Transcending the Econometric Discourse in Curriculum Design: Multi-trajectory Progression Planning

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Abstract

In 2014, *Alternation* carried an article by Rawatlal and Dhunpath (Special Edition 12) titled 'Stretching the Undergraduate Curriculum: A Compensatory Response to Curriculum Modelling?' In that article, the authors contended that the South African Council on Higher Education's (CHE) proposal to the South African government to extend the undergraduate curriculum by an additional year does not make a sufficiently compelling case, primarily because the proposal is inherently conservative in failing to move beyond the remedial. Furthermore, in challenging the veracity of the modelling scenarios presented in the proposal, we argued that the proposal inappropriately seeks to advance an econometric model to solve a pedagogic problem. In 2015, the Department of Higher Education and Training (DHET) rejected the CHE proposal because the modelling on which the proposal was based failed to account for a key driver in curriculum reform: The Foundation/Access Programmes, which, the DHET argues, had impacted student progression over the interceding years. In this article[1], the authors cautiously support the DHET decision to reject the CHE proposal, arguing that in the absence of radical curriculum transformation in structure, form and content, new possibilities do emerge from the now institutionalised Foundation/Access Programmes that support a Multi-Trajectory Approach (MTA) to designing curricula. The MTA approach is a

[1] This article is an extension of the arguments presented in one that appeared in *Alternation* Special Edition 12, 2014.

ISSN 1023-1757

departure from the perfunctory approach to curriculum design, and disrupts curriculum rituals by infusing a scholarship of intellectual generosity without sacrificing rigour in delivery. The authors conclude by offering a tangible illustration of MTA in the form of Progression Mapping which allows students to have real-time, online access to their projection trajectories.

Keywords: curriculum modelling, curriculum extension, progression mapping, econometric discourse

Introduction

The South African higher education system's ability to advance the project of an intellectually agile and productive citizenry has been the proverbial 'elephant in the room' for generations. Instead, what has persisted is a higher education curriculum which is often critiqued for its conservatism rather than its liberatory potential. This was the case until the SA CHE attempted to diagnose the enduring pathology. In 2013, the CHE boldly pronounced that the source of the problem may be located in the curriculum which had '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). To solve this problem, the CHE proposed to extend the three- and four-year undergraduate academic curricula by a year with a concomitant increase in the number of credits. The motivation for the original proposal was ostensibly to ameliorate the unsustainably low graduation rates in Higher Education. We argued in the original article (Rawatlal & Dhunpath 2014) that the notion of an 'irreducible core' underpinning the curriculum is inherently conservative and will not result in radical structural curriculum change, perpetuating a pedagogy that fails to move beyond the remedial. Secondly, we argued that the draft proposal provides financial modelling scenarios to motivate the feasibility of funding the extension of course duration, but fails to offer analogous scenarios to model the student progression and graduation benefits to be derived from funding such an extension. Our own modelling scenarios challenged the veracity and validity of the modelling scenarios set out in the proposal and their attendant resourcing implications. We concluded the article by proposing a different approach which involves the identification of alternative progression routes for students who

fail out of the mainstream. We argued that modern analytic methods such as those originating in the field of Artificial Intelligence (AI) enable 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.

In this article, which might be regarded as a sequel to the 2014 article, we explore the government's rejection of the CHE proposal, to establish whether the rejection is soundly motivated and whether the recommendations made by the Minister of Education and Training in response to this proposal are likely to generate productive outcomes. We then explore some of the disabling characteristics of existing curricula and how arbitrary ritualised curriculum structures continue to survive, despite their failure to promote student success. Finally, in concretising our conception of the Multi-Trajectory Approach (MTA) to navigating a curriculum, we offer, through the lenses of the Engineering curriculum, a tangible strategy in the form of Progression Mapping which enables students to take responsibility for their own progression, using existing technologies in real time. This is contingent upon curriculum leaders examining the logic of sequencing module content and coverage to ensure that students are exposed to fundamental conceptual knowledge and foundational principles before more complex content is attempted.

Back to the Design Board

Despite the popular approval the CHE received from the higher education sector on its proposal to extend the undergraduate curriculum by an additional year, the Minister of Higher Education and Training rejected the CHE's advice based on an apparent omission in the CHE's modelling scenarios, which do not factor in the impact of DHET interventions. This is articulated by the Minister as follows:

> DHET has in recent years introduced several important interventions impacting on teaching and learning at our universities. These include, inter alia, earmarked grants allocated to serve specific purposes. These grants are now firmly embedded in the system, having matured into effective instruments for developing capacity and bringing about change and improvements in performance. I believe that the Flexible

> Extended Curriculum proposal, based on 2005 cohort data, has underestimated the improvements brought about by these and other interventions, and thus has perhaps underestimated the possibilities of curriculum reform within the current structural dispensation (DHET 2015).

Is this rejection justifiable? To answer this question, we revisit the modelling which informed the proposal. In the 2013 proposal, the claim is made that the modelling demonstrates an increase in graduation rates from 21,000 to 28,000 using an intake of the same size (42,000). By extrapolation, the report points out that without curriculum change, to achieve the higher graduation rate of 28,000, an intake of 53,000 would be required. The report goes on to discuss the increased efficiency of subsidy usage that could be realised, but of course the basic premise is that by changing the curriculum, the graduation rate will increase by one third; this is the key assumption to be probed.

Nowhere in the document titled 'Advice to minister of higher education and training on the reform of the undergraduate curriculum in higher education' (2014) is this assumption probed. To do so, the reader must refer to the original document titled 'A proposal for undergraduate curriculum reform in South Africa: The case for a flexible curriculum structure'. Even before the model is presented, the document argued at length that increased efficiency can be achieved in graduation rates, should the DHET increase the subsidy levels. It also assumes that despite the prescribed additional year of study and the additional 120 credits in all curricula, the cost of education will remain unchanged. Setting aside the obvious questions that these statements raise, let us examine the modelling.

It should be noted that 'flexibility' in the report refers to the notion that criteria can be developed to determine which students can be exempted from the 120 additional credits. This would be extremely difficult to accomplish without being exclusive and potentially discriminatory. The obvious question that arises is: why create a more politically fraught system when alternative access in the form of Foundation Programmes has already been institutionalised? A further question is: why set an inflated default from which a student must be exempted?

The model development occurs quite late in the document, in chapter 8. In fact, in this chapter we find not so much model development but a set of scenarios resulting from particular assumptions. In the status quo scenario, the

current graduation and dropout stats are cited for the purpose of benchmarking. The first scenario relies on two assumptions: 1) that current minimum time students will continue to graduate in minimum time by receiving exemption from the increased 120 credits and 2) that students who take the extra year will achieve higher graduation rates due to the additional credits improving their preparedness for the subsequent years of study.

As described earlier in this article, the first assumption is not feasible. The second assumption is unsubstantiated and unjustified. At present, there is no indication of what the additional 120 credits will be; thus, it cannot be assumed that these credits will enhance cognitive development to attain other credits. In fact, it is entirely possible that the additional credits and concomitant time required to complete the extended degree programmes will simply be an additional set of hurdles that will accelerate student dropout.

With such large questions hanging over the basic assumptions of the CHE proposal, it is necessary to perform a risk analysis to determine what the outcomes might be, should the assumptions not be justified. In short, the proposal for extension is overly contingent and overly optimistic to inspire confidence in its potential to address the core of the problem which is the curriculum itself, rather than the time required for its successful completion.

In his response to the CHE proposal the Minister of Higher Education and Training recommends the following:

> Instead of adopting the extended curriculum as a guiding vision for reform, and introducing the recommended pilot process, I recommend the following:
>
> - That a more recent cohort study be undertaken to assess the extent to which interventions towards improving teaching and learning in the sector have borne fruit, and thus the extent to which the proposal to implement an extended curriculum as the norm is required;
>
> - That the number of students registered for Foundation Programmes be considerably increased, to reach at least 30% of all students entering first year.
>
> - That clearer advocacy takes place on the need for extended programs

in order to persuade students, their parents, and the institutions themselves of the benefits of such programmes for academic progress and success;

- That the use of a placement mechanism be introduced along with more realistic admissions points for 'regular' admissions, so that students who are currently struggling, although they have met admissions requirements, are placed in foundation programmes and receive the assistance they need; and

- That the Higher Certificate (Foundational) be introduced as a new intervention that will impact on the 'articulation gap' and preparedness for higher education study, as a matter of urgency in terms of access and preparation for specific fields of study (DHET 2015).

The original CHE proposal was based on the 2006 cohort data (CHE 2013); hence, the Minister is indeed justified in calling for a more recent cohort study to assess the extent to which interventions have borne fruit, and its implications for the curriculum extension proposal. It may be that the Minister's 'recommendations' will be implemented as the new de-facto policy and practice. What is not clear, however, is how the Minister arrived at the conclusion and what body of evidence, indicates the success of the Foundation Programmes to warrant their expansion to at least 30% of enrolments. There is some indication in the Report of the Ministerial Committee for the Review of the Funding of [South African] Universities (2013) that various universities consider the Foundation Programmes as useful in providing access to underprepared students. However, little attention is paid to the success of access students. The report also signals the weaknesses in the implementation of foundation provisioning within extended curriculum programmes. Among other things, it concludes that provisioning has been very uneven across universities and in some cases across Faculties or Schools in the same university. This unevenness has occurred in key areas such as:

- the extent to which foundation provision articulates effectively with the relevant mainstream curriculum (an essential condition for foster-

ing student success through to graduation);

- The profile of the student intake;

- The qualifications and service conditions of the staff appointed to teach foundation courses and manage extended curriculum programmes (in many cases the teaching staff are junior or under-qualified, inexperienced and on very short-term contracts, all of which inhibit the development of expertise and professionalism in a challenging educational area); and

- The extent to which foundation courses are properly accommodated in the institutional administrative and quality assurance system (*Report of the Ministerial Committee for the Review of the Funding of Universities* 2013).

The Report cautions that 'it is of the utmost importance that the foundation provision articulate with the mainstream programmes and pedagogy' (DHET 2013:324). Based on this somewhat unflattering portrait of foundation provisioning, it remains a mystery why investment in them should triple, without concomitant investment in the structure and quality of delivery. Earlier research into access programmes (Dhunpath & Vithal 2012) affirms the weaknesses identified above.

The Multi-Trajectory Approach (MTA) to Designing Curriculum Pathways

We maintain, as we did in the original (2014) article, that curriculum reform that is remedial rather than radical will not address the chronic underperformance of the South African higher education system. However, noting the rejection of the CHE proposal by DHET and its affirmation of Foundation/Access Programmes as a viable alternative to curriculum extension, we now turn our attention to exploring what possibilities exist to salvage or bolster these programmes, if the decision to implement the Minister's 'recommendations' is a fait accompli. In the section that follows, we expand and explicate our conceptualisation of the MTA to designing curriculum

pathways, which could complement the declared benefits of the Foundation Programmes. It should be noted that in this article, our focus is less on the content of the official 'curriculum' and more on programme design and its influence on student progression. While still not entirely convinced that the notion of the 'irreducible core' in the curriculum is a defensible construct in a rapidly changing world, we nevertheless suspend our scepticism and turn our attention to examining possibilities for enhancing the overall performance of the existing curricula.

By definition, Foundation/Access Programmes provide an alternative progression route through the prevailing mainstream curriculum (See DHET 2013). In the present article, we differentiate between the curriculum as a body of knowledge and the associated experiences, arranged in a specific sequence, determined by logic and conditions for scaffolding (Vygotsky 1978), distinct from a progression plan, which is a specific route taken by a student or group of students through such a curriculum. The sequence of the curriculum may be preserved in the progression plan, but the period of time between courses may vary depending on the rate at which the student(s) pass courses. As a review of any group of student registrations on any academic programme will reveal, there exist multiple routes for progression through a curriculum.

When one focuses on a narrow view of curriculum, as progression through a chosen curriculum path, then progression through an access route and progression through an extended route are just that – alternate routes, or trajectories through the curriculum. As proposed in the original 2014 article, we maintain that through a rigorous process of data-mining of student registration information, it is possible to identify alternative trajectories which may be identified, studied and institutionalised for enhanced student progression. To echo the words of Adam Heidebrink (2015:1) 'As educators, we must do more than expect critical engagement from our students - we must model it in our efforts to change, modify, and adopt new learning practices'.

In optimising the multiple benefits to be derived from studying alternative progression routes, the first, most important, 'in principle' step is to determine whether the curriculum structure makes any pedagogic sense. Typically, in curriculum design, the academics involved achieve some degree of consensus on which concepts should be established as the fundamental basis of disciplinary knowledge, which concepts can/should be derived, and which may be translated into applications. Regrettably, once established, curricula acquire a reified status and their design features are rarely interrogated,

resulting in the perpetuation of historicised, ritualised practices. The prevalence of pre-requisites and co-requisites in certain disciplines, which often serve as gatekeepers or gateway courses, are evidence of this ritualised behaviour in which the curriculum is accorded sacrosanct status, regardless of the outcomes.

As part of established compliance requirements, some informal review can and does occur at the discretion of regulatory structures. These include reviewing concession requests from students to register for courses for which they do not meet pre-requisites. In these and similar instances, concessions may be granted in exceptional cases or where the course convenors make the effort to ascertain whether the pre-and co-requisites are actually material to the students' progress or ability to perform in a particular profession or vocation. However, these modifications tend to be arbitrary and concessionary rather than serve as valuable data to probe curriculum structure. In short, these incidental exceptional variants of ritualised practices, which have the potential to provide insights into the less visible elements of curriculum structure, are rarely explored or interrogated and are therefore squandered.

The second, practical outcome to be derived from studying alternative progression trajectories (APTs) is the potential to influence the logistical aspects of curriculum offerings, such as timetables, which are often mapped on pre-existing historical templates. Where an alternative request and concession is frequent, this justifies changing the timetable structure so that clashes in academic activities are minimised. For example, if a frequently occurring alternative progression plan is haphazardly timetabled, without due consideration for feasibility, it could prove counterproductive by limiting the number of courses students are able to register for, undermining the value of the APT.

Third, simply acknowledging that an APT exists and the design of the progression could significantly improve student engagement levels. At present, when a student fails out of the minimum time trajectory, s/he is faced with the 'terrible unknown' of how to proceed. It is left to the student to navigate the sea of possibilities, and receive advice from a variety of sources, including, at best, staff who are aware of the alternate trajectory, and, at worst, other students who also failed and resorted to alternative paths. The simple act of labelling and acknowledging an alternative progression path grants the curriculum designer control over this possibility by mapping out a clear set of goals within the curriculum plan that the student is able to follow to optimise progress.

Viewed in this light, Access Programmes and extended curricula can be

implemented as virtual routes without the need to increase credit loads. Most importantly, the minimum time trajectory is unchanged, and remains an aspiration for the entering student. The original CHE proposal included the possibility of students exiting from the extended programme in minimum time. However, logistically, such an alternative exit option would simply have been impossible for practical reasons, especially considering that the proposal also necessitated a proportional increase in credit load with the increase in the duration of the programme.

Finally, we contend that rather than extend the duration of the (extended) curriculum as a default option, the minimum time trajectory should be retained as a normative aspiration; that Access Programmes be regarded as a pre-selected alternative path; that an extended curriculum be regarded as an alternative path which an under-performing student may adopt and that other alternative paths be identified, aggregated and analysed from student registration information. In the latter model, an excavation of student progression trajectories will reveal the naturally-occurring alternative trajectories which will provide additional insights into the curriculum that could inform its re-design. We posit that all of these can be achieved through existing technologies in dialogue with AI.

Reinforcing the Foundations of a Curriculum

In South Africa, curricula have changed over the past decade in incremental ways, and not necessarily in productive ways. The trend has been to reduce content in the earlier years of a curriculum by removing credits from courses that were once considered as developing the fundamentals of a field of study. In Engineering, for example, the tendency has been to reduce the credits typically dedicated to physics and foundational mathematics. As there is pressure to increase the output of students for professions, the courses with a stronger bias for action and application have taken precedence over deep comprehension and establishment of fundamentals. [Note the reference to US data of 233 institutions here: http://www.nspe.org/resources/blogs/pe-licensing-blog/engineering-credit-slide-continues]

This has the short-term result of curricula enjoying higher pass rates in the earlier years. However, when the applied concepts are confronted in later years, in the absence of deep understanding, each application appears to be new

content rather than being derived from some underlying principle. Consequently, there is a content explosion in the latter years of the curriculum. Where a student of the past would find a few principles to be understood and applied to a specific question, to a present day student, it appears that there is a vast multitude of specific methods and formulae that must be adapted to the problem at hand. This is the long-term disadvantage of the short-term gain.

Overall, in the discipline of Engineering, the shift in content away from foundations has negatively impacted the throughput rate. This is counter-intuitive; one would expect that as the total loading decreases, the pass rate would increase. However, this supposition precludes the notion of the penny dropping; that when a student is exposed to a high level and high volume of content, that student must rapidly develop engagement with the curriculum-specific discourse to the point of becoming fully conversant with it.

The lesson to be derived from this reality is that we do students a disservice by drip-feeding incremental, trivialised versions of deep content. Instead, we create a generation that is deeply conscious of the value to be accrued by merely mimicking and maintaining an appearance of comprehension without ever acquiring substantive disciplinary engagement with the content. We therefore argue that if there is to be curriculum revision, it should involve deeper establishment of the fundamentals in the earlier years of study (Dukhan & Schumack 2013).

Scaffolding from Fundamentals – Development of Higher Level Concepts

Drawing broadly on the rich theoretical body of work on cognition advanced by Leon Vygotsky, and using the discipline of Engineering as our unit of analysis, we argue for scaffolded mediation of complex concepts to ameliorate simplistic constructions of subject-object relationships. The Social Development Theory advanced by Vygotsky (1978) proposes that social interaction precedes cognitive development (Riddle 1999). Central to this theory is the belief that biological and cultural development do not occur in isolation. Vygotsky believed that this life long process of development was dependent on social interaction and that social learning actually leads to cognitive development. He called it the Zone of Proximal Development, which he describes as ‘the distance between the actual development level as determined by independent

problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers' (Vygotsky 1978:33).

According to Bailey-McEwan (2009), engineering problems require a high level of conceptualising, since students are required to conceptualise problems using mathematical concepts and principles of the basic sciences (Bailey-McEwan 2009).

Engineering curricula generally position the fundamentals through science courses in the first year of study, with courses increasing in frequency through the subsequent years. As such, the courses offered towards the middle and final stages of the curriculum tend to be more applied in nature. It is unfortunately the case that these courses tend to be taught without strong connection to the fundamentals (Dukhan & Schumack 2013). As a result, the earlier courses simply appear to be irrelevant and are construed by students as a waste of their time, while courses offered later in the curriculum are seen as stand-alone and content heavy. In other words, the content of the later courses becomes taught as a series of methods to be memorised rather than as concepts that arise from a well-developed basis.

Although academics often bemoan this state of affairs, even a cursory review of the assessments of these courses will reveal little to no efforts to connect with fundamentals. The result is that students are capable of solving only those types of problems for which they already have a prepared solution. In the authors' experiences, students in recent years tend to express indignation when faced with unfamiliar problems to which they have not been previously exposed, even though these problems are based on the fundamentals required to develop solutions.

Therefore, a second aspect of curriculum reform is that, alongside the establishment of the fundamental basis in the earlier years, the materials of the senior years should reinforce the fundamentals by requiring students to demonstrate the mastery of the basis through exposure to problems that do not have pre-determined stock solutions.

In summary, and as argued by Rawatlal and Dhunpath (2014:177), '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, such as structured progression counselling consultations, distinct from the

ritualistic orientation programmes that currently typify many South African universities. However, awareness campaigns are a necessary but insufficient condition for ensuring that students are fully in control of their curriculum choices and progression trajectories. Assuming therefore, that no further significant changes in structure and form are anticipated in the immediate future, it is possible to provide students with the requisite tools to take control of their ability to navigate the curriculum without onerous investments in systems and technology. This is possible through the implementation of Progression Mapping, one of the strategies under the banner of the MTA, to adopt existing Learning Management Systems and databases to provide real-time advice for students on their progression and alternative possibilities available to them.

Implementation of Progression Maps

Implementation of multi-trajectory progression planning is eminently possible today due to the existence of on-line systems which may be connected to an institution's database to generate progression maps which highlight particularly sensitive areas of a curriculum that may require re-design. This is done by data-mining student academic records of a specific academic programme and creating frequency counts of the various progression pathways. These frequency counts signpost 'bottleneck regions' indicative of a large group failing a certain number of credits. Hence, if student progression as a collective can be mapped across courses, then we can identify which progression routes are the most effective; that is, successful programmes which utilise a particular set of courses. This intelligence can be used to proactively advise future students particularly where students are identified as 'At Risk' by the university's extant monitoring system.

In particular, the application of AI algorithms enables analyses of large data sets to generate output which translates to natural-language advice to staff and students in managing academic progress. While several early warning systems exist to determine the academic standing of a student, there are now far more options available with advances in online technologies. In addition to the power of analysis made possible by AI, it has been demonstrated[2] that the strategies used in providing alerts to students in the

[2] Derived from an initial feasibility study into the implementation of AI-based approaches to generating customised student advice.

mapping exercise have the effect of making students extremely sensitive to specific presentations of their rankings within their individual programmes, to the extent that such interfaces can significantly incentivise enhanced student learning. It is not entirely clear why the interface design has such a large observable impact on student effort; early speculation is that since the interface presents an impartial view without human prejudice, it has a higher level of authority, according it a proportionally higher level of priority for students to act on.

In addition to advising students, such a system can also map progression data for academic programme managers. For example, the Nanostream Advisor systems being implemented in a pilot at the University of KwaZulu-Natal (UKZN) in South Africa data mines student information to obtain alternate progression paths, and advises on the means by which specific routes can be further supported (e.g., by changes to timetable systems). Once the UKZN data structure is mapped to the online facility, the Autopilot (a progression mapping tool), which is accessible to both students and academics, can be used to identify the routes by which students pass academic programmes, and to perform academic route frequency counts to expose progression plans which should be further supported to achieve improved overall graduation rates.

It is beyond the scope of the present article to analyse any specific progression maps in the process of being generated. However, it is useful to examine the nature of the progression mapping tool by way of illustration. In developing the illustration, we borrow some concepts from the field of Graph Theory.

In Figure 1 below, we plot the trajectories of students through an academic programme by plotting the percentage of credits passed against the number of students having passed that number of credits. In Graph Theory, a graph is composed of a set of nodes and edges (Diestel 2010). A node signifies a discrete event such as the end of a semester; it is at these points that we consider the number of students who have passed a certain percentage of credits. The length of an edge, i.e., the line connecting two points, reveals the increase in the percentage of credits passed. The longer the edge, the more credits passed. Note that route C (which also contains point A) is the best possible path for students since students who progress on this path do so in the minimum time.

It will be noted in this illustration, that three simplifications have been imposed:

1. We are assuming a five-semester programme since it allows us to discretise ideal percentage credits passed as 20%, 40%, 60%, etc. We note in the ideal route C that students complete the degree with just five edges (i.e., five semesters). When applying the method to real data, it is expected that there will be six and eight edges for three- and four-year degrees, respectively.

2. We note in this illustration that there is an assumption that 100 students enter the programme (see 0% credits); in this case, the total number of students at each stage will be 100 less the number of dropouts, plus the number of entries from other programmes/institutions. It is not necessary to include these effects in what is intended to illustrate the basic concept at this stage.

3. When a student fails out of the minimum time route, s/he will fail 50% of the credits (10% of the credits that should have been passed).

It is important to note again, that these simplifications will not be present in the actual analysis; they are used here to simplify the graphic to exemplify the core mapping concept.

We also note that the trajectories are not independent from each other; the group of trajectories are actually a 'tree'. Although cohort analysis (Glenn 2005) is an established concept, the graph developed here is more appropriately viewed as a tree. Trees are particular types of graphs in the field of Graph Theory; the interested reader is directed to a fuller treatment of this field in Trudeau (1994). In the present context, a new branch of the tree is created when a group of students splits off from the minimum-time group by failing a certain number of credits (restricted here to 10% for illustration as noted above). It is possible for students to fail the same number of credits, but to do so in different ways, i.e., by failing a different set of courses. See point A in the figure; the two new 'fail-out' paths could, in principle, be added together to obtain a new path if we wanted to know at what point in the

curriculum the failures are most likely to occur. However, the most important indicator which might be construed as the default outcome of progression mapping is its potential to highlight what courses students offer which result in their failure.

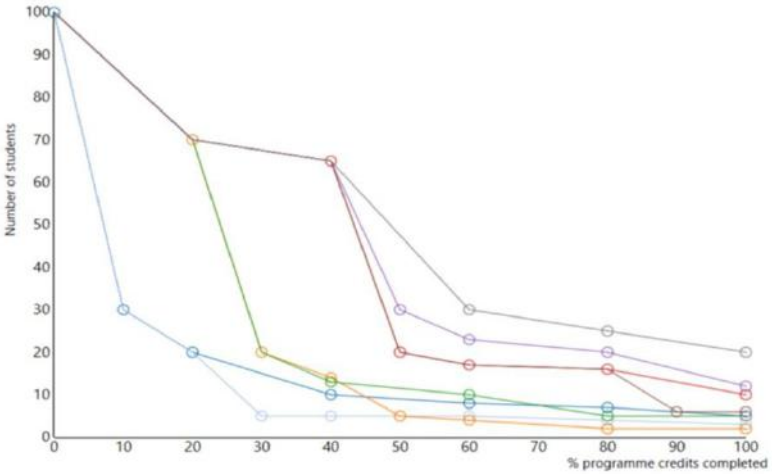

Figure 1. Progression maps observed in a specific academic programme

Applications of the Progression Map

Earlier in this article, we elucidated the potential benefits of applying Progression Mapping. First, by examining the paths on this map, it becomes possible to identify bottlenecks in the academic programme. This is not quite the same as simply considering the overall pass rate in a course; the pass rate reveals overall success, whereas the maps reveal which groups of students pass a course. It is possible that students' weakness in particular subject areas results in accumulated deficits which inhibit progress in higher level courses. This is revealed by finding trajectories where students that failed particular courses earlier on in the trajectory have a greater likelihood to fail at the point being considered. This may then reveal a cognitive dissonance (Festinger 1957) that requires cognitive disruption (Christensen 2006) reinforcement or scaffolding (Vygotsky 1978). If it is found that there is no cognitive correlation, it might

provide just cause for re-visiting the course pre-requisites. In other words, it may be the case that a course is a bottleneck merely because it is a pre-requisite for other courses rather than because it is required for scaffolding more advanced concepts in subsequent courses.

The major advantage of the progression map is that it reveals the number of students who will graduate through a specific route. It may well be that, even after making the potential revisions outlined above the most frequent route for passing a degree will not be the minimum time route. In this case, it is possible to re-consider timetabling and develop rules that would allow for a reduction in the time taken to complete. Where students have offered a course and failed it previously, we may reduce the number of clashes with new courses and exempt them from attending a certain fraction of the lectures of the previous course.

Arguably, the greatest benefit in Progression Mapping is igniting awareness amongst students of the benefits of the typical 'non-minimum' time route. At present, when students fail out of the minimum time, they have to navigate an unknown and uncertain future, and go on to receive advice from a variety of sources of varying quality. Through mapping, control of such advice is passed increasingly to the hands of staff who are more experienced in such matters. The student is then able to commit to a clear route to graduation.

It should also be noted that the implementation of such a system is not as onerous as one might expect. The present development is explicitly designed to ease the process of connecting the progression mapping to a foreign database. As such, it does not matter how the data in an institution's database is labelled, and, to an extent, even how it is structured. A translator module can be developed for virtually any database such that curriculum maps can be derived for all the institution's academic programmes. Furthermore, by applying modern development techniques, access to such systems is facilitated without the need for data to be transferred to any third party. In other words, the institution is able to develop progression maps without transfer to any server that is not under the control of that institution. These are all important aspects concerning the feasibility of implementing such systems.

Finally, we are reminded by Fisher and Scott *et al*. (2011:1) that 'despite significant progress in expanding access since 1994, higher education in South Africa remains a low participation–high attrition system'. A significant contributor to this under-performance is that higher education participation is narrowly perceived as access to university education. High

attrition rates are compounded by the inappropriate choices students make, fuelled largely by the dysfunctionality of the Further Education and Training (FET) sector which could potentially enable transitions from universities to FET institutions and vice-versa (see Akoojee & Nkomo 2012). Furthermore, given the isolationist and competitive cultures universities adopt which prevent unfettered movement of students within the university system, without loss of accumulated credits, there is a critical need for systematised articulation mechanisms which can be 'objectively' determined (Ngete *et al*. 2008). Given the pliability and adaptability of Progression Mapping, cross-institution mappings are also possible, allowing for bench-marking of programmes and an easing of the process of transferring credits from one institution to another, infusing a more fluid post-school system.

Concluding Observations

This article contributes to the on-going debates on higher education curriculum transformation. While there is consensus that the prevailing curriculum fails to adequately advance the intellectual project and develop a productive citizenry, there have been few attempts to develop and implement tangible alternative curriculum strategies. The CHE has candidly articulated the curriculum crisis and advanced an extended version of the current offerings as an alternative proposal to government. This proposal was dismissed by government as inappropriate in the context of apparently successful interventions in the form of Foundation Provisioning. We have attempted to interrogate the legitimacy of the government's rejection by examining the reasons advanced for expanding Foundation Provisioning as their alternative solution. We found that this policy position is based on flimsy evidence which does not justify the massive investments in these programmes which have not convincingly demonstrated their ability to address structural issues beyond access.

Noting that the government decision to upscale Foundation Provisioning is likely to materialise in the foreseeable future, the authors explore what alternative strategies exist to strengthen the capacity of the existing curriculum to enhance student progression. We explore the advances made in online technologies and artificial intelligence to support a MTA to designing curriculum pathways. The authors argue that using algorithms, it is possible to institutionalise Progression Mapping to enable students and

academic advisors to have online real-time, data on students' progression status, and the possibility of selecting alternative curriculum pathways which have a history of success. This data, when aggregated has the added potential to harvest evidence for more substantive curriculum reform to address what has become a stubborn pathology in higher education reform.

A key challenge in developing this article was identifying a body of literature on Progression Mapping as it relates to higher education curriculum reform. There simply isn't a substantive pre-existing theoretical basis to authorise our MTA as a viable alternative to the existing curriculum. The real test of the model will be in its application, beyond the pilot, to cohorts of students in different disciplines and, more ambitiously, in different institutions to derive comparative perspectives. This is a challenge to which we commit and keenly anticipate.

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