‘Stretching’ the Undergraduate Curriculum: A Compensatory Response to Curriculum Modelling?

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Abstract
In 2013 the South African Council on Higher Education (CHE) proposed an extension to the three and four-year undergraduate academic curricula by an additional year with a concomitant increase in the number of credits. This, ostensibly, was necessary to ameliorate the unsustainably low graduation rates in Higher Education. In this paper, the authors contend that the proposal does not make a sufficiently compelling case for curriculum extension for several reasons. We argue that the pronouncement that the curriculum has an ‘irreducible core’ is inherently conservative and will not result in radical structural curriculum change, perpetuating a pedagogy that fails to move beyond the remedial. Secondly, we argue that the Draft Proposal provides financial modelling scenarios to motivate the feasibility of funding the extension of course duration, but fails to provide analogous scenarios to model the student progression and graduation benefits to be derived from funding such an extension. Our own modelling scenarios provided in this paper challenge the veracity and validity of the modelling scenarios provided in the Proposal and their attendant resourcing implications. We further demonstrate that in the context of minimal structural curriculum reforms, save for the miraculous achievement of near 100% graduation and minimal attrition rates, the proposed extension will in fact increase the burden on students, institutions and the state without any significant increases in graduations. The authors advance an alternative approach which involves the identification of alternative progression routes for students who fail out of the

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mainstream. Based on progression trends of successful students, modern analysis methods such as those originating in the field of Artificial Intelligence, enables data-mining of progression information from successful students to determine how existing curricula and timetables may be optimised to better support students progressing through these alternative routes.

Keywords: student progression**,** curriculum reform, population balance modelling

Introduction

In response to the unsustainable progression rates in South African Higher Education, the Council on Higher Education (CHE) commissioned a task team to report on appropriate interventions to mitigate the 'systemic obstacles to access and success, particularly in relation to curriculum structure' (CHE p. 15) – referred hereafter as the Proposal. In contextualising the problem, the Proposal alludes to the existing curriculum structure which was adopted almost a century ago … and has remained largely unchanged … and constituted a prima facie justification for a review' (CHE p. 15). The proposal eloquently describes and analyses the 'curriculum crisis' in South Africa, making a compelling case for urgent reform.

In principle, the authors of this article endorse the proposed reform to: (a) increase the number of graduates of good quality; (b) improve the equity profile of graduates; and (c) enhance success rates in higher education (CHE 2012). The authors further acknowledge, as originally submitted in the University of KwaZulu-Natal's (UKZN's) official response to the proposal, that redesigned university curricula should address the articulation gap, facilitate key transitions in the context of knowledge areas and cognitive demands, engage meaningfully with student diversity in all its forms, foster deep learning and promote the acquisition of practical skills and experience that all students need for economic, societal, civic and personal success in the 21st century (UKZN 2013).

Noting the above, the authors commend the admission in the proposal that the problems facing higher education in South Africa are systemic and structural, warranting reform that transcends band-aid interventions. In this regard, the proposal inspires confidence in its admission that 'all signs are that the fundamental problem is systemic rather than a result of student deficits', placing the imperative for systemic change on the higher education sector and individual institutions. Regrettably, this confidence is eroded by the proposal's lapse into the default deficit paradigm evidenced in the declared proposition that the existing curriculum has 'wholly insufficient curriculum space to enable such provision to be incorporated without compromising the integrity of the 'irreducible core' of knowledge in the curriculum' (CHE 2013). What constitutes the irreducible core is not elucidated in the proposal, prompting suspicion that the existing curriculum will in fact, with all of its structural pathologies, be 'stretched' to accommodate an additional year, wherein student un/under-preparedness will be remedied. How enhanced student learning, with a view to increasing the number of graduates with 'attributes that are personally, professionally and socially valuable' (CHE 2013) will be achieved by an extended curriculum, is not elaborated in the proposal, rendering the claims of potential gains little more than aspirational policy rhetoric.

Curriculum Responsiveness: Transcending the Econometric Discourse

The need for curriculum responsiveness has become central to education policy and higher education in South Africa as it has for its counterparts elsewhere in the world. Governments and professional bodies are under pressure as they contemplate curriculum reforms which generate work-ready graduates as economic entities in service of the market and the global economy (Pinar 2014; Standing 2011; Ogude *et al.* 2005). Indeed, market responsiveness and the econometric imperative has taken root in much of the grand narratives of higher education curriculum reform, reducing complexity and multi-dimensionality as a subset of other equally important imperatives such as social, institutional, cultural, disciplinary, pedagogical and learning responsiveness (ibid.). Giroux (2013) articulates this crisis:

Tied largely to instrumental ideologies and measurable paradigms, many institutions of higher education are now committed almost exclusively to economic goals, such as preparing students for the workforce - all done as part of an appeal to rationality, one that eschews matters of inequality, power and the ethical grammars of suffering

Giroux (2013) notes that casino capitalism does more than infuse market values into every aspect of higher education; it also wages a fully-fledged assault on public goods, democratic public spheres, and the role of education in creating an informed and enlightened citizenry. In a society wedded to narrow instrumentalist values, ignorance is a political tool which nourishes a deep-seated fear of civic literacy. Critical thinking and a literate public have become dangerous to those who want to celebrate orthodoxy over dialogue, emotion over reason and ideological certainty over thoughtfulness (Dhunpath 2014).

Curriculum Reform that Moves beyond the Remedial

The advancement of an informed and enlightened citizenry has not been an imperative for the new democratic regime, as evidenced in its compensatory policy fetish. The post-apartheid policy process underpinning education reconstruction has frequently been characterised by the 'add another policy' syndrome, supported by optimism that policies are in themselves a sufficient condition for reform and reconstruction. In this regard, the Proposal's 'add another year' approach underpinning its proposal is reminiscent of a similar optimism that the structural and systemic conditions that mediate student progression can be remedied by extending students' exposure to the prevailing curriculum. The earlier incarnation of this discourse was derived from the widely accepted belief that under-prepared students bearing the bruises of apartheid education could be healed by being lavished with academic support as they were socialised into the dominant higher education culture (Dhunpath & Vithal 2012).

Meaningful and responsive curriculum re-design requires not only the foundational elements proposed in the additional year to provide epistemological access to mainstream curricula, but should also involve curriculum enrichment through a review of curriculum content and breadth of coverage. This should be underpinned by a shift in pedagogy that privileges the attainment/cultivation of learning principles and the development of intellectual skills rather than the acquisition of discrete content knowledge. The curriculum reform process should result in radical curriculum enrichment with changes in structure, content and pedagogy that move beyond the remedial, to the creation of conditions necessary for enhanced student learning. This ultimate outcome must require higher education to transcend structural reform and embrace the intellectual project of an emancipatory higher education that resists commodification (see also, UKZN 2013).

Curriculum Reform as Compensatory Legitimation

The outcomes noted above cannot be achieved by financial modelling. The Proposal refers to 'Modelling options for increasing graduate output' (page 24). It is not clear what analytical tools were used to model the projected gains which it claims will be realised from the curriculum extension in relation to a) increased student graduations and b) reduced wastage in resources. The modelling detailed in the document has been primarily concerned with the financial implications of the extension of the undergraduate curriculum and does not convincingly demonstrate how the problem of student progression will be solved. Such a fundamental omission, the authors assert, is an indication of how Higher Education in South Africa risks being appropriated by the state in its quest for 'compensatory legitimation' as proposed by Hans Wieler (1983) to explain the failure of curriculum reform in the Federal Republic of Germany (see also Jansen 1990).

Through the gaze of compensatory legitimation we are alerted to the authority and the gravity conferred to tools and instruments used by the state to legitimise policy proposals and pronouncements. These, Jansen (1990) argues, are 'sanctioned by expert studies and experimentation; participation and … the involvement of citizen participation as an instrument to restore the legitimacy of the state … as a manifestation of scientific `rationality' and objectivity' (p. 3). The CHE consultative process has the necessary ingredients for democratic participation in the policy process, but fails to sustain the confidence it inspires because the proposal advances an econometric model to solve a pedagogic problem.

A Higher Education Pedagogy of Possibility

In embracing a reconceptualised higher education pedagogy of possibility, we have an obligation to shift the gaze to other, more obvious, but unseen dimensions of student performance that can be equally significant, such as seeking mechanisms to accommodate students' interdependent modes of learning in order to shift them from more independent modes – modes that determine students' ability to actively participate in the academy.

We have argued elsewhere (see Dhunpath & Vithal 2012) that we need to put both the question of underprepared students and underprepared universities under the spotlight, entertaining the possibility that 'institutional culture is often disembedded and disembodied from the culture of the student body it was attempting to socialise' (p. 11). The CHE's Access Three Case Studies (2010) reveals that the caricatured 'underprepared' student is not confined to black students from disadvantaged schools. Many students with excellent matriculation scores struggle to negotiate their alienation resulting from the 'pedagogic distance' which universities fail to effectively manage. Pedagogic distance is not confined to geographic or physical space, but evinces at least five dimensions: 'emotional, political, pedagogical, linguistic and physical' (CHE 2010: 98) and find expression in students' alienation which is a consequence of their ignorance of the primary tools required to navigate university life.

The notion of student alienation is explored by Deil-Amen and Rosenbaum (2002), in their working paper: 'The Social Prerequisites of Success: Can College Structure Reduce the Need for Social Know-How?' They argue that community colleges 'require certain kinds of social know-how' which are often absent from the repertoires of disadvantaged students. They present seven obstacles: bureaucratic hurdles; confusing choices; student-initiated guidance; limited counsellor availability; poor advice from staff; delayed detection of costly mistakes; and poor handling of conflicting demands (ibid. p. 2). Amen & Rosenbaum argue that these conditions do not typify private occupational colleges which create conditions to 'structure out' the need for this social know-how, and address the needs of disadvantaged students more successfully. Their argument hinges on the proposition that higher education institutions assume that students have the social know-how necessary to succeed. The social know-how includes students' knowledge about 'how to handle enrolment, class registration, and financial aid, to initiate information gathering, to access sound and useful advice, to avoid costly mistakes, and to manage conflicting demands' (p. 3), all of which affect their ultimate college success. Conflicting demands, Stephens et.al. (2012) argue, are a consequence of a university culture that promotes competitive student behaviour which in turn privileges independence, and undermines students’ performance. Conversely, they contend, advancing a university culture which values interdependence (i.e. being part of a community) reduced the articulation and performance gap.

In summary, the cultural capital that students require to reduce the articulation gap and enhance students’ capacity to negotiate higher education can be provided by anticipating and demythologising access strategies. This can be achieved by institutionalising scrupulously designed and sustained awareness programmes, distinct from the ritualistic orientation programmes that currently typify many South African universities.

Thus far the authors have advanced a socio-political critique of curriculum reform in South Africa. We now return to the primary concern of this article which relates to the allegation that the Proposal advances an econometric solution to a pedagogic problem. Since the Proposal does not explain its modelling approach we can only speculate how it was developed. The speculation would be based on the supposition that the ‘model’ is based on the assumption that student under preparedness would be remedied by adding an extra year of study, resulting in an increased graduation rate. In this paper we argue that intervention does not require the addition of an academic year, but can and should be integrated into institutionalised academic monitoring and support programmes.

Population Balance Modelling

The alternative model presented in this paper is based on the field of **Population Balance Modelling**, which predicts the changes in properties of a population of entities (in this case students) based on kinetic parameters. In this case, the kinetics are the observed pass and dropout rates. The property being modelled is the academic year of study of the student. Once this model was shown to fit the available data, it was analysed in a series of five case studies to reveal the changes to the rates of graduation, failure and holdup. Holdup is an important concept since it yields the number of students that must be present in the system (in the curriculum) at any given time, and hence reveals the cost of maintaining that academic programme.

The authors interrogate hereunder the modelling scenarios in the Proposal which is based on predicting progression across the student population according to the year pass rate and the rate at which failed students return. A four-year academic programme was taken as a benchmark, and it was found that the model correctly predicts graduation and failure rates as well as total numbers of students in the system and number of students passing in the minimum time.

Various scenarios were simulated according to permutations of the options proposed by the CHE. No scenarios were found to yield an improvement in the graduation rate with significantly increasing the total number of students in the system. An alternative view of curriculum restructure is proposed that attempts to extract the most useful aspects of the proposal with the view to increasing graduation and retention rates.

Model Outline

To make any progress in assessing the likely outcome of any proposed intervention, a model is required to understand the implications of the outcomes mentioned. A crude 'model' would be to simply assume certain outcomes (graduation, failure rates) as a result of a proposed intervention. A more reliable predictor would result from taking the available student data, distilling from it the intrinsic factors such as likelihood of passing from one year to the next and the likelihood of dropping out of a curriculum, and therefrom to predict the number of students in each academic year of study.

Of the various modelling frameworks available, Population Balances, which predicts the outcomes of a group of members, is the most suitable for this type of prediction. In this branch of mathematics, the proportion of population members which exhibit specific properties is predicted. In the present case, the property is chosen to be the academic year of study, and the population is the group of students registered in an academic programme.

A comprehensive derivation of the model used in this analysis is provided in the Appendix A; in this section, we distil the major aspects of the model.

The number of years N is the number of years in the academic programme, e.g. $N = 4$ refers to an academic programme whose minimum time to graduate is four years. The pass rate p_i refers to the fraction of students in academic year i who will pass a sufficient number of credits to enter the next year of study $i+1$ while the return rate r refers to the fraction of students who after failing a year of study return to continue their studies.

We define the number of students who enter that year i to be e_i , where this entry could be due to the admission of new students into year 1, or it could be transfer students from other institutions into higher years of study, etc. We recognise also that the number of students who leave year i due to academically progressing to the next year is $p_i.s_i$. The number of students who fail year i must then be $(1 - p_i).s_i$. The number of students who fail out and who return to year i is then $r_i(1 - p_i).s_i$ and the number who fail and do *not* return is $(1-r_i).(1 - p_i).s_i$.

The rate of change in the number of students in any given year is then the sum of the students entering from external sources plus those who pass the previous year and enter that given year, minus those who pass the current year and enter the next, minus those who fail from the given and do not return to it. The other students are simply retained in the system, hence will not factor in the rate of change equation. The overall balance on year i is then given by:

$$\frac{ds_i}{dt} = e_i + p_{i-1}.s_{i-1} - p_i.s_i - (1-r_i)(1-p_i).s_i$$

Note that the symbol on the left hand side of the equation ds_i/dt is the rate of change of the number of students registered in year i. If N is the number of students in the academic programme, then s_{N+1} can be considered to be the number of graduates per annum, which can be calculated simply as $G = s_{N+1} = p.s_N$. We obtain the value s_N by solving the model equation.

According to the model (see Appendix A) these inputs are adequate to predict in a single year the total number of graduates of the programme G, the total number of students who will be registered in that academic programme T, the number of students who will fail out of the academic programme F and the number of students who will complete in minimum time M.

Model Validation and Scenario Simulation Principles

We wish now to restrict attention to the performance of a single academic programme as a result of the proposed change by the CHE. By selecting a single programme as a benchmark, we wish to further our understanding of the potential outcomes of the intervention to the institutional system as a whole. In other words, by understanding the influence of the intervention to a single benchmark academic programme, we anticipate that the overall effect upon whole institutions can be understood.

Such an approach also allows for the analysis to be generalised and simplified, in that it is not necessary to obtain data regarding, e.g., individual pass rates for each year in each programme at the university. It is sufficient for our purposes, therefore, to assume an academic programme with a target intake of new first year students of 100 per annum. In addition, the pass rate p will be assumed to be the same for all years of study. Although this is obviously generally not the case, the fluctuations in pass rate from year to year does not affect the analysis. It is therefore pointless to apply different values for each year. A single pass rate p will be used instead. The same applies to the return rate r.

These simplifications allow for benchmarking a representative programme; the fact that the pass and return rates actually differ from year to year does not affect the analysis to come.

We select p and r such that national averages in terms of overall graduation rate and overall dropout rate apply.

For a pass rate of $p = 0.7071$ and a return rate of $r = 0.65$, we find that the model predicts 58 students graduating per annum, 25 graduating in minimum time, 42 failing out of the programme in total and 408 students registered (across all years). These pass and return rates therefore give the typical performance of many engineering programmes.

These values of p and r therefore provide reasonable parameters for benchmarking an academic programme. In the following scenario models, we predict the system behaviour for interventions such as that suggested in the 'CHE proposal'.

Scenario Modelling Results

Table 1 summarises the results of modelling the scenarios described below. Note that scenario A is actually the benchmark case or current situation of an academic programme with four academic years that normally accepts 100 new first year students into the programme. The pass rate *p* and return rate *r* are chosen such that typical overall graduation and dropout rates apply.

Scenarios B, C, D and E consider the Proposal by simulating the model with the addition of one year ($N = 5$). The cases differ from each other in that the additional year of study is presumed to affect the pass and return rates.

The outcome of these changes is then observed in the graduation rate *G*, total in system *T*, failure rate *F* and graduation of minimum time students *M* [students/annum].

The most important output variable is the Graduation Efficiency GE; this value is defined as the Graduation Rate G divided by the total number of students in the system T, i.e. $GE = G/T$, and is the most useful way to summarise how effective a programme is in delivering its graduates.

The reason for this definition is as follows: The total number of students in the programme *T* is the number of students that must be supported by the academic programme in order to produce the number of graduates *G*. In addition, the value T is also the number of students that could be involved in other pursuits, whether academic or otherwise. As such, *GE* is a measure of how efficiently the academic programme is producing its graduates.

Table 1. Model outputs for benchmark A and four scenarios

Scenario	A	B	C	D	E
Years, N	4	5	5	5	5
Passrate, p	0.7071	0.7071	1	0.85	0.85
Return rate, r	0.65	0.65	0.65	0.65	0.3
Graduates, G	58	51	100	74	56
Total in sym, T	408	480	500	493	420
Fails, F	42	49	0	26	44
Minimum time, M	25	18	100	44	44
Graduation efficiency, GE	0.142	0.106	0.200	0.150	0.133

In scenario B, we simulate a doomsday case, where the addition of the year does not change either the pass rate or the return rate. It is useful to consider this case for two reasons: 1) it establishes the influence of the intervention with reference to the present performance level without the intervention, and

2) it establishes the minimum performance outcomes. The result is significantly worse than the case where the curriculum is not extended; the graduation efficiency is the lowest among all scenarios at 0.106. In terms of the unprocessed outcomes, the graduation rate declines (51), the total number of students in the system increases (480), the number of students failing out of the system increases (49), and the number of students finishing in minimum time also decreases (18). All these effects can be summed up simply as: the additional year is merely an extra year that the students can fail out of. It does nothing to change the level of understanding. Scenario B therefore establishes the worst possible case.

At the opposite extreme, in Scenario C, we consider the case where the number of years increases to five, but that the pass rate increases dramatically due to a change in curriculum design. In this scenario, we consider the ideal case that the pass rate goes to 100%. We note that the return rate really does not matter since there are no failures to return to the system. In this extreme/idealistic case, the number of graduates p.a. must equal the number of entrants (100), there are 0 students failing, and the number of minimum time students is 100. However, the total number of students in the system is then necessarily 500, making the graduation efficiency 0.2 (which is still the highest efficiency among the scenarios).

In this scenario, the increase in total student numbers is unavoidable; this is in fact a consequence of the success of the programme: the perfect pass rate results in all students of the given year entering the subsequent year as a block. Even in this ideal case, there are serious doubts regarding sustainability. Does the institution have the capacity for the increase in student numbers? Are there sufficient venues, labs and teaching staff to accommodate this increase in student numbers?

We note that the Proposal calls not merely for the extension of academic programmes by a year, but also for a proportional increase in the number of credits. As such, the classes do not merely become larger in size; rather, there are necessarily more classes, in fact 33% more in the case of three-year degrees and 25% more in the case of four-year degrees. 3) Does the relative cost of maintaining the increased number of students and increased number of classes justify the increased number of graduates?

We note here that the number of graduates has increased under the assumption of the pass rate becoming a perfect 100%, which is unrealistic.

However, this Scenario C was intended only to establish the opposite extremum to Scenario B.

Further to Scenario C, one could consider a modified version; it is possible to keep the total number of students at 400 if one simply accepts only 80 students and one is prepared for a reduced graduation rate (i.e. only 80 graduates even if the pass rate is 100%). Although this appears to be feasible, the national tendency is away from this option; institutions are routinely asked not just to increase the 'throughput', but the admission rates as well.

Further, this does not address the CHE requirement that the number of credits increase. If credits increase, then even if the number of students remains the same, the number of courses, venues and staff must all increase between 25 and 33%.

Scenarios B and C are the extrema, the doomsday and the perfect world scenarios respectively. In scenarios D and E, more realistic situations are explored in which the expectation of the pass rate increase is moderated. We simply average the doomsday and the ideal cases to adopt a value of $p = 0.85$, and apply different return rates, with D having the same return rate as the benchmark. Even with the moderated pass rate, the total number of students in D is unsustainable at 493 (although graduates are up at 74). The graduation efficiency is 0.15, which is not significantly different from the current situation in Scenario A, which has a GE value of 0.142.

If we force the return rate r to a lower value (0.3) in Scenario E, the number is more sustainable. However, the graduation efficiency is even lower at 0.133 and in all the indices, excepting the number of minimum-time students, the values are worse than for the benchmark case Scenario A, which, we note, is the performance of the education system at present without intervention.

To summarise the scenarios simulated, it is clear that should the Proposal be implemented, institutions would have to increase in size by between 25 and 33%, both in terms of number of staff and in terms of the physical size of the 'plant' or institution site.

Even the most optimistic outcomes are unfeasible; should the pass rate become a perfect 100% as a result of an increase in the number of years, the total number of students held up in the system would increase to cause not only the number of classes but also the size of the classes to increase.

When applying realistic estimates of an increased pass rate, it is clear that the very moderate increase in graduation numbers and negligible difference in graduation efficiency cannot justify the large expenses incurred during implementing and maintaining this proposal. Furthermore, given that the proposal requires a proportional increase in credits taught, the doomsday scenario B is more likely to occur than even the moderate increase in pass rate of Scenario D.

In addition to the expenses already mentioned, it should be noted that the time and effort required in developing the content required of the additional credits will be significant. Furthermore, there is a hidden cost that would not be apparent in the first years of implementation: at some point, for every academic programme that extends its curriculum, there will have to be one year in which that programme will produce no graduates. This cost might also be hidden by the graduation of students recycling through the system, but the overall effect is that there will exist a year in which there will be no graduates.

A third hidden cost is to the students. The extra year of study with new additional credits to pay for is simultaneously an additional cost of education as well as a lost year of employment. Students present at seminars where the Proposal has been discussed have strongly voiced their concern in this regard. These students have gone so far as to state that the proposal is viewed by them as motivated by educational institutions to increase the amount of fees that would be extracted. Considering the growing global concerns about the so-called Education Bubble and the global rise of student debt and the increasing inability of graduates even to service this debt, the fears expressed by students cannot be ignored.

A fourth hidden cost is specific to the education system in South Africa, which appears to be the only country considering this move. The reputational damage to the institutions, students and education system of the country in requiring an additional year to graduate the same degrees as available in other countries is enormous.

The Flexible Curriculum

A potentially valuable feature of the CHE's curriculum proposal is its flexibility which means, theoretically at least, that students who are able to pass the degree in the minimum time under the current curriculum structures will still be able to do so in the future. Regrettably, this has so far been promissory rather than concrete. The authors of this article concede that they are unaware of appropriate mechanisms to expedite accelerated student progression. However, this ideal does provide cues for how some useful changes might emanate from the notion of 'flexibility' suggested in the proposal.

First, it should be recognised that a 'Flexible Curriculum' already exists in the current regime and evolves in a 'natural' way. For instance, when a student fails a large enough number of credits typically a university's student advisory services develops an alternative progression in consultation with the student. These extra-year plans are in essence what the CHE is proposing should become the norm. If such progression routes are identified proactively rather than reactively, a simpler and more efficient approach would be possible in which the (current) minimum time programmes would be maintained as the default, and the extended year programme would be activated only when a student does not meet the criteria for continuing the minimum time programme.

The novelty of this approach lies in empirically defining these alternative progression routes. At present, when a student fails out of the minimum-time route, s/he is at the mercy of the various advisors to map out a new progression strategy. Indeed, the variety of progression routes attempted by students is well-recorded and documented in the student registration databases of every academic institution. Additionally, in these same databases, the student success rates in these various routes are also recorded. The modern algorithms available in the field of Artificial Intelligence can be applied to data-mine these sources to determine which progression routes yield the greatest chances for success. Such developments are beyond the scope of the present paper, but do feature in the future research intentions by the present authors.

Once these routes are known and understood, it becomes possible not only to label and acknowledge, and thereby de-stigmatise these alternative progression plans, but also to timetable courses such that the progression plans do not clash, or to minimise the extent of the clashes. Here, again, the database of previous student progression data is useful since it can be used to determine, when clashes were allowed, what the likelihood of progress was.

This approach would allow for the 'minimum-time' progression plan to be acknowledged as a route to be aspired to while still acknowledging alternative approaches are possible and even supported. Stronger students are therefore not denied the credit of completing degrees in a short space of time, and weaker students are still strongly supported and incentivised to perform better.

By contrast, the CHE proposal in its present form relegates all students to the lowest level of performance, and dis-incentivises students from performing optimally. Indeed, the proposal opens the door to future further extensions of academic programmes at a time when institutions are being criticised for fuelling an Education Bubble from which the world will never recover.

Another important concern implicit in the foregoing discussion is the role of pre and co-requisite modules in serving as gatekeepers of student progression. While a detailed treatment of this phenomenon also falls outside the scope of the present paper, it should be abundantly clear to many of us involved in curriculum design and quality assurance, that these gatekeeper modules are often historical and a product of academic rituals rather than the product of any compelling pedagogic justification. A systematic analysis of institutional practices in this regard should yield significant benefits.

Shifting the Deficit Gaze

A crucial and candid admission that underlies the CHE's call for curriculum reform is that not only is the problem of poor student progression a structural and systemic one (having its roots in the Oxbridge academic tradition), it is also a product of layers of institutional under preparedness. In particular, the proposal notes that 'it is clear that meeting the needs of the majority of the intake will require a greater emphasis on entry-level teaching and course design that is geared to bridging the articulation gap and enabling students to develop sound academic foundations, in terms of subject knowledge and relevant academic skills' (CHE 2013:143) [that not only looks but also sounds quite biblical!].

The problem of underprepared university teachers will not be minimised or eradicated by an extension of the curriculum. The problem is likely to be exacerbated as new, early career academics are typically allocated beginner undergraduate classes. It is therefore reassuring to note that both the CHE and DHET are in synch about the need to accelerate professional development as a pre-requisite for enhanced student success. The various cooperative efforts, including the Quality Enhancement Project (QEP), while not a panacea for radical change, certainly shifts the gaze from the student as the carrier of deficits to a realisation that we should be turning the gaze on ourselves as academics since structural reform alone will not remedy our deficits (see Dhunpath & Vithal 2012).

Concluding Observations

This paper has attempted a critical analysis of the CHE proposal to extend the duration of academic programmes by one year in relation to its claimed outcomes. As a first step, the assumption inherent to this proposal that the extension by a year of study will result in an increased pass rate is challenged, and a more rigorous model based on population balances is proposed. The model was validated using national graduation averages, and a benchmark scenario simulated. A series of case studies showed that in order to achieve increased graduation efficiencies, unrealistically high pass rates were required before even moderate increases in graduation rates could be realised.

In addition, given that the proposal requires a proportionally increased number of credits, the number of courses, academic staff, classrooms and facilities would have to increase for all academic programmes (and hence all academic institutions) by between 25 and 33%. A major drawback of the CHE proposal is that all students, including those who would ordinarily have graduated in the minimum time of N years, would now necessarily graduate in a minimum time of N+1 years. As such, the proposal forces all students to the same low rate of progress and disincentivises students from making better progress.

The proposal incurs heavy costs not only to academic institutions, but to students as well. At a time when the Education Bubble is being discussed globally, this aspect cannot be ignored. With a growing population of students who will never in their lifetimes be relieved of the debt incurred, the South African situation must be treated with particular care.

A simple modification of the proposal is suggested instead, based on using student data to identify alternative progression routes. At present, students who fail out of the minimum time programmes do not have clearly mapped progression routes. Student data can be used to identify the most frequent and successful alternative progression routes, and practical steps can be taken to acknowledge and support these alternatives. For example, if courses were timetabled such that clashes were minimised, the overall student success rates must increase significantly.

As such, although this paper shows that curriculum extension is not likely to justify the heavy costs enumerated, a modified notion of the flexible curriculum can indeed yield improvements in the education system and achieve more than compensatory legitimation.

Appendix A: Model Development

We wish to predict the student profile of an academic programme. The profile includes number of graduates per annum *G*, number of students failing across all years *F*, the total number of students registered in the programme *T* and the number of students completing in minimum time *M*.

It is expected that these quantities can be predicted when given 1) the number of years of the academic programme *N*, 2) the pass rate p_i, defined as the fraction of the students in year *i* of an academic programme who will pass to enter year i+1, 3) the return rate r_i, defined as the fraction of students who fail year i and who are re-admitted to year i, and 4) the entrance rate e_i, defined as the number of students per annum who enter year i from an external source (e.g. another academic institution).

We also defined s_i to be the number of students registered for the i_{th} year of an academic programme.

We wish to write population balances on the students in each year. We recognise that in a given year i, the number of students who enter that year will be e_i and the number of students who leave it due to progressing to the next year is $p_i.s_i$. The number of students who fail year i must then be $(1 - p_i).s_i$. The number of students who fail out and who return is then $r_i(1 - p_i).s_i$ and the number who fail and do *not* return is $(1-r_i).(1 - p_i).s_i$.

The rate of change of students in any given year is then the sum of the students entering from external sources plus those who pass the previous year and enter that year, minus those who pass the current year and enter the next, minus those who fail and do not return. The other students are simply retained in the system, hence we need not account for them. The overall balance on year i is then given by

$$\frac{ds_i}{dt} = e_i + p_{i-1}.s_{i-1} - p_i.s_i - (1-r_i)(1-p_i).s_i$$

We note that p_0, which is the pass rate from year 0 to year 1 is necessarily zero; there is no year 0 from which to pass into year 1 since we have already accounted for entrants into year 1 through e_1. This equation is therefore valid for i = 1 as well as for i>1 and i<N+1. If N is the number of students in the academic programme, then s_{N+1} can be considered to be the number of graduates per annum, which can be calculated simply as $G = s_{N+1} = p.s_N$. The challenge then is to predict the number of students in the final year of study.

Constant Performance Assumption

Since in this article, we wish only to evaluate the implications of the CHE proposal, it is not necessary to consider variance in pass rate and return rate across the years. We wish simply to benchmark the performance of an academic programme against an applied change such as a change in the number of years N with a related change in the global pass rate and possibly the return rate. For this purpose, it is sufficient to allow that the pass rate p_i is the same for all years p and similarly, the return rate r_i will be accepted as r.
It is quite easy to relax this assumption when doing more detailed analysis; when we wish to do so, it is trivial to data mine student records for year-by-year values.

New First Years Assumption

When again considering the purpose of the present evaluation, it is sufficient to consider that the entrants to the programme are only in the first year of study; as such, $e_1 > 0$ and ei = 0 for i>1.

Detailed Development for a Four-year Programme

When applying the Constant Performance Assumption (CPA) and the New

First Years Assumption (NFY) for a four-year academic programme the following model equations apply.

$$\frac{ds_1}{dt} = e_1 - p.s_1 - (1-r)(1-p).s_1$$

$$\frac{ds_2}{dt} = p.s_1 - p.s_2 - (1-r)(1-p).s_2$$

$$\frac{ds_3}{dt} = p.s_2 - p.s_3 - (1-r)(1-p).s_3$$

$$\frac{ds_4}{dt} = p.s_3 - p.s_4 - (1-r)(1-p).s_4$$

We can write these equations more conveniently in the following vector matrix form:

$$\frac{d\mathbf{s}}{dt} = \mathbf{A}.\mathbf{s} + \mathbf{e}$$

Where

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \end{bmatrix}, \ \mathbf{e} = \begin{bmatrix} e_1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

And

$$\mathbf{A} = \begin{bmatrix} -p-(1-r)(1-p) & 0 & 0 & 0 \\ p & -p-(1-r)(1-p) & 0 & 0 \\ 0 & p & -p-(1-r)(1-p) & 0 \\ 0 & 0 & p & -p-(1-r)(1-p) \end{bmatrix}$$

We are now in a good position to perform analysis. Since this a question concerning curriculum design, we are interested in the steady state performance, i.e. ds/dt = 0. In this case, we obtain

$$\mathbf{s} = -\mathbf{A}^{-1}.\mathbf{e}$$

where $\mathbf{A}^{-1}$ is the inverse of the matrix **A** above. It can be shown that for 'reasonable' values of p and r, this matrix is well-conditioned and invertible; this model then has the fortunate property that it is easy to solve.

Model Generalisation to N Years

The model development has so far been for a four-year programme. In accordance with the purpose of this document, the development must be generalised for any number of years *N*.

It is clear from the previous section that for N years, the model becomes:

$$\frac{ds_1}{dt} = e_1 - p.s_1 - (1-r)(1-p).s_1$$

…

$$\frac{ds_i}{dt} = p.s_{i-1} - (p + (1-r)(1-p)).s_i$$

…

$$\frac{ds_N}{dt} = p.s_{N-1} - (p + (1-r)(1-p)).s_N$$

From this, we can derive the simple algorithm as follows:

$A_{i,j}$ = 0 excepting

For i=1:

$$A_{1,1} = -p - (1-r)(1-p)$$

For i>1:

$$A_{i,i-1} = p$$
$$A_{i,i} = -p - (1-r)(1-p)$$

While e_i = 0 excepting e_1>0.

We have then

$$\mathbf{s} = -\mathbf{A}^{-1}.\mathbf{e}$$

And the chief outputs of interest are as follows

$$G = s_{N+1} = p.s_N$$
$$T = \sum_{i=1}^{N} s_i$$
$$F = \sum_{i=1}^{N} (1-p_i)(1-r_i)s_i = (1-p)(1-r)\sum_{i=1}^{N} s_i$$
$$M = e_1 \prod_{i=1}^{N} p_i = e_1 p^N$$

[It is not necessary or even normal to provide code in a paper like this; I am simply deleting]

The results are given in the following figures.

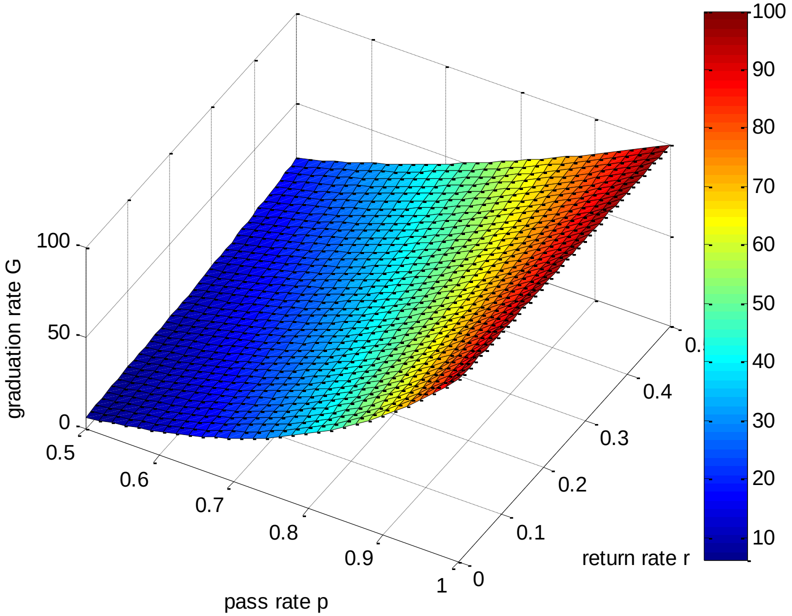

Figure 1. Graduation RateT

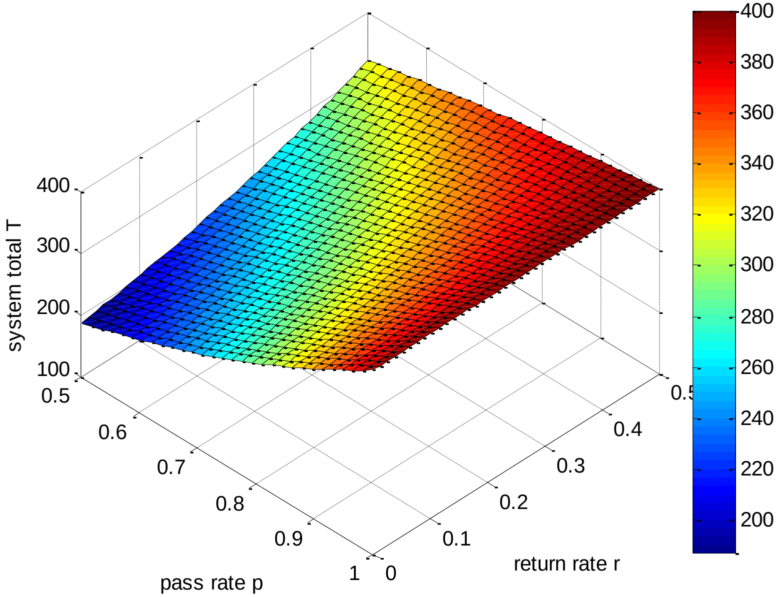

Figure 2. Total Students in System T

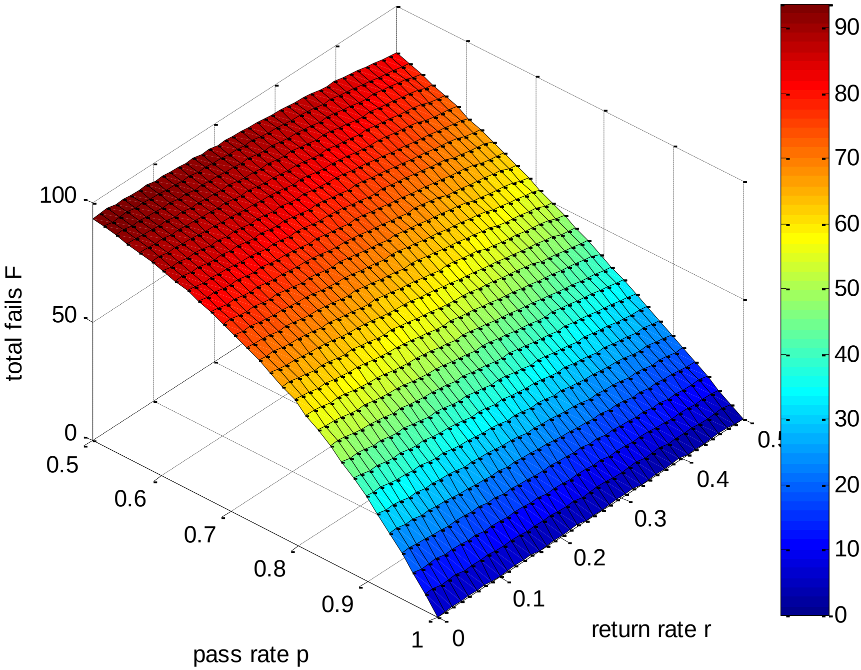

Figure 3. Total failing out of system F

All figures are returning expected trends and generating reasonable results. More detailed analysis is provided in the body of this document.

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