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Projections of Educators by Age and Average Cost to 2070

A first report

Martin Gustafsson (7 December 2022)

Teacher Demographic Dividend.

RESEP
Research on Socio-Economic Policy

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Summary

This report explains the design and projections of a teacher supply and demand model for South Africa. While the report addresses a number of policy issues, it pays special attention to two. One is the **number of new teachers universities will need to graduate** over the coming two decades, given a context of a wave of retirements among older educators over the next ten years. Secondly, the report deals with the possibility of a **'demographic dividend'**, or lower-than-expected salary costs resulting from a decline in the average age of educators as a wave of younger teachers enter the system.

Though the model described here is still subject to further changes, these are likely to be refinements which would not influence key model outputs in a substantive manner.

In some respects, the current report builds on earlier work done for the Department of Higher Education and Training (DHET). That earlier work, released early in 2022, warned of an imminent shortage of teachers if universities did not increase the output of teacher graduates. One limitation of that previous work is that it did not differentiate between newly graduated teachers and older teachers re-joining the profession. It moreover used breakdowns by age in a very limited fashion, and did not examine financial impacts at all. The current report, which reaches broadly similar conclusions to the DHET report, seeks to address these methodological limitations.

The model uses the number of **educators by age, notch and type** in a base year as a central input. There are two types of educators: **level 1 teachers and senior educators** (also referred to as 'non-teachers'). The Excel tool uses VBA coding, but is relatively straightforward and easily editable by the user. It produces statistics for fifty future years. In each year, four processes, each subject to changeable assumptions, occur: **attrition**; **promotion**; **annual notch progression**; and **joining**.

There is not much in the way of existing and publicly available tools and reports to guide this kind of work, but what was sourced was useful, and is discussed here.

As a validation exercise, the model was used to **project retrospectively developments between 2011 and 2021**, using 2011 as the base year, to see how well the model predicts the actual 2021 situation. This check led to some enhancements of the model and decisions around how to deal with attrition and joining assumptions. This retrospective check was only run with respect to educator numbers by age, not unit costs, given complexities created by the switch from a 1.0% annual notch progression to 1.5%, a process whose phasing in began in 2019.

For projections beyond 2021 it was important to have an appropriate set of 2021 base year statistics. The report explains how 2021 Persal payroll data were processed, and decisions around which employees to include and which to exclude from the modelling.

Section 5.1 explains a vital phenomenon for understanding the demand for teachers in the coming decades: **an *unexpected* and sharp increase in the school-age population**. This

increase has already begun, and partly as a consequence of this enrolments in the public plus independent schooling system has risen by over a million between 2010 and 2021. Projections of the school-age population point to an increase of a further one million or so learners between 2021 and 2030 (see Figure 8). This is clear in both the UN's population projections and those of the local Thembisa Project. A part of the problem is that an increase in the child population was not anticipated a decade or so ago, when the National Development Plan was drawn up. Instead, a continual *decline* was expected, resulting in for instance a decline in the school-age population of around half a million between 2020 and 2030. Much planning in South Africa has been premised on a 'demographic dividend' based on a decline in the child population. Planning, including teacher planning, must still adjust to the reality of a very different demographic reality.

Section 5.2 presents projected educator counts to 2071. Four scenarios are presented. One scenario envisages no change to the size of the educator workforce, despite the abovementioned child population growth. Another middle-of-the-road scenario increases the stock of publicly employed educators in line with population growth, meaning the **learner-educator (LE) ratio would not worsen relative to 2021**. This scenario moreover allows for **improvement in 'survival' to Grade 12** to continue along its recent trajectory, and incorporates some savings from reduced grade repetition. (The scenario is referred to as 'Population + Grade 12' in Table 9 and Table 10.) The scenario envisages 84% of youths reaching (not necessarily successfully completing) Grade 12 by 2030 – in recent years the figure has stood at 78%. For all these conditions to be met, the publicly paid educator workforce, which has in recent years been around 400,000 people, would need to enlarged by around 25,000 people by 2030.

The scenario described here translates to an **increase in the output of new teacher graduates from universities, from around 28,000 in 2020 to around 34,000 in 2030**. The assumption is used that **three in four graduates enter public employment as teachers** soon after graduating. Around one in seven grades 1 to 12 educators currently working in schools are privately employed, either in a public or an independent school. This stock of teachers must obviously be replenished. Furthermore, some teacher graduates have in the past ended up not working in a South African school, for instance because they find employment elsewhere in the South African labour market, or leave the country. The projections presented in the report take into account the in-migration of foreigners who become publicly employed teachers in South Africa. This phenomenon has in recent years been tiny. (See section 5.3.).

This workforce expansion scenario is conservative insofar as it does not aim to reverse a deterioration in the learner-educator seen in the 2011 to 2021 period. The ratio has risen from 27.4 to 29.8 between 2011 and 2021, which in large part explains a worsening class size problem in the sector, especially among historically disadvantaged schools. This trend has come about because the educator workforce has not grown, while the number of learners has. A more ambitious scenario (referred to as 'Population + Grade 12 + LE' in the report) envisages returning the LE ratio to its 2011 level by 2030. This scenario would require the educator workforce to grow by 64,000 and for the output of new graduates from universities to reach around 46,000 by 2030. If a very healthy economy in 2030 is envisaged, higher attrition among younger educators could push the annual demand for new graduates by 2030 as high as 55,000. Past patterns suggest that when the economy fares well, and additional opportunities for young teachers exist in the labour market, attrition rates among these teachers rise substantially, meaning the training system would have to compensate for this.

It should be noted that even in this more ambitious scenario **South Africa's LE ratio would remain a little higher than what is typically seen in middle income countries**. The 2011 reference point is in other words not in any sense an ideal one.

Clearly, there are **many uncertainties among the factors influencing the future demand for new teacher graduates**. The report aims to clarify what the more likely future outcomes are. Expansion in the capacity of universities to produce teacher graduates has occurred, and should continue to occur, but the magnitude of the latter will need to be revisited from time to time as the context changes.

The ratio of three in four graduates becoming publicly employed teachers is based on historical patterns. A clear problem since around 2017 is that an increasing proportion of graduates have *not* entered public employment as teachers. The data suggest that by 2020, only around half of graduates were joining the public system. This is due to two factors: universities have been relatively successful at increasing the output of teacher graduates, in response to government targets, yet **budget constraints in the schooling system**, combined with **a change in the rules governing teachers' annual increments** introduced in 2019, have made it difficult for provincial education departments to absorb enough new graduates, even though the LE ratio was deteriorating. This situation is unlikely to continue, especially as the retirements wave will force employers to ramp up the intake of young graduates in order to maintain the size of the workforce at at least past levels, but also due to some easing of the per educator cost problem through the 'teacher demographic dividend'. Yet the recent situation points to a need to **align spending on initial teacher education at universities and spending on personnel in the schooling system** in better ways. This should be done within a holistic plan that considers how many teachers the schooling system can afford to employ. The current report provides important guidance relating to what is financially viable in this regard over the next decade.

Like the earlier DHET analysis, the projections of the current report point to the **demand for graduates *dropping* somewhat beyond 2030**, though the extent of this is sensitive to various assumptions (Figure 18). This means that some of the expansion in the required training capacity of universities would need to be scaled down after 2030.

The **average cost of an educator is projected to remain virtually unchanged, in real terms**, with there being an overall increase of 0.5%, or just 0.06% a year, between 2021 and 2030. Behind this is **a 1.8% overall increase for teachers** and **a 2.9% *decline* for senior educators** across the entire period – these translate to annual changes of 0.2% and -0.3% respectively. It is clear that a small increase in the unit cost of teachers is offset by a small decline in the unit cost of senior educators. The assumption is that all educators would receive an annual notch progression of 1.5%, and only CPI-linked cost-of-living adjustments. The fact that the overall unit cost trend to 2030 is found to be virtually flat, while educators receive 1.5% increases per year in their purchasing power, through the notch progression, is in part possible because **the declining age of educators offsets the effects of the notch progression** (though the logic of this dictates that even with no decline in the average age, annual increases at the aggregate level would be well below 1.5%). The figures provided here emerge from a scenario where the total number of educators does not increase after 2021. If the most expansive scenario is taken, then slight declines in the overall educator unit cost are seen, given the larger proportion of young teachers.

Before work on the project began, it had been assumed that there would be a real saving arising from the decline in the average educator age, given that younger educators cost less. Those assumptions were based on rough calculations and not the detailed modelling which is now possible, and which is able to estimate the impacts of different magnitudes of annual notch progression, and how a changing age profile affects promotions. What is now clear is that **a substantial real decline in the average unit cost in the foreseeable future is unlikely**. Instead, what can be expected are unit costs which remain almost constant over time, as explained above.

In a sense, however, there is a teacher demographic dividend. Had the 'less favourable' educator age structure seen in 2011 existed in 2021, the real annual increase would have been 0.41% a year, and not the expected 0.06% referred to above. This implies that the educator wage bill in 2030 will be **R6.4bn lower due to the 'more favourable' 2021 age structure** – it will be R193.5bn and not R199.8bn (all in 2021 Rand terms). This is one way of quantifying the demographic dividend. However, its impact is not large enough to result in a substantial real *decline* in the average unit cost. Had there not been a shift from an annual notch progression of 1.0% to 1.5%, the situation would have been rather different. If the period 2021 to 2030 is modelled with a notch progression of just 1.0%, then there is an annual *decline* in the real cost of an educator of 0.27%, as opposed to the tiny increase of 0.06% a year seen with the presence of the 1.5% progression. This translates to a wage bill which is R5.6bn lower in 2030 in 2021 Rand values.

Though the average cost does not decline, there is a further dividend, not a demographic one, which is available if **cost-of-living adjustments are aligned with CPI**. If this strategy is followed, and there is no workforce growth, the total cost of the educator workforce over GDP is likely to decline from the current 3.1% to 2.7% in 2030, and 2.3% by 2040. This assumes a pessimistic GDP growth trajectory of 1.7% from 2024 onwards. Given the way the budgeting system works, it is extremely unlikely that such large declines in the ratio of education personnel spending to GDP would be realised. As far back as 2007, spending on educators by provinces over GDP was 3.0%, close to the current level. If very large declines in this ratio are not permitted, and if cost-of-living increases for educators are pegged to CPI, then there is considerable scope for expanding the workforce to deal with learner-educator ratio pressures. This window of opportunity would allow for the educator workforce to grow gradually, reaching an additional 57,000 educators in 2030. This is almost sufficient to return the LE ratio to more desirable historical levels. Around a quarter of this window of opportunity comes about because of a declining average age, the so-called teacher demographic dividend (as quantified above), while three-quarters comes about by simply having CPI-linked cost-of-living adjustments. Obviously, the opportunities are linked to GDP growth assumptions. **Spending on educators, and the schooling system as a whole, relative to GDP, needs to become a central feature of the education policy debates**.

The report ends with a section outlining refinements to the model which would be useful. Modelling explicitly **which joiners are newly graduated teachers**, and which are not, should be possible, but requires further analysis of recent patterns in the payroll data. A further useful enhancement would be to allow **pre-qualified joiners** to enter *below* the official entry-level salary notch for qualified teachers. In 2021, additions to the stock of qualified educators within the public system were 93% due to entering joiners, but 7% due to teachers already in the system who were completing their qualifications while on the job, and obtained the qualification in 2021. The phenomenon of pre-qualified teachers has been on the decline, but this could rise in future to address under-supply problems. The phenomenon obviously impacts on the average unit cost.

There is a strong interest in breakdowns of teacher demand **by province and specialisation in terms of language, non-language subject and phase**. The specialisation breakdown needs better input data on how teachers with different specialisations differ in their age structure, if the modelling is to move beyond the rudimentary modelling of specialisations of the earlier DHET report. It seems at least some of the required data will become available. However, what seems important is to run the model as it now stands with data from subsets of the educator workforce – specific provinces or a specific level (primary or secondary). This would assist in providing a sense of the specialisations most in need, including province-specific language needs.

Contents

1 Introduction

This report explains projections of numbers of educators by age, and their average unit costs, up to 2071. The work falls within a larger project known as the Teacher Demographic Dividend project, begun in 2021. How the projections were calculated and are presented is informed by the aims of the project, which is largely to identify risks and opportunities associated with the movement of a large age peak of educators through retirement in around 2030. While this phenomenon will result in a peaking of retirements around 2030, an increase in retirements as the system moves towards 2030 has already commenced.

Workstream 1 of the project deals is headed 'Developing a demand and supply model'. Research questions relating to this workstream appearing in the original project plan are as follows:

- Questions relating to **past work**: What can be learnt from past attempts at modelling teacher supply and demand in South Africa? For instance, how exactly was the severe under-supply crisis anticipated to arise out of the HIV/AIDS pandemic avoided (Crouch, 2001)?

- Questions relating to **modelling methods**: What format should a model take in order for it to be both sufficiently comprehensive and sufficiently accessible and adaptable? What variations with respect to salary scales, promotions, employee benefits, non-retirement attrition, future learner enrolments and the utilisation of teacher time should be considered? What are the impacts of earlier/later retirement ages? (For example the increase in early retirements during COVID-19).

- Questions relating to **future costs**: What might be the financial and educational implications or likely scenarios for tackling the teacher supply issues? What are the key assumptions driving likely declines in the projected wage bill? What are the short, medium and long-term implications of an immediate rise in the number of semi-qualified teachers expected to complete their qualifications while working (this being a solution already implemented in more remote parts of the schooling system)?

- Questions relating to **educators not paid by the state**: What do current trends suggest will be the role of independent schools, and privately paid teachers in public schools (the so-called 'SGB teachers'), in the coming years?

The project, run from Stellenbosch University, involves stakeholders from inside and outside government. The work presented in the current report relies strongly on collaboration with the national Department of Basic Education (DBE).

This is a first substantive version of the report, intended for public release, the focus being on elements of the above four over-arching questions which were identified by various stakeholders as being urgent for the project as a whole, as well as other priority matters not referred to in the above four bullets.

Methodological issues of relevance to the current analysis arising from previous modelling work are discussed in section 2. Section 3 discusses the design of the model used for the current report. Section 4 discusses the input data used to generate the projections, and a retrospective validation done on the model. Section 5 discusses the headcounts and section 6 the costs emerging from the various scenarios, and their implications for policy, including policy on how many teacher graduates universities need to produce. Section 6.3 explores the meaning and magnitude of the 'demographic dividend'.

A point on terminology should be made. This report refers to 'projections' and not 'forecasts'. The two are closely related, though forecasts are generally understood as pictures of the *likely* future, based on historical trends and what is known about changes to impact factors in future. Projections, on the other hand, may also include *unlikely* future scenarios, driven by relatively unlikely factors, where the aim is to demonstrate the design of the projection model, or point out risks or opportunities[1].

2 Methodological issues in past work

2.1 Projected future teachers and their costs

Given that a 2012 UNICEF-funded model is adapted for the new modelling of this report, and given the direct relevance of modelling behind a 2020 Department of Higher Education and Training (DHET) report, the UNICEF-funded and DHET work is discussed in considerable detail in section 3. This section thus provides a short overview of other work, including work using South African data.

The review of past work is in part informed by the need to find ways of undertaking three tasks. Firstly, the current South African context, with its age peak approaching retirement, requires careful modelling by single age. Secondly, modelling educator unit costs in a context of rapidly changing age profiles and the sensitivity of unit costs to age, is necessary. Thirdly, as this report will make clear, there is considerable 'churning' into and out of the publicly paid workforce, meaning entry and exiting is often not a once-in-lifetime event. How to model this optimally is a key issue.

Williams (1979) provides generic guidance in a report published by UNESCO's International Institute for Educational Planning (IIEP). Unfortunately, nothing more recent of its kind seems to exist. An update could have provided guidance on how to use technologies such as modern spreadsheet applications, particularly Excel, to do the work. While Williams (1979) provides a useful set of concepts and equations, the three critical tasks of modelling by age, unit costs and churning are not covered in any depth.

There are few teacher supply and demand models used by education authorities which are available in the public domain. The 2020 DHET report makes reference to a few other reports,

[1] See for instance 'Financial forecasts and projections' of the American Institute of Certified Public Accountants (AICPA) at https://us.aicpa.org/content/dam/aicpa/research/standards/auditattest/downloadabledocuments/at-00301.pdf.

from beyond South Africa, which offer the results of some modelling. In preparing the current report, a search of other existing models was undertaken. Only one model with the tools required to implement it was found: the model of the Department for Education in England[2].

The England model is able to make use of considerable background data on why educators leave the system and who is joining the system. This allows the model, for instance, to accommodate shifts in the willingness to take up early retirement.

The background information on joiners in the England model is rich, and clearly beneficial for the modelling. Joiners are broken down into three groups. Firstly, there are joiners who qualified as teachers in the previous year. Secondly, there are 're-entrants' who have worked in the system in the past. These are people which drive the phenomenon of churning. It is not made explicit how far back the historical data needed for this goes, but it seems to be extensive. Thirdly, there are all other joiners, essentially educators who have not recently qualified, and who did not work in the system previously. This could include immigrant teachers, or teachers who qualified some time back but worked in the private sector. Obtaining this background information on joiners assumes good data availability, and relatively easy processes for merging databases. For example, data on who qualifies as a teacher in a training institution would need to be merged with the employed teacher database. In South Africa, achieving this level of data integration would require considerable investments, and a closer technical engagement between the DBE and DHET.

Gender breakdowns are used throughout the England modelling, which is valuable for a number of reasons. For instance, it is clear that men and woman have displayed different attrition rates in the past.

In one respect, the England model is limited. It is not designed to examine the effect of major demographic transitions of the kind seen currently in South Africa, with its bulge of older teachers retiring over the coming decade. The England model uses five-year age bins, not single ages, and assumes that joiners always display the same age breakdown as the existing workforce. Moreover, the England model does not deal with unit costs.

Crouch (2001) specified a teacher supply and demand model, in large part as a response to the educator morbidity and mortality expected to arise from the HIV/AIDS pandemic. This model is relatively simple but comprehensive, using just high-level aggregates and inputs. It does not break down educators by age, and does not deal with unit costs or churning. Ramrathan (2003) focusses on the numbers of one South African province and underscores how sensitive models such as that presented by Crouch (2001) are to the assumptions made.

2.2 Lessons from projections in the health sector

It appears that globally more rigorous work on workforce supply and demand has occurred in the health sector, compared to the schooling sector. The health equivalent of education's Williams (1979) is Hall and Mejía (1978), published by the World Health Organization. Indeed, the 1970s saw a keen interest in the production of planning manuals in several public sectors. More recently, Roberfroid *et al* (2009) have reviewed existing models projecting the workforce in the health sector across several developed countries. They apply retrospective analysis to existing models to test their reliability. This involves running the models using historical data and comparing model outcomes to what actually occurred. Retrospective analysis is clearly an important way of examining how reliable a model is, and is used in section 4 below.

Willis *et al* (2018) provide an account of work done by government in England to plan for the health sector workforce through the use of system dynamics. System dynamics is an analytical approach that assists in understanding systems, for instance natural ecosystems, industrial processes or the labour market. Typically, system dynamics is done using specialised software which organises the system in terms of stocks and flows over time. The software pays special attention to graphical representation of the system and its dynamics. As is clear from Willis *et al* (2018), a fully-fledged systems dynamic approach entails considerable investment in human

[2] England: Department for Education, 2015.

and institutional capacity, as the method easily leads to high levels of complexity and may require years of work by a team of skilled analysts. However, it seems possible to learn from system dynamics while conducting more rudimentary modelling. In many ways, this is what the modelling presented in this work does.

3 Model design

3.1 The original UNICEF-funded model and how it was adapted

What is referred to here as the UNICEF-funded model is an Excel tool that formed part of a broad UNICEF-funded study examining the financing of schooling in South Africa. The Excel tool is described in one of the reports emerging from the study (Gustafsson, 2012b).

The UNICEF-funded model was in many ways appropriate for the needs reflected in the questions put forward in section 1 above. In particular, this model modelled the future educator workforce by single age, and produced future unit costs. Yet in some respects the model needed adaptation to meet the needs of the current project. Moreover, repeated use of the model with new data revealed aspects of the coding which had to be corrected[3] or adapted to avoid run-time errors.

The original UNICEF-funded model allowed the user to insert basic enrolment drivers. These elements were removed as they were too basic to add much value to the model. Instead, the model now requires the user to insert future educator totals needed. Whatever drives that, must be calculated outside the model. This means that with respect to the modelling of demand, the model focusses on the demand for *joiners* per year, and does not model the demand for the *total stock of educators* in a future year. As will be seen in section 5.1 below, how future educator numbers are calculated, outside the model, is relatively straightforward. It could be made far more complex if comprehensive modelling of enrolments were done. This is complex largely because of grade repetition. The educator projection would benefit from such work, but full-scale enrolment modelling is generally done as a separate standalone model[4].

Returning to the UNICEF-funded model, certain reporting features that allowed for unit costs to be reported against GDP per capita were removed, in part because they were inflexible. Future costs relative to GDP are reported on in the current report, but the calculations for this occurred outside the model. In enhancing the model for the current analysis, it seemed optimal to invest in those aspects of the model which are, firstly, complex and clearly require programming and, secondly, which address key questions of interest.

Figure 1 below describes the workings of the model. Illustrative values are those that would apply for the scenario 'Population + Grade 12' described in section 5. This means that the time period covered is 2021 to 2071. This report provides a summary of the model's design. Further details would be reflected in the first sheet of the Excel file, and the VBA code, which is freely accessible in the Excel file[5].

The model requires two major input tables, found in the Excel sheets *Educators* and *Notches* – the former is represented in the top-right of Figure 1, the latter near the bottom-right. *Educators* has a row for every combination of single age, educator type, and notch. For each row, the number of educators with these characteristics in the base year, 2021 in this case, appears. Ages are in the range 21 to 65. Educator type is 1 for a level 1 teacher, and 0 for a senior educator above this level. For the 2021 to 2071 projections, there are 491 notches. The table *Notches* has a row for every notch, with the notch code and 2021 monetary notch value in each row.

[3] Some corrections related to the way rounding to the closest integer occurred. Fixes in this regard were necessary to ensure that final integer values appearing in the output tables tallied as they should.
[4] See Department of Basic Education (2017) for past work on modelling future enrolments.
[5] Reference is to the Excel file *TSD model 2022 12 07 2.2 To 2071.xlsm*. The *Developer* tab must be visible, which in turns leads to the *Visual Basic* button.

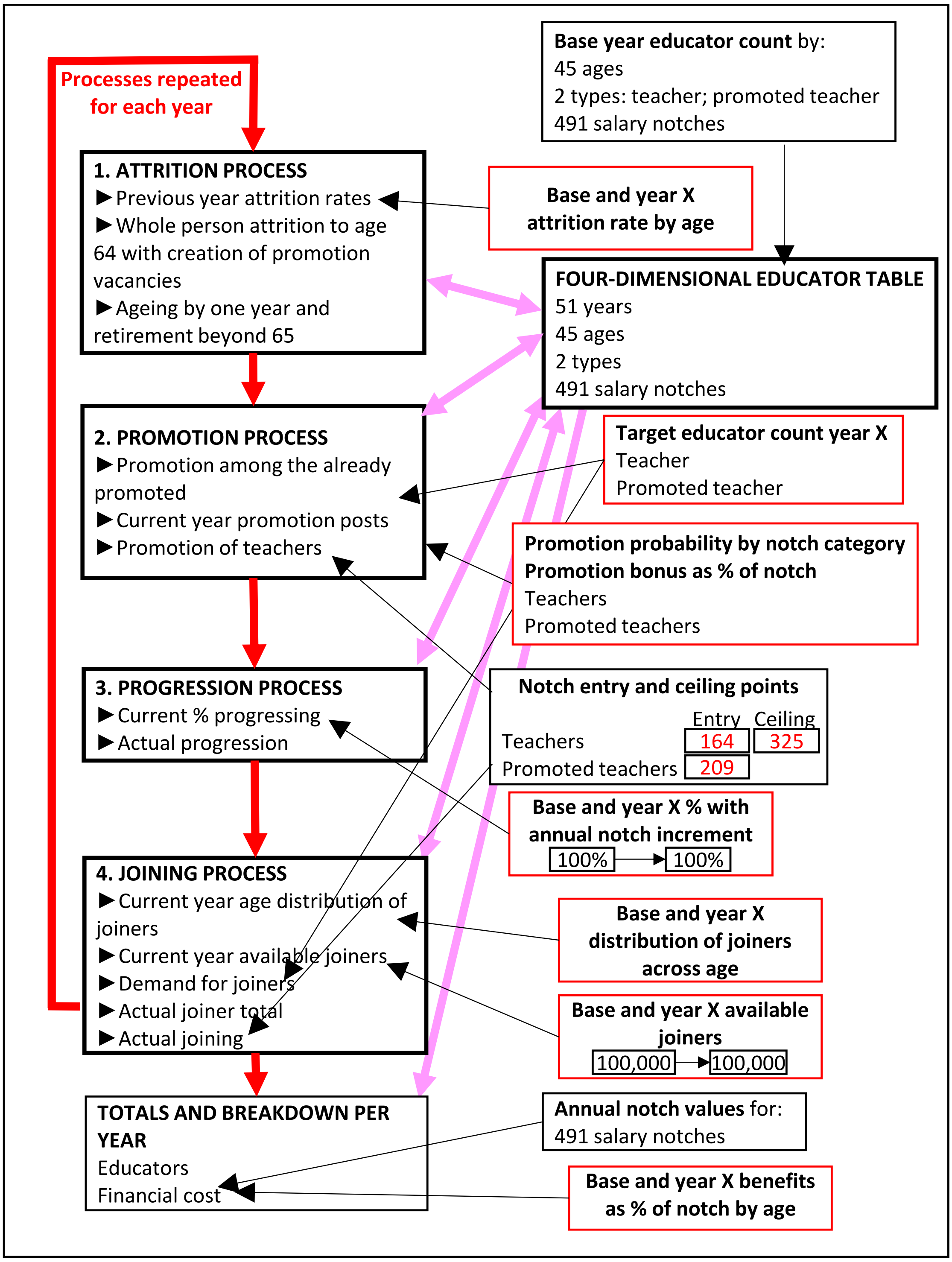
Beyond the base year, 2021, there are 50 future years for which projected values are calculated. There are four processes implemented for each future year: attrition; promotion; progression; and joining. The promotion and progression processes affect the unit costs in the model, but not the distribution of all educators across age, or the total number of educators in each of the two educator categories.

The **attrition process** uses year- and age-specific attrition rates. The source for this is a small table in first sheet of the tool (*Main*) giving the attrition rate per age for the base year, but also for some future year. Attrition rates will change linearly towards this future year, and beyond this will remain constant. A key element of the model is a four-dimensional educator table, the dimensions being age, educator type, notch and year. This table, which exists in the computer's memory only, is continuously updated while projections are being calculated. For the year 2022, the four-dimensional table is populated with the 2021 data from *Educators*. Educators aged 21 to 64 are moved to 2022 in the four-dimensional table, with age being incremented by one, and with a subtraction for leavers, in line with the age-specific attrition rates. Rounding occurs, so that no fractions of educators ever appear in the four-dimensional table. Educators aged 65 in 2021 are all assumed to retire, and not be present in 2022.

In the **promotion process**, two rounds of promotion occur. In the first round, promoted senior educators are moved into higher notches. In the second round, level 1 teachers are promoted to senior educators. The promotion process was easily the most complex of the four processes in the original UNICEF-funded model, yet it was the most problematic process insofar as its results did not seem reliable. The process was thus completely redesigned, and anchored more firmly in historical patterns of promotion. The number of senior educators who must move up to a higher notch, and the extent of their notch gains, are driven by two columns of data, each with 101 values. The minimum and maximum notch values in the sheet *Notches* are taken, and between these values 99 values are selected such that the gap between any two adjacent Rand values is the same. The 99 values are unlikely to match notch values exactly. The reason for using the 101 values and not the 491 notch values is to avoid having the model design dependent on a specific notch structure. In the first column of input values, the probability of being promoted from one senior position to another is given. This is based on historical data (see section 6.1). The second column gives the 'promotion bonus', or the percentage gain in the notch value expected for someone at that particular original notch level. The coding in the model finds a correspondence between the 99 values and actual notch values. This correspondence is then used to place promoted senior educators in new notches. The destination notch is the one that will produce a notch gain which is as close as possible to the 'promotion bonus' specified in the input data.

In the second round of promotions, level 1 teachers are promoted into senior positions. The first step here is to calculate how many promotion posts are available in the current year, as the model user can allow the total number of senior educators to vary over time. The user selects a future year for setting targets, and then specifies the number of teachers and promoted teachers for this future year. Targets per year up to the specified year are set linearly. The teacher-to-senior promotion process has its own two 101-row columns of input values using the same logic as that applicable to the senior-to-senior promotions. Here, however, if the inputted 'percentage bonus' is not sufficient to take the teacher to the minimum notch for senior educators, which is notch 209, then the teacher is automatically taken to notch 209.

Figure 1: Design of the Excel model



In the **progression process**, educators move up salary notches in line with parameters set by the user. In nearly all the scenarios discussed in this report, the parameters are simple: 100% of educators move up three 0.5% notches every year, producing an overall increment of around 1.5%, unless they have reached the maximum notches for the two types of educators: notches 325 and 491. The exception is a scenario where the impact of having a 1.0% annual notch progression was tested.

In the **joining process**, the first step is to establish the distribution across ages of joiners for the specific year. This is based on user inputs. The number of teachers available to join the system is taken into account as a ceiling for actual joiners. If this number is set very high, for instance at 100,000, then the supply constraint is effectively removed. Next the number of joiners needed is calculated. With no changes in the total number of educators, the number of joiners needed would be the same as the number of leavers. Joiners are always level 1 teachers, never promoted teachers. Joiners are brought into the four-dimensional table, always at the official entry level notch for teachers, which is notch 164 – a 2018 policy change makes it realistic to place even older joiners, which are likely to be re-joiners, at the teacher entry level notch (see section 6.1). Importantly, the model in its current form does not allow under-qualified teachers to join at lower notches, though under-qualified teachers can exist in the base year.

The four processes described thus far are run 50 times, for 50 years. Thereafter, headcount and financial statistics which have been stored by the model are deposited into output tables in the Excel file broken down into three groups: statistics by year, age and notch. Financial statistics are influenced by user parameters around annual cost-of-living adjustments and the percentage of the notch value, or basic salary, that is accounted for by benefits. This latter percentage is different for each age. If benefits and cost-of-living adjustments are set at zero, the model will calculate constant monetary values that represent just the basic salary.

In the sheet *Log* of the Excel file details such as the numbers of educators moved in and out of the system, across notches, at different points in the projection processes, are recorded.

In the rest of this report, the model described above is referred to as simply 'the Excel model', and not the UNICEF-funded model, in part because the changes done to the original UNICEF-funded model change it fairly substantially.

3.2 How the new model differs from the DHET 2020 calculations

There are a few key differences between the model described in section 3.1 and that used for a 2020 report to the Department of Higher Education and Training (DHET)[6]. The latter is much simpler than the model used here, largely as it does not disaggregate anything by age. This means that a single attrition rate is used for each year, though this is disaggregated by the primary and secondary levels. Moreover, it is not possible to see the age distribution of joiners, meaning it is not possible to see which joiners are more likely to be newly graduated teachers. The rise in the number of required joiners referred to in the DHET report is therefore not strictly the number of new graduates required, as some could come from other sources, including a reserve stock of teachers among older adults who have not taught for some years, or have been teaching in the private sector, or come from abroad.

The DHET model uses future enrolments and a learner-educator (LE) ratio as a driver of the future total demand for teachers. But it does this in a very basic manner. The new Excel model, on the other hand, assumes that this work occurs outside of the model, and therefore requires a future total number of teachers to be entered.

A key advantage of the DHET model is that it breaks the future total demand and joiners down by home language for Foundation Phase teachers and by subject specialisation for grades 10 to 12. But the approach is basic, as it assumes that annual leavers and the total pool of teachers have the same distribution of specialisations. For instance, the fact that mathematics teachers may be older or younger than average is not taken into account. Joiners disaggregated by specialisation is important for universities that train teachers. This could be fairly easily incorporated into the new model in a very basic manner, though a more refined age-specific approach is likely to be difficult, given how weak the potential input data are on the specialisations of existing individual teachers. Specifically, there is no database from the last ten years or so with all key details for every schools-based educator, including age, what specialisations lie behind the teacher's qualifications, and what subjects and grades are *actually* taught by the teacher. There are currently attempts to pull together provincial data drawing from

[6] Department of Higher Education and Training, 2020.

the SA-SAMS school management system used by over 90% of schools, and this may produce the required database[7].

3.3 Modelling opportunities and risks

The Excel model from which the current report draws, and which currently has some 1000 lines of VBA code, is relatively simple. However, it could become considerably more complex, depending on the level of effort that can be made available, what additional source data become available, and the needs of policymakers. What are some of the opportunities and risks lying ahead?

The opportunities are fairly clear. While the future is inherently unpredictable, modelling the future well can help to reduce some uncertainties, and contribute towards better strategies. The modelling can bring to the fore the strengths and gaps in the existing historical data. Conversations around how to construct a model provides opportunities for learning how a complex system actually works, and can dispel certain myths.

Modelling the future provides opportunities for collaboration across different specialisations. Crookes and De Wit (2014) have argued that there is value in bridging the approaches, and ideologies, of the economists and system dynamics specialists. Economists have traditionally relied on models such as those dealing with a computable general equilibrium (CGE) to understand the future, while systems dynamic specialists (see section 2.2 above) tend not to be economists. Put differently, the insights of economists around how systems have worked in the past could be applied more extensively to the design of models used in system dynamics.

It is worth clarifying how projections based on system dynamics differ from time series analysis techniques often used by economists. Time series is statistical in the sense that it seeks correlations over time, often based on some form of regression. It then uses parameters based on past trends to forecast into the future. Relatively few variables are used, and the thinking is often to subsume details within certain indicators, without attempting to make details explicit. System dynamics, on the other hand, makes many details explicit, through a multitude of stocks and flows. One typical weakness in system dynamics is that as high-level indicator variables are not extensively used, 'invisible' dynamics relating to human behaviour may not be taken into account.

The Excel model used for this report is arguably a basic system dynamics model. The advantage with Excel is that the software is widely available, making it relatively easy for a range of users to adapt the model, especially if some basic VBA skills are learnt. Optimally, however, system dynamics is implemented using software specifically designed for this purpose, such as Vensim. This software tends to be costly – the Vensim software costs around USD 1,200.

Turning to risks, an 'illusion of accuracy' easily arises[8]. Put differently, consumers of the model outputs may not appreciate the difference between *precision* and *accuracy*. Outputs of the Excel model discussed below are precise insofar as they are exact. However, this is illusory insofar as there is considerable uncertainty around the assumptions underlying the modelling. A further illusion is the 'illusion of reduced complexity'. A model will only deal with a limited number of factors, and will often not include political factors, or disruptive factors relating to health crises and natural disasters. The orderliness embodied by the model can lead to the illusion that it is more comprehensive than it in fact is.

A further risk relates to confusing 'detail complexity' with 'dynamic complexity'. An example can illustrate this. It would be relatively easy to break down all the stocks, or 'boxes', in the Excel teacher supply and demand model by gender. This would create more *detail* complexity. But this on its own would not make the model deal properly with gender. For gender to be dealt with

[7] South African School Administration and Management System. The analysis of this data will be released as part of the Teacher Demographic Dividend project.
[8] See for instance Hennesy's short article titled 'From spreadsheets to system dynamics models' at https://thesystemsthinker.com/from-spreadsheets-to-system-dynamics-models.

properly, the way the *flows*, or inter-relationships across stocks, work differently for men and women would need to be taken into account. For instance, differentiated attrition rates and preferences in applying for a promotion would ideally need to be considered. This is the *dynamic* complexity. The mistake should be avoided of bringing in additional complexity only partially, and only in relation to the detail, or stocks.

Making a model more complex obviously has costs in terms of development time, and a loss in transparency. The risk of errors in the model also rises. The 'law of parsimony' when it comes to models states that one should not add complexity to a model if this does not help to answer key questions[9]. It is important to point out to any audience that models are typically not mini-worlds that capture everything in, say, a schooling system. It is not unusual to come across this expectation. Such an understanding would represent an exaggerated view of what can possibly be modelled. Any model must be evaluated relative to a few central questions it is designed to answer.

4 A retrospective validation of the Excel model

Good practice in refining a projection model is to use the model to predict patterns in past years, and then to compare projections to what actually occurred. Through a process explained below, the model produced in 2012 was used with 2011 input data, to produce projected values to 2021. The 2021 figures were then compared to the actual data of 2021 to assess how accurately the model performed the projections.

4.1 2021 input data

The 2021 input data are discussed first, as these are the data that will be used as the point of departure for projections to 2071, and several questions needed to be answered regarding what educators to include and what educators to exclude in the modelling exercise. It was important to ask these questions first with respect to the 2021 data. Thereafter, in section 4.2, the same exclusions are applied to the 2011 data.

The following three tables provide details on excluded educators and breakdowns of the included. The data source is a November 2021 Persal payroll download, November being a month when typically a high proportion of available posts are filled. As shown in Table 1, there were 413,344 educators in the 2021 data, identified through their rank code (codes in the range of 60000 to 69999 indicate educators). From these, 123 educators were excluded as their ages were outside the 21 to 65 range the model is designed to deal with. Three-quarters of these 123 educators were above age 65. The number of excluded 'examination revisers' was 570. These educators all carried a notch value of zero and had no other employment in the basic education system at the time. These employees are not significant in terms of the modelling that is needed. Lastly, 7,182 ECD practitioners were excluded. All these 7,182 educators received spending classified as '0518 -EARLY CHILD DEV PRAC'. The breakdown of the 7,182 by province is provided in Table 2, which illustrates the fact that only some provinces pay ECD practitioners through Persal. Why are ECD practitioners excluded? This exclusion occurs largely because ECD practitioners are currently not required to have a university qualification, and the modelling is to a large degree intended to inform universities to what degree the output of teacher graduates will have to increase in the coming years. Moreover, ECD practitioners are rather different in terms of their cost to the system. The mean cost per month to the employer of the 7,182 practitioners is R8,282, or R99,384 per year. As will be seen below, this is less than a quarter of the cost of other educators.

After the three exclusions, the remaining educators are 405,469. These would include teachers, but also educators in 'promotion posts', in particular posts of schools-based heads of department, deputy principals, principals, and certain more education-focussed officials based in offices.

[9] Batty and Torrens, 2001.

Table 1: Exclusion of non-core educators in 2021

Educators (according to rank) before exclusions	413,344
Exclusions	
Outside 21 to 65 age range	123
Examination revisers with no other employment	570
ECD practitioners	7,182
Educators after exclusions	405,469

Table 2: ECD practitioners excluded by province

	Practitioners excluded
EC	0
FS	1,113
GP	3
KN	5,292
LP	0
MP	2
NC	771
NW	1
WC	0
SA	7,182

Table 3 below provides breakdowns of the 405,469 educators by category relating to their salary notch type. A key task was to provide a notch value *on one notch scale* for the model. 390,727 of the 405,469 educators, so 96% of educators, have a notch on the standard OSD[10] scale, details of which appear in Government Notice 1600 of 2021. There are 432 notches on this standard scale. The average spending column in the table draws from the Persal expenditure file and refers to the average monthly spending per educator in November 2021. The average notch value 'before' is the *annual* salary notch value. This is less than the average spending multiplied by twelve as the notch represents just the basic salary, and not benefits.

Table 3: Details behind the November 2021 educator input data

	Educators aged 21 to 65	Average spending	Average notch before	Average notch after (if different)	Educators below entry notch of 284,238
With standard notch values	390,727	41,922	340,651		25,494
With low 'inclusive' notch values	1,698	89,496	914,115	912,791	
With high 'inclusive' notch values	234	109,825	1,155,981		
With non-OSD notch values	8,095	36,785	343,842	344,101	4,245
With zero notch value	4,715	13,695		153,595	4,713
Sub-total without zero notch	400,754	42,059	343,461	343,621	29,739
Total	405,469	41,730		341,412	34,452

There were 1,932 senior educators carrying notch values appearing in the 'inclusive' OSD category – this is the sum of the 1,698 and 234 in the table. The 'inclusive' scale also appears in the aforementioned policy. The 1,698 refers to educators with an 'inclusive' notch value at or below the maximum value in the standard table, namely 1,066,416 Rand. The 234 figure refers to those with a notch value above this level. For the 1,698, the closest notch value in the standard table was found, and this became the new notch value for each person. This explains why the 'before' and 'after' notch means are slightly different in the second row of Table 3. For the 234 educators, the 'inclusive' notch was retained, and added onto the standard scale, extending this from 432 notches to 491 notches. The additional 59 notches thus added were contiguous notches from the 'inclusive' table.

[10] OSD refers to Occupation Specific Dispensation.

The new notch table used for the model was thus the standard table up to 1,066,416 Rand, with inclusive values added beyond that. The range for the new notch table constructed for the purposes of the model was R125,085 to R1,425,018. The gap between these two values, across the 491 notches, provides a notch-on-notch increment of 0.497%, almost the 0.5% that is widely understood to be the gap between notches. Annual notch progressions for employees involve moving up *three* notches, meaning the progression, without any accompanying cost-of-living adjustment, comes almost exactly to a 1.5% annual increase.

For 8,095 educators with notch values not found in either of the OSD notch scales, the closest notch value in the newly constructed notch table was used. There were 4,715 educators with a zero notch value. 96% of these educators had nature of appointment number 32, which means 'abnormal appointment'. Notch values were imputed for the 4,715, drawing from the coefficients of a regression of notch on total spending per employee, where a non-zero notch value existed[11]. The value in the notch table closest to the imputed notch value was then used.

The final column of Table 3 indicates how many educators had a notch value which was below the entry level notch applicable to newly appointed educators. This entry level is R284,238. That this is the entry level can easily be confirmed by looking at the concentration of joiners between 2020 and 2021 at this notch level. The fact that 34,452 educators should be below this level is important for the modelling and policy discussions. One way of dealing with a future under-supply of teachers is to hire teachers with incomplete qualifications, and to allow them to complete their qualifications while working. The 34,452 seen in the table are likely to be under-qualified educators, and in 2021 they constituted 8% of educators in the system. Indeed, if REQV values are brought into the analysis, 95% of educators with a notch value of R284,238 or more have the minimum for a new and young teacher of REQV 14, while this is true for only 6% of those with a notch value below the entry level[12]. Importantly, the under-qualified are not younger educators, as can be seen in the next table. In fact, the under-qualified are a bit older than the qualified on average. Moreover, the average age of the 34,452 on below-entry notches is about the same as that of other educators.

Table 4: Average age of educators by qualification and notch categories

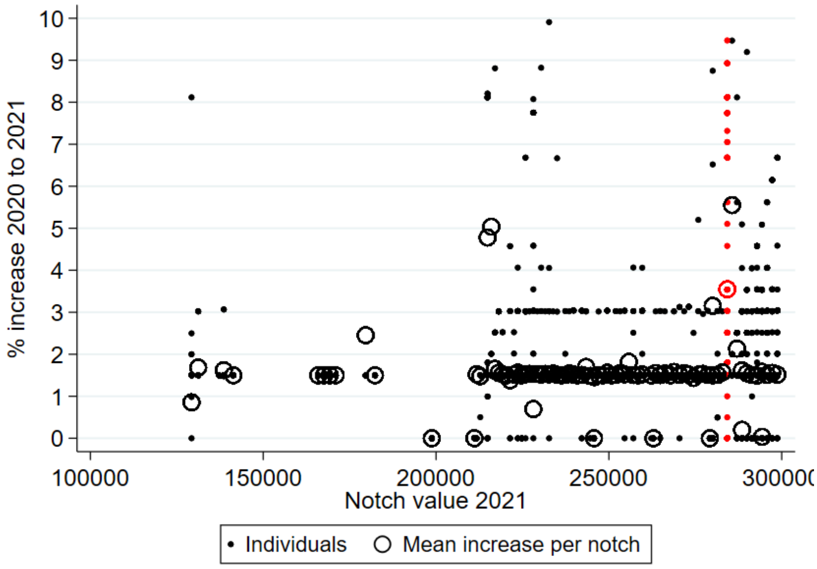
	With notch at least R284,238	With below-entry notch	Overall
REQV 10 to 13	55	47	50
REQV 14 to 17	45	32	45
Overall	45	46	45

Movement up the notches appears to occur without many hurdles or ceilings. In particular, among the around 48,000 educators on the entry level notch in 2021 of R284,238, virtually no-one did not experience notch progression between 2020 and 2021. In fact, the notch progression for the 48,000 or so was *especially high*. The following graph examines this in more depth. The average 2020 to 2021 notch increase experienced by individuals on R284,238, marked in red in the graph, was 3.5%, while that for individuals on other notches was mostly 1.5%. One likely explanation for this is that educators were studying for their full qualifications on the job, and hence moved up to the entry level notch, in many instances experiencing an increase above the regular 1.5%. In fact, if one examines the total expenditure on notch progression for those on a notch no higher than R300,000 in 2021, 55% of this expenditure was on educators who were on notch R284,238 in 2021. The number of educators on notch R284,238 in 2021 who experienced an increase of more than 1.5%, or three notches, is 2,265 and these educators experienced a notch increase of on average 45% (which is beyond the top of Figure 2).

[11] Total spending is what the employer spent in November 2021. The median of this spending value per notch value was calculated, and then notch was regressed on the median values.

[12] REQV stands for Relative Education Qualification Value. To illustrate, REQV 13 is a Matric plus three years of post-Matric training, REQV 14 is a Matric plus four years of post-Matric training, and so on.

Figure 2: Notch increase between 2020 and 2021



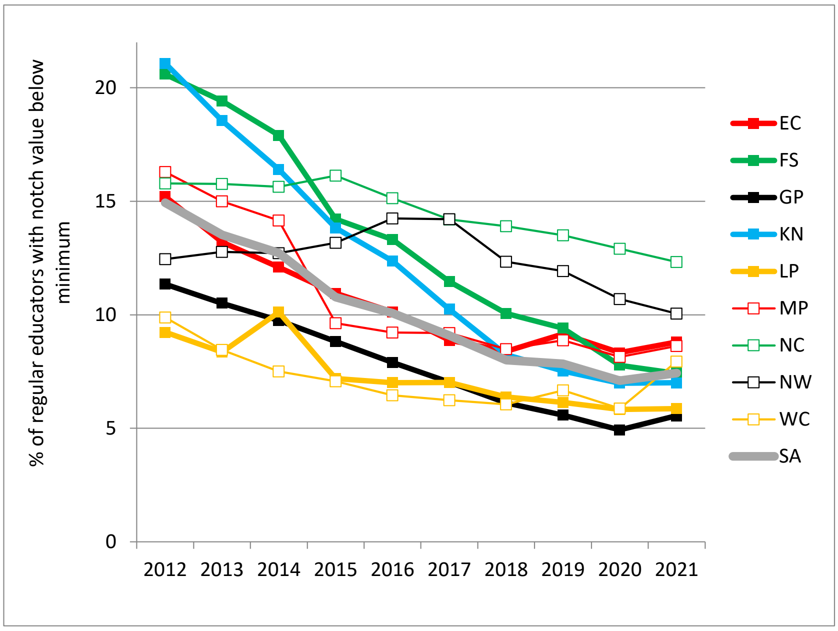
Note: Only data on notches where there were at least 20 individuals on that notch in 2021 were used in generating this graph.

What are the chances that many of the 34,452 on notches below the entry level are ECD practitioners, even though they are not marked as such on Persal[13]? An examination of the total cost to the employer was run to see how many of the 34,452 were paid as little as the ECD practitioners reflected in Table 2, around R8,000 a month. It seemed possible that 414 of the 34,452 were in fact ECD educators. Around half of the 414 had no notch value, and the other half non-OSD notches. 201 were in Western Cape, and 150 in Free State. Judging from the number of *learners* enrolled in Grade R in 2021, one might expect around 21,000 ECD practitioners overall. There are thus around 14,000 practitioners not accounted for in the payroll data – 21,000 minus the 7,000 of Table 2. Against these details, it seems clear that there is no major unaccounted for presence of ECD practitioners in the Persal data, nor is there any substantial risk in assuming that the great majority of the 34,452 on below-entry notches are *not* ECD practitioners.

Figure 3 below illustrates the fact that around 8% of educators nationally were below the entry-level notch in 2021[14], with levels being noticeably higher in North West and Northern Cape. The graph also illustrates that this percentage has declined substantially over time. It was twice as high in 2012. If the analysis is restricted to educators aged 30 or below joining the workforce in that year, the trend is also a downward one. This is important for the modelling and the broader Teacher Demographic Dividend project. The implication is that the entry of under-qualified young teachers, possibly UNISA[15] distance education students with an incomplete qualification, has been on the decline. If this were to increase to deal with an under-supply crisis, then the historical trend would be *reversed.*

[13] Apart from the check using expenditure item referred to above, a check of the rank description was also used. Many educators did have rank descriptions indicating they were ECD practitioners, but they were also clearly ECD practitioners according to the expenditure item.
[14] The 2021 national value in the graph is 7%. The graph is taken from a separate report where a slightly different method was followed.
[15] University of South Africa.

Figure 3: Educators whose notch is below the entry level



A key breakdown of the 405,469 educators used for the model is that between level 1 teachers and senior educators, referred to as 'teachers' and 'non-teachers' in the Excel file. In the model, non-teachers are any educators not classified as teachers according to the rank code of the Persal data. This breakdown, average age and average notch are shown in Table 4.

Table 5: Teachers and non-teachers in the final 2021 data

Category	Employees	Average age	Average notch
Teachers	320,400	43.6	309,389
Non-teachers	85,069	51.6	462,020
Total	405,469	45.3	341,412

4.2 2011 input data

Persal data from October 2011 were processed in the same manner as the November 2021 data. Details on exclusions appear in Table 6 below. One category of educators which had to be excluded in 2011 was college lecturers. In 2021 colleges were no longer a provincial responsibility and hence there were no lecturers paid through provincial departments.

Table 6: Exclusion of non-core educators in 2011

Educators (according to rank) before exclusions	431,909
Exclusions	
Outside 21 to 65 age range	546
Examination revisers with no other employment	666
ECD practitioners	6,822
College lecturers	4,017
Outside 21 to 65 age range	419,858

The 2011 equivalent of the earlier Table 3 is the following table. In 2011 there were far fewer notches, and the gap between notches was around 1.0%. The total number of notches was 257, of which 42 were derived from the 'inclusive' table.

Table 7: Details behind the October 2011 input data

	Educators aged 21 to 65	Average spending	Average notch before	Average notch after (if different)	Educators below entry notch of 162,354
With standard notch values	400,169	22,422	196,709		66,212
With low 'inclusive' notch values	2,138	51,933	531,608	531,007	
With high 'inclusive' notch values	379	62,265	648,705		
With non-OSD notch values	3,362	16,637	111,537	124,695	2,565
With zero notch value	13,810	5,032		77,491	13,587
Sub-total without zero notch	406,048	22,567	198,189	198,294	68,777
Total	419,858	21,990		194,321	82,364

The breakdown across the two levels of educators considered in the model is given below.

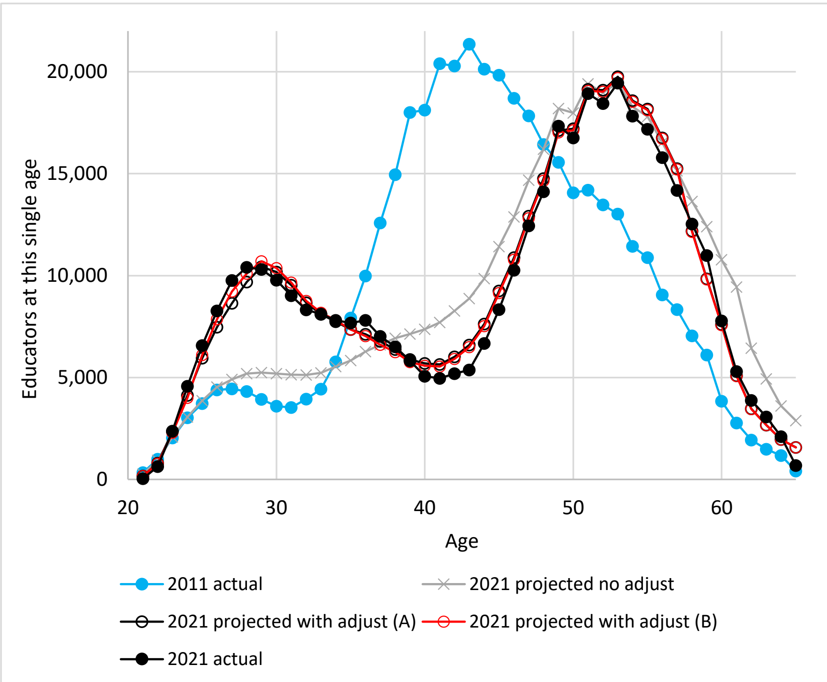
Table 8: Teachers and non-teachers in the final 2011 data

Category	Employees	Average age
Teachers	323,631	43.2
Non-teachers	96,227	48.5
Total	419,858	44.4

4.3 A retrospective 2011 to 2021 projection

Figure 4 below illustrates the actual age distributions of educators in 2011 and 2021. Clearly, between the two years the age peak had shifted to the right, from age 43 to 54. The 2021 actual curve points to a few obvious realities, assuming the maximum age for employed educators, or the maximum retirement age, remains 65. By 2030, at least 19% of the existing workforce will have left, as they are age 56 or older in 2021. And a whole 42% of the workforce will have aged beyond 65 in 2035 and would therefore have left the workforce.

Figure 4: Educators by age in 2011 and 2021



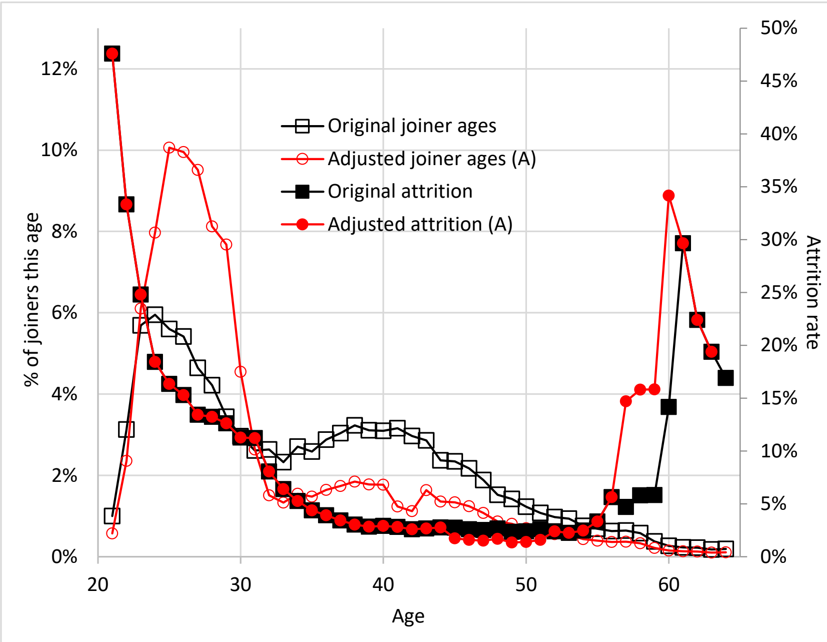
Original age-specific input values for the attrition rate and joiner age distribution calculated over a decade ago were inserted into the model. The base year was set at 2011, and outputs for the year 2021 were requested through the facility in the model that allows interim years to be selected. The result was the 2021 age distribution referred to as '2021 projected no adjust' in

Figure 4. Clearly this age distribution deviates considerably from the actual 2021 distribution. The 2021 projection displays too few educators below age 38, and too many above that age, though the projected peak at age 53 matches reality almost perfectly.

For ‘2021 projected no adjust’ future targets for the joining and attrition inputs were set at the level of the base year, meaning attrition and joiner age distribution patterns were assumed not to change. The total number of educators was set to increase linearly from 419,859 to 405,469. Lastly, no supply constraint was assumed: there would always be enough joiners to meet the demand.

The attrition and joiner inputs used for the initial retrospective are illustrated by black curves in Figure 5 (and repeated in Figure 6). These inputs are based on an analysis of the 2010 and 2011 Persal data. The analysis pointed to high levels of attrition below around age 35 and age 60 and above. Between these two ages around 3% of educators left between 2010 and 2011. The joiner analysis revealed two peaks of joiners: at age 24 and around age 40. Clearly, these patterns were not successful at reproducing the actual 2021 age distribution, something which can be seen from Figure 4.

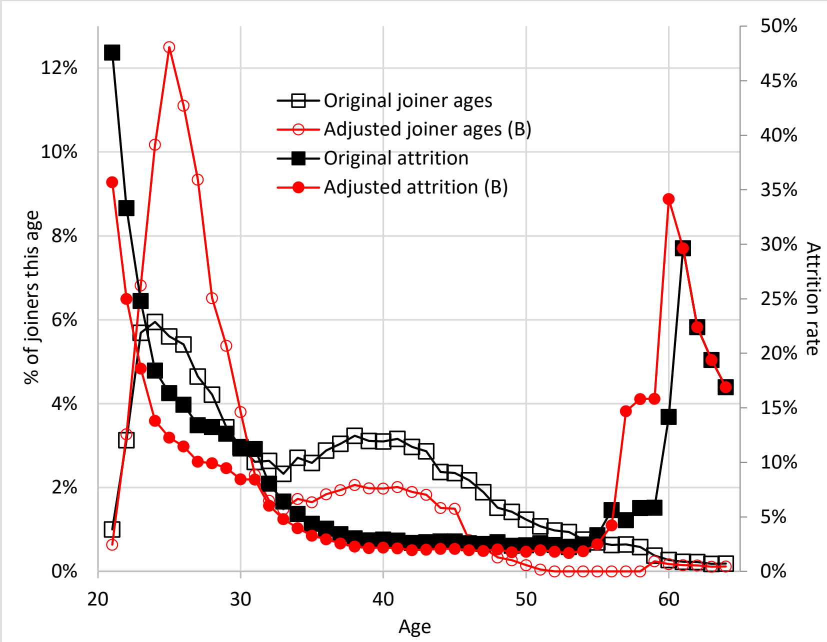
Figure 5: Attrition and joiner inputs for retrospective



Adjusting both the attrition and joiner inputs in a manual trial-and-error manner permitted the actual 2021 age distribution to be reproduced rather well – see ‘2021 projected with adjust’ A and B in Figure 4. The important thing to note, however, is that *different* sets of attrition and joiner patterns were able to produce roughly similar and accurate age distributions. Two sets of attrition and joiner values underlie A and B: A appears in Figure 5 above and B in Figure 6 below.

With regard to attrition, adjustment A is closer to the original patterns than adjustment B. The key differences between the original patterns and adjustment A are (1) that attrition had to be adjusted upward for ages 57 to 60, in order to reduce the excess of older educators seen in ‘2021 projected no adjust’ and (2) that the proportion of joiners who are age 30 and below had to be increased. Note that because attrition was raised, the overall *number* of joiners would also increase.

Figure 6: Attrition and joiner inputs for low-attrition retrospective



Attrition rates are both politically sensitive and easily confusing, because of the phenomenon of churning, whereby educators leave the system and then return. If just two years of payroll data are used, attrition rates appear relatively high. The attrition rates shown in Figure 5, which are based on an analysis of 2010 and 2011 data, produce an overall attrition for ages 21 to 64 of 4.6% – in terms of the model this would be non-retirement attrition, as all retirement is assumed to occur at age 65 (though high 'pre-retirement' attrition can be simulated at the ages just below 65, effectively producing early retirement)[16].

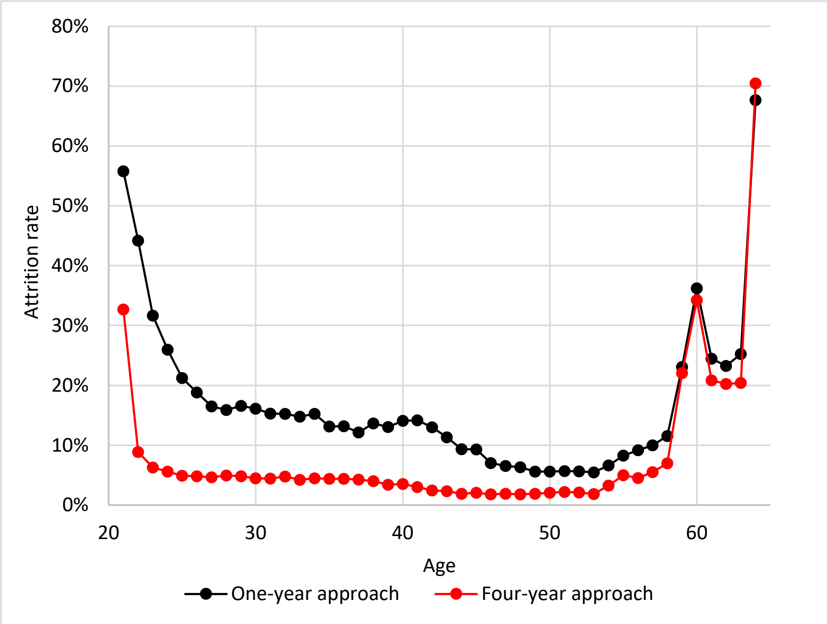
An attrition rate of 4.6% can appear worryingly high, and could suggest that a high proportion of teachers are unhappy about their careers. However, what should be taken into account is that the attrition rate more than halves if four years of data are considered. What this means is that if a leaver is considered someone who is present in a year, but then absent in each of the following three years, then attrition emerges as lower. The conceptual problem is that many think of the attrition rate as reflecting the number of educators who are lost to the system each year. The reality is that many are not lost, as they may return a couple of years later. This is the phenomenon of churning.

Figure 7 below illustrates how different using two years of data, in this case 2020 and 2021, versus using four years of data, 2018 to 2021, is. The one-year approach seen in the graph translates to 12.2% attrition rates for ages 21 to 64, while the figure for the four-year approach is 5.5%. The former is more than twice the latter. The abovementioned 4.6% is much lower than the 12.2%, which points to the fact that attrition has risen over time in the context of far more educators in their late fifties and sixties – see Figure 4 – for whom attrition rates are high. Importantly, the gap between the one-year and four-year approaches in Figure 7 is larger for educators below around age 43. These educators are far more likely to 'churn'. This in turn is linked to the fact that younger teachers are more likely not to have obtained permanent tenure

[16] There are two key reasons why actual retirement is not dealt with in the current report. Firstly, retirement details are captured in separate Persal files, and not those merged and normalised for the current analysis. A preliminary analysis of these separate files revealed that the descriptors of retirement are complex, and not that easy to interpret. The second reason is that for the purposes of the current report, it does not matter whether, say, an educator aged 60 leaves the system due to retirement, death or ordinary resignation. The effect on the system is essentially the same. The term 'non-retirement attrition' here should be understood in terms of the model, in other words it means attrition of anyone who is not aged 65.

yet and to be employed on a temporary basis. The percentage of educators employed on a temporary basis has been around 12% since at least 2017[17].

Figure 7: Different attrition rates for 2021



The question is what attrition rate to use when modelling the demand for joiners. The high two-year attrition rates are clearly deceptive insofar as they create the impression that the system is losing more educators than is actually the case. A 2009 DBE report that looks into the matter argues as follows: 'Educator demand figures that are used for planning and in the policy debates should not be calculated on just two years of data, as this exaggerates the extent of the under-supply of new graduates'[18]. Put differently, the higher attrition rate resulting from a two-year approach exaggerates the problem of younger teachers leaving the system[19].

Despite the deceptiveness of two-year attrition rates, such attrition rates will be used for the modelling because they reflect what is actually happening across two years. Attrition rates using a longer series of data are difficult to apply conceptually. This is in part because the number of years of data chosen is fairly arbitrary. There is nothing special about a series of four years of data. A series of three, five or six years would also assist in controlling for churning. A cleaner approach for the work that follows seems to be to use the two-year attrition rates, *but also joiner statistics based on two years of data.* Attrition and joiner inputs need to be aligned. The approach would then involve translating *outside the model* joiner numbers to the demand for newly qualified teachers, based on recent trends trends seen in the payroll data. This indirect approach is necessary because, unlike in England (see section 2.1), we do not have easy availability of student-level records of who has graduated when, something captured in DHET's HEMIS[20] system. How joiner numbers can be translated to the demand for new graduates is explained in section 5.3 below.

Returning to the retrospective analysis, in adjustment B the attrition rates for ages 56 and below were cut by 25%. Attrition rates for ages 57 to 60 were as for adjustment A. This produced an

[17] Department of Basic Education, 2022a: 7.
[18] Department of Education, 2009.
[19] An earlier teacher supply and demand study by Centre for Development and Enterprise (CDE) concluded that high attrition rates, or a 'leaky bucket' syndrome, was a central problem in the schooling system (Centre for Development and Enterprise, 2015; Simkins, 2015). It has been argued that the CDE's conclusion is in part driven by an under-estimation of levels of churning, and that if alternative attrition rates are used, South Africa's attrition rates do not emerge as high in an international comparison – see Department of Basic Education (2015).
[20] Higher Education Management Information System.

overall non-retirement attrition rate for adjustment B of 4.4%. As one might expect, adjustment A with its elevated attrition produces more joiners overall than adjustment B, the average annual joiner figures for 2012 to 2021 being 25,080 and 22,096 respectively, a difference of 14%. If the focus is only on joiners aged 30 and below, the figures are 16,774 and 15,369, a difference of 9%. For joiners *above* age 30, the difference is a relatively large 23%, with more joiners in adjustment A. It should be remembered that there is no supply constraint in the modelling as run here, so enough joiners to reach the annual total educators are always available.

Despite a spike at age 25 in the *proportion* of joiners in adjustment B (Figure 6), the proportion of teachers of ages 21 to 30 are similar across the two adjustment scenarios: 70% in adjustment B against 67% in adjustment A.

The key thing emphasised by adjustment B is that that same future age distributions in the workforce can be reached with rather different attrition rates, as long as joiner age inputs are adjusted. For instance, while adjustment A sees a few joiners aged 48 to 53, in adjustment B there are no joiners in these ages. This can be thought of as the fact that in adjustment B the effects of churning are removed, while in adjustment A this effect is reflected.

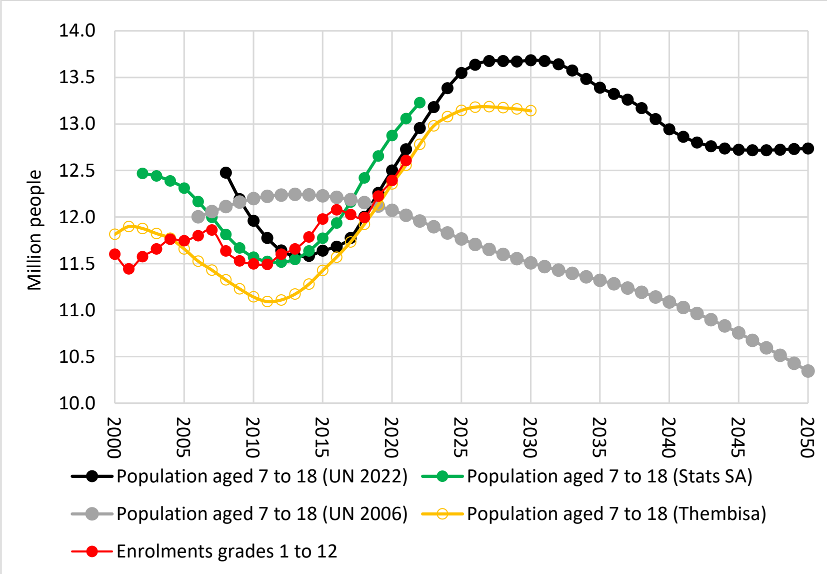
5 Headcount projections beyond 2021

5.1 Child population, enrolment and LE ratio assumptions

The expected future size of the twelve age cohorts corresponding to grades 1 to 12 is illustrated in Figure 8 below. Clearly, expectations have changed dramatically over time. The 2006 United Nations Population Division projections foresaw a decline in the school-age population, specifically the population aged 7 to 18, of around half a million between 2020 and 2030. However, 2022 UN projections point to an *increase* of just over a million over the same period. It is the earlier expectation of a decline which underpins the National Development Plan's concept of a 'demographic dividend, in the sense of a freeing up of resources arising out of having fewer children to care for. Clearly, the number of children is increasing. The increase in the school-age population between 2021 and 2030 comes to 7.5%, using the UN projections of World Population Prospects 2022. The earlier 2019 World Population Prospects produced a lower increase of 5.6%. It is this 5.6% increase which informs the teacher demand scenarios presented in this report, as the 2022 WPP data were brought into the analysis after the teacher demand scenarios had been run. Insofar as the more recent WPP projections are correct, they would result in educator demand in the growth scenarios presented below being slightly under-estimated.

Two patterns relating to the UN projections are noteworthy. Firstly, there is an expected peak in the school-age population in around 2028, after which this population declines somewhat. Secondly, actual grades 1 to 12 enrolments have, at least since 2007, displayed trends which are consistent with the UN population trend. Figure 8 thus suggests that enrolments can be expected to increase substantially to 2030, even without improving levels of participation, or 'survival' to particular grades.

Figure 8: Projections for school-age population



Sources: The source for population is the World Population Prospects of 2006 and 2022 of the United Nations, available through https://population.un.org. For projections, the UN's 'medium variant' was used. For Stats SA, values in the 2022 MYPE were used. For the UN 2022 series figures for ages 7 to 18 were derived using the UN data and Stats SA's Sprague tool to calculate single age values, and a simple linear trend to derive years between every fifth year of the UN data. Stats SA's Sprague tool was last released online together with the 2016 Mid-Year Population Estimates files. The source for the enrolment values is published reports of the national education department. These values include both public and independent ordinary schools. Thembisa projections were obtained from the Thembisa website (https://www.thembisa.org) in October 2022, and were produced in 2022.

Enrolments over school-age population in 2021, using values from Figure 8, come to 96%. This is high, if one considers that only around 78% of youths have reached Grade 12 in recent years[21]. The explanation lies partly in grade repetition[22]. Repetition, meaning children take specific grades more than once, pushes up participation ratios such as the 96%.

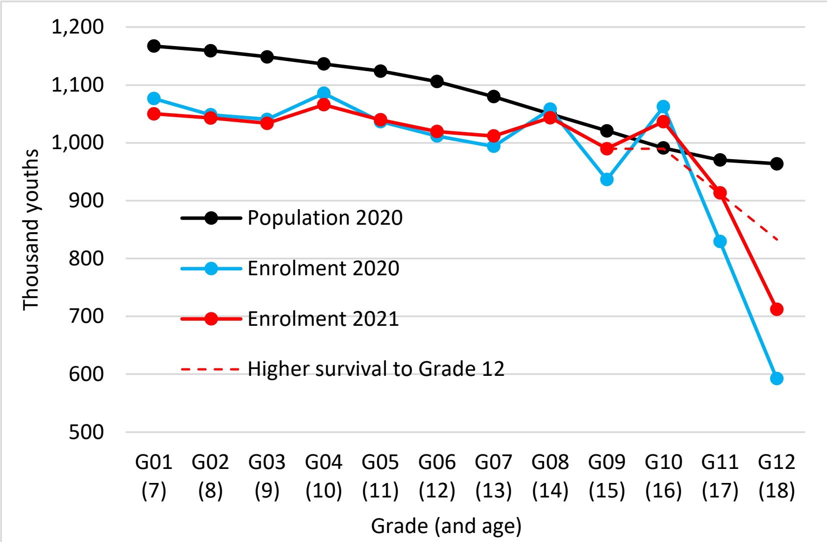
Stats SA population estimates follow a trajectory which largely agrees with the UN trajectory in Figure 8. Projections produced by the Thembisa project in April 2022 also point to large increases – here the 2021 to 2030 increase in the school-age population is 4.7%. However, this increase is much smaller than the 7.5% seen in the World Population Prospects 2022 data. This fact, and the fact that the Thembisa projections needed no Sprague disaggregation as values were already in single ages, should caution against uncritical acceptance of the higher 7.5% increase.

Figure 9 below provides a somewhat crude picture of survival to Grade 12 in the public schooling system. There was a dramatic increase in Grade 12 enrolments in 2021, linked to the COVID-19 pandemic. If the 2021 situation is used as a point of departure, and if beyond that year public Grade 12 enrolment as a percentage of the age 18 population is assumed to increase by 1.4 percentage points each year, the result is a percentage of 84% by 2030. The annual increase of 1.4 percentage points a year is what has actually been seen in the period 2012 to 2020. The 84% is thus informed by recent trends, and is roughly in line with government targets[23]. As can be seen in Figure 9, the alternative enrolment scenario, 'Higher survival to Grade 12', includes some savings insofar as Grade 11 enrolment is expected to decline slightly

[21] This is a grand total of 750,478 Grade 12 learners for 2021 published through the DBE's *School Realities*, divided by 964,000 eighteen-year-olds in 2020 based on the UN data behind Figure 8.
[22] A further reason would be over-estimation of the population – see Gustafsson (2012a).
[23] Van der Berg *et al*, 2020.

due to lower grade repetition. If the abovementioned 5.6% population-driven increase is combined with the higher level of Grade 12 survival, the result is that enrolments, and by implication educators, would increase by 6.2% between 2021 and 2030.

Figure 9: Higher survival to Grade 12 in public schools



Sources: As for the previous graph in the case of enrolments, and 2019 WPP for population.

Note: Only public ordinary school enrolments are reflected here. Note that the 'Higher survival to Grade 12' curve is an adjusted version of 'Enrolment 2021', without taking into account future population trends. The reason why the population curve is considerably above the enrolment curve for the younger ages is due to independent school enrolments not being counted, and a strong likelihood that the population values are over-estimates (see for instance Gustafsson [2012a]).

Turning to the learner-educator ratio, this has steadily increased from 27.4 in 2011 to 29.8 in 2021. These LE ratios are calculated by dividing official public ordinary school enrolments in grades 1 to 12 by the number of educators as defined for Table 3 above[24]. More details on the LE ratio trend are provided in an internal DBE report[25]. The effect of a worsening in the LE ratio has clearly been larger classes, particularly in historically disadvantaged schools[26].

A publicly available analysis of LE ratios for the 2003 to 2017 period indicates that the years 2009 to 2012 were good years with respect to the ratio[27]. Before that period, and after that period, values were higher. For the purposes of the educator projections, one scenario assumes the LE ratio would move gradually and linearly back to the 27.4 it was in 2011, by the time we reach 2030. However, this value must be adjusted slightly to take into account that the envisaged percentage of enrolments at the secondary level would rise, as implied by the previous discussion. LE ratios are slightly higher at the primary level than at the secondary level. The required adjustment would take the 27.4 ratio to 27.3.

[24] One difference is that for these LE ratios there was no age exclusion when counting educators.
[25] Report titled 'What are our learner-educator (LE) ratio trends?', dated 18 June 2022, by the author of the current report.
[26] The percentage of learners in grades 1 to 7 in classes with more than 45 learners clearly increased in many education districts across the country – see Department of Basic Education (2021: 14-15). An important study by Köhler (2020) found class size not to have an impact on Grade 12 results in historically disadvantaged schools. However, no such research exists for the primary level, where class size is likely to be a stronger determinant of learning, given the need for more individualised attention.
[27] Department of Basic Education, 2020a: 30.

If one compares South Africa's LE ratio to that in other middle income countries, it emerges that it was about five learners higher than the norm in around 2016[28]. The norm suggests the ideal for South Africa is around 23. Thus, taking the LE ratio back to the 27.4 level seen in 2011 is still conservative insofar as this would still place South Africa's ratio considerably above the norm.

If the improvement in the LE ratio is added to the 6.2% growth in the educator workforce referred to previously, the result is a much larger growth figure of 15.8%. Taking the LE ratio back to its previous and more favourable level is clearly a relatively ambitious undertaking.

Beyond 2030, the total stock of educators is assumed to remain constant. Given that beyond 2030 enrolments are likely to decline somewhat – Figure 8 above points to a 7% decline between 2030 and 2050 in the school-age population – keeping educator numbers constant implies a reduction in the LE ratio, though the extent of this would be sensitive to issues such as grade repetition and survival to Grade 12. The reason for having a constant stock of educators beyond 2030 is to keep the modelling simple for that period, in part because what stock of educators will be affordable so far into the future is highly unpredictable. What is of greatest interest beyond 2030 is, firstly, the evolving age structure and, secondly, unit costs. These model outputs would not be very sensitive to minor changes in the LE ratio.

5.2 Employee counts emerging from the model

The three key non-zero percentage increases discussed in section 5.1 are listed in Table 9 below. With the 0% 'Constant educators' scenario, there are four scenarios. The three growth scenarios imply an increase in the educator workforce of 22,706, 25,139 and 64,064 respectively.

Table 9: Drivers behind total educator demand to 2030

Driver of the increase	**Short name of scenario**	**Increase in stock of educators 2021 to 2030**
	Constant educators	0%
Growth in population aged 7 to 18	Population	5.6%
Above plus improvement in survival to Grade 12	Population + Grade 12	6.2%
Above plus reduction in LE ratio to levels seen a decade ago	Population + Grade 12 + LE	15.8%

Joiners are needed because educators leave. Before joiner estimates are discussed, two graphs relating to leavers are provided. Figure 10 uses the 'Constant educators' scenario in order to reduce the number of effects occurring simultaneously and thus simplify the explanation. What is clear is that as the age curve moves rightwards, as educators age, the peak becomes smaller. There is a certain flattening of the curve. This occurs because not everyone leaves the system at the same age.

[28] Department of Higher Education and Training, 2020: 44.

Figure 10: Educators by age up to 2030 in 'Constant educators' scenario

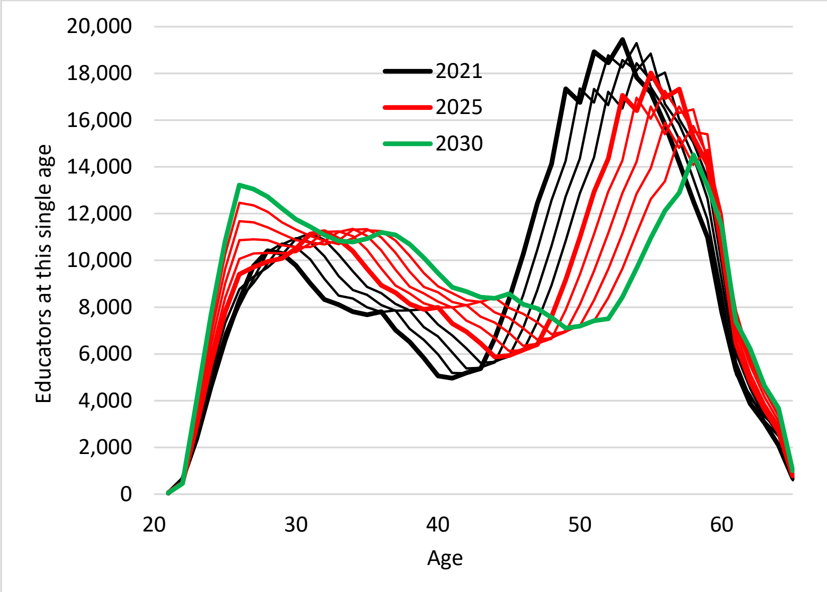
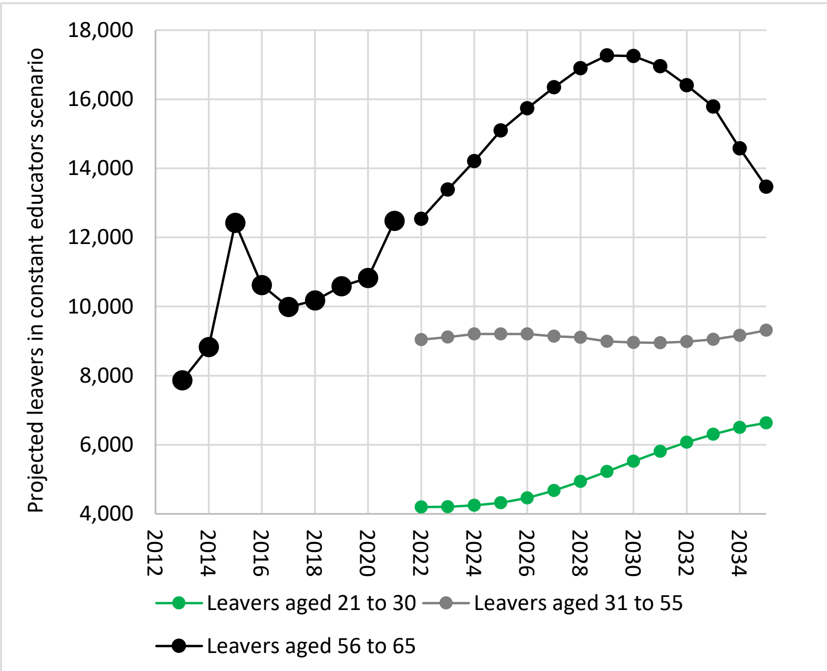


Figure 11 illustrates the number of leavers per age category in the 'Constant educators' scenario. Historical values from 2013 for ages 56 to 65 are also provided. The 2015 spike in departures was due to uncertainties and rumours relating to pension reform, which prompted many educators to take out early retirement. The 2021 increase in leaving among older educators largely reflects deaths and illness due to the pandemic (details provided below). Looking beyond the 2015 and 2021 irregularities, there is a clear upward trend among leavers of retirement age, which reflects the fact that an increasing number of educators have reached retirement age. The model's projections point to departures among those aged 56 to 65 reaching just over 17,000 by 2030.

Figure 11: Leavers by age category in 'Constant educators' scenario



Note: Year for each point is the year in which the educator is no longer in the system. Age is the age in the previous year.

The increase in young leavers in Figure 11 is noteworthy. This occurs because there are more young teachers in the system, so the absolute numbers of young leavers can be expected to rise in the absence of large changes in the attrition rates.

Figure 12 below presents the number of joiners per year for the period up to 2040 produced by three of the four scenarios listed in Table 9. ‘Population’ is not reflected as it is almost indistinguishable from the similar ‘Population + Grade 12’ scenario. Moreover, two of the scenarios in Figure 12 have variants labelled ‘HIGH ATTRITION’. These variants use what are clearly the higher levels of attrition for *younger* educators seen around ten years ago – this is clear in Figure 14 below. This higher attrition reflects what might be seen if the economic situation improves and young educators have more opportunities outside public employment in teaching.

In all scenarios, the age distribution of joiners was managed in a manner that ensured that annual joiners aged 31 and above, up to 2030, remained on average between 11,000 and 12,000, the level seen between 2018 and 2019. Behind this was the assumption that much of the joining and leaving among older educators was churning, but above all that any rise in the demand for joiners would have to be met mostly by younger and newly graduated educators, as the reserve pool of older educators was limited. The age distribution of joiners over the years was managed through manipulation of just one value per scenario: the future year in which the target age distribution was arrived at. The baseline age distribution for joiners was derived from an analysis of 2018 and 2019 Persal data – comparing 2020 to 2021 was deliberately avoided to exclude unusual COVID-19 pandemic effects. Using joiners between 2018 and 2019 as a guide has the advantage that this takes into account a 2018 policy change which essentially penalised re-joining financially, and which reduced the incentives for churning (see section 6.1).

The target age distribution assumes that the great majority of joiners are young, specifically aged 23 to 26. Age distributions are illustrated in Figure 16 below. To illustrate the target years that produced stability in the number of older educators who are joiners, in the scenario ‘Constant educators’ 2048 emerged as an optimal target year, while for the scenario ‘Population + Grade 12 + LE’ the optimal target year was 2032.

Figure 12: Joiners in five scenarios

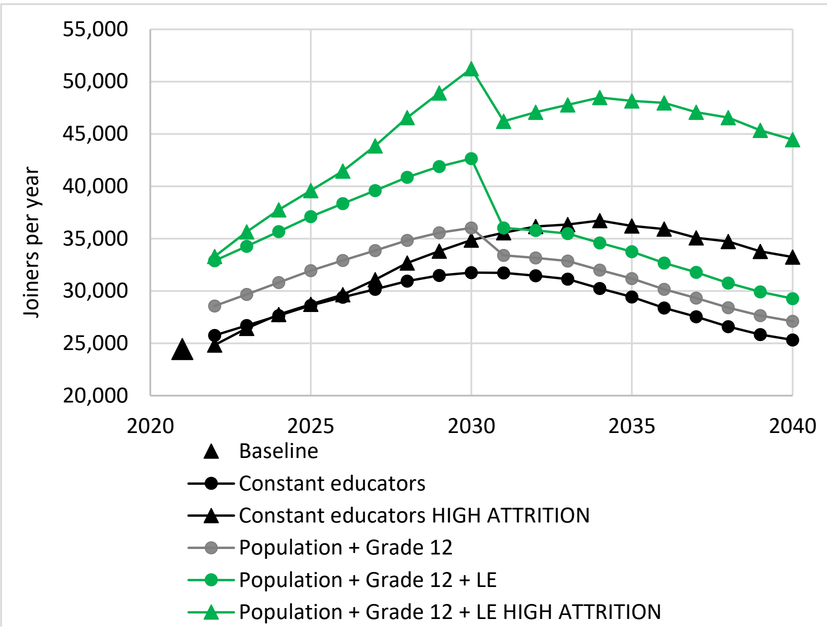
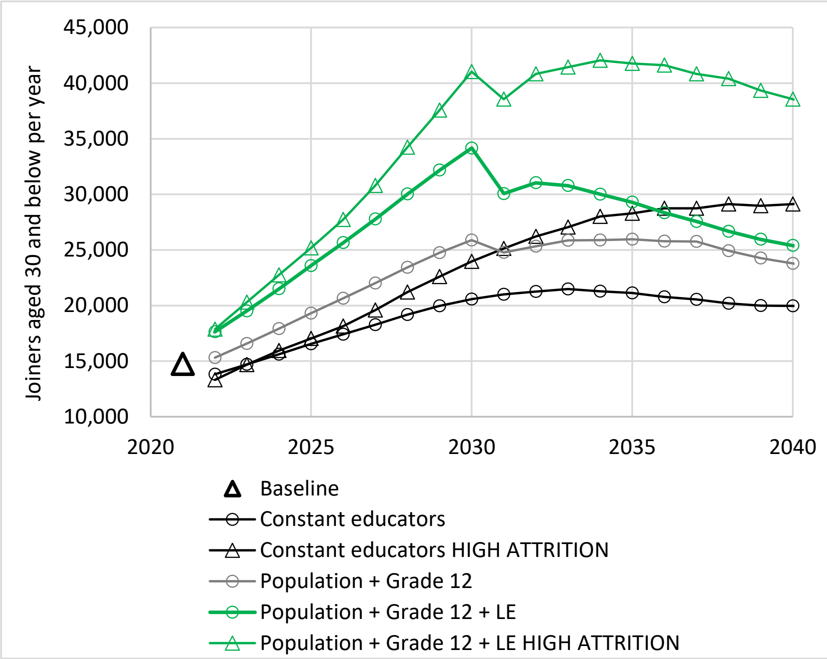


Figure 13 reflects just the projected joiners aged 30 and below. This is of obvious importance for the question of the extent to which university-based training will have to be ramped up. The values in the graph are interpreted further in section 5.3.

Figure 13: Young joiners in five scenarios



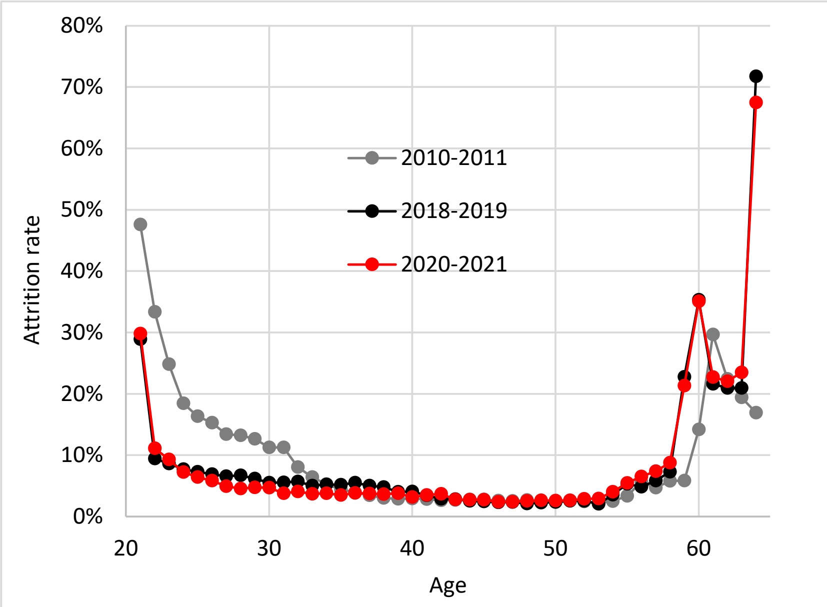
In both of the previous graphs the 2021 baseline is given. Scenarios other than 'Constant educators' reflect large jumps between the 2021 baseline and the 2022 projection, but also large declines between the 2030 projection and the 2031 projection. This is because the total demand for educators increases between 2021 and 2030, while this increase is made to suddenly halt in 2031.

The source for the 2021 baseline values is the report Department of Basic Education (2022b: 5-6), where joiners are calculated using the 'simple approach' of using just two years of Persal data. As discussed in section 5.3, for at least younger joiners, whether one uses a 'simple approach' or an approach using several years of data does not make a substantial difference to the number of joiners found. The all joiners figure has remained in the range 24,456 to 29,793 in the six years 2016 to 2021, the mean being 27,019. The trend for the young joiners figure is discussed in section 5.3.

The attrition rates illustrated in Figure 14 below were calculated afresh for the current analysis using the same approach for each pair of years, in the interests of comparability. The 2018-2019 rates were used for the three scenarios in Figure 12 (and Figure 13) without 'HIGH ATTRITION', while the 2010-2011 rates were used for the 'HIGH ATTRITION' scenarios. It is clear that there was much higher attrition among young educators in 2010 than a decade later. Especially for younger educators, a slight drop in attrition between 2018 and 2020 is visible in the graph. This would have been driven in part by the crisis of the pandemic, specifically even fewer employment opportunities outside teaching.

In calculating the attrition rates, an adjustment was made to exclude the effect of an overall decline or increase in the size of the workforce. For instance, the workforce grew by 1.2% between 2018 and 2019, and attrition rates were thus increased proportionally. If the workforce is growing, because there are more posts available, attrition will be artificially reduced, relative to a stable post situation.

Figure 14: Attrition by age statistics used



In Figure 15, numbers of leavers seen in the most recent pairs of years are shown. The green arrow points to a rise in attrition during the pandemic among older educators. Analysis of a field capturing reason for departure from Persal was analysed (in a separate study), and pointed to excess deaths of around 3,500 educators from April 2020 to December 2021. That analysis drew from downloads for every month during the pandemic, and for the whole of 2019 to establish a baseline. This losses due to COVID-19 mortality came to around 0.8% of the publicly employed educator workforce.

Figure 15: Leavers by age in recent years

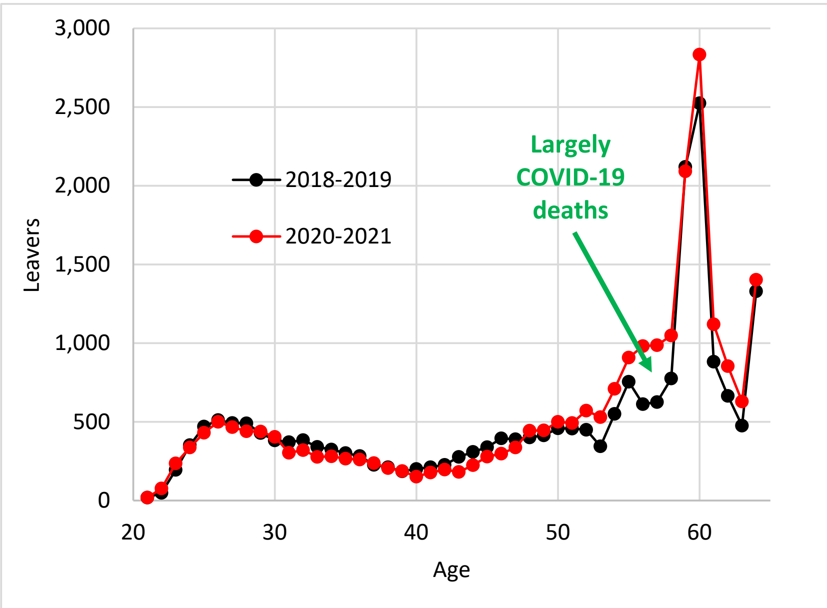
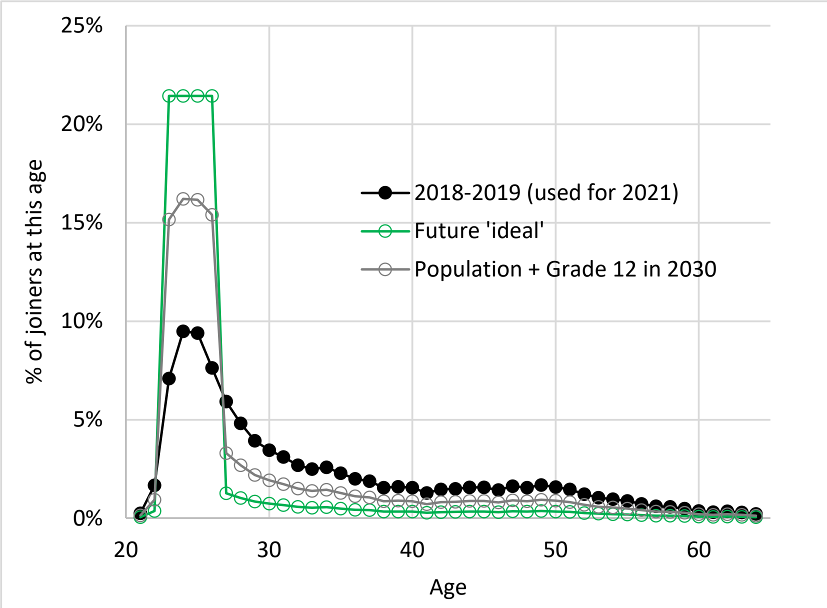


Figure 16 below illustrates the joiner age distributions used for all five future scenarios illustrated in Figure 12 – see ‘2018-2019 (used for 2021)’ and ‘Future ‘ideal’’. This was discussed previously. The age distribution applicable in 2030 would be somewhere between the 2021 baseline (for which an analysis of 2018 to 2019 data was used) and the ‘ideal’, depending on the year attached to this future situation. The 2030 distribution applicable in the scenario ‘Population + Grade 12’ is provided for illustration. The future year for the ‘ideal’ was always beyond 2030. As mentioned previously, an attempt was made to keep joiners aged 31 and above between 11,000 and 12,000 a year, thus forcing the model to seek educators of age 30 and below to address large increases in the demand.

Figure 16: Joiner by age statistics used



The last four graphs in this section illustrate projections to 2070. All the scenarios in Figure 17 (which is an expanded version of earlier Figure 12) point to the peak in the demand for joiners, around 2030, being an exceptional response to the exceptional peak in retirements. However, Figure 19, which focusses on young joiners, suggests that the decline in the demand for new graduates beyond 2030 may not be as pronounced as was suggested by the DHET report. Much depends on the availability of a reserve pool of older educators from which joiners can be drawn.

Figure 17: Joiners in five scenarios to 2070

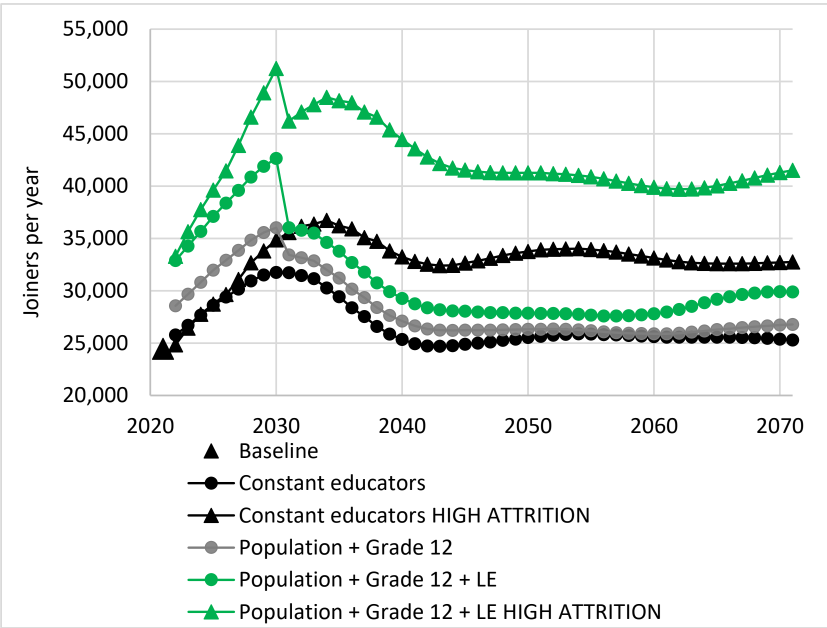


Figure 18: Young joiners in five scenarios to 2070

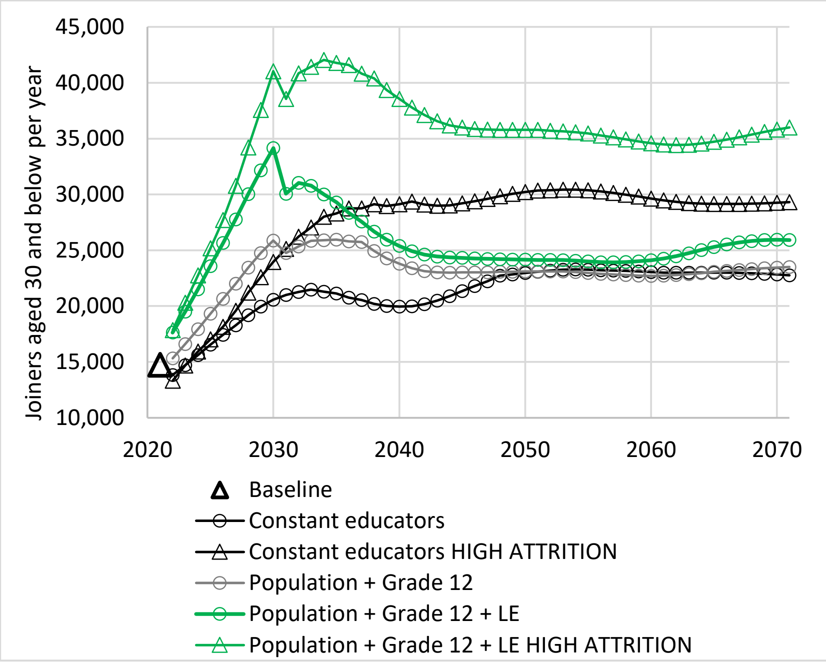


Figure 19 below suggests that the average age for educators will decline from the current 45 years to somewhere between age 38 and age 40. For this graph, three of the five scenarios were selected.

Figure 19: Average educator age up to 2070

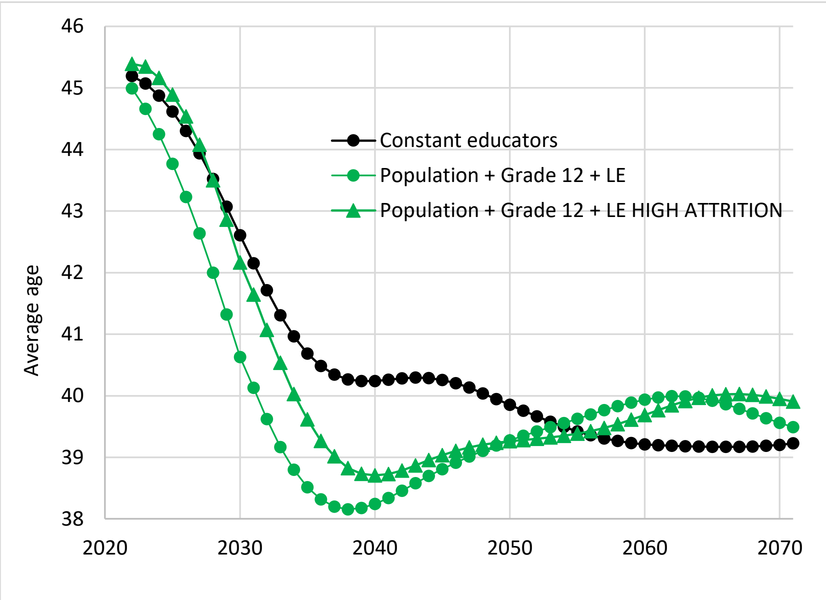
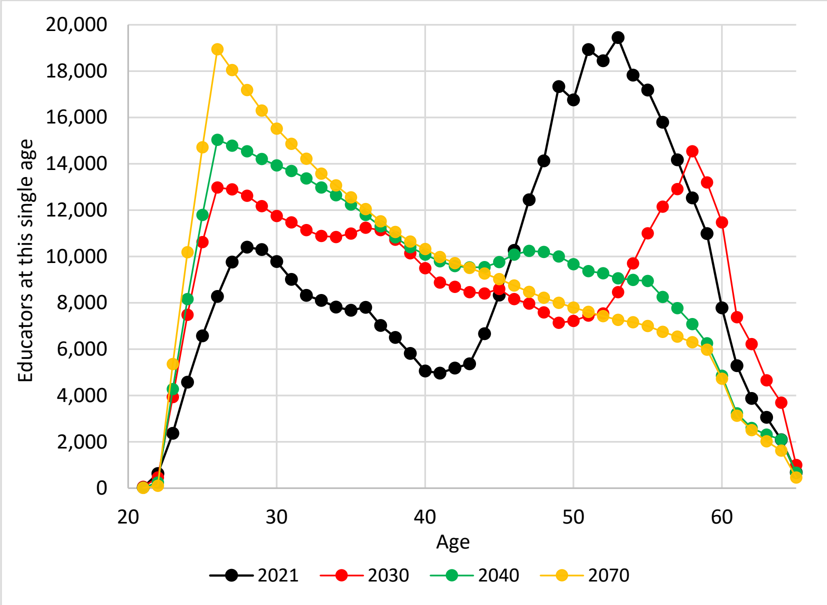


Figure 20 focusses on the 'Constant educators' scenario, though other scenarios would display similar patterns. Only between 2030 and 2040 does the age distribution become more 'normal' in the sense that the major peak shifts to young educators, or the left-hand side of the graph. A peak among young educators is normal if one assumes that people become educators and enter public service early in life, and then gradually leave the pool of publicly employed educators for a number of reasons, including employment opportunities elsewhere, either in the public or private sectors.

Figure 20: Educators by age up to 2070 in 'Constant educators' scenario



5.3 Translating joiner numbers to graduate demand

Figure 13 above points to an annual demand for young joiners, aged 30 and below, increasing from the current level of around 15,000, to a level of between 20,000 and 40,000 by 2030, depending on various demand-side assumptions. To translate the 2030 demand figures to the number of initial teachers graduates which South African universities should graduate by that year, several factors must be taken into account. The 15,000 a year for 2021 includes some *re*-entries due to churning, but this is a minor factor. Existing analysis of joining patterns using different methods points to around just 5% of the 15,000 being re-entering teachers[29]. Thus, 95% are entering for the first time, and would have graduated recently. This leaves the following five potentially important factors which must be taken into account.

- There are graduated teachers who become **employed privately as teachers within the country**. While there are some 400,000 publicly paid educators working in the schooling system, there are a further approximately 29,000 teachers paid by school governing bodies in public schools[30], and an additional 42,000 educators working in independent schools[31]. This stock of 71,000 privately paid educators would currently require replenishment amounting to some 2,600 individuals a year (the 15,000 multiplied by 71,000 over 400,000). This demand on the private side would increase, along the lines of what has been seen above, assuming that on the private side a bulge of older educators also exists. There are currently no statistics on the age structure of privately employed educators, but it is possible that these educators are a bit younger than publicly paid educators[32].

- There are graduated teachers who **take up employment in other sectors of the economy**, without entering teaching. A critical question is the following. If there are some 470,000 educators working in the schooling system (based on figures in the previous bullet), then how many qualified teachers are there in South Africa as a whole, and how many of these are of a pre-retirement age? These grand totals do not seem available anywhere, though a potentially useful source is the database of qualified educators of the South African Council for Educators (SACE). How many people are on this database does not appear to be a published statistic. This seems like a matter worth following up, in part

[29] Department of Basic Education, 2022b: 6.
[30] Department of Basic Education, 2018.
[31] Department of Basic Education, 2022c.
[32] Preliminary analysis of SA-SAMS data points to this being the case.

because it would throw some light on how many teachers are outside teaching in the labour market.

- Some **young graduate teachers emigrate each year**, possibly without ever teaching within South Africa. It is difficult to obtain reliable figures on this phenomenon, and on the related phenomenon of teachers who spend just a few years abroad and then return. Foreign demand includes the demand for South African English teachers in countries, such as China, with a large private teaching English as a foreign language (TEFL) sector. Available statistics almost certainly under-represent the extent of emigration. One set of figures points to around 18,000 originally South African teachers working as teachers abroad, but this statistic only covers rich OECD[33] countries, and not countries such as China and Vietnam[34]. To replenish a stock of around 18,000 teachers outside South Africa would require just under 1,000 graduated teachers to leave South Africa each year. The actual annual out-migration of younger teachers could easily be higher than this figure.

- The **in-migration of qualified teachers from outside South Africa** relieves the country of some of the obligation and expense of training teachers. While the South African Qualifications Authority (SAQA) reports on the number of holders of foreign qualifications which become recognised per year, statistics relating just to teachers are not provided. It is possible that SAQA could provide these statistics on request. On the other hand, SACE has provided some statistics on foreigners becoming registered to teach in South Africa. The recent figures are low, with newly registered foreign teachers declining from 395 in 2018 to 129 in 2019[35]. Online news sites explain that the decline is in part due to a more stringent verification process having been put in place. November 2019 Persal data point to 0.8% of publicly paid educators nationally, or 3,239, not being South African citizens. Of these, 70% are Zimbabwean while Ghana and India each account for 8% of the total. Importantly, only 1% of foreign educators on Persal were age 30 or below in 2019, compared to 10% for South African educators[36]. Young foreign joiners thus appear to be an extremely small portion of all joiners in the public system.

- A recent analysis of Persal data examines the extent to which **incompletely qualified teachers enter public service and complete their qualifications through distance education while on the job**[37]. Some statistics in this regard were provided in section 4.1 above. While this phenomenon would not change the overall demand from South African universities, it could help 'flatten the curve' when there is an increase in demand, of the kind expected in South Africa in the coming years. Put differently, if there is a surge in teacher retirements, young teachers can be pulled in a few years before they qualify, to ensure that there is a teacher in front of every class. This is facilitated by the fact that around 38% of teachers obtain their first qualification through distance education. The recent analysis reveals that of the addition to the stock of young qualified educators in Persal in 2021, 93% was due to qualified teachers entering the system, while 7% was due to pre-qualified teachers *already within the system* obtaining their full qualification. The 7% translates to just over 1,000 teachers. The phenomenon is thus relatively small, but the important thing is that the system is already geared towards dealing with an under-supply in this manner. The presence of pre-qualified teachers is higher in certain provinces, particularly North West, and in schools serving poorer communities, which are likely to be schools that are affected first by teacher supply problems, given that teachers tend not to prefer such schools.

Figure 21 below illustrates the recent trend for young joiners in Persal, as well as the trend for young teacher graduates, as reported by DHET[38]. The gap between the two has clearly been

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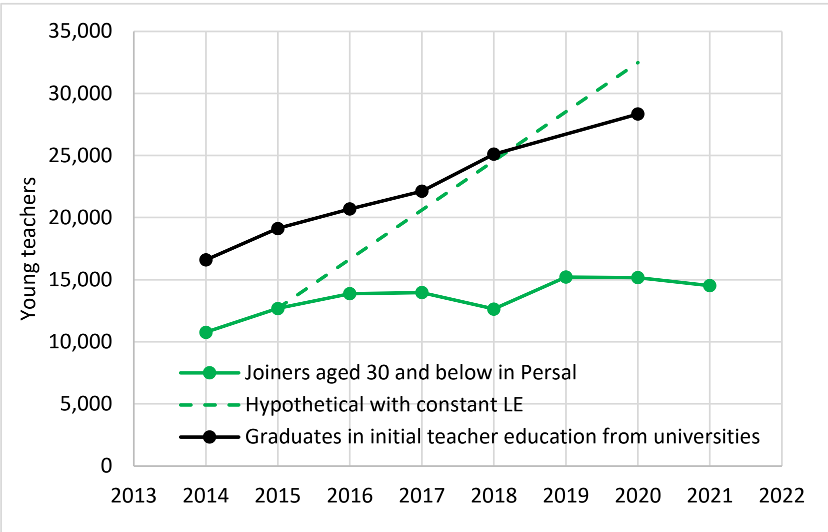
33 Organisation for Economic Co-operation and Development.
34 Mlambo and Adetiba, 2020. The South African Council for Educators (2011) produced a report on the migration of educators into and out of South Africa around ten years ago, but it lacks many key statistics.
35 South African Council for Educators, 2021: 13.
36 Statistics provided by Department of Basic Education.
37 Department of Basic Education, 2022d.
38 The DHET figures are not incompatible with SACE figures on 'new educators registered' (South African Council for Educators, 2020: 27). For instance, where DHET refers to 25,223 newly graduated teachers in 2018/19, SACE refers to 29,765 newly registered educators. There are several possible reasons for the

widening. By 2020, only 54% of the 28,335 teachers graduating from universities in the previous year were being absorbed into the public system as public employees. If one considers that around 2,600 young graduates would be required to replenish the 71,000 privately employed teachers working in schools, that leaves some 10,000 young teachers who are going elsewhere. The discussion of the above five factors suggests these 10,000 teachers would be moving mostly into other segments of the South African labour market, or other countries.

There have been public concerns around young teachers wishing to find employment as teachers, but not succeeding, and thus ending up as unemployed. Analysis of the DBE's database of unemployed educators[39] reveals that the 7,100 teachers declaring themselves in need of a post in 2022 translate to an 'unemployment rate' of around 1.7%. These unemployed teachers are slightly older than the employed. Around a fifth of the 7,100, or some 1,400, are aged 34 and below, and patterns suggest they wish to be employed in specific locations, such as Gauteng and more urban areas in KwaZulu-Natal, and would be reluctant to work in schools far from these locations. It is difficult to draw hard conclusions from this, but these figures suggest that the great majority of the abovementioned 10,000 young graduates find employment somewhere, either in some non-teaching job in South Africa, or in some occupation abroad.

Figure 21: Initial teacher graduates and young Persal joiners



Sources: For graduates, source is the DHET annual reports of 2019/20 and 2020/21. To illustrate, the DHET value for 2020/21 would be plotted as the 2020 value in the graph. The annual report indicates that these are teachers who would have graduated in 2019, and it is thus assumed they would be able to take up employment in 2020. For Persal joiners, the source is values behind the 'simple approach' in Figure 5 of Department of Basic Education (2022b).

Critically, while only around half of graduates were moving into public employment as teachers in 2020, two-thirds were doing this in the years 2015 and 2016, and some years before that around three-quarters were moving into public employment, according to analysis presented in

18% discrepancy: the SACE figure would include teachers trained abroad, but there could also be definitional differences relating to, for instance, adult educators, pre-school teachers, and so on. Even within DHET's reporting system substantial differences across different sources can appear. For instance, according to DHET's *Trends in teacher education* reports, the number of university students receiving either a Bachelor of Education (BEd) or a Post-Graduate Certificate in Education (PGCE) was 28,203 in 2018 (Department of Higher Education and Training, 2020: 74), a figure that is a few thousand higher than the corresponding figure reflected in Figure 21. The current discussion relies strongly on the assumption that *within* an indicator, such as the DHET one reflected in Figure 21, there is definitional consistency. Note the joiner numbers reflected in Figure 21 are highly comparable over time.

[39] Department of Basic Education, 2022e.

the 2020 DHET report[40]. This points to an important problem, and could explain in part the perception that more graduated teachers are ending up unemployed. While universities have responded to pressure to train more teachers, the schooling system has not been successful at absorbing the increase, in part due to budgetary constraints. DHET university enrolment plans from 2014 make growth in teacher training a priority for universities. DHET's 2022/23 annual performance plan envisages future growth in teacher outputs, beyond the growth already seen, the target being 30,000 by 2024. This contrasts with less moderate growth in the absorption of young teachers into public employment by the nine provincial education departments responsible for schools. To illustrate, while graduate output in Figure 21 increases by around 1,900 a year between 2015 and 2020, the increase for young joiners in Persal for the same period is just 600 a year. Importantly, this is not because more teachers than this were not needed in schools.

As discussed in section 5.1, the learner-educator ratio worsened considerably between 2011 and 2021. Had the LE ratio been maintained at 2011 levels, the publicly employed educator workforce would have consisted of around 457,000 people in 2021, and not the 405,000 actually seen in 2021 (see Table 5 above). The dotted line in Figure 21 is what the young joiner numbers would have looked like if the decision had been taken to expand the educator workforce, starting in 2016, in a gradual manner in order to 'inject' the additional 52,000 teachers into the system, completing this process in 2020. It is clear that in such a scenario, demand from the schooling system would have exceeded graduates exiting universities. The fact that the hypothetical joiner trajectory was not followed is a result of both budget constraints, and arguably the decision to improve the annual notch progression of educators from 1.0% to 1.5%, in line with the 2018 agreement between the employer and unions[41].

It is assumed here that the system would return to a situation where three-quarters of graduates would find work in the public sector. Doing so would convert the 20,000 to 40,000 range for young joiners from Figure 13 to a range of 27,000 to 53,000 new graduates required in 2030. This means increasing graduate output, by 2030, by anywhere between zero and 25,000, relative to 2021 levels of graduate output. The increase would be zero if it was accepted that LE ratios could continue to worsen substantially over the next ten years, and that the focus would be purely on maintaining the size of the educator workforce at 2021 levels. This would almost certainly be detrimental to schooling and national development. The upper limit of 53,000 new graduates a year is very unlikely to reflect demand in future as the three-quarters assumption is likely not to be applicable in a scenario of an unprecedented expansion in the publicly employed educator workforce. In such a scenario, it is unlikely that there would be a large and proportional increase in qualified educators seeking employment outside the education sector. Moreover, preliminary analysis of new SA-SAMS data from schools suggest that privately employed educators in public schools are considerably younger than those who are publicly employed, meaning the replacement of older leavers in this category is not a major pressure.

Universities have arguably been 'stocking up' the country's reserve of teachers due to the relative *over*-supply by universities illustrated in Figure 21. Had universities outputted four graduates for every three required in the public system, and had they taken into account the fact that the publicly employed educator workforce would not grow in line with enrolments, universities would have produced 28,500 *fewer* teachers in the 2016 to 2020 period than they actually did. Assuming this 'surplus', or at least 75% of it, can be pulled back into public teacher employment in future years, some 21,000 still relatively young teachers would be available to deal with the effects of the retirement wave. Spread out over the next ten years, this is some 2,000 additional 'reserve' teachers.

Table 10 below displays the *additional* university graduates needed in 2030, *over and above* the 2021 level of 28,335 shown in Figure 21. Six scenarios are used, the five shown in Figure

[40] Department of Higher Education and Training (2020: 106) reports that of 5,862 people who enrolled for the first time in a Bachelor of Education programme in either 2010 or 2011, 4,436 had graduated by eight years later, so by 2018 or 2019, and of these graduates, 3,285 were found in Persal in those later years. The figures 3,285 and 4,436 provide a ratio of three is to four.
[41] Public Service Co-ordinating Bargaining Council (PSCBC) Resolution 1 of 2018.

18, plus the 'Population' scenario (which was excluded from Figure 18). It was assumed that the young joiners value for 2030 from Figure 18 had to be inflated by four over three to deal with graduates who do not become employed publicly as teachers. From this was subtracted the baseline value of 28,335.

Table 10: Additional 2030 demand for graduates using a three-in-four ratio

Driver of the increase	Short name of scenario	Additional needed (above 28,335 of 2021)	Additional needed *assuming higher attrition among the young*
	Constant educators	0	3,600
Growth in population aged 7 to 18	Population	5,788	
Above plus improvement in survival to Grade 12	Population + Grade 12	6,164	
Above plus reduction in LE ratio to levels seen a decade ago	Population + Grade 12 + LE	17,214	26,397

It should be noted that the 'Constant educators' scenario would severely worsen the LE ratio situation further. Specifically, beyond the worsening from 27.4 to 29.8 already seen between 2011 and 2021, further worsening would take the ratio to 31.5 in 2030. This 2030 estimate uses just the 5.6% increase in the school-age population discussed previously, and thus assumes no increases in survival to Grade 12.

6 Unit cost projections beyond 2021

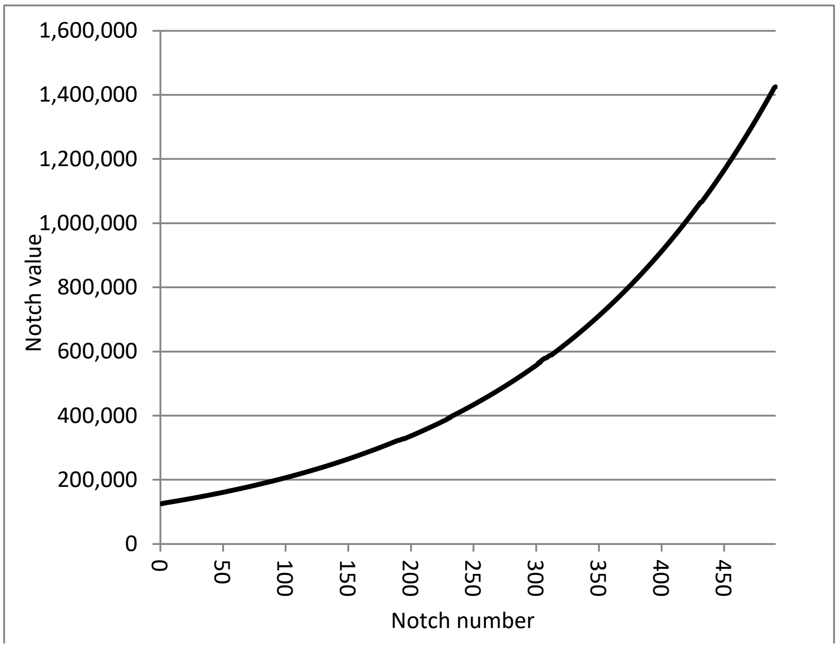
6.1 Background on progression, re-joining, promotion and benefits

The focus now shifts to the financial aspects of the modelling. The current section discusses issues that influence the unit cost modelling, drawing from various existing analyses.

Figure 22 below illustrates the 2021 notch values appearing in the Excel model. Notch-on-notch increases are widely understood to be 0.5%, and this is mostly true if the values are examined, though there are minor deviations. If the lowest notch value of 125,085 is taken as a point of departure, and increases of exactly 0.5% over the 491 notches are calculated, notch 491 takes the value 1,447,910. This is just 2% above the actual notch 491 value of 1,425,018.

Educators have experienced a different notch progression dispensation in the education sector relative to non-educators in the sector at a comparable salary level. For the approximately 8,000 non-educators at salary levels 7 to 12, the levels applicable to qualified educators, notch progression is not nearly as automatic as it is for educators. While over 99% of educators experienced the policy-stipulated annual notch progression between 2020 and 2021, assuming they were present in both years, the figure for non-educators in the sector has been around two-thirds for many years. As already mentioned in section 5.3, a 2018 policy change increased the annual notch progression for educators from 1.0% to 1.5% to bring it in line with practices in more favourable parts of the public service. What was not widely discussed in the lead-up to this policy change was the extent to which the likelihood of experiencing the progression differs across parts of the public service.

Figure 22: The notch values of the salary scale

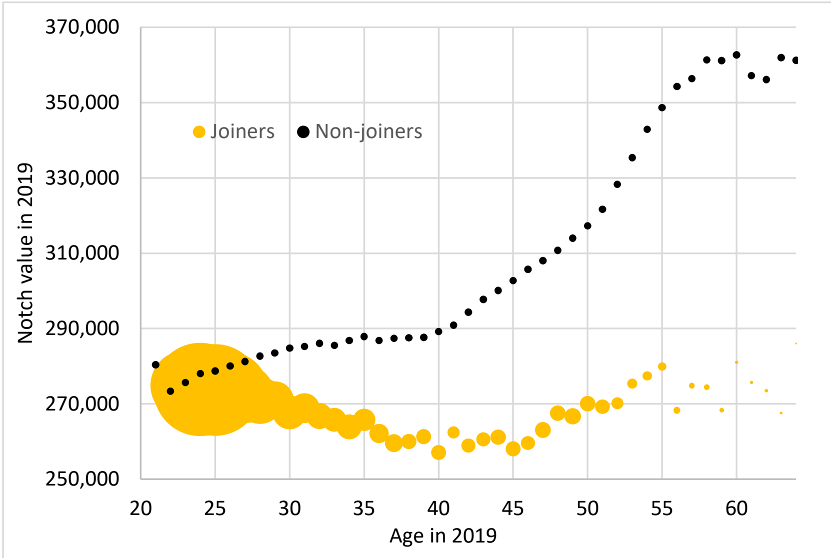


The following two graphs illustrate the effects of another important policy change occurring in 2018[42]. Resolution 2 of the Education Labour Relations Council (ELRC) made it very likely that an educator with a break in service would return to the public schooling system at the entry level notch for teachers, and not the notch the educator was on when he or she left the system. The motivation for this change was a phenomenon whereby older educators were taking a break from service mainly in order to access their pension savings, a practice which was considered undesirable. Older joiners in 2014 (Figure 24) were clearly entering on higher notches than in 2019 (

[42] See also Department of Basic Education (2022g).

Figure 23), after the policy change – these graphs represent joiners in general, whether they were in the system previously or not. More specifically, up to 2018 older joiners aged 40 and above moved on average to a pay level which was 4% *above* the entry level for teachers, while from 2019 to 2021, this has been around 3% *below* the entry level for teachers. This lies behind the decision to place all older joiners at the entry level notch for teachers in the Excel model.

Figure 23: Notches of those joining in 2019



Note: The bubbles representing joiners per year have a width which is proportional to the number of joiners. The size of the non-joiner markers has no meaning.

Figure 24: Notches of those joining in 2014

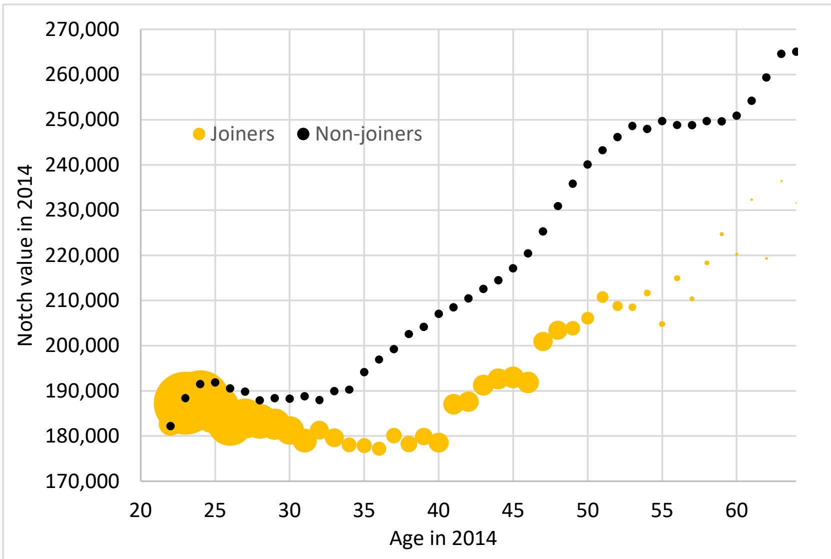


Figure 25 and Figure 26 below reflect the inputs used in the model to drive the promotions process in the model. This has not been discussed in earlier sections because the promotions process only affects the unit cost, and does not affect the total number of *all* educators projected by the model, or even the total number of level 1 teachers and senior teachers, variables which are determined outside the model. The two graphs reflect some of the 101 boundary points that divide the range of notch values into 100 equal parts. The derivation of the statistics in both graphs is based on a detailed 2022 analysis of promotion patterns in the system[43]. The statistics presented here draw from an analysis of 2020 and 2021 Persal data. In Figure 25, the fact that the peak for the total number of promotions for teachers should be on the far left of the range should not be surprising if one considers that around half of teachers are situated below an annual notch value of around 300,000 Rand. The number of promoted people in Figure 25 should be read against the right-hand vertical axis, while the probability of being promoted, as

[43] Department of Basic Education, 2022f.

a percentage, should be read against the left-hand vertical axis. It is the latter series of values which are inserted into the model.

Figure 25: Promotion probability inputs in the model

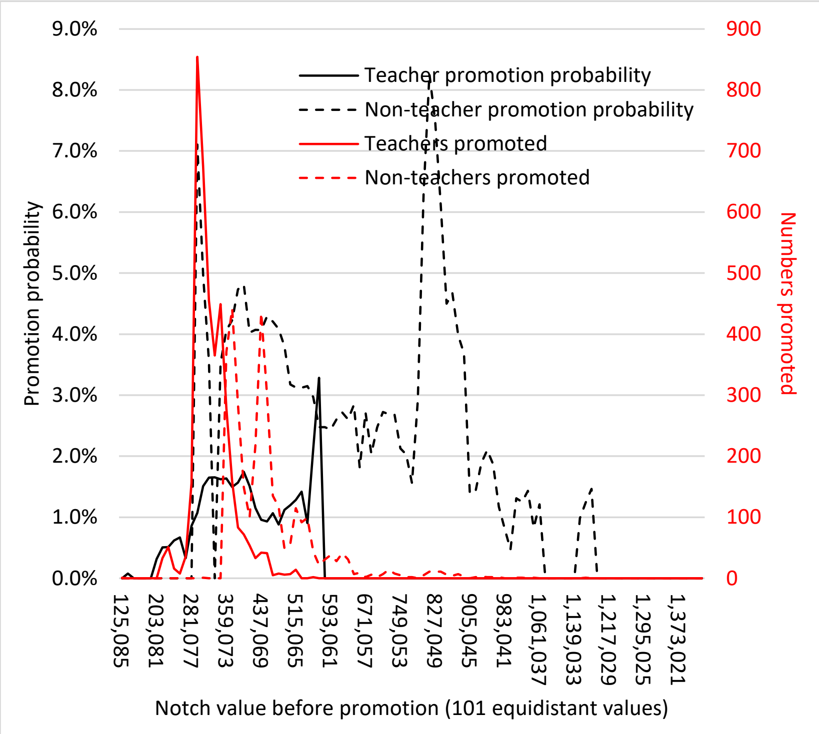
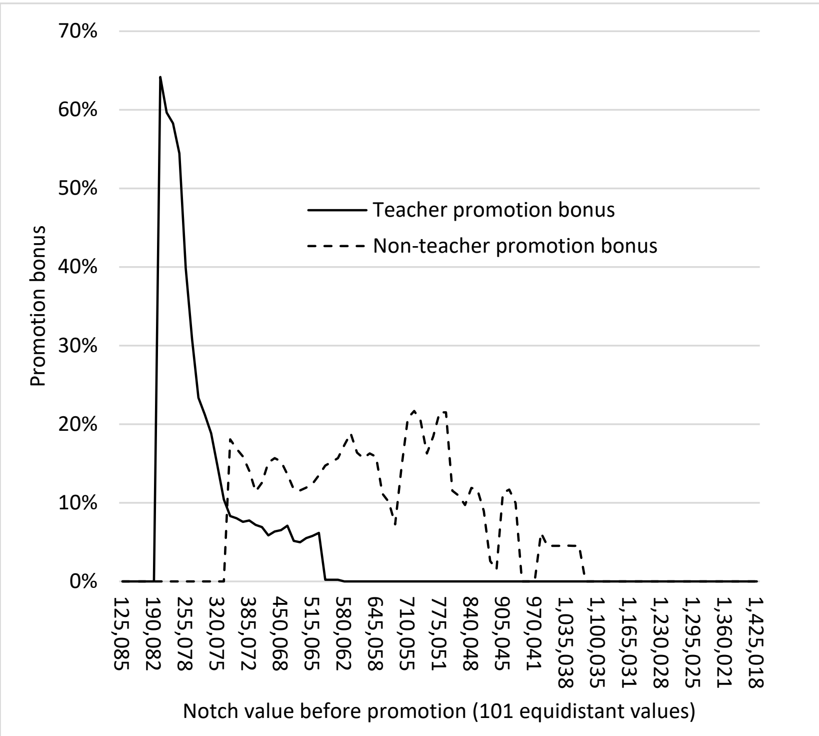


Figure 26 reflects the percentage increase in the notch value experienced by teachers and non-teachers, at different points in the range of notch values, as a result of the promotion. This 'promotion bonus' is over and above any increases relating to annual notch progression.

Figure 26: Promotion bonus inputs in the model



The Excel model does not allow people to move into the system and straight into a senior educator position. This does occur in reality, but it is very limited. Of all people moving into a senior educator post per year, roughly half are teachers and a further half were educators occupying a lower senior educator position. Only 4% are joiners to the system. These patterns are based on several years of historical data.

It should be noted that every year a few educators, mostly senior educators, move to senior non-educator public servant posts within the sector. Though these educators would consider themselves promoted, the model considers them leavers, as the model does not cover non-educators. This phenomenon is extremely small: annually the number of people experiencing this move is around ten.

Though average benefits received over and above the basic salary, such as medical aid, increase in absolute Rand terms as age increases, benefits as a *percentage* of the basic salary *declines* slightly with age. This can be seen in Figure 27 below. The 2021 values are exceptionally high is in part due to the special cash payment intended to compensate for a zero cost-of-living adjustment in 2021[44], a payment which 95% of educators received. Across all educators, this cash payment produces an average in one month of R1,397. However, an even larger factor behind the unusual 2021 patterns is backdated basic pay, paid to 96% of all educators in November 2021. This works out to an average of R2,009 across all educators.

Figure 27: Total cost and notch cost by single age

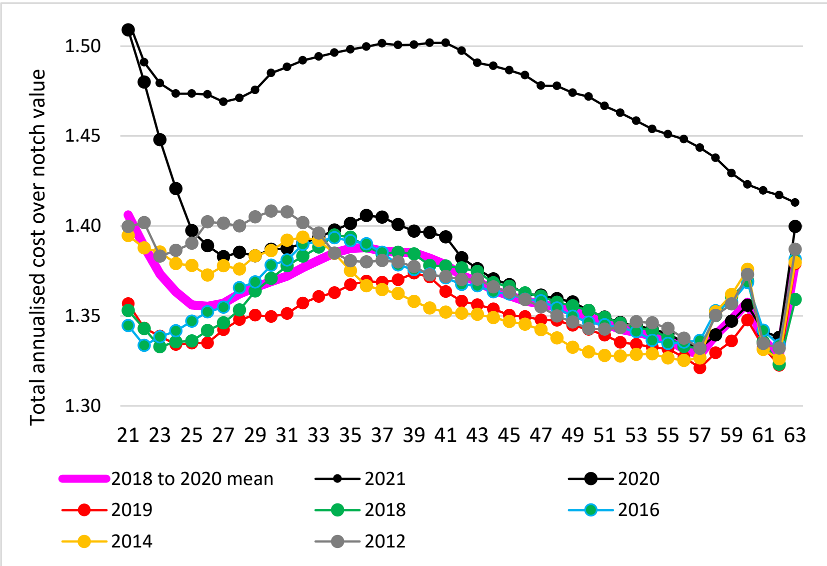
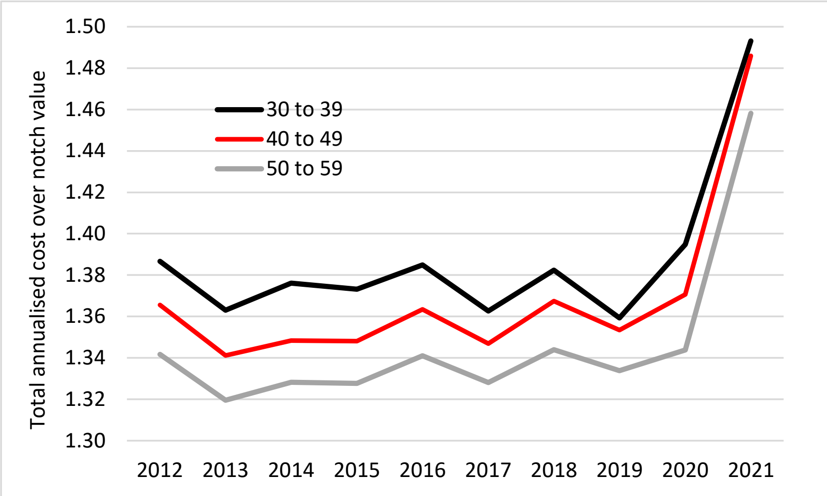


Figure 28 provides an alternative view of the benefits data, and indicates that monthly benefits over basic pay, which is one-twelfth of the notch value, has not changed much over time if the exceptional developments in 2021 are ignored. The '2018 to 2020 mean' values from the previous graph were inserted into the Excel model and drive the conversion of notch values to total cost.

[44] Public Service Co-ordinating Bargaining Council (PSCBC) Resolution 1 of 2021.

Figure 28: Total cost and notch cost 2012 to 2021



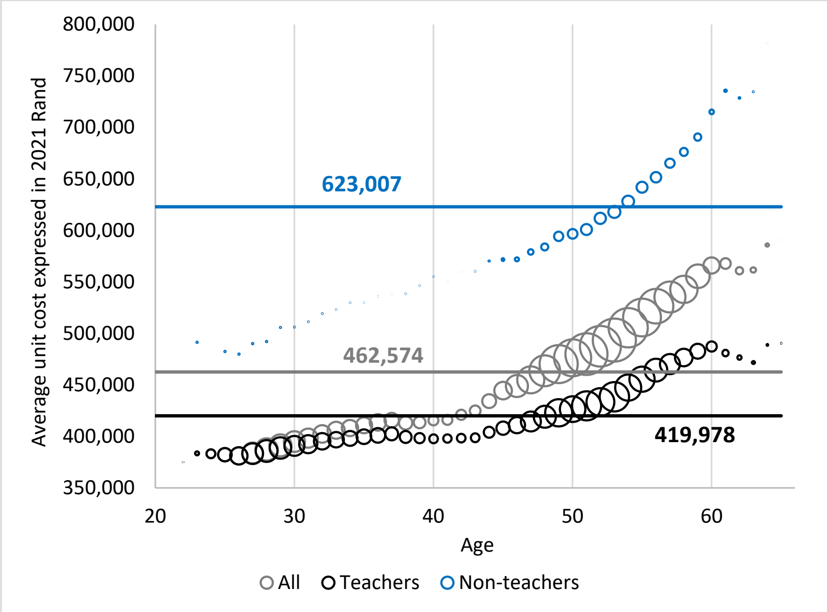
6.2 Unit costs emerging from the model

Turning to the unit costs seen in the model, Figure 29 below illustrates the age and cost breakdown of the 405,469 educators of 2021 referred to in earlier Table 5. This was obtained by using actual notch values, and inflating these by the '2018 to 2020 mean' illustrated in Figure 27.

The National Development Plan has referred to the problem of the 'flat wage gradient' in the educator workforce[45]. Indeed, up to around age 43, the curve for all educators rises relatively slowly, though beyond that there is a stronger upward slope. This is in part due to the fact that first-time joiners are often relatively old in the sense of being above age 22, the age at which most joining would occur if teachers completed their schooling and post-school education with no interruptions or delays. A teacher entering at, say, age 29 would typically enter at the official entry level, this being notch 164, with a value of 284,238 Rand in 2021. The difference between the average notch value of a teacher aged 60, compared to a teacher aged 43, is 1.3% for each additional age for just teachers. Considering that prior to 2019 annual notch progression came to just 1.0%, the obvious question is how an age gap of 1.3% for notch values came about. This 1.3% gap would in part be driven by notch increases experienced a couple of decades ago, as as well as adjustments made in 2009 to deal with inequalities in the historical trajectories of teachers. In other words, the relatively steep upward curve for teachers beyond age 43 seen in Figure 29 is the result of policies applicable many years ago. But the 1.5% annual progression promulgated in 2018 has as its intent a slope slightly steeper than that of teachers between 43 and 60.

[45] National Planning Commission, 2012: 309.

Figure 29: Age and average cost in the 2021 data

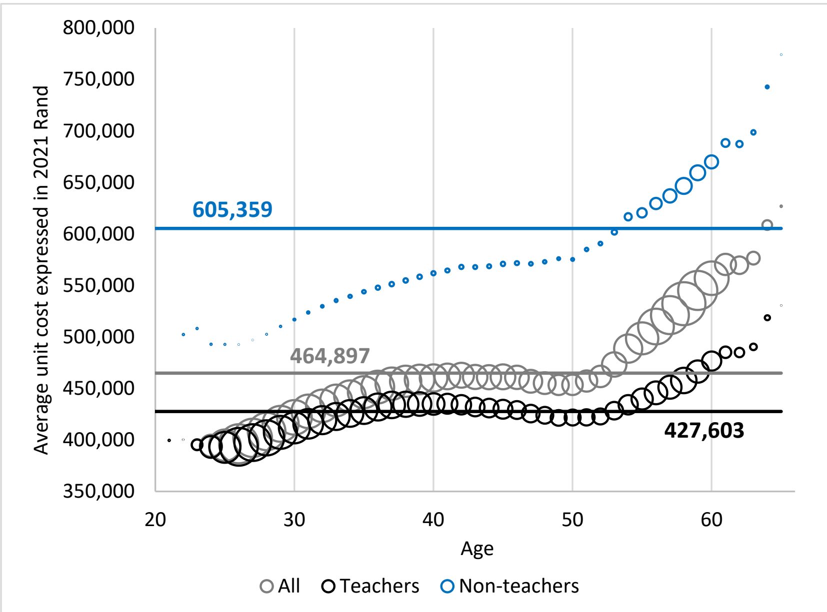


Note: The width of each bubble is proportional to the number of employees of that age. Horizontal lines illustrate averages.

Figure 30 below illustrates the situation in 2030, assuming a constant number of level 1 teachers and senior educators, and thus the 'Constant educators' scenario referred to previously. No cost-of-living adjustments are applied, meaning unit costs in Figure 30 (and subsequent Figure 31) are expressed in terms of 2021 Rand values. One clear difference between the 2030 situation and the 2021 situation seen in the above graph is larger bubbles at the lower ages and smaller bubbles at the higher ages in 2030. This would be in line with the age decline for all educators seen in Figure 19.

The bubbles for younger senior educators are also larger in 2030 than 2021. The average age for these educators declines from 51.6 to 49.2 between 2021 and 2030.

Figure 30: Age and average cost projected for 2030



A further difference that stands out are below average wages for a substantial number of teachers aged around 50. This is due to many teachers, especially in relatively high notches, moving into promotion posts, thus leaving lower paid teachers behind. The average cost of a teacher rises from 419,978 in 2021 to 427,603 in 2030, a 1.8% real increase that works out to 0.2% a year. This increase would be smaller if joiners were permitted to enter at a notch below the entry notch for fully qualified teachers. In 2021, there are 34,452 employees below the R284,238 entry level, while by 2030 only 12,957 remain. The average cost of a senior educator declines by 2.8%, from 623,007 to 605,359 between 2021 and 2030, an annual decline of minus 0.3%. Largely, this would be due to the fact that the average senior educator is younger in 2030 than 2021.

The average cost for educators as a whole increases by 0.50%, from 462,574 to 464,897, which works out at 0.06% a year.

Figure 31 illustrates the 2040 situation for the 'Constant educators' scenario. Between 2030 and 2040 the real increase in the average educator cost is 0.17% per year, around three times as steep as the 0.06% applicable to 2021 to 2020.

Figure 31: Age and average cost projected for 2040

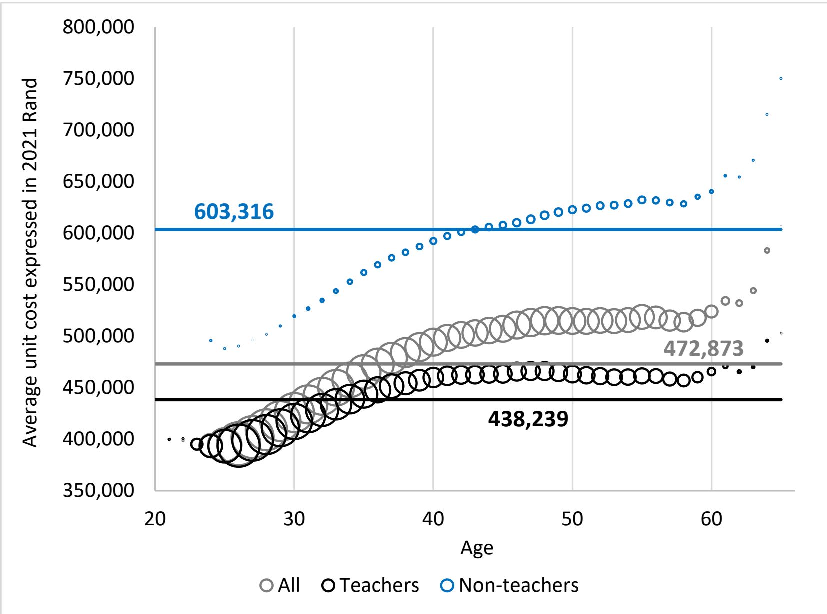


Figure 32 below illustrates the distribution of the 405,469 educators across *notch* values in three years, using the 'Constant educators' scenario. The fact that the model does not place joiners below the 284,238 entry level for teachers results in educators below this level declining from 8.5% in 2021 to 3.3% in 2030 and 0.4% in 2040. The fact that the 2021 distribution statistics are higher than the 2030 and 2040 statistics for the range 275,000 to 325,000 is largely due to the placement of many educators *below* the 275,000 level in 2021. The percentages on the vertical axis are *cumulative.* But there is a further explanation. The relatively high number of teachers in 2021 at the entry level represents not just joiners, but also teachers who were in the system previously but obtained their full qualification. This delayed attainment of a qualification is not catered for by the model for the years beyond 2021.

Figure 32: Distribution of notch values in 2021, 2030 and 2040

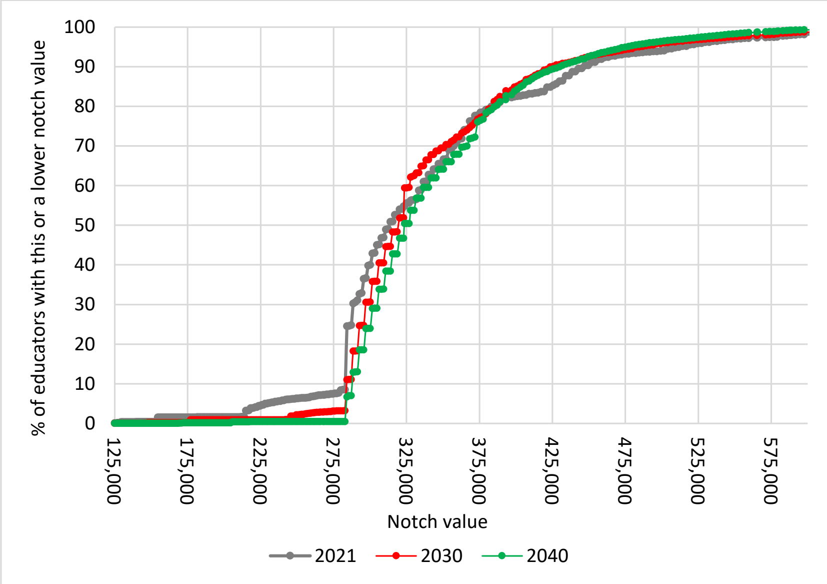
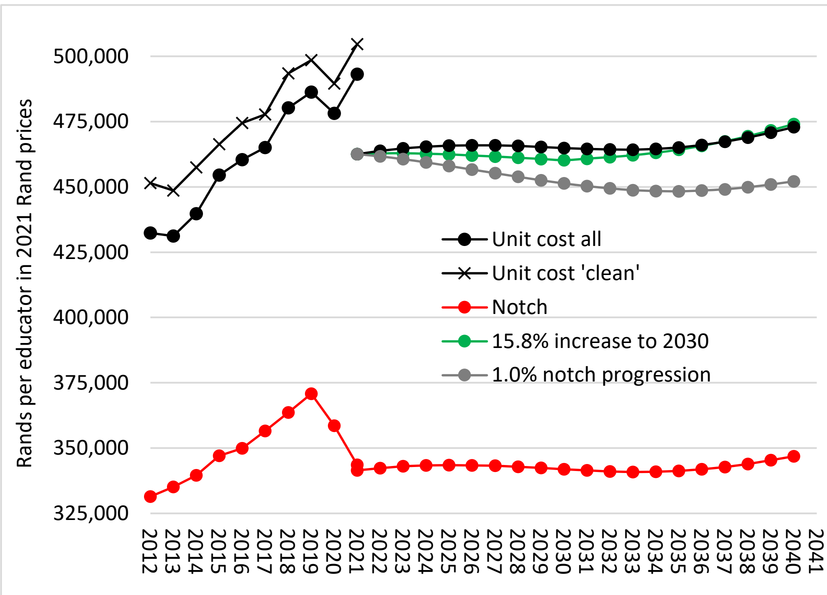


Figure 33 below illustrates both historical and future unit costs over the period 2012 to 2040. Future notch trends (the red curve) use the 'Constant educators' scenario. It is clear that the future outcome would be a return, in real terms, to more or less notch values that existed in 2015.

The final historical 2020 to 2021 trend with respect to notch is a decline of around R15,000, while the trend for the same years for the overall unit cost is an *increase* of R15,000. As indicated above, this latter increase is largely due to backdated basic pay in November 2021, though the special cash payment also plays a significant role. The starting point for the 2021 to 2040 'Unit cost all' series represents what the unit cost would have been in 2021 had there not been the unusual backdated pay and the special cash payment.

Figure 33: Unit cost trends 2012 to 2040



Assuming the cash payment is given across all twelve months in a year, it comes to a 4.9% increase relative to the *notch* value, but an increase of around 4.3% relative to the total spending by the employer[46]. The projected 'Unit cost all' values in Figure 33 do not carry forward this 4.3% increase, because the modelling anchors all pay on the notch values[47]. At the same time, projections for 2022 and beyond in the graph assume that notch values would increment between 2021 and 2022 in line with CPI – the vertical axis represents real Rand values. CPI increases by around 7% between 2021 and 2022. Yet, at the time of writing, it seemed teacher unions were ready to accept an increase of just 3% in the notch values between 2021 and 2022, meaning the projections provide 4% (7% minus 3%) more to educators than the actual agreement. The ignoring of the abovementioned 4.3% gain in reality and the ignoring of a 4% *loss* in reality essentially cancel each other out, meaning the projections essentially respect recent wage bargaining developments.

Projected unit costs from 2022 onwards are clearly far more stable in real terms than patterns seen in the recent past. This is largely due to the assumption of CPI-linked cost-of-living adjustments, though the 'demographic dividend' of having younger educators also plays a role. The relative magnitudes of these two factors are discussed in section 6.3 below. The '15.8% increase to 2030' projections in Figure 33 indicate that expanding the workforce by 15.8%, as discussed in section 5.2, results in slightly lower unit costs than those associated with the constant educators scenario. This would be due to the larger presence of younger educators in the more expansive scenario.

The '1.0% notch progression' projection in the graph reflects the outcome of switching the annual progression from 1.5% to the 1.0% that had existed before the 2018 policy change. Though only impacts on costs from 2022 onwards are modelled, this calculation nonetheless provides some sense of how large the impact of changing the progression was. In this scenario, the annual average change in the unit cost between 2021 and 2030 is minus 0.27%, which can be compared to the positive annual change of 0.06% for the same period in the 'Unit cost all' scenario. The difference between these two figures is 0.33 percentage points, considerably less than the 0.5 difference a more naïve calculation, which does not consider demographics, would suggest. In terms of total spending, the difference between the 'Unit cost all' and '1.0% notch progression' projection comes to R5.6bn in 2030, in terms of 2021 prices.

6.3 How large is the 'demographic dividend'?

The project within this report has been produced is named the Teacher Demographic Dividend project, because there is an interest is quantifying and planning for expected financial savings arising out of the declining average age of educators in the future (see Figure 19 above). When the project began, it was estimated that roughly the demographic shifts would result in a steady reduction in the educator wage bill, reaching a saving of around R13bn in 2030. This assumes no increase in the size of the educator workforce, in other words the 'Constant educators' scenario referred to above. The R13bn estimate was based on rather crude modelling that did not properly take into account dynamics such as the shift from a two-notch to a three-notch annual progression following the 2018 policy change, and how the demographic changes would affect promotion patterns.

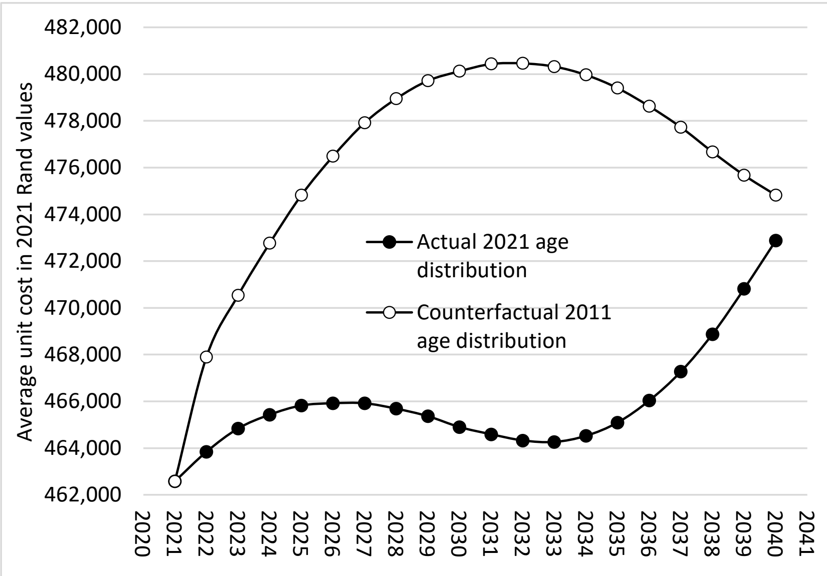
The new modelling described in the current report provides a much more reliable basis for estimating the dividend. As explained below, a dividend as originally conceptualised does not exist. In fact, even with no change in the size of the workforce, and assuming cost-of-living adjustments which equal CPI, the wage bill in 2030 will be 0.5% *higher* in 2030 than 2021 in real terms, as explained in section 6.2. This translates to an additional R930m. This is virtually a no-increase scenario – the annual increase is 0.06%. Limitations of the modelling, for instance the fact that it currently does not take into account pre-qualified teachers entering the system and obtaining their qualifications on the job, while earning a below-entry salary, could alter the findings slightly. Moreover, unexpected changes in educator behaviour, in particular changes in the uptake of employee benefits, could change the scenarios presented here.

[46] This percentage is lower, because while notch increases impact positively on, above all, pension contributions, the cash payment is 'non-pensionable' and does not impact on pension contributions.
[47] Moreover, as explained above, the ratio of total cost over notch cost is based on 2018 to 2020 data, meaning the unusual 2021 situation is ignored.

Despite there being no large saving in absolute monetary terms, there is still a dividend in the sense that the wage bill, assuming no workforce growth, would grow much more slowly than what is implied by Treasury budgeting manuals, which are firmly entrenched in the planning and budgeting cycle. These manuals specify that provincial education departments should take into account cost-of-living but also annual progression in their cost forecasts[48]. In the absence of above-CPI cost-of-living increases, this implies cost increases equal to 1.5% a year. Clearly, the 0.06% annual increase referred to above is well below 1.5%.

In a further sense, there is a demographic dividend. If the age distribution of educators in 2021 had looked like it was in 2011, the future trajectory of the average educator unit cost, using the 'Constant educators' scenario, would look substantially different. This is shown in Figure 34 below. The average educator cost would have been 3.2% higher in 2030, relative to the 'actual' scenario, because the effects of the declining average age would have been felt a decade later[49]. Put differently, instead of an annual increase in the average unit cost of 0.06%, this would have been 0.41%. In terms of overall costs, instead of a total cost in 2030 of R193.5bn (in 2021 Rand values) this would be R199.8bn, a difference of R6.4bn.

Figure 34: The effect of a different age distribution on the average cost



More important than any demographic effect, however, is the question of whether above-CPI cost-of-living adjustments occur in future, as has occurred in the past[50]. If they do not, *this* is what contributes substantially to the scope for hiring more educators in order to deal with a rising learner-educator ratio. In Figure 35 below, it can be seen that even with the 'less favourable' age distribution of 2011, but cost-of-living increases that equal CPI, the total cost of all educators over GDP will decline steeply. This assumes no workforce growth. Here annual GDP growth of 2.1% in 2022, 1.6% in 2023 and 1.7% beyond that is assumed. These estimates are from the 2022 *Budget Review.* Specifically, spending on educators, which is fairly

[48] See for instance National Treasury (2021). It is worth noting that even in the case of an ideal demographically stable workforce, where the average age and age distribution do not change over time, the assumption that budget forecasts should simply add what educators gain as experience-linked increases annually is problematic. That approach ignores that even with a constant age distribution, annual 'progression' increases are more less or offset by older employees leaving and younger employees entering each year. It is this demographic effect which is too seldom taken into account in South African budgeting.

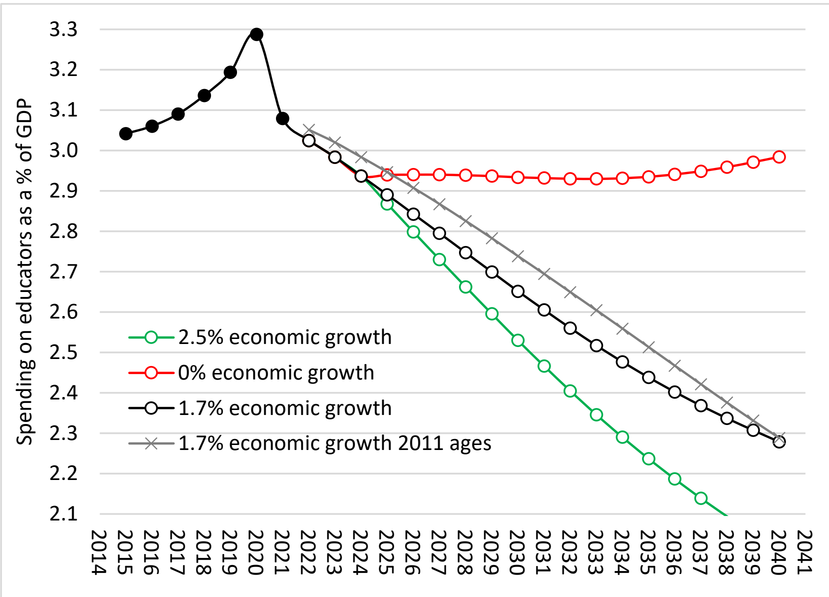
[49] For the counterfactual age scenario, a different educator input sheet in the model was constructed as follows. 2011 educators were lined up individually in a dataset, and sorted by age. Some educators were excluded randomly so that the total number of educators equalled the actual 2021 total. Then the 2021 educators were lined up and sorted by age, and within each single age educators were sorted randomly. The 2011 ages were then imported and replaced the original 2021 ages. The educator input sheet in the Excel tool was then recompiled.

[50] See Spaull *et al*, 2020.

consistently around 89% of all 'compensation of employees' spending in provincial departments, has come to around 3.1% of GDP in recent years, if one ignores the unusual shock of the pandemic, especially in 2020. This has changed very little over time: Treasury sources provide a ratio of 3.0% for 2007/08, for instance. If there are annual cost-of-living adjustments equalling CPI, though educators would receive their annual 1.5% progression, then by 2030 the educator wage bill over GDP would decline to around 2.7%, whether actual 2021 age distributions or the counterfactual distributions are used. With these parameters, by 2040 the percentage would be as low as 2.3%. It is unlikely that spending on basic education would be allowed to shrink this radically, especially in the context of the rising child population referred to above.

With a 1.7% GDP growth assumption, *and in the absence of above-CPI increases,* it would be easy to argue that the workforce should be 14% higher in 2030 than it was in 2021. This 14% translates to around 57,000 additional educators in the system, and is almost sufficient to cover the 15.8% workforce growth envisaged by the most ambitious scenario in Table 9 above. Around 14,000 of the additional 57,000 educators can be considered to have been made possible by a change in the demographics (see the vertical gap for 2030 between the two 1.7% scenarios in Figure 35). But clearly, the bulk of the opportunity for workforce growth arises out of the assumption of no above-CPI increases.

Figure 35: Total educator cost over GDP to 2040



Sources: The numerator and denominator up to 2021 are nominal values, beyond that they are real values expressed in terms of 2021 prices. For the numerator 2014 to 2021, the sum of compensation of employees (CoE) across the provinces, as seen in Treasury's EPRE Excel files (available on the Treasury website), was multiplied by the percentage of CoE spending going to educators, derived from November Persal datasets. This percentage ranges from 88.6% to 89.7% over this period. For the 2014 to 2021 denominator, the most recent nominal GDP published in the Budget Review *(up to 2022) was used. For years beyond 2021, the denominator is the 2021 GDP value based on the GDP growth values cited above.*

Figure 35 also illustrates that in the extreme case of no economic growth at all, the cost of educators over GDP would remain roughly the same, at around 3.0%. In such an extreme scenario, the scope for workforce expansion would be wiped out. The 2.5% growth trajectory in the graph provides a sense of the extent to which the case for workforce growth could strengthen within a more favourable economic context.

Essentially what is presented above suggests the system should budget for real increases in spending on the educator wage bill that is close to GDP growth. If Treasury's projections of

1.7% GDP growth are realised over a longer period, and this can be considered a relatively pessimistic outlook, then spending on educators should increase by 1.7% a year in real terms. This happens to be roughly the equivalent of what is implied by the 1.5% annual progression, and hence the methods currently employed by planners. However, these magnitudes of increases are required not because annual progression pushes up the average cost of an educator by 1.5% a year, an assumption which is clearly not true, but because they would allow the schooling system to stabilise the learner-educator ratio through workforce growth.

7 Next steps in the modelling

As explained in the introduction, the current report is an initial version. Further work, based in part on conversations between the various experts with an interest in the modelling, is needed. The report has already pointed to some clear needs for further work. This section sums up current understandings of next steps. Some of these relate to further development of the Excel model itself, some relate to gaining a clearer understanding of issues outside the model, and for some questions it is debatable whether the current model should be changed, or questions should be answered outside the model.

First, the following enhancement within the Excel model could strengthen information on the **number of new teacher graduates** needed:

a. While there is no easy way of finding out exactly which joiners recently graduated, through the combining of university data and Persal, further examination of just Persal can establish a clearer picture of what percentage of joiners, by age, are newly graduated. This can occur by including in the analysis salary notch, especially in the case of pre-2018 data. Two types of joiners could then be specified in the Excel model: first-time entrants who recently qualified, and other joiners. This would remove the need to use age 30 as a threshold below which all newly graduated teachers are assumed to exist. There could of course be such teachers aged a little over 30.

The following two issues need further exploration, but this is perhaps best done outside the model, but using the outputs of the model.

b. There is an interest in knowing **province-specific demand figures**. Differences across provinces in the age distribution of educators makes it clear that provinces will experience under-supply problems at different points in time. This could partly be resolved by running the existing model nine times, once for each province. Adapting the model so that it deals explicitly with all nine provinces at once, which implies dealing with inter-provincial movements, is perhaps not worth the cost. However, this is debatable.

c. There is a strong interest on the part of universities in knowing how **changing demand differs by school phase and school subject**. This overlaps with the question of provincial breakdowns as foundation phase language specialisations correlate closely to province. It would be relatively easy to use the outputs of the Excel model in the rudimentary phase- and subject-level type of analysis seen in the 2020 DHET report. However, the aim should be to move beyond this rudimentary analysis, by obtaining better data on the demographics of teachers with different specialisations. As mentioned in section 3.2, it appears that data could become available soon. This would be a major step forward, and would open the door to considerably better breakdowns by specialisation. However, such further work is probably best done in a separate, and relatively simple, model. One thing that can and should be done fairly easily, is to run the Excel model separately for primary and secondary schools, categories which are fairly clear though not completely watertight in the context of atypical grade combinations. A primary-secondary breakdown would be informative for the planning of training at universities.

One enhancement relates specifically to understanding **unit costs**, and is connected to earlier point (a).

d. There seems to be clear value in adapting the model so that **pre-qualified teachers enter the system at notches below the official entry level**, and move to the entry level after a specified lag reflecting the time it takes to obtain the full qualification on the job. This is a phenomenon which already exists, and could expand in future years.

A recent analysis has revealed how important **income tax bracket creep** has been in determining the after-tax net unit cost to the state in recent years[51]. Because of the bracket creep phenomenon, *percentage* increases in spending on educators as expressed in expenditure reports are over-stated by around a third, because these reports ignore what employees pay back to the state in the form of income tax. In the period 2013 to 2019, which has been characterised by above-inflation wage increases in the public sector, many educators moved into a higher tax bracket, meaning the percentage of their total income paid back to the state increased. It would not be difficult to incorporate this phenomenon into the model. However, it is unlikely this phenomenon would be a major factor when above-inflation increases are *not* given to employees, along the lines of the proposal made in section 6.3.

[51] Department of Basic Education, 2020b.

References

Batty, M. & Torrens, P.M. (2001). Modelling complexity: The limits to prediction. *Cybergeo: The European Journal of Geography*.

Centre for Development and Enterprise (2015). *Teachers in South Africa: Supply and demand 2013-2025.* Johannesburg.

Crookes, D.J. & De Wit, M.P. (2014). Is system dynamics modelling of relevance to neoclassical economists. *South African Journal of Economics*, 82(2): 181-192.

Crouch, L. (2001). *Turbulence or orderly change? Teacher supply and demand in the age of AIDS*. Pretoria: RTI.

Department of Basic Education (2015). *Comments on the CDE's 2015 teacher supply and demand reports*. Pretoria.

Department of Basic Education (2017). *Use of LURITS data to arrive at transition rates and enrolment scenarios*. Pretoria. [Unpublished report.]

Department of Basic Education (2018). *Per learner spending inequities in 2016*. Pretoria.

Department of Basic Education (2020a). *Action Plan to 2024: Towards the realisation of Schooling 2030*. Pretoria.

Department of Basic Education (2020b). *Recent purchasing power trends among public employees in basic education*. Pretoria. [Unpublished report.]

Department of Basic Education (2021). *Using EMIS assessment and class size data to inform the COVID-19 response.* Pretoria. [Unpublished report.]

Department of Basic Education (2022a). *Trends from the Persal data to inform basic education planning*. Pretoria. [Unpublished report.]

Department of Basic Education (2022b). *Inflow of new teachers into the public system*. Pretoria. [Unpublished report]

Department of Basic Education (2022c). *2021 school realities*. Pretoria.

Department of Basic Education (2022d). *Young teachers who enter public employment and become fully qualified while working*. Pretoria. [Unpublished report]

Department of Basic Education (2022e). *Interpreting the contents of the DBE's National Recruitment Database*. Pretoria. [Unpublished report]

Department of Basic Education (2022f). *Indicators to track historical educator promotions and their financial implications over time.* Pretoria. [Unpublished report]

Department of Basic Education (2022g). *Impacts of Resolution 2 of 2018 on unit costs and older joiner numbers.* Pretoria. [Unpublished report]

Department of Education (2009). *Teacher supply patterns in the payroll data*. Pretoria.

Department of Higher Education and Training (2014). *Ministerial statement on student enrolment planning 2014/15-2019/20 for universities*. Pretoria.

Department of Higher Education and Training (2020). *School teacher supply and demand in South Africa in 2019 and beyond*. Pretoria.

England: Department for Education (2015). *2016/17 teacher supply model user guide.* London.

Gustafsson, M. (2012a). *The gap between school enrolments and population in South Africa: Analysis of the possible explanations*. Stellenbosch: University of Stellenbosch.

Gustafsson, M. (2012b). *Incentives for teachers within the salary system*. Pretoria: Oxford Policy Management.

Hall, T.L. & Mejía, A. (eds.) (1978). *Health manpower planning: principles, issues, methods*. Geneva: World Health Organization.

Köhler, T. (2020). *Socioeconomic status and class size in South African secondary schools*. Stellenbosch: Stellenbosch Economic Working Papers.

Mlambo, V.H. & Adetiba, T.C. (2020). The brain drain of teachers in South Africa: Identifying the dynamics of its push factors. *Journal of Social Sciences and Humanities*, 17(1): 152-164.

National Planning Commission (2012). *National development plan 2030: Our future - make it work*. Pretoria.

National Treasury (2021). *Guidelines for costing and budgeting for compensation of employees*. Pretoria.

Ramrathan, P. (2003). Troubling the numbers: is teacher demand projections possible within the context of HIV/AIDS. *South African Journal of Higher Education*, 17(2): 177-186.

Roberfroid, D., Leonard, C. & Stordeur, S. (2009). Physician supply forecast: better than peering in a crystal ball? *Human Resources for Health*, 7(10).

Simkins, C. (2015). *Technical report: Teacher supply and demand in South Africa: 2013 to 2025*. Johannesburg: Centre for Development and Enterprise.
South African Council for Educators (2011). *Teacher migration in South Africa: Advice to the ministries of basic and higher training.* Pretoria.
South African Council for Educators (2020). *Annual report 2019/20*. Pretoria.
South African Council for Educators (2021). *Annual performance plan 2021/22*. Pretoria.
Spaull, N., Lilenstein, A. & Carel, D. (2020). *The race between teacher wages and the budget.* Stellenbosch: University of Stellenbosch.
Van der Berg, S., Gustafsson, M. & Malindi, K. (2020). *Education and skills for the economy and links to labour markets in South Africa*. Pretoria: National Planning Commission.
Williams, P. (1979). *Planning teacher demand and supply*. Paris: IIEP.
Willis, G., Cave, S. & Kunc, M. (2018). Strategic workforce planning in healthcare: A multi-methodology approach. *European Journal of Operational Research*, 267: 250-263.