical science	240	28.1	31.54	1292	2.21	6.45	25.89***	(2.041)
Total number of students writing SG physical science	240	23	25.11	1292	14.53	22.45	8.468***	(1.735)
Total number of students writing HG physical science	240	28.06	31.48	1292	2.21	6.44	25.86***	(2.037)
Total number of students passing SG physical science	240	21.23	22.67	1292	10.18	16.68	11.05***	(1.533)
Total number of students passing HG physical science	240	24.58	29.1	1292	0.85	2.49	23.73***	(1.877)

FIGURE 2. EVOLUTION OF THE SHARE OF MATHEMATICS CANDIDATES WRITING THE SENIOR CERTIFICATE

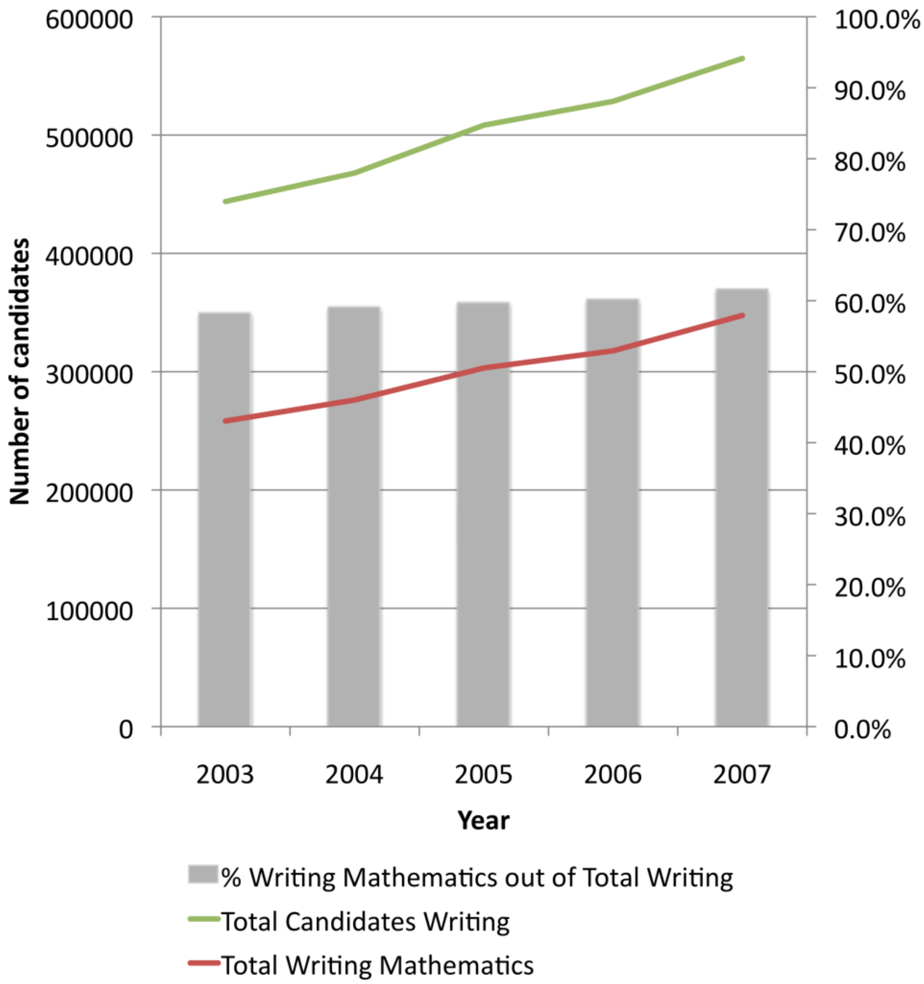


FIGURE 3. EVOLUTION OF THE SHARE OF MATHEMATICS CANDIDATES PASSING THE SENIOR CERTIFICATE

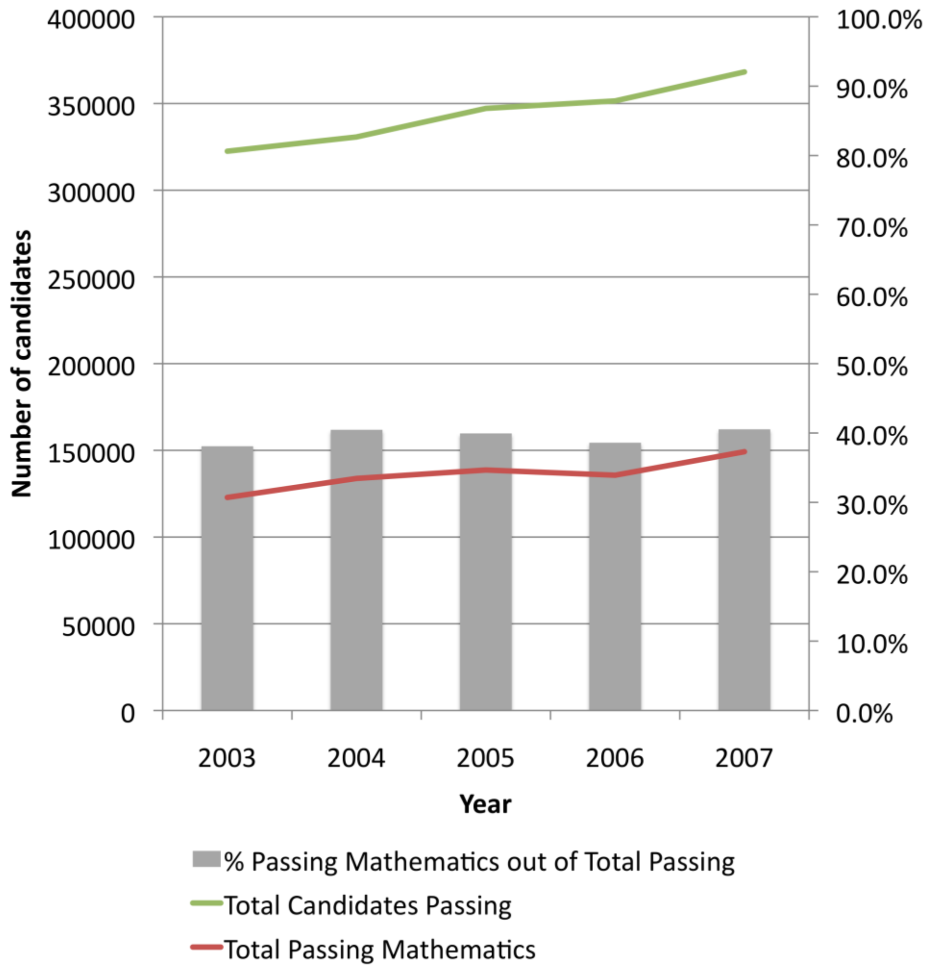
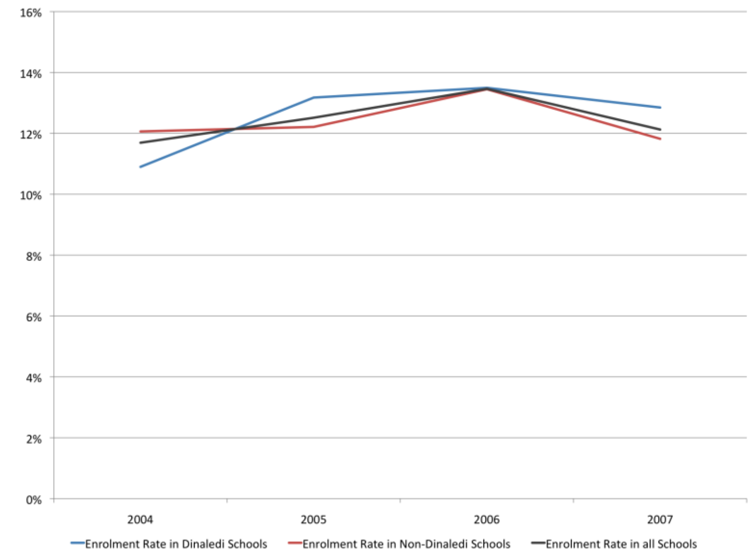
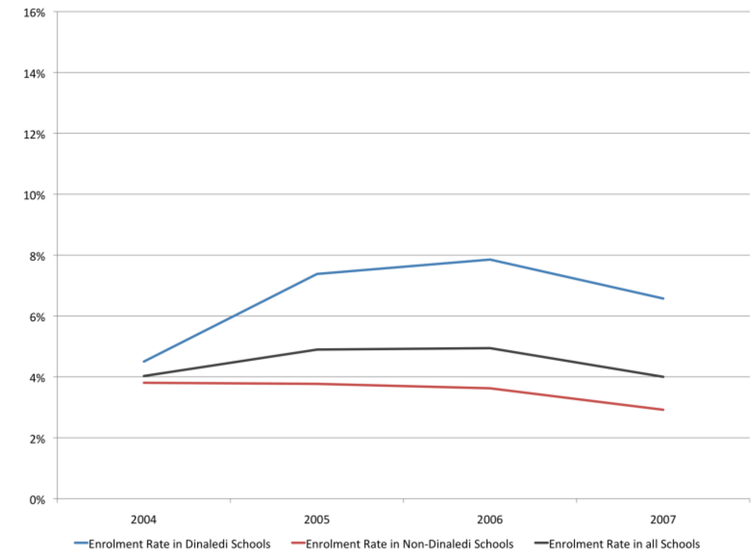


FIGURE 4. BREAKDOWN OF ENROLMENT RATES AND PASSING RATES FOR DINALEDI AND NON-DINALEDI SCHOOLS (2004-2007)[1]

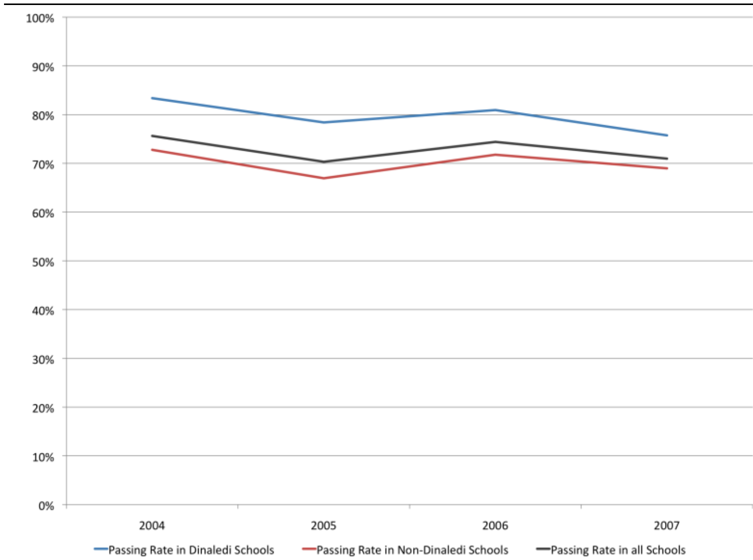
SG PHYSICAL SCIENCES ENROLMENT RATE



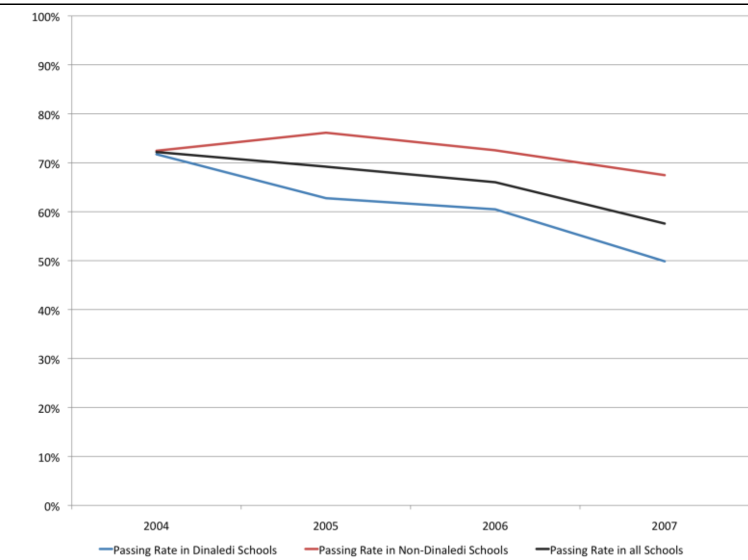
HG PHYSICAL SCIENCES ENROLMENT RATE



SG PHYSICAL SCIENCES PASSING RATE[2]



HG PHYSICAL SCIENCES PASSING RATE2



[1]The enrolment and passing rates in this chart have been calculated for a subset of 1,571 schools for which data on grade 12 enrolment and on the number of students entering and passing SG and HG Physical Sciences is available for each year from 2004 to 2007. The sample comprises 1,230 non-Dinaledi schools and 341 Dinaledi schools. It is not representative of the entire school population, such that population enrolment and passing rates may differ from the values reported here.

[2]In the aggregate, standard and entry-corrected passing rates are equal.

TABLE 14. PHYSICAL SCIENCES RESULTS. RATIO MEASURES. DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(1) Enrolment rate of grade 12 students in SG physical science	(2) Enrolment rate of grade 12 students in HG physical science	(3) EC PR SG physical science	(4) EC PR HG physical science	(5) WC PR SG physical science	(6) WC PR HG physical science	(7) Passing rate out of those entering SG physical science	(8) Passing rate out of those entering HG physical science	(9) Passing rate out of those writing SG physical science	(10) Passing rate out of those writing HG physical science
2004-2005										
Dummy for 488 Dinaledi schools (2005)	-0.0193**	-0.0153**	-0.109***	-0.0365	-0.111***	-0.0367	0.0339**	0.0424	0.0324**	0.0424
	(0.00977)	(0.00720)	(0.0264)	(0.0303)	(0.0264)	(0.0304)	(0.0142)	(0.0274)	(0.0142)	(0.0274)
Year 2005	0.0116	0.0122	-0.0666***	-0.0185	-0.0581***	-0.0159	-0.0979***	-0.0723**	-0.0890***	-0.0677**
	(0.00948)	(0.00763)	(0.0218)	(0.0302)	(0.0217)	(0.0303)	(0.0167)	(0.0294)	(0.0165)	(0.0294)
Interaction Dinaledi Dummy * Year2005	0.0247*	0.0499***	0.180***	0.143***	0.180***	0.142***	0.0559**	0.0544	0.0557**	0.0509
	(0.0133)	(0.0117)	(0.0338)	(0.0407)	(0.0338)	(0.0408)	(0.0218)	(0.0378)	(0.0216)	(0.0378)
Constant	0.156***	0.0789***	0.764***	0.551***	0.767***	0.553***	0.835***	0.661***	0.838***	0.664***
	(0.00683)	(0.00523)	(0.0155)	(0.0217)	(0.0156)	(0.0218)	(0.0102)	(0.0207)	(0.0102)	(0.0208)
Observations	1396	1397	1412	1412	1412	1412	1251	1200	1251	1199
R-squared	0.012	0.042	0.022	0.016	0.023	0.016	0.058	0.018	0.052	0.016
2004-2006										
Dummy for 488 Dinaledi schools (2005)	-0.00636	0.000491	-0.0343	0.0367	-0.0360	0.0377	0.0347**	0.0825***	0.0297*	0.0792***
	(0.0101)	(0.00685)	(0.0294)	(0.0309)	(0.0295)	(0.0309)	(0.0157)	(0.0291)	(0.0154)	(0.0290)
Year 2006	0.0712***	0.00653	0.0446*	0.0264	0.0539**	0.0274	-0.101***	-0.0277	-0.0861***	-0.0253
	(0.00984)	(0.00639)	(0.0241)	(0.0300)	(0.0241)	(0.0300)	(0.0178)	(0.0298)	(0.0170)	(0.0297)
Interaction Dinaledi Dummy * Year2006	-0.0342**	0.0714***	0.0721**	0.107***	0.0695*	0.108***	0.0692***	-0.00721	0.0618***	-0.00667
	(0.0136)	(0.0110)	(0.0360)	(0.0404)	(0.0360)	(0.0405)	(0.0228)	(0.0385)	(0.0221)	(0.0383)
Constant	0.140***	0.0617***	0.681***	0.470***	0.684***	0.471***	0.833***	0.616***	0.839***	0.622***
	(0.00723)	(0.00471)	(0.0199)	(0.0222)	(0.0199)	(0.0222)	(0.0119)	(0.0224)	(0.0116)	(0.0223)
Observations	1370	1369	1384	1384	1384	1384	1200	1141	1195	1135
R-squared	0.056	0.095	0.017	0.030	0.020	0.031	0.063	0.017	0.051	0.015
2004-2007										
Dummy for 488 Dinaledi schools (2005)	-0.00790	-0.000699	-0.0387	0.00915	-0.0402	0.0102	0.0221	0.0622**	0.0175	0.0590**
	(0.0105)	(0.00687)	(0.0291)	(0.0307)	(0.0292)	(0.0308)	(0.0149)	(0.0285)	(0.0146)	(0.0284)
Year 2007	0.0520***	0.0133**	0.0314	0.00257	0.0457**	0.00581	-0.112***	-0.0632**	-0.0991***	-0.0642**
	(0.00993)	(0.00660)	(0.0233)	(0.0298)	(0.0233)	(0.0298)	(0.0160)	(0.0294)	(0.0154)	(0.0293)
Interaction Dinaledi Dummy * Year2007	-0.0235*	0.0625***	0.0572	0.0458	0.0510	0.0443	0.0308	-0.0611	0.0283	-0.0555
	(0.0136)	(0.0107)	(0.0349)	(0.0402)	(0.0350)	(0.0403)	(0.0221)	(0.0382)	(0.0216)	(0.0381)
Constant	0.143***	0.0644***	0.690***	0.502***	0.693***	0.503***	0.846***	0.638***	0.852***	0.644***
	(0.00779)	(0.00476)	(0.0197)	(0.0222)	(0.0198)	(0.0222)	(0.0111)	(0.0219)	(0.0107)	(0.0219)
Observations	1378	1377	1408	1408	1408	1408	1228	1185	1225	1181
R-squared	0.032	0.090	0.010	0.004	0.014	0.004	0.067	0.023	0.055	0.023

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 15. PHYSICAL SCIENCES RESULTS. ABSOLUTE MEASURES. DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(11) Total number of students entering SG physical science	(12) Total number of students entering HG physical science	(13) Total number of students writing SG physical science	(14) Total number of students writing HG physical science	(15) Total number of students passing SG physical science	(16) Total number of students passing HG physical science
2005						
Dummy for 488 Dinaledi schools (2005)	-8.388***	-5.150***	-8.249***	-5.108***	-6.538***	-2.184
	(2.800)	(1.854)	(2.771)	(1.846)	(2.275)	(1.437)
Year 2005	6.329*	1.742	5.244	1.564	-0.924	1.028
	(3.574)	(2.048)	(3.431)	(2.035)	(2.658)	(1.573)
Interaction Dinaledi Dummy * Year2005	3.629	11.33***	4.193	11.32***	7.329**	5.926***
	(4.209)	(2.841)	(4.075)	(2.824)	(3.162)	(2.147)
Constant	38.02***	19.18***	37.80***	19.12***	31.35***	12.28***
	(2.363)	(1.496)	(2.332)	(1.488)	(1.936)	(1.101)
Observations	1412	1412	1412	1412	1412	1412
R-squared	0.018	0.030	0.016	0.029	0.008	0.015
2006						
Dummy for 488 Dinaledi schools (2005)	-3.425	-0.150	-3.275	-0.116	-2.266	1.483
	(2.852)	(1.693)	(2.821)	(1.686)	(2.304)	(1.254)
Year 2006	20.35***	2.483	18.70***	2.408	7.017***	0.757
	(4.132)	(1.680)	(3.871)	(1.672)	(2.717)	(1.123)
Interaction Dinaledi Dummy * Year2006	-10.38**	14.08***	-9.208**	13.97***	0.315	7.630***
	(4.703)	(2.617)	(4.460)	(2.603)	(3.246)	(1.840)
Constant	32.67***	13.97***	32.45***	13.90***	26.70***	8.431***
	(2.411)	(1.279)	(2.378)	(1.272)	(1.962)	(0.834)
Observations	1384	1384	1384	1384	1384	1384
R-squared	0.042	0.074	0.039	0.073	0.015	0.052
2007						
Dummy for 488 Dinaledi schools (2005)	-3.801	-0.756	-3.682	-0.727	-3.165	0.352
	(2.845)	(1.721)	(2.815)	(1.714)	(2.323)	(1.309)
Year 2007	21.54***	3.739**	19.62***	3.628**	7.687***	0.849
	(4.146)	(1.757)	(3.880)	(1.744)	(2.847)	(1.259)
Interaction Dinaledi Dummy * Year2007	-5.864	17***	-4.636	16.43***	1.810	6.378***
	(4.900)	(2.884)	(4.661)	(2.857)	(3.456)	(1.906)
Constant	33.25***	14.82***	33.05***	14.76***	27.78***	9.759***
	(2.413)	(1.325)	(2.382)	(1.318)	(1.991)	(0.925)
Observations	1408	1408	1408	1408	1408	1408
R-squared	0.045	0.088	0.043	0.084	0.019	0.030

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 16. PHYSICAL SCIENCES RESULTS. RATIO MEASURES. BIAS-CORRECTED DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(1) Enrolment rate of grade 12 students in SG physical science	(2) Enrolment rate of grade 12 students in HG physical science	(3) EC PR SG physical science	(4) EC PR HG physical science	(5) WC PR SG physical science	(6) WC PR HG physical science	(7) Passing rate out of those entering SG physical science	(8) Passing rate out of those entering HG physical science	(9) Passing rate out of those writing SG physical science	(10) Passing rate out of those writing HG physical science
					2004-2005					
SATT	0.0264***	0.0498***	0.180***	0.143***	0.180***	0.142***	0.0435*	0.0172	0.0441*	0.0159
	(0.0101)	(0.00940)	(0.0309)	(0.0394)	(0.0305)	(0.0396)	(0.0257)	(0.0356)	(0.0249)	(0.0356)
Observations	2241	2243	2287	2287	2287	2287	1742	1126	1740	1124
					2004-2006					
SATT	-0.0345***	0.0695***	0.0721*	0.107***	0.0696*	0.108***	0.0516	-0.0717	0.0215	-0.0646
	(0.0132)	(0.0115)	(0.0400)	(0.0416)	(0.0402)	(0.0416)	(0.0368)	(0.0438)	(0.0297)	(0.0437)
Observations	1782	1782	1830	1830	1830	1830	1476	855	1471	853
					2004-2007					
SATT	-0.0233*	0.0593***	0.0572	0.0457	0.0510	0.0442	0.0120	-0.115**	0.0155	-0.110**
	(0.0134)	(0.0106)	(0.0360)	(0.0425)	(0.0358)	(0.0427)	(0.0308)	(0.0462)	(0.0292)	(0.0459)
Observations	1817	1818	1886	1886	1886	1886	1543	921	1529	906

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 17. PHYSICAL SCIENCES RESULTS. ABSOLUTE MEASURES. BIAS-CORRECTED DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(11) Total number of students entering SG physical science	(12) Total number of students entering HG physical science	(13) Total number of students writing SG physical science	(14) Total number of students writing HG physical science	(15) Total number of students passing SG physical science	(16) Total number of students passing HG physical science
			2004-2005			
SATT	3.629	11.33***	4.193*	11.33***	7.333***	5.927***
	(2.632)	(2.131)	(2.498)	(2.121)	(1.771)	(1.160)
Observations	2287	2287	2287	2287	2287	2287
			2004-2006			
SATT	-10.41***	14.08***	-9.233**	13.97***	0.314	7.632***
	(4.035)	(3.074)	(3.891)	(3.058)	(2.173)	(1.495)
Observations	1830	1830	1830	1830	1830	1830
			2004-2007			
SATT	-5.893	17.00***	-4.661	16.43***	1.813	6.378***
	(4.174)	(3.229)	(3.965)	(3.168)	(2.795)	(1.298)
Observations	1886	1886	1886	1886	1886	1886

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 18. MATH RESULTS. RATIO MEASURES. PROPENSITY SCORE MATCHING ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(1) Enrolment rate of grade 12 students in SG mathematics	(2) Enrolment rate of grade 12 students in HG mathematics	(3) EC PR SG mathematics	(4) EC PR HG mathematics	(5) WC PR SG mathematics	(6) WC PR HG mathematics	(7) Passing rate out of those entering SG mathematics	(8) Passing rate out of those entering HG mathematics	(9) Passing rate out of those writing SG mathematics	(10) Passing rate out of those writing HG mathematics
2005										
Dummy for 488 Dinaledi schools (2005)	0.0450***	0.0200**	0.116***	0.178***	0.115***	0.177***	0.121***	0.143***	0.121***	0.141***
	(0.0115)	(0.00849)	(0.0206)	(0.0288)	(0.0205)	(0.0289)	(0.0200)	(0.0264)	(0.0199)	(0.0264)
Constant	0.328***	0.0724***	0.578***	0.519***	0.587***	0.523***	0.584***	0.638***	0.594***	0.644***
	(0.00807)	(0.00549)	(0.0157)	(0.0222)	(0.0157)	(0.0223)	(0.0156)	(0.0218)	(0.0155)	(0.0219)
Observations	693	697	706	706	706	706	696	602	696	602
R-squared	0.022	0.008	0.043	0.051	0.043	0.050	0.050	0.048	0.050	0.047
2006										
Dummy for 488 Dinaledi schools (2005)	-0.0216*	0.0533***	0.120***	0.178***	0.117***	0.176***	0.129***	0.0835***	0.126***	0.0659**
	(0.0114)	(0.00844)	(0.0202)	(0.0270)	(0.0202)	(0.0271)	(0.0199)	(0.0257)	(0.0199)	(0.0255)
Constant	0.385***	0.0532***	0.521***	0.493***	0.532***	0.498***	0.521***	0.620***	0.532***	0.641***
	(0.00839)	(0.00494)	(0.0151)	(0.0211)	(0.0151)	(0.0213)	(0.0151)	(0.0204)	(0.0151)	(0.0203)
Observations	682	683	692	692	692	692	687	605	687	599
R-squared	0.005	0.055	0.049	0.059	0.046	0.057	0.058	0.018	0.056	0.011
2007										
Dummy for 488 Dinaledi schools (2005)	-0.0178	0.0486***	0.0771***	0.153***	0.0740***	0.152***	0.0807***	0.0413	0.0776***	0.0321
	(0.0112)	(0.00721)	(0.0192)	(0.0273)	(0.0192)	(0.0273)	(0.0191)	(0.0273)	(0.0191)	(0.0271)
Constant	0.378***	0.0552***	0.552***	0.466***	0.561***	0.472***	0.552***	0.591***	0.561***	0.607***
	(0.00842)	(0.00406)	(0.0145)	(0.0214)	(0.0145)	(0.0215)	(0.0145)	(0.0217)	(0.0145)	(0.0216)
Observations	679	680	704	704	704	704	702	623	702	618
R-squared	0.004	0.062	0.022	0.043	0.021	0.042	0.025	0.004	0.023	0.002

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 19. MATH RESULTS. ABSOLUTE MEASURES. PROPENSITY SCORE MATCHING ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(11) Total number of students entering SG mathematics	(12) Total number of students entering HG mathematics	(13) Total number of students writing SG mathematics	(14) Total number of students writing HG mathematics	(15) Total number of students passing SG mathematics	(16) Total number of students passing HG mathematics
			2005			
Dummy for 488 Dinaledi schools (2005)	-0.813	4.079**	0.326	4.096**	9.649***	2.210
	(4.668)	(1.993)	(4.473)	(1.979)	(2.726)	(1.584)
Constant	86.09***	15.90***	83.61***	15.78***	45.17***	11.64***
	(3.843)	(1.260)	(3.643)	(1.250)	(2.250)	(1.184)
Observations	706	706	706	706	706	706
R-squared	0.000	0.006	0.000	0.006	0.017	0.003
			2006			
Dummy for 488 Dinaledi schools (2005)	-11.99**	12.04***	-10.23**	12.01***	9.708***	6.957***
	(4.952)	(1.704)	(4.634)	(1.695)	(2.350)	(1.250)
Constant	95.85***	10.69***	92.65***	10.58***	40.61***	7.604***
	(4.270)	(0.821)	(3.948)	(0.819)	(1.808)	(0.737)
Observations	692	692	692	692	692	692
R-squared	0.008	0.068	0.007	0.068	0.024	0.043
			2007			
Dummy for 488 Dinaledi schools (2005)	-5.026	12.43***	-3.264	12.00***	8.920***	5.381***
	(5.592)	(2.068)	(5.289)	(2.028)	(2.807)	(1.373)
Constant	102.7***	13.11***	99.60***	13.01***	47.09***	9.054***
	(4.431)	(0.998)	(4.101)	(0.997)	(2.185)	(0.902)
Observations	704	704	704	704	704	704
R-squared	0.001	0.049	0.001	0.047	0.014	0.021

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 20. MATH RESULTS. RATIO MEASURES. BIAS-CORRECTED PROPENSITY SCORE MATCHING ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(1) Enrolment rate of grade 12 students in SG mathematics	(2) Enrolment rate of grade 12 students in HG mathematics	(3) EC PR SG mathematics	(4) EC PR HG mathematics	(5) WC PR SG mathematics	(6) WC PR HG mathematics	(7) Passing rate out of those entering SG mathematics	(8) Passing rate out of those entering HG mathematics	(9) Passing rate out of those writing SG mathematics	(10) Passing ra out of thos writing H mathemati
					2005					
SATT	0.0443***	0.0193*	0.116***	0.178***	0.115***	0.177***	0.118***	0.127***	0.118***	0.127***
	(0.0161)	(0.0110)	(0.0314)	(0.0433)	(0.0311)	(0.0434)	(0.0313)	(0.0397)	(0.0310)	(0.0398)
Observations	2249	2256	2287	2287	2287	2287	2256	1414	2255	1404
					2006					
SATT	-0.0215	0.0537***	0.120***	0.178***	0.117***	0.176***	0.127***	0.0784**	0.124***	0.0566*
	(0.0176)	(0.0118)	(0.0303)	(0.0391)	(0.0302)	(0.0393)	(0.0303)	(0.0355)	(0.0302)	(0.0343)
Observations	1793	1797	1830	1830	1830	1830	1824	1113	1823	1106
					2007					
SATT	-0.0170	0.0493***	0.0773**	0.153***	0.0741**	0.152***	0.0792**	0.0156	0.0760**	0.00729
	(0.0165)	(0.0104)	(0.0313)	(0.0415)	(0.0313)	(0.0416)	(0.0313)	(0.0395)	(0.0313)	(0.0392)
Observations	1824	1830	1886	1886	1886	1886	1882	1177	1876	1146

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 21. MATH RESULTS. ABSOLUTE MEASURES. BIAS-CORRECTED PROPENSITY SCORE MATCHING ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(11) Total number of students entering SG mathematics	(12) Total number of students entering HG mathematics	(13) Total number of students writing SG mathematics	(14) Total number of students writing HG mathematics	(15) Total number of students passing SG mathematics	(16) Total number of students passing HG mathematics
			2005			
SATT	-0.852	4.078	0.288	4.095	9.632**	2.210
	(6.963)	(3.351)	(6.591)	(3.340)	(4.031)	(3.119)
Observations	2287	2287	2287	2287	2287	2287
			2006			
SATT	-12.08	12.04***	-10.31	12.01***	9.684***	6.955***
	(8.196)	(2.267)	(7.778)	(2.261)	(3.562)	(1.856)
Observations	1830	1830	1830	1830	1830	1830
			2007			
SATT	-5.148	12.43***	-3.380	11.99***	8.882**	5.380*
	(8.122)	(3.417)	(7.619)	(3.392)	(4.275)	(2.909)
Observations	1886	1886	1886	1886	1886	1886

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 22. HETEROGENEOUS TREATMENT EFFECTS BY FORMER DEPARTMENT. RATIO MEASURES. DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Enrolment rate of grade 12 students in SG physical science	Enrolment rate of grade 12 students in HG physical science	EC PR SG mathematics	EC PR HG mathematics	WC PR SG mathematics	WC PR HG mathematics	Passing rate out of those entering SG physical science	Passing rate out of those entering HG physical science	Passing rate out of those writing SG physical science	Passing rate out of those writing HG physical science
Former House of Assembly schools										
Dummy for 488 Dinaledi schools (2005)	-0.0540**	0.00246	-0.0831*	-0.0143	-0.0820	-0.00405	0.0404	0.0627*	0.0417	0.0741**
	(0.0230)	(0.0260)	(0.0501)	(0.0484)	(0.0502)	(0.0486)	(0.0270)	(0.0375)	(0.0270)	(0.0372)
Year 2007	-0.0424**	-0.0131	0.0816***	-0.0412	0.0863***	-0.0404	0.0816***	-0.0412	0.0863***	-0.0404
	(0.0208)	(0.0214)	(0.0163)	(0.0394)	(0.0161)	(0.0395)	(0.0163)	(0.0394)	(0.0161)	(0.0395)
Interaction Dinaledi Dummy * Year2007	0.0464	0.0286	0.0600	0.130**	0.0607	0.120*	-0.0635**	0.0528	-0.0630**	0.0415
	(0.0294)	(0.0352)	(0.0521)	(0.0637)	(0.0520)	(0.0638)	(0.0306)	(0.0558)	(0.0303)	(0.0556)
Constant	0.200***	0.174***	0.877***	0.738***	0.877***	0.739***	0.877***	0.738***	0.877***	0.739***
	(0.0157)	(0.0163)	(0.0132)	(0.0236)	(0.0132)	(0.0236)	(0.0132)	(0.0236)	(0.0132)	(0.0236)
Observations	206	206	208	208	208	208	201	203	201	203
R-squared	0.041	0.008	0.105	0.034	0.111	0.033	0.081	0.055	0.094	0.060
Former Department of Education and Training schools										
Dummy for 488 Dinaledi schools (2005)	-0.0181	0.00938	0.0530	-6.03e-05	0.0503	-0.000643	0.0360	0.0542	0.0329	0.0536
	(0.0152)	(0.00768)	(0.0385)	(0.0444)	(0.0386)	(0.0444)	(0.0225)	(0.0403)	(0.0224)	(0.0402)
Year 2007	0.0491***	0.00176	-0.0888**	-0.0712	-0.0801**	-0.0675	-0.184***	-0.0615	-0.165***	-0.0574
	(0.0158)	(0.00756)	(0.0352)	(0.0443)	(0.0354)	(0.0444)	(0.0270)	(0.0427)	(0.0263)	(0.0428)
Interaction Dinaledi Dummy * Year2007	-0.0160	0.0392***	0.0898*	0.0250	0.0932**	0.0245	0.107***	-0.0759	0.0997***	-0.0769
	(0.0214)	(0.0111)	(0.0470)	(0.0603)	(0.0471)	(0.0604)	(0.0351)	(0.0568)	(0.0344)	(0.0568)
Constant	0.176***	0.0436***	0.706***	0.568***	0.709***	0.569***	0.801***	0.609***	0.805***	0.610***
	(0.0117)	(0.00570)	(0.0281)	(0.0315)	(0.0281)	(0.0315)	(0.0166)	(0.0302)	(0.0166)	(0.0302)
Observations	456	456	472	472	472	472	447	435	445	435
R-squared	0.045	0.107	0.050	0.009	0.047	0.008	0.170	0.032	0.147	0.030
Former Bantustan schools										
Dummy for 488 Dinaledi schools (2005)	-0.0112	0.0120***	-0.00494	0.108**	-0.00492	0.109**	0.0310	0.130*	0.0312	0.131*
	(0.0198)	(0.00457)	(0.0564)	(0.0517)	(0.0565)	(0.0517)	(0.0350)	(0.0775)	(0.0349)	(0.0776)
Year 2007	0.0796***	0.0365***	0.205***	0.0894*	0.225***	0.0916*	-0.164***	-0.111	-0.138***	-0.0876
	(0.0178)	(0.00742)	(0.0460)	(0.0500)	(0.0464)	(0.0500)	(0.0331)	(0.0754)	(0.0329)	(0.0758)
Interaction Dinaledi Dummy * Year2007	-0.0417*	0.116***	-0.00145	0.0333	-0.0158	0.0351	0.0368	-0.0839	0.0236	-0.0950
	(0.0251)	(0.0165)	(0.0688)	(0.0682)	(0.0692)	(0.0683)	(0.0478)	(0.0924)	(0.0473)	(0.0927)
Constant	0.114***	0.00894***	0.421***	0.223***	0.422***	0.223***	0.822***	0.537***	0.825***	0.537***
	(0.0139)	(0.00165)	(0.0395)	(0.0352)	(0.0396)	(0.0352)	(0.0257)	(0.0623)	(0.0257)	(0.0623)

Observations	488	487	492	492	492	492	345	320	343	314
R-squared	0.060	0.346	0.067	0.046	0.075	0.047	0.103	0.053	0.082	0.045

TABLE 23. HETEROGENEOUS TREATMENT EFFECTS BY FORMER DEPARTMENT. ABSOLUTE MEASURES. DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(11) Total number of students entering SG physical science	(12) Total number of students entering HG physical science	(13) Total number of students writing SG physical science	(14) Total number of students writing HG physical science	(15) Total number of students passing SG physical science	(16) Total number of students passing HG physical science
Former House of Assembly Schools						
Dummy for 488 Dinaledi schools (2005)	-13.90***	-4.308	-13.96***	-4.365	-9.346**	-2.058
	(4.795)	(6.662)	(4.787)	(6.650)	(3.952)	(6.409)
Year 2007	-1.981	5.442	-2.231	5.385	3.769	0.942
	(4.419)	(6.462)	(4.410)	(6.447)	(3.837)	(6.716)
Interaction Dinaledi Dummy * Year2007	7.135	2.423	7.212	2.462	1.635	4.808
	(6.427)	(9.405)	(6.414)	(9.384)	(5.701)	(9.148)
Constant	47.27***	45.29***	47.27***	45.25***	39.90***	36.37***
	(3.221)	(4.756)	(3.221)	(4.746)	(2.469)	(4.784)
Observations	208	208	208	208	208	208
R-squared	0.055	0.012	0.055	0.012	0.054	0.004
Former Department of Education and Training schools						
Dummy for 488 Dinaledi schools (2005)	-3.958	0.288	-3.669	0.305	-3.424	1.424
	(5.426)	(2.447)	(5.344)	(2.435)	(4.273)	(1.046)
Year 2007	38.47***	1.814	34.91***	1.720	6.805	-1.347
	(9.573)	(2.655)	(8.916)	(2.633)	(5.758)	(0.917)
Interaction Dinaledi Dummy * Year2007	-22.71**	10.26***	-20.03**	10.17***	1.703	4.636***
	(10.55)	(3.442)	(9.933)	(3.415)	(6.506)	(1.356)
Constant	43.13***	12.70***	42.75***	12.67***	34.34***	6.136***
	(4.773)	(2.145)	(4.684)	(2.133)	(3.860)	(0.827)
Observations	472	472	472	472	472	472
R-squared	0.078	0.070	0.073	0.069	0.013	0.086
Former Bantustan schools						
Dummy for 488 Dinaledi schools (2005)	-12.48**	1.244*	-12.43**	1.228*	-11.51**	0.593
	(5.337)	(0.690)	(5.309)	(0.688)	(4.647)	(0.546)
Year 2007	29.78***	8.561***	27.24***	8.211***	11.31*	0.602
	(7.559)	(1.705)	(7.491)	(1.651)	(5.946)	(0.475)
Interaction Dinaledi Dummy * Year2007	-8.228	31.86***	-6.610	30.54***	2.171	13.14***
	(9.041)	(4.854)	(8.945)	(4.782)	(7.037)	(1.786)
Constant	31.76***	2.211***	31.63***	2.211***	27.41***	1.691***
	(4.643)	(0.404)	(4.618)	(0.404)	(4.126)	(0.353)
Observations	492	492	492	492	492	492
R-squared	0.087	0.286	0.078	0.275	0.042	0.273

TABLE 24. HETEROGENEOUS TREATMENT EFFECTS BY FORMER DEPARTMENT. RATIO MEASURES. BIAS-CORRECTED DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(1) Enrolment rate of grade 12 students in SG physical science	(2) Enrolment rate of grade 12 students in HG physical science	(3) EC PR SG physical science	(4) EC PR HG physical science	(5) WC PR SG physical science	(6) WC PR HG physical science	(7) Passing rate out of those entering SG physical science	(8) Passing rate out of those entering HG physical science	(9) Passing rate out of those writing SG physical science	(10) Passing rate out of those writing HG physical science
[Former] House of Assembly schools										
SATT	0.0635**	0.0327	0.0419	0.150**	0.0425	0.140*	-0.0675	0.0661	-0.0691*	0.0542
	(0.0321)	(0.0294)	(0.0700)	(0.0732)	(0.0691)	(0.0718)	(0.0424)	(0.0572)	(0.0408)	(0.0540)
Observations	184	184	190	190	190	190	175	172	175	171
Former Department of Education and Training schools										
SATT	-0.0153	0.0332**	0.0900	0.0248	0.0934	0.0243	0.109*	-0.0708	0.0970*	-0.0705
	(0.0256)	(0.0162)	(0.0869)	(0.123)	(0.0871)	(0.123)	(0.0578)	(0.123)	(0.0579)	(0.123)
Observations	555	555	584	584	584	584	536	366	533	362
Former Bantustan schools										
SATT	-0.0416	0.113***	-0.00237	0.0333	-0.0167	0.0351	0.0461	-0.150	0.0425	-0.130
	(0.0294)	(0.0209)	(0.0800)	(0.0772)	(0.0796)	(0.0776)	(0.0972)	(0.154)	(0.0923)	(0.152)
Observations	572	573	598	598	598	598	394	118	388	114

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 25. HETEROGENEOUS TREATMENT EFFECTS BY FORMER DEPARTMENT. ABSOLUTE MEASURES. BIAS-CORRECTED DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(11) Total number of students entering SG physical science	(12) Total number of students entering HG physical science	(13) Total number of students writing SG physical science	(14) Total number of students writing HG physical science	(15) Total number of students passing SG physical science	(16) Total number of students passing HG physical science
[Former] House of Assembly schools						
SATT	8.363	1.329	8.431	1.380	1.703	5.100
	(6.854)	(10.00)	(6.843)	(9.956)	(7.049)	(6.641)
Observations	190	190	190	190	190	190
Former Department of Education and Training schools						
SATT	-22.78*	10.23*	-20.09*	10.13*	1.754	4.648***
	(13.14)	(6.031)	(11.59)	(6.021)	(5.486)	(1.689)
Observations	584	584	584	584	584	584
Former Bantustan schools						

SATT	-8.136	31.85***	-6.512	30.52***	2.167	13.12***
	(8.369)	(5.843)	(8.245)	(5.791)	(6.358)	(2.093)
Observations	598	598	598	598	598	598

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 26. HETEROGENEOUS TREATMENT EFFECTS BY PROVINCE. RATIO MEASURES. DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(1) Enrolment rate of grade 12 students in SG physical science	(2) Enrolment rate of grade 12 students in HG physical science	(3) EC PR SG physical science	(4) EC PR HG physical science	(5) WC PR SG physical science	(6) WC PR HG physical science	(7) Passing rate out of those entering SG physical science	(8) Passing rate out of those entering HG physical science	(9) Passing rate out of those writing SG physical science	(10) Passing rate out of those writing HG physical science
Gauteng, Free State, Mpumalanga, North West and Western Cape										
Dummy for 488 Dinaledi schools (2005)	-0.00393	0.00381	0.00522	-0.0127	0.00324	-0.0133	0.0134	-0.0241	0.0114	-0.0247
	(0.0123)	(0.0105)	(0.0163)	(0.0290)	(0.0163)	(0.0290)	(0.0153)	(0.0260)	(0.0153)	(0.0260)
Year 2007	0.0326**	-0.00768	-0.144***	-0.0947***	-0.129***	-0.0880***	-0.133***	-0.0908***	-0.104***	-0.0803***
	(0.0128)	(0.00942)	(0.0207)	(0.0320)	(0.0208)	(0.0321)	(0.0201)	(0.0296)	(0.0191)	(0.0295)
Interaction Dinaledi Dummy * Year2007	-0.0271	0.0271**	0.0905***	0.0195	0.0846***	0.0156	0.0799***	-0.00265	0.0593**	-0.0104
	(0.0168)	(0.0136)	(0.0272)	(0.0431)	(0.0272)	(0.0432)	(0.0256)	(0.0404)	(0.0247)	(0.0403)
Constant	0.178***	0.0939***	0.849***	0.683***	0.852***	0.684***	0.849***	0.724***	0.852***	0.725***
	(0.00963)	(0.00774)	(0.0114)	(0.0208)	(0.0114)	(0.0208)	(0.0114)	(0.0183)	(0.0114)	(0.0183)
Observations	829	829	844	844	844	844	837	804	833	803
R-squared	0.014	0.013	0.084	0.018	0.069	0.016	0.088	0.027	0.060	0.025
Kwazulu Natal and Limpopo										
Dummy for 488 Dinaledi schools (2005)	-0.00290	-0.000577	-0.0102	0.0877**	-0.0102	0.0928**	0.254	0.338***	0.254	0.357***
	(0.00205)	(0.000901)	(0.0444)	(0.0399)	(0.0444)	(0.0407)	(0.158)	(0.109)	(0.158)	(0.110)
Year 2007	0.178***	0.0848***	0.441***	0.168***	0.457***	0.170***	0.0164	0.0910	0.0338	0.0934
	(0.0118)	(0.00923)	(0.0433)	(0.0347)	(0.0437)	(0.0348)	(0.117)	(0.0747)	(0.118)	(0.0747)
Interaction Dinaledi Dummy * Year2007	-0.0641***	0.134***	0.0218	0.162***	0.0131	0.156***	-0.150	-0.125	-0.149	-0.140
	(0.0164)	(0.0183)	(0.0655)	(0.0562)	(0.0661)	(0.0568)	(0.163)	(0.116)	(0.163)	(0.118)
Constant	0.00379*	0.00283***	0.112***	0.0544**	0.112***	0.0544**	0.579***	0.178**	0.579***	0.178**
	(0.00202)	(0.000756)	(0.0321)	(0.0225)	(0.0321)	(0.0225)	(0.114)	(0.0686)	(0.114)	(0.0686)
Observations	391	390	392	392	392	392	201	234	200	233
R-squared	0.476	0.499	0.329	0.241	0.336	0.237	0.050	0.141	0.049	0.148
Eastern Cape										
Dummy for 488 Dinaledi schools (2005)	0.0232	-0.0205	-0.0195	0.0311	-0.0197	0.0319	-0.0195	0.0169	-0.0197	0.0180
	(0.0257)	(0.0151)	(0.0224)	(0.0973)	(0.0220)	(0.0973)	(0.0224)	(0.0516)	(0.0220)	(0.0512)
Year 2007	-0.0586***	-0.0283*	-0.146***	-0.124	-0.112***	-0.123	-0.127***	-0.114	-0.0920***	-0.0440

	(0.0216)	(0.0162)	(0.0362)	(0.0982)	(0.0331)	(0.0982)	(0.0316)	(0.0809)	(0.0273)	(0.0694)
Interaction Dinaledi Dummy * Year2007	0.00736	0.0556**	0.0774	0.137	0.0512	0.146	0.0588	-0.121	0.0318	-0.164*
	(0.0341)	(0.0214)	(0.0472)	(0.133)	(0.0445)	(0.133)	(0.0438)	(0.104)	(0.0404)	(0.0940)
Constant	0.228***	0.0575***	0.927***	0.544***	0.930***	0.544***	0.927***	0.866***	0.930***	0.866***
	(0.0156)	(0.0126)	(0.0132)	(0.0690)	(0.0128)	(0.0690)	(0.0132)	(0.0387)	(0.0128)	(0.0387)
Observations	170	170	172	172	172	172	171	118	171	115
R-squared	0.073	0.042	0.125	0.023	0.088	0.025	0.117	0.114	0.082	0.108

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 27. HETEROGENEOUS TREATMENT EFFECTS BY PROVINCE. ABSOLUTE MEASURES. DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(11) Total number of students entering SG physical science	(12) Total number of students entering HG physical science	(13) Total number of students writing SG physical science	(14) Total number of students writing HG physical science	(15) Total number of students passing SG physical science	(16) Total number of students passing HG physical science
Gauteng, Free State, Mpumalanga, North West and Western Cape						
Dummy for 488 Dinaledi schools (2005)	-13.67***	-1.408	-13.29***	-1.412	-11.11***	-1.896
	(4.922)	(2.496)	(4.835)	(2.493)	(3.874)	(2.165)
Year 2007	25.31***	2.621	20.65***	2.403	3.896	-1.147
	(8.549)	(2.649)	(7.772)	(2.639)	(5.553)	(2.312)
Interaction Dinaledi Dummy * Year2007	-18.84**	4.024	-14.72*	4.100	-0.768	2.161
	(9.026)	(3.580)	(8.284)	(3.566)	(5.950)	(3.048)
Constant	54.07***	23.58***	53.60***	23.55***	44.52***	17.80***
	(4.600)	(1.926)	(4.509)	(1.924)	(3.644)	(1.655)
Observations	844	844	844	844	844	844
R-squared	0.049	0.010	0.044	0.009	0.019	0.001
Kwazulu Natal and Limpopo						
Dummy for 488 Dinaledi schools (2005)	-0.204*	0.133	-0.204*	0.122	-0.153	0.163***
	(0.117)	(0.122)	(0.117)	(0.121)	(0.114)	(0.0604)
Year 2007	42.55***	20.89***	41.18***	20.42***	21.61***	4.398***
	(3.925)	(2.257)	(3.808)	(2.205)	(2.095)	(0.571)
Interaction Dinaledi Dummy * Year2007	-8.235	35.15***	-7.857	34.05***	1.857	17.97***
	(6.063)	(5.767)	(5.922)	(5.688)	(3.934)	(2.357)
Constant	0.378***	0.357***	0.378***	0.357***	0.296***	0.0612**
	(0.104)	(0.0602)	(0.104)	(0.0602)	(0.103)	(0.0243)
Observations	392	392	392	392	392	392
R-squared	0.298	0.395	0.295	0.388	0.253	0.389
Eastern Cape						
Dummy for 488 Dinaledi schools (2005)	0.302	0.395	0.326	0.372	0.674	0.326
	(8.136)	(1.351)	(8.087)	(1.347)	(6.508)	(1.155)
Year 2007	4.605	-1.419	1.837	-1.488	-3.070	-1.512
	(10.52)	(1.217)	(10.31)	(1.215)	(7.818)	(0.990)
Interaction Dinaledi Dummy * Year2007	13.74	10.86***	15.74	9.651***	11.98	4.721***
	(13.52)	(3.094)	(13.28)	(3.010)	(9.886)	(1.742)
Constant	42.09***	4.767***	41.91***	4.767***	36.60***	3.907***
	(7.127)	(0.861)	(7.086)	(0.861)	(5.685)	(0.738)
Observations	172	172	172	172	172	172
R-squared	0.029	0.165	0.029	0.139	0.021	0.096

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 28. HETEROGENEOUS TREATMENT EFFECTS BY PROVINCES. RATIO MEASURES. BIAS-CORRECTED DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(1) Enrolment rate of grade 12 students in SG physical science	(2) Enrolment rate of grade 12 students in HG physical science	(3) EC PR SG physical science	(4) EC PR HG physical science	(5) WC PR SG physical science	(6) WC PR HG physical science	(7) Passing rate out of those entering SG physical science	(8) Passing rate out of those entering HG physical science	(9) Passing rate out of those writing SG physical science	(10) Passing rate out of those writing HG physical science
Gauteng, Free State, Mpumalanga, North West and Western Cape										
SATT	-0.0228	0.0209*	0.0906**	0.0199	0.0845**	0.0158	0.0771*	0.00875	0.0514	0.00281
	(0.0229)	(0.0125)	(0.0407)	(0.0605)	(0.0409)	(0.0605)	(0.0407)	(0.0589)	(0.0405)	(0.0589)
Observations	942	942	973	973	973	973	897	732	893	726
Kwazulu Natal and Limpopo										
SATT	-0.0667***	0.135***	0.0200	0.161**	0.0113	0.156**	-0.122	-0.00947	0.417*	0.0737
	(0.0216)	(0.0222)	(0.0799)	(0.0777)	(0.0811)	(0.0777)	(0.268)	(0.197)	(0.216)	(0.196)
Observations	242	241	243	243	243	243	47	53	44	51
Eastern Cape										
SATT	0.0212	0.0534***	0.0775	0.137	0.0513	0.146	0.0541	-0.178	0.0280	-0.159
	(0.0284)	(0.0160)	(0.0514)	(0.111)	(0.0497)	(0.113)	(0.0506)	(0.113)	(0.0480)	(0.107)
Observations	633	635	670	670	670	670	599	136	592	129

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 29. HETEROGENEOUS TREATMENT EFFECTS BY PROVINCES. ABSOLUTE MEASURES. BIAS-CORRECTED DID ESTIMATES OF DINALEDI PROGRAM EFFECTS FOR YEARS 2005-2007

	(11) Total number of students entering SG physical science	(12) Total number of students entering HG physical science	(13) Total number of students writing SG physical science	(14) Total number of students writing HG physical science	(15) Total number of students passing SG physical science	(16) Total number of students passing HG physical science
Gauteng, Free State, Mpumalanga, North West and Western Cape						
SATT	-19.05**	3.989	-14.88*	4.066	-0.769	2.165
	(8.709)	(4.892)	(7.628)	(4.851)	(4.139)	(1.570)
Observations	973	973	973	973	973	973
Kwazulu Natal and Limpopo						
SATT	-8.773	35.01***	-8.383	33.91***	1.566	17.94***
	(7.491)	(6.637)	(7.306)	(6.655)	(4.626)	(2.737)
Observations	243	243	243	243	243	243
Eastern Cape						
SATT	13.73	10.85**	15.73*	9.639***	11.93*	4.710***
	(9.906)	(4.601)	(9.546)	(2.174)	(6.556)	(0.941)
Observations	670	670	670	670	670	670

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 30. CHARACTERISTICS OF PROVINCE SUBSETS. DINALEDI SCHOOLS BY FORMER DEPARTMENT AND PROVINCE

	Province subset 1										Province subset 2				Province subset 3		Excluded		
	Free State		Gauteng		Mpumalanga		North West		Western Cape		Kwazulu Natal		Limpopo		Eastern Cape		Northern Cape		Total
Non-Bantustan	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	
CAPE EDUCATION DEPART	0	0.0%	0	0.0%	0	0.0%	0	0.0%	5	13.9%	0	0.0%	0	0.0%	4	8.9%	0	0.0%	9
DEPARTMENT OF EDUCATION AND TRAINING	24	80.0%	38	48.1%	13	40.6%	15	44.1%	10	27.8%	10	15.9%	2	5.4%	6	13.3%	1	33.3%	119
FREE STATE EDUCATION	1	3.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1
HOUSE OF ASSEMBLY	4	13.3%	40	50.6%	0	0.0%	0	0.0%	0	0.0%	9	14.3%	0	0.0%	0	0.0%	1	33.3%	54
HOUSE OF DELEGATES	0	0.0%	1	1.3%	0	0.0%	0	0.0%	1	2.8%	1	1.6%	0	0.0%	1	2.2%	0	0.0%	4
HOUSE OF REPRESENTATIVES	0	0.0%	0	0.0%	0	0.0%	0	0.0%	18	50.0%	2	3.2%	0	0.0%	4	8.9%	1	33.3%	25
NEW EDUCATION DEPT.	0	0.0%	0	0.0%	2	6.3%	7	20.6%	0	0.0%	1	1.6%	0	0.0%	4	8.9%	0	0.0%	14
WESTERN CAPE EDUCATION	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	5.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2
INDEPENDENT	1	3.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1
TO BE UPDATED	0	0.0%	0	0.0%	1	3.1%	1	2.9%	0	0.0%	1	1.6%	1	2.7%	0	0.0%	0	0.0%	4
Bantustan																			
BOPHUTATSWANA (BOP)	0	0.0%	0	0.0%	3	9.4%	11	32.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	14
CISKEI	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	6.7%	0	0.0%	3
GAZANKULU	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	5	13.5%	0	0.0%	0	0.0%	5
KANGWANE	0	0.0%	0	0.0%	9	28.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	9
KWANDEBELE	0	0.0%	0	0.0%	2	6.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2
KWAZULU NATAL EDUCATION DEPT.	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	39	61.9%	0	0.0%	0	0.0%	0	0.0%	39
LEBOWA	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	14	37.8%	0	0.0%	0	0.0%	14
TRANSKEI	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	23	51.1%	0	0.0%	23
TRANSVAAL EDUCATION DEPT.	0	0.0%	0	0.0%	2	6.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2
VENDA	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	15	40.5%	0	0.0%	0	0.0%	15
Bantustan total	**0**	**0.0%**	**0**	**0.0%**	**13**	**40.6%**	**0**	**32.4%**	**0**	**0.0%**	**39**	**61.9%**	**34**	**91.9%**	**26**	**57.8%**	**0**	**0.0%**	**112**
Total	**30**	**100.0%**	**79**	**100.0%**	**32**	**100.0%**	**34**	**100.0%**	**36**	**100.0%**	**63**	**100.0%**	**37**	**100.0%**	**45**	**100.0%**	**3**	**100.0%**	**359**

TABLE 31. DIFFERENCE-IN-DIFFERENCE MEANS TEST BETWEEN RETAINED AND NON-RETAINED DINALEDI SCHOOLS. PRE-TREATMENT OUTCOME MEASURES, ROBUST STANDARD ERRORS

Baseline characteristics (2004)	Retained Dinaledi			Non-retained Dinaledi			Difference-in-difference means Dummy for retained Dinaledi schools	SE
	N	Mean	SD	N	Mean	SD		
Total number of students entering SG physical science	352	29.45	28.27	88	30.67	38.32	-1.224	-4.341
Total number of students entering HG physical science	352	14.06	20.61	88	13.52	19.16	0.537	-2.314
Total number of students writing SG physical science	352	29.37	28.16	88	30.58	38.22	-1.21	-4.329
Total number of students writing HG physical science	352	14.03	20.58	88	13.49	19.12	0.545	-2.309
Total number of students passing SG physical science	352	24.62	22.44	88	25.91	33.15	-1.293	-3.72
Total number of students passing HG physical science	352	10.11	17.36	88	7.85	10.19	2.259	-1.424
Passing rate out of those entering SG physical science	352	0.65	0.4	88	0.6	0.42	0.053	-0.05
Passing rate out of those entering HG physical science	352	0.51	0.4	88	0.47	0.39	0.044	-0.047
Passing rate out of those writing SG physical science	352	0.65	0.4	88	0.6	0.42	0.053	-0.05
Passing rate out of those writing HG physical science	352	0.51	0.4	88	0.47	0.39	0.045	-0.047
Proportion entering SG Physical Sciences of students enrolled in grade 12	352	0.14	0.13	74	0.13	0.15	0.001	-0.019
Proportion entering HG Physical of students enrolled in grade 12	352	0.06	0.09	74	0.07	0.1	-0.007	-0.013

TABLE 32. DIFFERENCE-IN-DIFFERENCE MEANS TEST BETWEEN RETAINED AND NON-RETAINED DINALEDI SCHOOLS. PRE-TREATMENT LEARNER, ENROLMENT, AND LANGUAGE CHARACTERISTICS,
ROBUST STANDARD ERRORS

Baseline characteristics (2004)	Retained Dinaledi			Non-retained Dinaledi			Difference-in-difference means Dummy for 352 retained Dinaledi schools	SE
	N	Mean	SD	N	Mean	SD		
Total number of learners	352	5736.14	2913.97	88	4433.59	3304.94	1,302.545***	-383.972
Number of African learners in the school	352	4938.07	3264.73	68	4880.96	2873.82	57.109	-388.044
Number of male African learners	352	1344.05	900.5	68	1329.57	846.22	14.48	-112.844
Number of female African learners	352	1519.04	935.93	68	1515.06	825.88	3.984	-111.461
Learners in grades 10, 11 and 12	352	966.31	410.96	88	744.43	554.82	221.878***	-62.886
Number of African learners in grades 10 through 12	352	847.44	500.63	88	647.17	565.22	200.273***	-65.717
Total enrolment	352	3249.7	1521.13	88	2711.49	1743.44	538.207***	-202.21
Total male enrolments	352	1512.93	814.84	75	1460.37	792.3	52.558	-100.93
Total female enrolments	352	1736.76	880.75	75	1721.11	730.02	15.658	-96.186
Enrolments in grade 10	352	443.35	210.22	75	444	200.14	-0.651	-25.597
Enrolments in grade 11	352	345.11	149.71	75	352.24	162.02	-7.126	-20.267
Enrolments in grade 12	352	223.43	96.18	75	214.03	121.82	9.402	-14.916

Male enrolments in grade 10	352	141.12	71.92	75	140.41	71.9	0.712	-9.113
Male enrolments in grade 11	352	105.05	50.9	75	107.56	57.25	-2.515	-7.12
Male enrolments in grade 12	352	67.69	34.09	75	63.04	36.79	4.647	-4.604
Female enrolments in grade 10	352	157.35	77.42	75	159.28	65.99	-1.928	-8.638
Female enrolments in grade 11	352	128.4	60.11	75	130.8	55.02	-2.399	-7.092
Female enrolments in grade 12	352	83.16	41.77	75	81.67	47.34	1.49	-5.881
Number of learners with English as medium of instruction	352	542.71	272.44	76	513.92	266.31	28.795	-33.711

TABLE 33. HETEROGENEOUS TREATMENT EFFECTS ON HG PHYSICAL SCIENCES ENROLMENT RATES BY FORMER BANTUSTAN STATUS

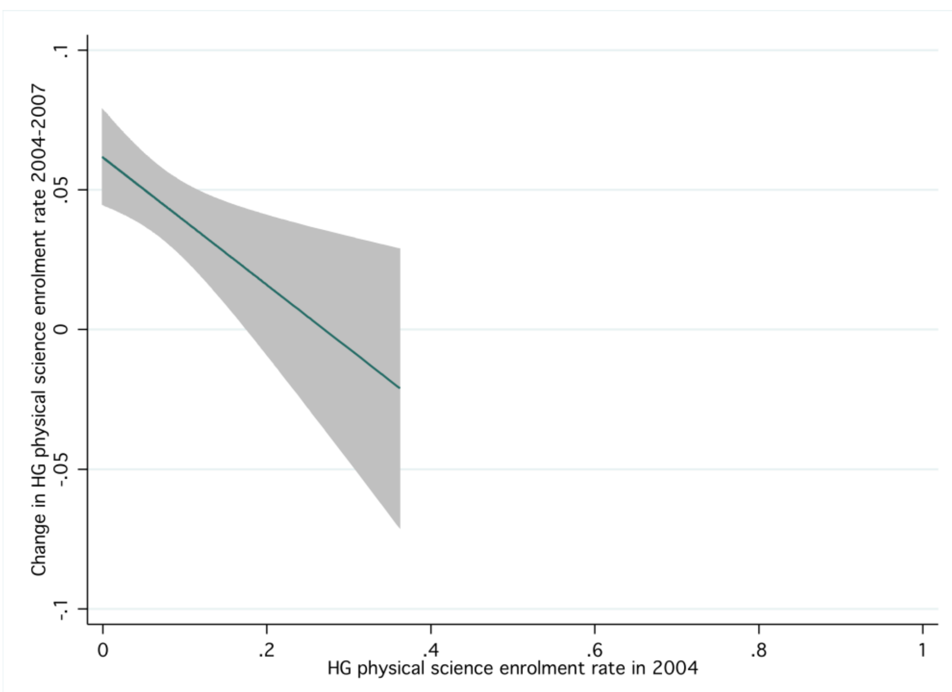
	(1) Change in enrolment rate of grade 12 students in HG physical sciences from 2004 to 2007	(2) Change in enrolment rate of grade 12 students in HG physical sciences from 2004 to 2007	(3) Change in enrolment rate of grade 12 students in HG physical sciences from 2004 to 2007
Department of Education and Training school (dummy)	-0.0514***	0.0108	0.0121
	(0.0105)	(0.0115)	(0.0112)
House of Assembly school (dummy)	-0.0661***	-0.000128	0.0125
	(0.0212)	(0.0229)	(0.0200)
House of Representatives school (dummy)	-0.0674***	-0.0411**	-0.0276*
	(0.0105)	(0.0166)	(0.0167)
Other school (dummy)	-0.0332***	-0.00161	0.00972
	(0.0118)	(0.0146)	(0.0143)
Dummy for 488 Dinaledi schools (2005)[1]	**0.103*** **	**0.107*** **	**0.107*** **
	(0.0171)	(0.0147)	(0.0147)
Interaction Department of Education and Training school (dummy) and Dinaledi	-0.0617***	-0.0746***	-0.0760***
	(0.0195)	(0.0177)	(0.0174)
Interaction House of Assembly school (dummy) and Dinaledi	-0.0679**	-0.0821***	-0.0828***
	(0.0326)	(0.0270)	(0.0250)
Interaction House of Representatives school (dummy) and Dinaledi	-0.0533**	-0.0652***	-0.0625***
	(0.0218)	(0.0204)	(0.0194)
Interaction Other school (dummy) and Dinaledi	-0.0818***	-0.0655***	-0.0664***
	(0.0232)	(0.0215)	(0.0212)
Proportion of students enrolled in grade 12 entering HG physical sciences			**-0.492*** **
			(0.128)
Constant	0.0500***	0.0614***	0.0804***
	(0.00820)	(0.0162)	(0.0160)
Controls used for propensity score estimation	No	Yes	Yes
Observations	678	678	678
R-squared	0.214	0.475	0.499

[1]The Dinaledi dummy estimates the Dinaledi program interaction effect with Bantustan schools, as the Bantustan school dummy is omitted from the regression for collinearity.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 34. HETEROGENEOUS TREATMENT EFFECTS BY PRE-TREATMENT HG PHYSICAL SCIENCES ENROLMENT RATES.
SUBCLASSIFICATION IN EQUAL-SIZE SUBSETS OF 60 OBSERVATIONS WITH RESPECT TO ENROLMENT RATES

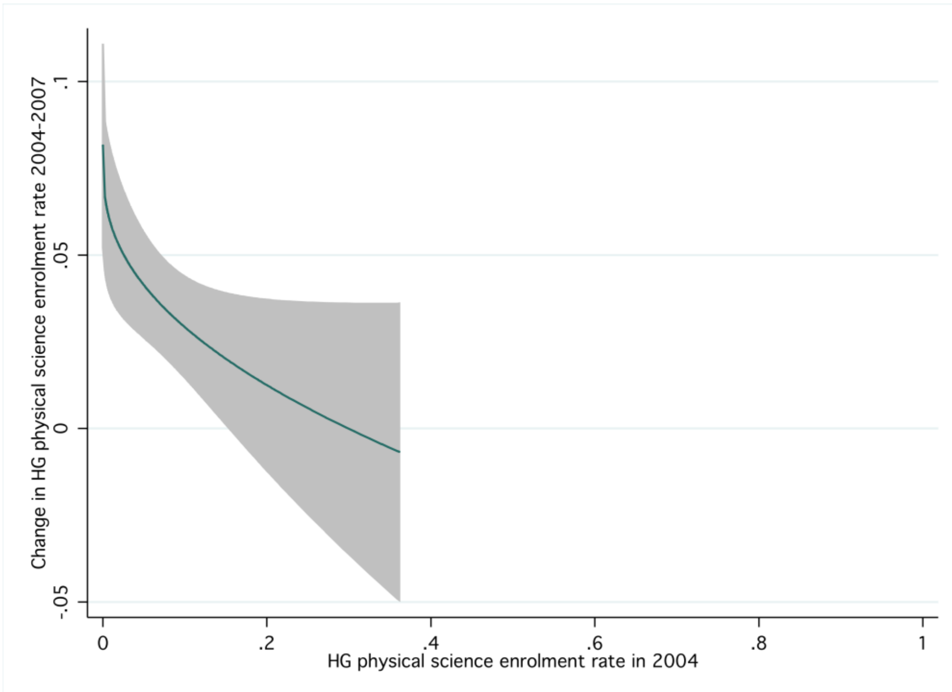
	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6
	HG physical science enrolment rate	HG physical science enrolment rate	HG physical science enrolment rate	HG physical science enrolment rate	HG physical science enrolment rate	HG physical science enrolment rate
Dummy for 488 Dinaledi schools (2005)	0***	0.000707*	-0.00344***	0.00321*	-0.00101	0.0292
	(0)	(0.000389)	(0.00127)	(0.00175)	(0.00297)	(0.0189)
Year 2007	0.0793***	0.0562***	0.0358***	0.0237**	-0.00900*	-0.0365**
	(0.0160)	(0.0103)	(0.00906)	(0.0117)	(0.00532)	(0.0172)
Interaction Dinaledi Dummy * Year2007	**0.0577****	**0.0875*****	**0.0590*****	**0.0192**	**0.0459*****	**0.00281**
	(0.0240)	(0.0213)	(0.0186)	(0.0188)	(0.0116)	(0.0277)
Constant	-0***	0.00103***	0.0206***	0.0426***	0.0902***	0.203***
	(0)	(0.000251)	(0.000825)	(0.00112)	(0.00210)	(0.0112)
Observations	235	234	225	216	240	219
R-squared	0.288	0.351	0.240	0.070	0.132	0.050
			Set characteristics			
Minimum enrolment in 2004	0	0	0.0067	0.032	0.064	0.12
Maximum enrolment in 2004	0	0.0067	0.032	0.064	0.12	1
N of Dinaledi schools in set (pre-matching)	60	60	60	60	60	59

FIGURE 5. HETEROGENEOUS TREATMENT EFFECTS BY PRE-TREATMENT HG PHYSICAL SCIENCES ENROLMENT RATES.
MULTIVARIABLE FRACTIONAL POLYNOMIALS INTERACTIONS WITH ONE DEGREE OF FREEDOM FOR INTERACTION TERMS (LINEAR).



Notes: MFPI model with a single power term (1) and lower and upper 95 percent confidence limits. The estimated model includes controls[24] for the same set of covariates employed for estimating the propensity score (see Box 1).

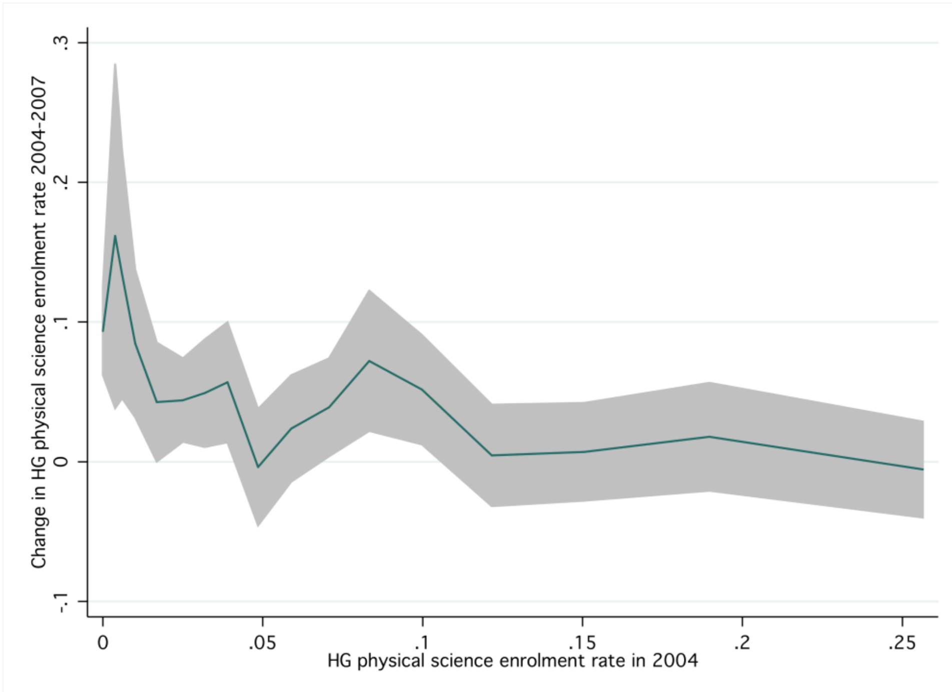
FIGURE 6. HETEROGENEOUS TREATMENT EFFECTS BY PRE-TREATMENT HG PHYSICAL SCIENCES ENROLMENT RATES.
MULTIVARIABLE FRACTIONAL POLYNOMIALS INTERACTIONS WITH TWO DEGREES OF FREEDOM FOR INTERACTION TERMS.



Notes: MFPI model with two power terms (0 and -0.5) and lower and upper 95 percent confidence limits. The estimated model includes controls[25] for the same set of covariates employed for estimating the propensity score (see Box 1).

[24] The controls actually included in the confounder model are selected at the 5 percent significance level.
[25] The controls actually included in the confounder model are selected at the 5 percent significance level.

FIGURE 7. HETEROGENEOUS TREATMENT EFFECTS BY PRE-TREATMENT HG PHYSICAL SCIENCES ENROLMENT RATES.
SUBPOPULATION TREATMENT-EFFECT PATTERN PLOT (SLIDING WINDOW VARIANT)



Notes: Sliding window STEPP variant with 60 observations in each subpopulation and an overlap of 30 observations between neighboring sub-populations and lower and upper 95 percent confidence limits. The estimated model includes controls[26] for the same set of covariates employed for estimating the propensity score (see Box 1).

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[26] The controls actually included in the confounder model are selected at the 5 percent significance level.