CONCEPT PAPER

The relation between knowledge and practice in curriculum and assessment

Jeanne Gamble

University of Cape Town

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Introduction

A distinguishing feature of any curriculum that leads to a vocational or professional qualification is that it 'turns its face both ways' (Barnett, 2006). In other words, it requires a mix of different forms of knowledge, drawn from both non-empirical (conceptual) and empirical (situated in everyday life) domains, for the curriculum to enable both knowledge progression and occupational progression.

In the South African education and training domain various policy documents attempt to capture this double-dimension by making reference to the idea of *applied competence*, as the overarching terms for three kinds of competence:

- *Practical competence:*
  Demonstrated ability to perform a set of tasks;
- *Foundational competence:*
  Demonstrated understanding of what we or others are doing and why;
- *Reflexive competence:*
  Demonstrated ability to integrate or connect performances with an understanding of those performances, so that we learn from our actions and are able to adapt to changes and unforeseen circumstances

[See for instance: Green Paper on Skills Development Strategy for Economic and Employment Growth in South Africa, Department of Labour (1997); The National Qualifications Framework and Curriculum Development, SAQA, (2000, 17-18); Norms and Standards for Educators, Government Gazette No 20844,(2000a, 10)]

In this definition practical work does not stand on its own. It is the reflexive link between task performance and the ability to understand and explain the grounds for action that provides the basis for problem solving in new and unfamiliar situations. A knowledge-grounded discursive ability provides the means to reason about new trial solutions that are not dependent on the specificity of the immediate situation or context for meaning; or, to put it in another way, the ability to think virtually rather than mechanically performing previously-rehearsed routines.

It has been suggested that most learning programmes do provide learners with propositional knowledge or foundational competence. However within the context of applied competence, they should also offer learners opportunities to gain practical

> competence, not only in controlled and defined environments … but also outside the safety of the classroom and laboratory, in real-world contexts, where learners will be required to adapt and re-contextualise their learning to function successfully in complex and unpredictable circumstances. These opportunities enable the development of reflexive competence and self improvement. In the assessment of learners too the notion of applied competence is often ignored and assessment focuses on foundational competence or in limited cases, practical competence. Rarely is assessment directed at reflexive competence (SAQA 2000, 17-18).

The same argument is made in the international literature. Grubb and Lazerson (2004) argue, for instance that, in the United States, what is today expressed as a need for all high school students to have higher-order skills, in order to prepare them for the world of work in the globally competitive twenty-first century, is not so new. It is rather a reformulation of the nineteenth century call for 'industrial intelligence'.

> By this is meant mental power to see beyond the task which occupies the hands for the moment to the operations that have preceded and to those which will follow it – power to take in the whole process, knowledge of materials, ideas of cost, ideas of organizations, business sense and a conscience which recognises obligations (2004, 9).

While perhaps couched in more antiquated language this description is remarkably similar to what South African policy makers intend when they refer to applied competence. It also resonates with more contemporary descriptions of what is meant by higher-level cognitive skills.

> The ability to analyse complex issues, to identify the core problem and the means of solving it, to synthesize and integrate disparate elements, to clarify values, to make effective use of numerical and other information, to work co-operatively and constructively with others and, above all, perhaps, to communicate clearly both orally and in writing (Ball: 1985, 232).

However, when such prescriptions are translated into curriculum language they point to a combination of conceptual knowledge and practical work that is by no means as straightforward as the definitions seem to imply. What is/should be the knowledge base that acts as a springboard for practical application and novel problem solving? Should an explicit conceptual knowledge base be acquired in a classroom situation *prior to* practical work in a workshop, laboratory, or simulated workplace? Should understanding be developed *in and through* practical work, so that it is practical rather than conceptual understanding that develops? If students can perform practical tasks, can it be assumed that they understand the basis for action and that they can articulate what is often called the 'underpinning knowledge base'? How should assessment happen: separately, or in combination?

This paper builds a conceptual framework for addressing these kinds of questions. The first section provides a brief overview of different curricular approaches to the knowledge-practice combination. The second section examines different theoretical perspectives on knowledge and practice and their relation to educational policy.

The third section explores the structuring logic of curriculum though the lens of 'rules of combination', in terms of selection, sequence and pace. A theoretical model of knowledge-practice relations is developed and then used as the basis for a taxonomy of knowledge-practice combinations. This is followed by an examination of how such combinations play out in the empirical domain of curriculum practice.

In the final section the preceding work is condensed into a succinct set of conceptual tools with which to consider the assessment and quality assurance of practical subjects and/or the practical component of subjects. Using the tools, exemplars of assessment specifications are put forward, as a proposal towards building scope and depth into the assessment and quality assurance of theory and practice in the intended and assessed curriculum.

The knowledge-practice relation in curriculum: an overview

If one were to draw up a continuum of possible curricular relations between knowledge (or what is called 'theory') and practice, there would be a range of combinations between the two poles of the continuum:

Table 1: Relations between theory and practice

TYPE		RELATION	SITE	EXAMPLES
1.1	Practice only	None	Everyday life; world of work	• Learning from experience in everyday life • On-job training • Work-based apprenticeships
1.2	Theory and practice	**Simultaneous** with a **direct relation** of application	Classroom + simulated site of application, or formally structured work experience component	• In educational institutions where practical facilities are available (school, college, university) • Co-operative learning arrangements

1.3	Theory and practice	**Simultaneous** with an **indirect relation** of application	Classroom + site of application (outside the institution)	• Apprenticeships (with evening classes or block release to college for theory) • Job shadow or work experience during vacations
1.4	Theory and practice	Theory **followed by** practice	Classroom + site of application (outside the institution)	Professional education (e.g. diploma or degree followed by internship)
1.5	Theory only	None	Classroom	Subjects with high abstract content (e.g. mathematics, philosophy)

Although a typology such as this one does not capture all the ways in which theory and practice combine, it illuminates some of the key concerns discussed in literature that examines the theory-practice relation in professional and vocational qualifications. We briefly review some of the arguments.

In a historical overview of vocational education and training (VET) reforms in Britain, Young (2006) distinguishes between knowledge-based, standards-based and connective approaches to VET. In the *knowledge-based approach* that dominated the vocational curriculum in Britain from the late 19th century to the early 1980s, it was assumed that the natural sciences (Physics, Chemistry and Mathematics) provided the appropriate body of reliable, objective knowledge needed in craft and technical occupations. The curriculum explicitly excluded the application of knowledge in workplaces, or any form of 'trade knowledge'. Learning how to apply scientific knowledge in specific workplace contexts was left to the apprentices and individual employers, with no direct relation between theory and practice. The natural sciences were also seen as a model for non science-based fields such as business studies, which expanded dramatically from the 1960s onwards.

In contrast (and in opposition) to a provider-led, knowledge-based approach, an employer-led *standards-based approach* (related to National Vocational Qualifications, or NVQs) was introduced in the 1980s. This approach focused on what students or trainees needed to do when they were at work. Knowledge came second and was only considered important in so far as it *underpinned* performance. In its most extreme form the standards-based approach assumed that all vocational knowledge was implicit in competent workplace performance. If someone was assessed as performing competently it was assumed that they must have adequate (underpinning) knowledge. This position was later modified through the introduction of criteria for identifying what became known as 'underpinning knowledge and understanding' (UKU). This resulted in considerable diversity between sectors and what Young calls 'a largely *ad hoc* approach to specifying underpinning knowledge' (2006, 111).

> This can take the form of a list of topics which either amount to little more than what anyone would know after a few weeks in a workplace (as in the case of sectors like retail and distribution), or involve a combination of everyday workplace facts (what tools are needed or where to find them) together with some scientific or highly technical topics with little idea as to what depth they should be studied. Not surprisingly, some sectors such as Accountancy, Electrical Installation, and Engineering in which the acquisition of off-the-job knowledge is vital, resisted the excesses of the standards-based approach. Furthermore, not only did the standards-based model fail to take off at higher levels, but the demand for more traditional types of knowledge-based vocational courses has continued to grow (Young, 2006, 111).

Young views the subsequent introduction of Technical Certificates as an attempt to re-instate the importance of off-the-job learning in work-based programmes. He describes this as a *connective approach* to vocational knowledge.

> In contrast to the knowledge-based approach initiated at the end of the 19^{th} century, Technical Certificates stress the importance of knowledge acquired at work and, in contrast to the standards-based approach, they explicitly recognise that knowledge acquired at work is often inadequate on its own, especially in knowledge-intensive workplaces (Young, 2006, 111).

The direct lineage between the British system and the South African system of apprenticeship and technical education more generally makes Young's historical overview particularly pertinent, in that he introduces several themes that resonate with the South African reform trajectory. In an overview of the history of apprenticeship development in South Africa, Gamble (2004) shows how the formation of technical colleges can be traced to the Apprenticeship Act of 1922[1], which stipulated that classes in technical education should be undertaken in a technical college, in addition to on-job instruction in a workplace. As in Britain the relation between the two components was an indirect relation. With the rise of semi-skilled production processes around the time of World War 11 the system of training was changed and based on mass production methods. This served as a precursor of the competency-based modular training (CBMT) approach introduced by the Manpower Training Amendment Act of 1990. Under this Act, sector-based Training

[1] It should be noted that this Act only applied to the training of White apprentices.

Boards became responsible for meeting the training needs of an industry or sector and for ensuring the maintenance of high standards of training, including control of artisan training. This gave employers increased autonomy in decision-making about training issues. While the requirement for technical education at a technical college remained, a marked dilution or reduction in the theoretical component of apprenticeship training resulted in many industry sectors. Such dilution was based on the assumption that the new CBMT modules included all the theory that an apprentice would need (as underpinning knowledge).

In its turn, this curriculum model was the forerunner of the NQF unit standard-based approach, which specifies critical and specific outcomes. It also shares an 'outcomes' logic with outcomes-based education (OBE) in schools. Allais argues that the two approaches have a great deal in common and her critique of the 'design down'–from-outcome statements approach taken by the South African Qualifications Authority (SAQA) applies to both.

> The emphasis is on competence statements in the learning outcomes; knowledge is relegated to a category called 'essential embedded knowledge', which is supposed to mean knowledge that underpins the particular competence that has been specified in the learning outcome. Knowledge cannot, in this approach, be the starting point; the 'essential embedded knowledge' is derived from the outcome', and not stipulated as part of a body of knowledge worth mastering … Learning programmes should [thus] not be designed based on the internal requirements or logic of a knowledge area; instead knowledge areas should be selected on the basis that they can lead to the competence in question, or that they 'underpin' it (2006, 25).

Further afield, Wheelahan (2008) similarly argues that competency-based vocational education and training qualifications in Australia deny students access to the theoretical knowledge that underpins vocational practice.

Contestations about how knowledge relates to practice manifest not only in curriculum policy debates but also in theoretical positions that inform such debates. We turn briefly to this relation and the effect on policy.

Theoretical perspectives on knowledge and practice and their relation to educational policy

Constructivist perspectives

The term practical knowledge, though often used to refer to know-how and expertise gained through practical or experiential activity, is one that is widely debated in academic literature. The crux of the debate revolves round what counts as knowledge and how we come to know. From what we can broadly call a constructivist perspective, knowledge is deemed to refer to the 'internal mental constructions of individuals' (Smith, 1995, 23), with these constructions typically viewed as 'individually constructed in the process of interpreting experiences in particular contexts' (Palincsar, 2005). There is thus no philosophical distinction between what is in the head and what is in the world. Knowledge is what the individual knower comes to know subjectively in her/his head – often referred to as 'ways of knowing' (Driver at al, 1994). In this approach students actively construct their own ways of knowing (Cobb, 1994)

Other variants of constructivism emphasise the social and cultural rootedness of individual cognition and therefore the situated and social nature of learning. From a situated learning perspective, learning happens through participating in the ongoing everyday activities of a 'community of practice' (Lave and Wenger, 1991), with no qualitative differentiation between the knowledge and practices of different communities, whether they be soccer players, mathematicians, butchers or musicians (as random examples). However, even when a distinction is drawn between subject-matter knowledge (as we find it in educational institutions) and experience gained in the everyday domain, a central argument of this position is that the two should be integrated. Everyday knowledge is viewed as 'a pre-condition for childrens' learning of subject-matter knowledge' (Hedegaard, 1998, 123), so that, in a sense, all knowledge becomes situated knowing.

This perspective articulates well with the emphasis on 'integration' which has underpinned recent educational reform in South Africa. In Chapter 3 of the Report of the Curriculum 2005 Review Committee (2000b), the rationale for this focus in schools is explained.

> The term 'integration´has come into educational debate in South Africa from three different directions. These are related but not identical. They include first, the discussions in the early 1990s around the proper relation between education and training, second, a specifically curricular initiative called 'integrated studies´, explored in a few independent schools in the 1980s, and third, the view that schooling is a preparation for life and work. These debates have all had a bearing on the development of learning areas in Curriculum 2005.
>
> The definition and selection of the eight learning areas for C2005 grew out of these diverse strands but also built on the curriculum framework produced in 1994 under the previous regime which proposed a division of fields of study into seven learning areas (DoE, 1994). C2005 has added Economic and Management Sciences to make up the eight learning areas. C2005 has also added to the basic knowledge fields a set of design features. *These promote strong integration within and across the learning areas and integration of learning with everyday life.* (http://www.polity.org.za/polity/govdocs/reports/education/curric2005/curric2005.htm, accessed on 18/09/2009; emphasis added).

The national policy, through which National Certificates (Vocational) were introduced in FET Colleges in 2007, also follows this pathway and states that:

> The National Certificate (Vocational) at Level 2 on the NQF will provide learning experiences in situations contextually relevant to the particular vocational area in which the programme is situated. The National Certificate (Vocational) at level 2 on the NQF will offer programmes in the form of subjects that will consist of *academic knowledge and theory integrated with the practical skills and values* specific to each vocational area (*Government Gazette*, 29 March 2006, No. 28677, 12; emphasis added).

The Higher Education Qualifications Framework (*Government Gazette*, 5 October 2007 No. 30353) similarly refers to 'integrated assessment' (2007, 6) and 'work-integrated learning (WIL)' (2007, 9), in relation to certain of the qualifications set out in the Framework.

Realist perspectives

The integration of everyday knowing and subject-matter knowledge is one position, their separation is another. The latter is usually called a realist position that pre-supposes the existence of 'a reality that exists independently of our representations of it' (Searle, 1995, 153). It follows that, in this approach, objectified subject-matter knowledge is not deemed the same as everyday experiential knowing; neither is its acquisition premised on integration with the experiential world of the student's everyday activity. In order to get to grips with this argument we need to examine the distinction that is made between the domain of everyday practice or activity and the domain of abstract knowledge (or knowledge that is not dependent on its immediate context for meaning). The table below shows how this distinction is expressed in various ways in the work of different writers.

Table 2: Knowledge distinctions

	Context-dependent knowledge	Context-independent knowledge
Bernstein (1975)	Commonsense knowledge	Uncommonsense knowledge
Bernstein (1990, 2000)	Horizontal discourse	Vertical discourse
Gamble (2004)	Particular knowledge	General knowledge
Acquired through:		
Martin (2007)	Oral transmission (doing)	Written transmission (studying)
Dowling (1998)	Localising strategies	Generalising strategies

In order to explore this distinction further we consider an analytical model that shows the division between knowledge forms.

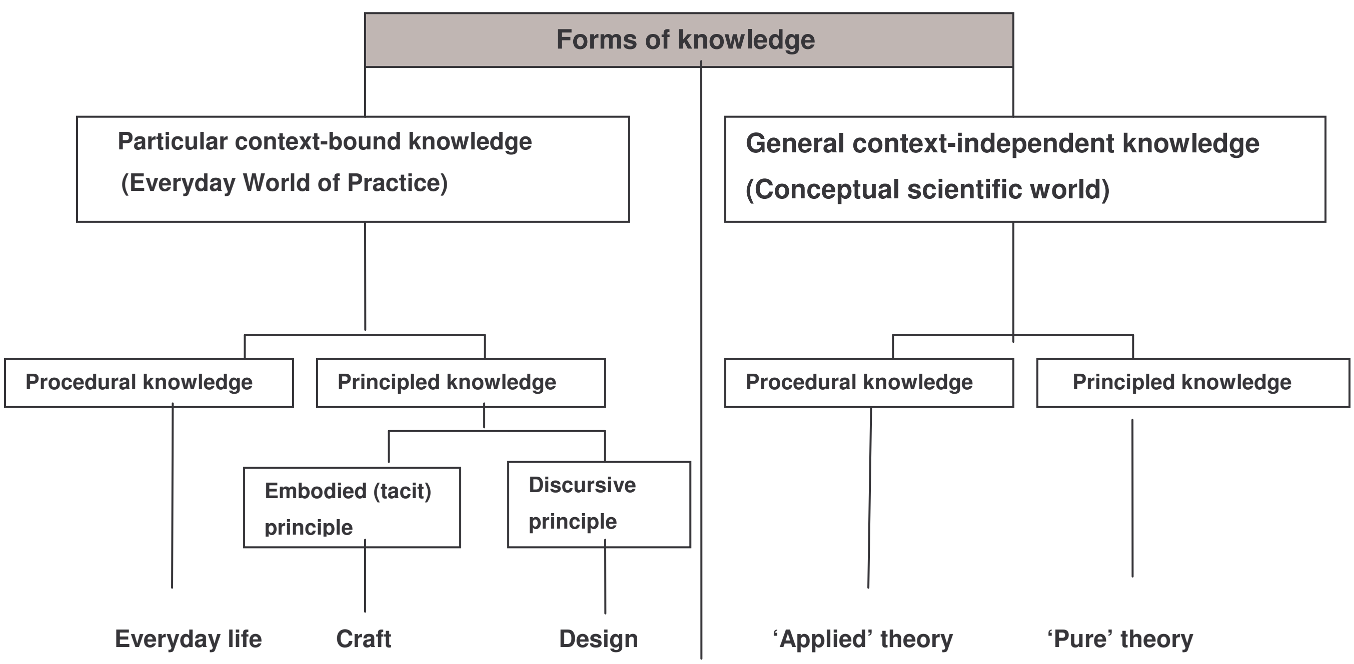

Figure 1: Forms of knowledge and their application (adapted from Gamble, 2004)

The logic on which the analytical model is based is briefly outlined below:

1. Abbott's principle of self-similarity in the fractal division of cultural and social structures is employed. Abbott argues that at each level of a fractal chain of division one finds the original fractal repeated so that 'the relation of the general terms is recapitulated in the specific ones' (Abbott, 2001, 9). Fractal models therefore avoid what Moore & Muller (2002, 632) call 'the distorting simplicities of a two-column fractionating dichotomy'. *The model can be read from the top downwards or from the bottom upwards.*

2. We see in the model that the division between empirically and non-empirically generated knowledge is expressed at the highest level as a 'particular-general' knowledge fractal, which is then repeated at the second level as a 'procedural-principled' knowledge fractal. As these fractals appear on both sides of the fundamental division between the two knowledge forms, this level shows that *each contains something of the other.*

3. In the ***conceptual world*** (the world of science) the second fractal ('procedural-principled knowledge'*)* is historically located in the birth of modern science in the 1300s to 1600s. When logical reasoning merged with experimental methods of discovery, deductive and inductive methods of scientific investigation became positioned in a side-by-side or collateral relationship to constitute modern science as we know it today (Zilsel, 2000). (Science is used here in a broad sense to refer to systematic, codified reasoning.)

4. In the ***world of practice*** the second fractal ('procedural-principled knowledge'*)* is historically located in the separation of the personal unity of head and hand (in craft) that came about after the invention of the printing press and the mechanical clock. Printed books and plans and the costing of work activities in terms of the precise amount of time they took, changed craft from a holistic 'knowledge of how one does' to a 'knowledge of how one explains things' which could circulate easily and allow the work of the hand to be set out in procedural terms (Sohn-Rethel, 1978).

5. The third-level fractal ('discursive-embodied knowledge') in the ***world of practice*** is historically located in the literature of design and making as specialised human activities that are informed by both art and science. Pye (1978) argues that there is an embodied principle of arrangement, which specifies the

> relation between parts and whole, in the invention, design and making of any device. A device is described as something 'intended to get some result that was not there before' (1978, 15). This principle of arrangement manifests in two forms: discursively (in language and writing) and diagrammatically (in visual form). In written form the essential principle of the device is described as a generalisation. A diagram, on the other hand represents a particular instantiation of the invention, but the principle, which has to be grasped through visualisation still functions at the level of generalised 'class' or 'type' – and thus at the level of context-independent meaning. Both a discursive and an embodied (or tacit) principle of arrangement relate parts to wholes and generate meanings at a more abstract level than the immediate process of invention, design or production.

From a realist perspective there is thus an insistence on the separation of everyday knowing and formal subject-matter knowledge. The implication of this logic is not that knowledge forms do not relate, but rather that straightforward 'integration' is a political rather than an educational answer. If we consider the *White Paper on Education and Training* (DoE, 1995), issued in 1994 by the first democratically elected South African government, it is clear that the political imperative was to overturn the old apartheid education order, to open up access to all forms of education to all South Africans and, in doing so to promote goals of social justice, equity and development for the future.

> An integrated approach implies a view of learning which rejects a rigid division between 'academic' and 'applied', 'theory' and 'practice', 'knowledge' and 'skills', 'head' and 'hand'. Such divisions have characterised the organization of curricula and the distribution of educational opportunity in many countries of the world, including South Africa. They have grown out of, and helped to reproduce, very old occupational and social class distinctions. In South Africa such distinctions in curriculum and career choice have been closely associated in the past with the ethnic structure of economic opportunity and power (DoE, 1995, 15).

Yet, by 2000 a review of the outcomes-based Curriculum 2005, introduced in schools, argued that while they found 'overwhelming support for the principles of outcomes-based education and Curriculum 2005, which has generated a new focus on teaching and learning' implementation had been confounded by, amongst other things 'a skewed curriculum structure and design'.
(http://www.polity.org.za/polity/govdocs/reports/education/curric2005/curric2005.htm, accessed on 18/09/2009).

The causes of this skewing of curriculum structure and design become clearer in the next section where we examine the structuring logic of curriculum.

The structuring logic of curriculum

When considering the structure and design of curriculum the crucial question is:

- **What rules of combination structure the theory-practice relation in curriculum?**

We will examine 3 rules of combination:

1. Sequencing rules: the order in which theory and practice combine

2. Selection rules: what counts as theory and what counts as practice

3. Pacing rules: time allocated to theory and to practice

1. Sequencing rules

In order to illustrate different theory-practice sequencing rules we draw on Kruss's (2000) analysis of how the ways in which theory and practice are ordered or sequenced bring about either a direct or an indirect relation between education and the labour market. She argues that the purpose of this relation can be either employment or employability (work-readiness). The diagram below sketches out four positions which are discussed.

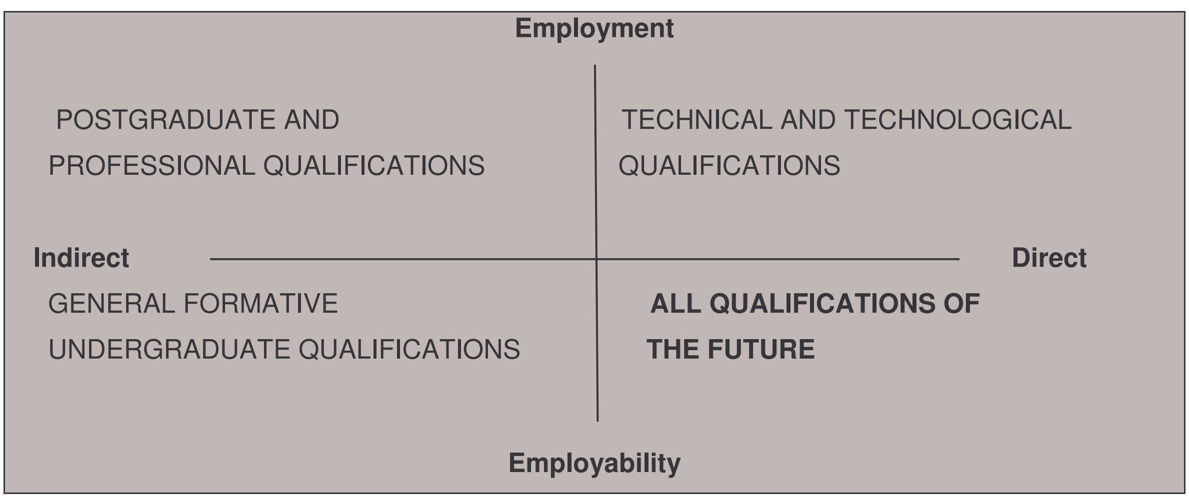

Figure 2: Relation between education and the labour market (adapted from Kruss, 2002)

What distinguishes these four positions, apart from level of knowledge content, is the sequencing rule applied to achieve a theory-practice combination.

Kruss argues that, for many years, the focus of undergraduate qualifications in general education was on *employability, with an indirect link* to the labour market. Degrees were intended to provide a 'general formative grounding on a broad disciplinary basis, to prepare educated citizens' (2000, 4). Work experience and skill specialisation in specific occupations lay in the domain of employers.

Figure 3: Purpose of qualification: Employability with an indirect link to the labour market

The model underpinning graduate and professional education was one of e*mployment with an indirect link to the labour market*. Once a graduate had a degree, the professional associations, as statutory bodies and in co-operation with employers, stipulated, regulated and accredited a period of mentored work experience. The professional qualification was obtained after completion of the workplace-based training period.

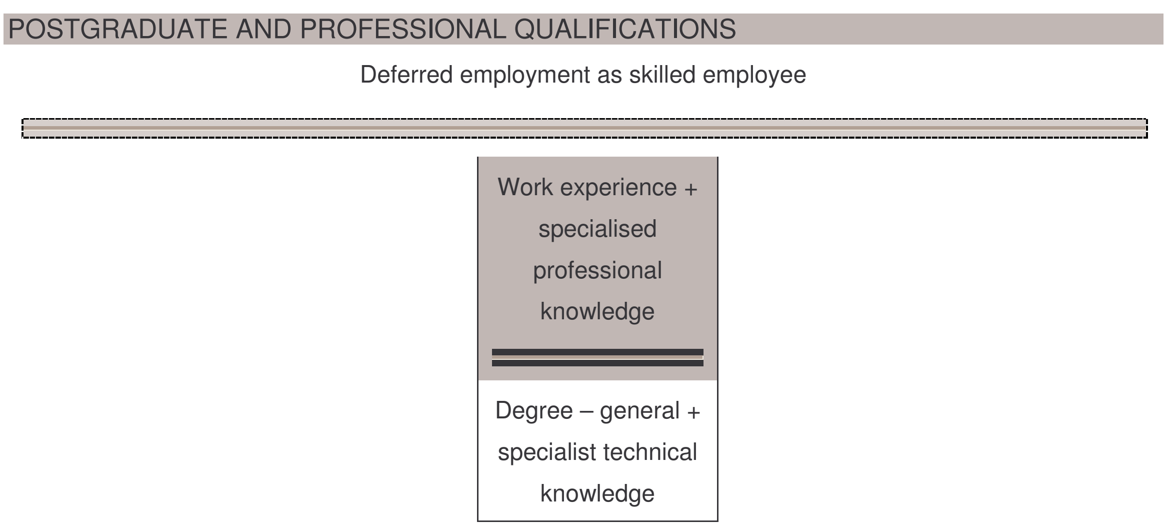

Figure 4: Purpose of qualification: Employment with an indirect link to the labour market

Technikons (now Universities of Technology) were mandated to prepare graduates *directly for employment* in technical and technological fields. Experiential learning, in blocks of structured work experience, formed a critical component of the qualification, with employment virtually guaranteed after successful completion of the qualification.

TECHNICAL AND TECHNOLOGICAL QUALIFICATIONS (Universities of Technology)

Direct employment as skilled employee

Work experience

Diploma

Work experience

Diploma

Figure 5: Purpose of qualification: Employment with a direct link to the labour market

However, in response to globalisation, the marketisation of education and the advent of a democratic government in South Africa, higher education policy now expects institutions to be come more directly responsive to an increasingly volatile labour market, where employment can no longer be guaranteed by a degree or professional qualification. The model increasingly becoming the norm is one of *direct employability.* In this model, experiential learning and tacit skills are drawn down into the degree or professional qualification itself, thus *falling into the domain of the educational institution*. This curriculum model is intended to ensure that the graduate is immediately employable, even though not guaranteed a job (Kruss, 2002).

QUALIFICATIONS OF THE FUTURE

Directly to labour market as skilled employee

Work experience + skills

Degree

Figure 6: Purpose of qualification: Employability with a direct link to the labour market

Not only in higher education but even more specifically in vocational and occupationally-directed education and training, this direct relation between education and the labour market has replaced the earlier indirect relation of knowledge-based and apprenticeship models. In South Africa, for instance, the rationale for the recently-introduced National Certificate (Vocational) is expressly to ensure that all programmes are world-of-work aligned: both in terms of promoting workplace readiness and through ensuring that occupation-specific outcomes are aligned to labour market demands. This means that, as outlined in Kruss's model, the educational institution itself is increasingly being made responsible for both the conceptual and practical components of the curriculum. For the remainder of this paper we therefore concentrate on a curriculum that includes both knowledge and practice as integral parts of the qualification. To explore possible connections between the two components we turn to selection rules.

2. Selection rules: A theoretical perspective

'Not everything goes with everything' (Muller, 2008, 18)

Following a realist perspective on knowledge, the model of forms of knowledge, as set out in the previous section, allows us to begin to tease out the ways in which knowledge and practice combine or do not combine. But, before we do so, there are two key ideas that help us to examine boundary/border crossing between knowledge forms. The first is the idea of 'coherence' (Muller, 2008), which relates to the domain of curriculum. The second is the idea of 'distributing strategies and directionality' (Dowling, 1998), which relates to the domain of pedagogy.

Lenses for interrogating relations between knowledge and practice

Coherence

The idea that a curriculum (any curriculum) should show internal coherence is one of the key conclusions of the Review of Curriculum 2005 which took place in 2000. As Muller (208, 18), puts it: 'not everything goes with everything'. In this argument a distinction is made between *conceptual and contextual curriculum coherence* (Muller, 2008, 17-18) [2].

[2] Muller was a member of the C2005 Review Committee and his later paper draws on this earlier work. In the C2005 report the terms 'conceptual coherence' and 'connective coherence' are used but they refer to the same issue.

When a curriculum is conceptually coherent there is an upward or vertical hierarchy of conceptual abstraction, with later concepts dependent on earlier concepts for their meaning. Order or sequence, pacing and progression matter greatly as the knowledge 'bits' have to fit together in a time and space not given by a specific context. Logic is thus the key criterion for coherence.

Sequence matters less in a curriculum that seeks contextual coherence. Here each segment or topic is selected for relevance and coherence to a particular context. The order in which the topics are presented does not really matter, as the key criterion for coherence is adequacy-to-context. Adequacy-to-context is a visible evaluative criterion that announces itself as soon as there is an inadequate fit between practice and context (Muller, 2008, 17).

Using this lens the Curriculum 2005 Review Committee found that the original designers of Curriculum 2005 focussed only on contextual coherence, which is appropriate for practical subjects but not for conceptual subjects. C2005 thus ignored the 'vertical spine' (Muller and Gamble, in press) of subjects such as Mathematics, Science and English. When this happens the sequence of reasoning necessary to acquire the logic of concept-rich subjects becomes invisible. The evaluative criteria are thus disguised, often with disastrous consequences for students who cannot 'read' invisible 'knowledge signposts' (Muller, 2008, 17).

What we have to work out is how conceptual coherence and contextual coherence are possible when there is a requirement for practice to be included in the curriculum.

Distributing strategies and directionality

Paul Dowling's (1998) concept of 'distributing strategies' in pedagogy provides another useful lens for interrogating the idea of different forms of knowledge and their combination. Working within a theoretical framework which he calls social activity theory, Dowling shows how it is that school mathematics textbooks distribute mathematics to 'higher' and 'lower' ability groups. One of the distributing strategies which shifts the knowledge discipline (mathematics) towards abstraction is a *principling* strategy. Another which moves knowledge towards particular events in a context is a *proceduralising* strategy.

> Take, for example, the procedure which is commonly employed in the division of fractions: turn upside-down and multiply. The effect of such 'coding' of mathematical discourse as an algorithm is to particularize mathematical knowledge, to reduce its level of abstraction. The general quality which distinguishes principled form procedural discourse is that the former exhibits connective complexity, whereas the latter tends to impoverish this complexity, minimizing rather than maximizing connections and exchanging instructions for definitions (1998, 146).

Dowling also argues that the use of examples which refer to specific instances renders the message more context-dependent. Context-dependency is reduced when the abstractive properties of examples are made explicitly available and logical connections become visible. This means that the example has to be 'stripped of context' so that the knowledge object becomes visible (e.g. in 'story sums' the mathematical object has to be made explicit).

In school textbooks and in classroom pedagogy the distributing strategies that give effect to moving knowledge in either a principling or proceduralising direction is a set of distributing strategies, which Dowling terms 'generalizing or localizing strategies' (1998, 147)[3]. When a generalising strategy is employed knowledge moves in a principled direction ('pure' theory). When a localising strategy is employed, knowledge moves in a procedural direction ('applied' theory).

What we have to explore is the direction in which knowledge moves (and what this does) when practice is included in the curriculum.

How to cross the border between the conceptual world and the world of practice

We now return to the model of forms of knowledge. The model reproduced on the next page is a refinement of the previous diagram to show 'border crossing relations' between theory and practice.

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[3] Breier (2004) employs Dowling's conceptual language of 'generalising' and 'localising' strategies to two labour law programmes at university level. Hoadley (2005) similarly employs this language in her analysis of literacy and numeracy in primary school classrooms.

Our two lenses help us to formulate selection rules for ‘border crossing’:

The ‘coherence’ lens gives us rule 1:

- **Conceptual and/or contextual coherence can only be maintained when ‘like’ is linked with ‘like’ in terms of how theory and practice combine.**

The ‘distributing strategies and directionality’ lens gives us rule 2:

- **When conceptual knowledge moves towards the world of practice it becomes proceduralised. This brings about a distinction between ‘pure’ and ‘applied’ theory.**

Let us now turn to the model (see next page).

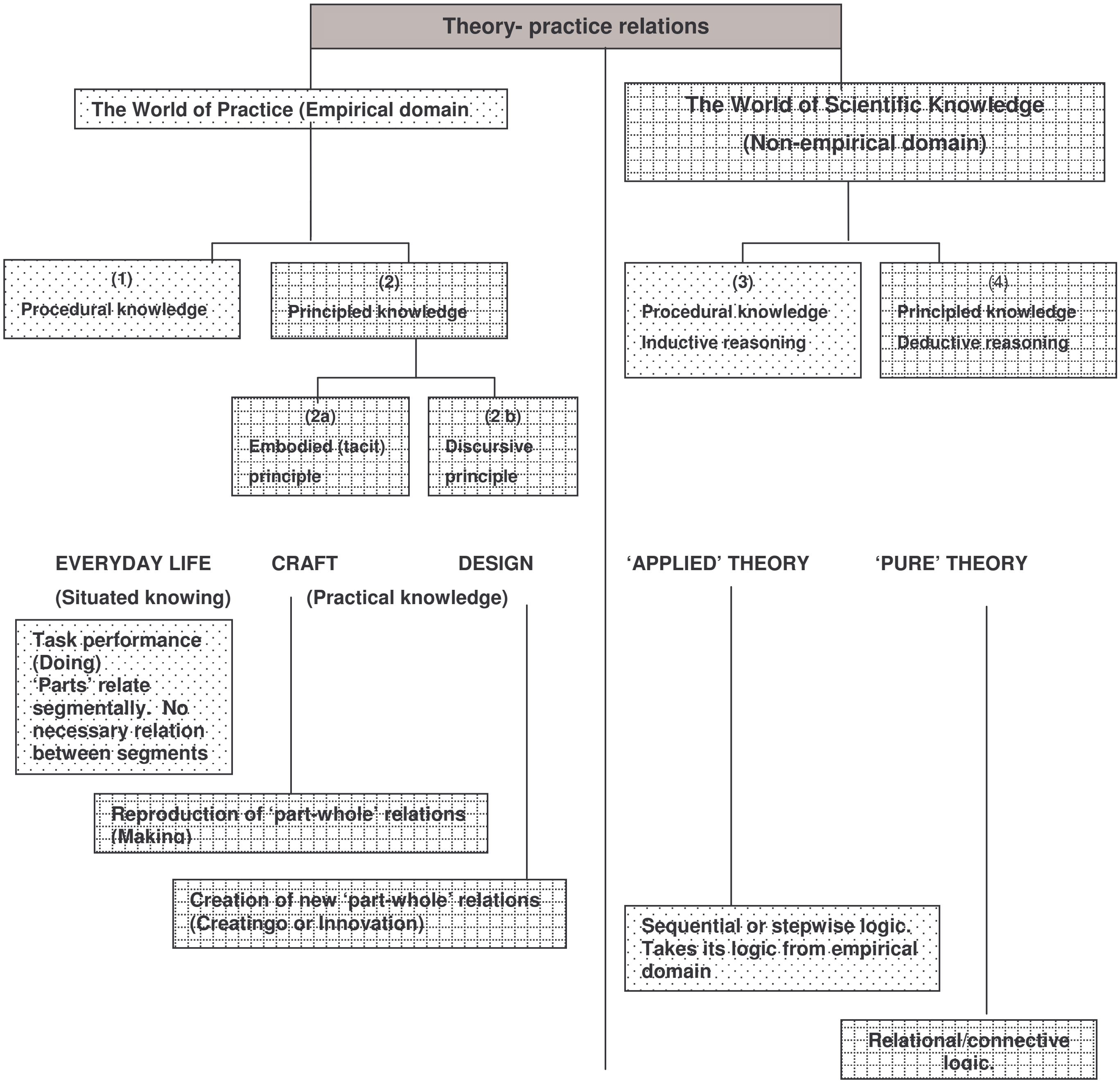


Figure 7: Theory-Practice Relations (adapted from Gamble, 2004)

When we apply our two selection rules, there are several implications:

1. 'Pure 'theory' (4) can function on its own with no reference to the empirical domain.

2. Situated knowing can function on its own with no reference to 'theory' of any kind.

BUT:

3. 'Pure' theory (4) can never be linked unproblematically to situated knowing (1), as so many curricula attempt to do in the interest of 'integration'. These two knowledge forms are not of the same kind.

HOWEVER:

4. 'Applied' theory (3) can be linked **directly** to everyday life (1) as they are of the same 'procedural' kind.

5. 'Pure' theory (4) can be linked **indirectly** to design (2b) as they are of the same 'principled' kind and they are both *available discursively*.

   The link is indirect as there is never a one-on-one relation between principle and application. As Pye (1978, 65) put it: it is the 'prepared mind' that is able to make connections between seemingly unrelated entities. This is what is required for invention or design.

6. Craft has a tacit principled knowledge base, which is acquired through 'making'. There is an indirect (tacit) link to design principles but *no direct relation* to theory. The tacit principle is grasped when the relation between parts and whole is visualised (Gamble 2004). That is why technical drawing, that has a basis in mathematics, is considered crucial 'theoretical' preparation for craft mastery.

These implications help us to grasp how knowledge and practice combine or do not combine. In the next section we systematise these findings as a taxonomy of knowledge-practice combinations.

A taxonomy of knowledge-practice combinations

Taking context-independent knowledge as the starting point, we can now put forward a taxonomy, or systematic classification, of how theory and practice fit together. In the table below, Level 5 represents the highest level of abstraction.

Table 2: Hierarchy of knowledge-practice relations in terms of level of knowledge abstraction

Level 5: Theoretical conceptual coherence (Classroom model)
'Pure' Theory functions on its own, with no reference to the world of practice.
Level 4: Contextualised conceptual coherence (Classroom + Workshop model)
'Pure' Theory is linked *indirectly* to **Design Practice**, as they are of the same 'principled' kind and they are both available discursively.
Level 3: Theorised contextual coherence (Classroom + Work experience model)
'Applied' Theory is linked *directly* to events or problems encountered in **Everyday Life.**
Level 2: Tacit conceptual coherence (Project model)
Craft has a tacit principled knowledge base, which is acquired through 'making'. There is an indirect (tacit) link to design principles but *no direct relation* to 'Pure' or 'Applied' theory.
Level 1: Everyday contextual coherence (Work experience model)
Situated knowing in everyday life functions on its own with no reference to 'theory' of any kind.

At levels 5 and 1, the top and the bottom of the taxonomy (a systematic classification), we find knowledge and experience functioning on their own.

Explicit theory-practice combinations appear at levels 3 and 4. They draw on different forms of knowledge in the conceptual world and combine these with different forms of practice to show that practical knowledge can only be called *knowledge* when it is lifted above the immediacy of everyday life (or situated knowing). This happens when practice is combined with a knowledge form from the conceptual world.

Level 2 (Craft) is a tacit theory-practice combination. Its connective or relational logic only comes into play when 'parts' and 'wholes' are kept together, in the process of 'making'. The project model is illustrated in Gamble's (2004) study of craft, which shows that cabinet making apprentices never practice procedures in isolation. When, for instance, they are learning to make a dove-tail joint ('part') they learn it in the context of a bigger project, such as making a tray or a wine rack or some small item ('whole'). The tacit conceptual coherence of craft (the 'project model',) has wider application than just in craft. Designers would, for instance, draw on both level 2 and level 4 in the actual process of design. The rationale for what is, at first, grasped intuitively (tacitly) may follow the 'act of design'.

The model and taxonomy help us to understand how theory and practice combine most effectively in curriculum. However, models and taxonomies are theoretical constructs, so we should not necessarily expect to see exact instantiations of the taxonomic categories in the world of curriculum practices. We need to turn to the empirical domain to examine how selection rules play out in practice. However, before we do so, we need to remind ourselves that a curriculum is not necessarily a flat horizontal plane, regulated by contextual coherence. When conceptual coherence is required, questions of knowledge progression and cognitive demand become crucial. For this we turn to Bloom's Taxonomy of Educational Objectives (1956), a well-known educational resources world-wide. This will also help us to consider the relation between intended and assessed curriculum.

3. Selection and pacing rules: An empirical perspective

Progression and cognitive demand

Bloom's taxonomy was originally developed in the United States in the 1950s, as a means of facilitating the exchange of text items among university departments. The ultimate goal was to create banks of test items that would measure the same educational objectives (Kratwohl, 2002, 212). It was hoped that, in this way, the quality of instruction and assessment would be improved. The taxonomy was intended to promote agreement among educators about what constituted assessment and how assessment should be conducted. There was also an expectation that consensus around a framework that set out the basic structure and intentions of the educational enterprise, would lead to better educational practices (Anderson, 2005, 102 - 103).

Anderson argues that 'almost a half century after its publication, the *Handbook* [Bloom et al, 1956] in which the taxonomy first appeared remains one of the most familiar educational books of all times' (2005, 103). Its six categories, as set out below, are familiar to educators all over the world.

Table 3: Bloom's original taxonomy of educational objectives (Kratwohl, 2002, 213)

Structure of the Original Bloom's Taxonomy (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956)	
1.0 Knowledge	**2.0 Comprehension**
1.10 Knowledge of specifics	2.1 Translation
1.11 Knowledge of terminology	2.2 Interpretation
1.12 Knowledge of specific facts	2.3 Extrapolation
1.20 Knowledge of ways and means of dealing with specifics	**3.0 Application**
	4.0 Analysis
1.21 Knowledge of conventions	4.1 Analysis of elements
1.22 Knowledge of trends and sequences	4.2 Analysis of relationships
1.23 Knowledge of classifications and categories	4.3 Analysis of organizational principles
1.24 Knowledge of criteria	**5.0 Synthesis**
1.25 Knowledge of methodology	5.1 Production of a unique communication
1.30 Knowledge of universals and abstractions in a Field	5.2 Production of a plan, or proposed set of operations
	5.3 Derivation of a set of abstract relations
1.31 Knowledge of principles and generalizations	**6.0 Evaluation**
1.32 Knowledge of theories and structures	6.1 Evaluation in terms of internal evidence
	6.2 Judgments in terms of external criteria

In the original taxonomy, the six categories were aligned on a single dimension, arranged in a progression from simple to complex and from concrete to abstract. A cumulative hierarchy was assumed, so that each 'lower' category served as a prerequisite for mastery of the next 'higher category' (Anderson, 2005, 104). In this logic the different sub-categories of knowledge, arranged from the most specific to the most general or abstract, served as the foundation for all cognitive processes. Comprehension of a systematic, hierarchical knowledge base led to higher-order cognitive processes of application, analysis, synthesis and evaluation.

However, Kratwohl (2002, 213) argues that analyses of the breath and dept of test items, based on Bloom's original taxonomy, almost always showed a strong emphasis on objectives that required the recognition or recall of information, rather than on the higher-order categories usually considered the most important objectives of education. This led to a revision of the taxonomy, which was split into two dimensions: *a knowledge dimension* (with nouns as the basis for describing forms of subject matter content) and *a cognitive process dimension* (with verbs as the basis for describing required student behaviour in terms of cognitive processes). Changes were also made to both dimensions in terms of additional knowledge categories and the renaming and re-arrangement of cognitive processes (see below).

Table 4: Revised taxonomy of educational objectives (Anderson & Kratwohl (Eds.), 2001)

REVISED TAXONOMY OF EDUCATOINAL OBJECTIVES **(Anderson, Krathwohl (Eds.), 2001)**	
Structure of the Knowledge Dimension of the Revised Taxonomy	**Structure of the Cognitive Process Dimension of the Revised Taxonomy**
A. Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. **Aa. Knowledge of terminology** **Ab. Knowledge of specific details and elements**	***1.0 Remember*** – Retrieving relevant knowledge from long-term memory. ***1.1 Recognizing*** ***1.2 Recalling***
B. Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. **Ba. Knowledge of classifications and categories** **Bb. Knowledge of principles and generalizations** **Bc. Knowledge of theories, models, and structures**	***2.0 Understand*** – Determining the meaning of instructional messages, including oral, written, and graphic communication. ***2.1 Interpreting*** ***2.2 Exemplifying*** ***2.3 Classifying*** ***2.4 Summarizing*** ***2.5 Inferring*** ***2.6 Comparing*** ***2.7 Explaining***
C. Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. **Ca. Knowledge of subject-specific skills and algorithms** **Cb. Knowledge of subject-specific techniques and methods** **Cc. Knowledge of criteria for determining when to use appropriate procedures**	***3.0 Apply*** – Carrying out or using a procedure in a given situation. ***3.1 Executing*** ***3.2 Implementing***
	4.0 Analyze – Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose. ***4.1 Differentiating*** ***4.2 Organizing*** ***4.3 Attributing***
D. Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. **Da. Strategic knowledge** **Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge** **Dc. Self-knowledge**	***5.0 Evaluate*** – Making judgments based on criteria and standards. ***5.1 Checking*** ***5.2 Critiquing***
	6.0 Create – Putting elements together to form a novel, coherent whole or make an original product. ***6.1 Generating*** ***6.2 Planning*** ***6.3 Producing***

When the two dimensions of the revised taxonomy is represented as a table (as below, with Xs inserted for illustrative purposes only), *remembering factual knowledge* is clearly indicated. If test items only test this combination, the rest of the taxonomy table will be blank.

Table 5: Two-dimensional revised taxonomy table (adapted from Krathwohl, 2002 , 216)

Knowledge Dimension	Cognitive Process Dimension					
	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual knowledge	X					X
Conceptual knowledge		X		X	X	X
Procedural knowledge			X			
Metacognitive knowledge						

In the revised model cognitive progression is still hierarchical in the sense that the 'higher' categories of analyse, evaluate and create are deemed to be more complex and more abstract than the 'lower' ones but this hierarchy is no longer viewed as being cumulative (Anderson, 2005, 106). Instead of representing knowledge as a single category, with various sub-categories, the revised taxonomy table contains four main categories of knowledge – not linked to one another in a hierarchical order. Emphasis is placed on different kinds of knowing so that students might, for instance, apply procedural knowledge without this being preceded by understanding conceptual knowledge. Knowledge of how to do or make something can operate independently, without being grounded in a conceptual knowledge base.

The implications of this revision are far-reaching. In the example examined in the next section we see, for instance, how a selection of factual knowledge, conceptual and procedural knowledge (to create 'applied' theory) bypasses the conceptual knowledge category completely in the assessed curriculum.

Selection and pacing rules in curriculum and assessment: a case study

In this section we consider an empirical study carried out by Umalusi, as one of the studies to the report *Apples and oranges? A comparison of school and college subjects* (2006). In a sub-report (undated) on equivalence of NQF level 4 science courses, a team of higher education practitioners was asked to conduct an investigation of three NQF level 4 courses to determine their equivalence. The courses examined were:

- Matric Physical Science (Std 10 / Grade 12) Higher Grade [HG]
- Matric Physical Science (Std 10 / Grade 12) Standard Grade [SG]
- Engineering Science (N3) offered in FET colleges

It is worth citing sections of the report in detail as the analysis shows how distinctions between 'pure' and 'applied' theory are achieved through differences in *selection of content, level of cognitive demand in examination questions and time allocated to instruction.*

Comparing content across three NQF level 4 Science curricula

In the table below the three curricula are compared for coverage and depth of science content.

Table 3: Comparison of content coverage in three NQF level 4 science courses

PHYSICS		
Physical Science (HG)	**Physical Science (SG)**	**Engineering Science N3**
Bodies in Motion: Newton's 1st law of motion, Newton's 2nd law of motion, Newton's 3rd law of motion	Bodies in Motion: Newton's 1st law of motion, Newton's 2nd law of motion	Bodies in Motion: Newton's 2nd law of motion
Newton's Law of Universal gravitation, projectile motion (up and down)	Newton's Law of Universal gravitation	
Concept of friction	Concept of friction	Friction: Static & kinetic friction, horizontal and inclined planes
(Covered in Grade 11, including graphs of motion)	(Covered in Grade 11, including graphs of motion)	Velocity and acceleration, equations of motion, no graphs of motion
(Vectors in general covered in Grade 11)	(Vectors in general covered in Grade 11)	Force as a vector, equilibrium of forces, resultant force, equilibrant, frameworks, roof trusses
		Belt drives and angle of contact
Momentum: as vector, conservation, change in momentum in collisions, force = rate of change of momentum	Momentum: as vector, conservation, change in momentum in collisions	Momentum: conservation
Work, energy and power: concepts and conservation of mechanical energy	Work, energy and power: concepts and conservation of mechanical energy	Work, energy and power: concepts and conservation of mechanical energy
		Moments: Turning moment for constant motion, levers and lamina, beams

(Heat: specific heat capacity, transfer of heat covered in Grade 10)	(Heat: specific heat capacity, transfer of heat covered in Grade 10)	Heat: specific heat capacity, transfer of heat, heat value of a fuel, efficiency, expansion and steam
		Hydraulics: hydraulic presses, work done against a pressure
Electrostatics: electricity at rest, force between charges, electric fields, quantization of charge	Electrostatics: electricity at rest, force between charges, electric fields	
Electric current: current concept, force on current-bearing conductor in magnetic field, force between current-bearing conductors (quantitative), resistance, ohm's law, heating effect, power (quantitative), alternating current	Electric current: current concept, force on current-bearing conductor in magnetic field, force between current-bearing conductors (qualitative), resistance, ohm's law, heating effect, power (qualitative), alternating current	Cells, simple electrical circuits, electrolysis, Joule's law, power and energy in DC circuits, alternating current, single-phase transformer
CHEMISTRY		
Physical Science (HG)	**Physical Science (SG)**	**Engineering Science N3**
(Covered in Grade 10)	(Covered in Grade 10)	Elements: constituents of matter, periodic table, metals and non-metals, structure of the atom
Reaction rates and chemical equilibrium, energy of reactions, dynamic equilibrium, equilibrium constant, change of state of equilibrium, equilibrium in solutions, some industrial and other applications	Reaction rates and chemical equilibrium, energy of reactions, dynamic equilibrium, change of state of equilibrium, equilibrium in solutions, some industrial and other applications	
Acids and bases: dissociation of water, pH (quantitative), models for acid and base, acid-base titrations	Acids and bases: pH (qualitative), models for acid and base, acid-base titrations	
Redox reactions: definition in terms of gain or loss of electrons, identifying oxidising and reducing agents	Redox reactions: definition in terms of gain or loss of electrons, identifying oxidising and reducing agents	Redox reactions (brief introduction) and corrosion
Electrochemical cells: copper-zinc cell, electrolysis and electroplating	Electrochemical cells: copper-zinc cell, electrolysis and electroplating	Electron transfer: formation of ions, brief definition of electrolysis and electroplating
Half-cell potentials: table of redox half-reactions and applications, selection of reference electrode, calculations of potential difference	Half-cell potentials: table of redox half-reactions, use of table to balance redox half-reactions	
Organic chemistry: definition, structure, nomenclature, hydrocarbons, alkyl-halides, alcohols, carboxylic acids	Organic chemistry: definition, structure, nomenclature, hydrocarbons, alkyl-halides	

Note: While there are some obvious gaps in the table in terms of broad content categories, it should be noted that within categories that are covered by all courses there are notable differences.

On the basis of this comparison the evaluators concluded that:

> It is clear from this comparative table that the Matric HG syllabus goes into the most depth in all content topics. The SG course covers a similar set of topics, although somewhat reduced in depth and breadth. In the N3 course there are clear and serious omissions, although this syllabus covers a greater number of specific industrial applications.

It is also clear that there is much less chemistry-related content covered in the N3 course, compared with the other two courses (Undated Sub-Report to Umalusi, 2006, 2-4).

Linking knowledge content to assessment

When analysing examination questions (the assessed curriculum), questions were broken down into three categories and three levels of cognitive demand (see table below).

Table 4: Categories and levels of cognitive demand

Category	Level	Descriptions	Examples
Factual recall/ rote	**Simple (1)**	State a simple law or equation	State Newton's laws etc.
	Medium (2)	Recall complex content	Process for lab preparation of chemical compounds; testing for presence of diff chemicals; inorganic chemical interactions
Understanding of concept/ principle	**Simple (1)**	Simple relationships; simple explanations	Relationship between resultant and equilibrant; explain what is meant by … ;
	Medium (2)	Counter-intuitive relationships; Qualitative proportional reasoning; more complex relationships or explanations	Direction of acceleration for free-fall; effects of changes in circuits; identifying acid-base conjugates, redox pairs etc; simple influences on dynamic equilibrium
	Challenging (3)	Identify principles which apply in a novel context	Identify all influences on realistic motion; identify isomers of organic compounds; complex influences on dynamic equilibrium
Problem solving	**Simple (1)**	Simple procedure; plug into formula with only one unknown; no extraneous information; known or practiced context	Given current and resistance, calculate voltage; etc
	Medium (2)	Construction or interpretation of diagrams; problems with 2 or more steps; basic logic leaps; proportional reasoning; interpretation of table of data	Graphs of motion; force or vector diagrams; concentration or molar calculations; naming of organic compounds; writing and balancing equations for reactions
	Challenging (3)	Complex abstract representation; combination of concepts across sub-fields; complex problems involving insight and logic-leaps; formulating new equations (using all unknowns); problem solving in novel context	Interpret complex graphs; translate between various graphs of motion; combine equations for mechanical energy and motion; combine gravitational and electrostatic forces; complex circuit calculations; combination of various factors influencing equilibrium

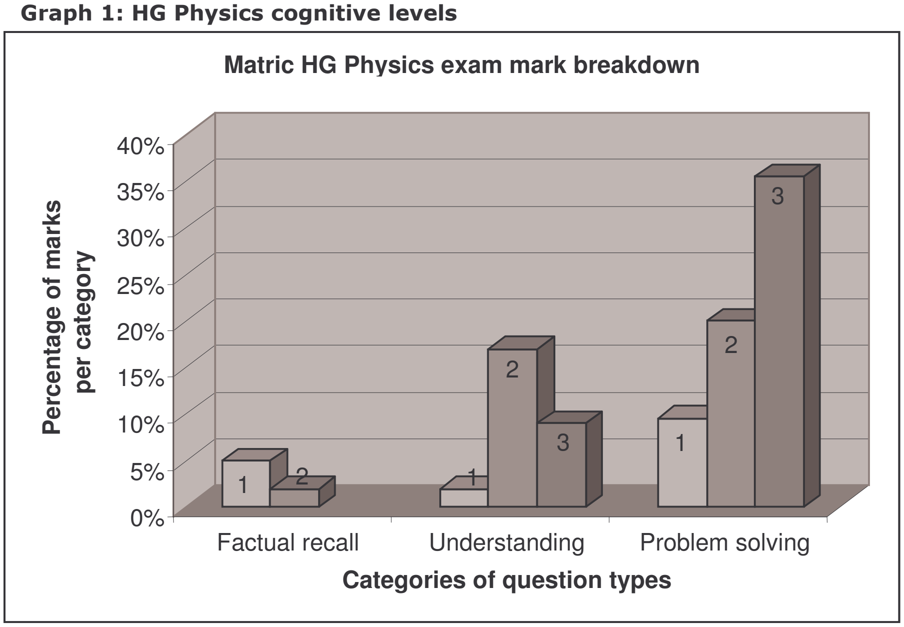
The allocation of marks in the various examination papers was analysed according to the above categories and levels. The next table shows the breakdown of marks.

Table 3: Comparison of cognitive demand

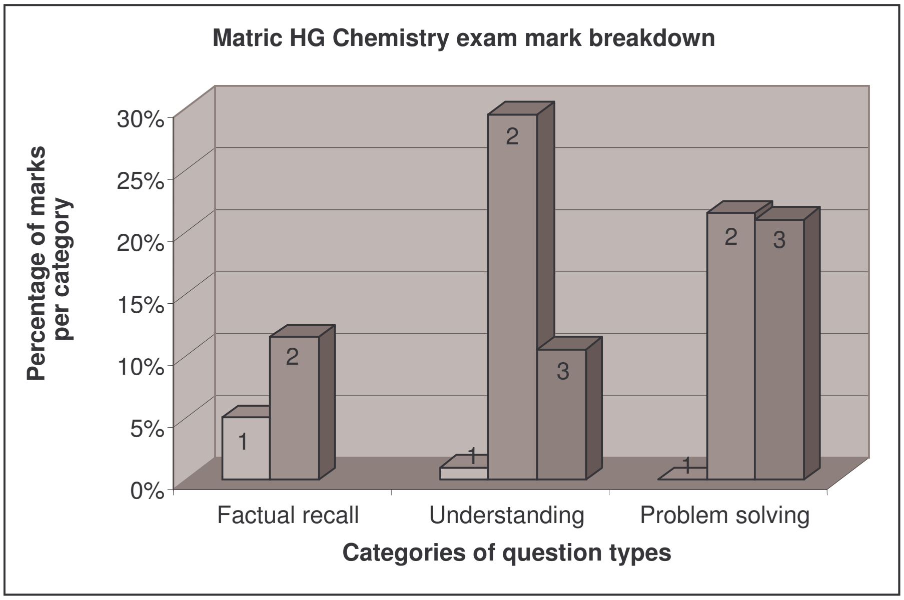
		Factual recall		Understanding			Problem solving		
		Level 1	Level 2	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
HG (Physics)	Marks / 200	10	4	4	34	18	19	40	71
	Percentage	**5%**	**2%**	**2%**	**17%**	**9%**	**10%**	**20%**	**36%**
HG (Chem)	Marks / 200	10	23	2	59	21	0	43	42
	Percentage	**5%**	**12%**	**1%**	**30%**	**11%**	**0%**	**22%**	**21%**
SG (Physics)	Marks / 150	18	10	8	29	3	12	70	0
	Percentage	**12%**	**7%**	**5%**	**19%**	**2%**	**8%**	**47%**	**0%**
SG (Chem)	Marks / 150	22	22	13	47	0	9	37	0
	Percentage	**15%**	**15%**	**9%**	**31%**	**0%**	**6%**	**25%**	**0%**
N3 Engineering Science	Marks / 100	16	5	0	0	0	44	35	0
	Percentage	**16%**	**5%**	**0%**	**0%**	**0%**	**44%**	**35%**	**0%**

Comparisons of levels of cognitive demand were then presented in graphic form. We will compare the graphs for Matric Higher Grade General Science (Physics and Chemistry) to the graphs for N3 Engineering Science offered by FET colleges.

Graph 1: HG Physics cognitive levels

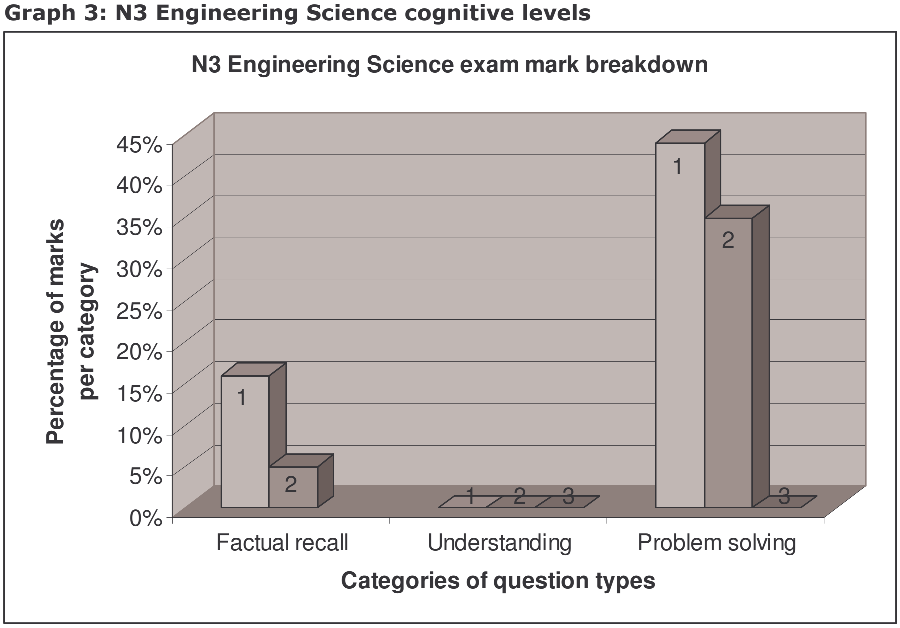


Graph 2: HG Chemistry cognitive levels



The graphs show that the HG examinations placed very little emphasis on the simple level of cognition, and contained a substantial proportion of challenging questions. In the combined HG Physics and Chemistry examinations, **11%** of the marks were allocated to cognitive level 1 (simple), **51%** to cognitive level 2 (medium) and **38%** to cognitive level 3 (challenging).

Graph 3: N3 Engineering Science cognitive levels



The N3 Engineering Science examination contained no questions which probed understanding of concepts or principles. All questions fell into either the factual recall or problem solving categories. The examination contained no questions in the problem solving category at level 3 (the challenging level). The exam mostly tested application of procedures (level 1). **60%** of the N3 exam marks were allocated to questions at cognitive level 1 (simple), the remaining **40%** at level 2 (medium)[4].

The 'black hole' in the 'understanding' category of the N3 Engineering Science assessed curriculum, shows how the way in which 'applied' theory is examined, can often result simply in procedural knowledge, even though the content selected and stipulated in the intended curriculum contains general laws and principles.

Time allocated to instruction (pacing)

Reasons for lack of conceptual knowledge in the N3 Engineering Science examination become clearer when one considers the difference in the pacing rule applied.

> Although the Matric Physical Science courses are considered one-year courses of study, in reality the actual teaching takes place during the first six months of the school year (approximately 104 hours of tuition), the remainder of the year being devoted to revision, trial examinations and final examinations. However, this course is developmentally built upon knowledge learned in Grades 10 and 11, and in fact explicitly examines work covered in the Grade 11 syllabus. It should therefore be considered as a culmination of *three years* of Physical Science study.
>
> The N3 Engineering Science course, by comparison, is a *single trimester* (three month/13 week) course, which in reality is usually taught in just 10 weeks (approximately 60 hours of tuition) due to logistical limitations such as enrolment delays. Although in general N1 and N2 courses are necessary pre-requisites for enrolment in N3, a learner may follow an alternate route after completing Matric by enrolling directly in the N3 Engineering Science course without doing the N1 and N2, provided he/she has also completed Grade 12 mathematics and usually technical drawing or trade theory as well. Therefore, when addressing the question of equivalence, the N3 course content should be considered on a stand-alone basis. *By implication, although less time is available for teaching in the N3 course, more time may be needed because students are not necessarily building on prior knowledge…*

---

[4] When I discussed this graph with college lecturers they conceded that many of the questions under 'problem solving' actually belonged in the 'factual recall ' category in that they were rehearsed solutions which students had practiced many times in class. The question thusloks as if it asks for novel problem-solving but the response given is a routinised, procedural response

> There is clearly a vast difference between the Matric Physical Science courses and the N3 Engineering Science course in terms of time spent on tuition and concept development (Undated Sub-Report to Umalusi, 2006, 1-2, emphasis added).

Pacing, or the time allocated to instruction, is thus considered crucial to the scope and level of content coverage that can be achieved.

Recommendations made by the evaluation task team

It is worth noting the recommendations made by the evaluation team as they point to the complexity of achieving an appropriate balance between factual, conceptual and procedural knowledge and application in everyday contexts.

> Applications of knowledge in a wide variety of everyday life contexts and problem solving in novel contexts are important for learners to appreciate the relevance of the material being learned, and hence engage with it at a deeper level. This is a short-coming particularly of the matric SG syllabi. The N3 syllabus, on the other hand, is more applied than the SG matric syllabi, but in very limited, industrial contexts. Context specific industrial applications without the development of principled, deep conceptual knowledge are unlikely to develop skills that are transferable across contexts.
>
> A more conceptual approach to learning is recommended, as opposed to the breadth of content knowledge covered in the matric syllabi. It is suggested that fewer content topics be covered in greater conceptual depth, with explicit emphasis placed on the development of sound understanding and competencies. To achieve this, more time may be needed for the N3 Engineering Science course…
>
> … Finally, it should be noted that ultimately much would depend on the way the intended curriculum is implemented. For example, the extent to which students are engaged with underlying knowledge principles depends to a large extent on the educator's subject expertise and specialized knowledge as well as access to other resources. Continuous capacity development of educators is therefore essential to ensure the success of any teaching curriculum (Undated Sub-Report to Umalusi, 2006, 11).

What the case study illmuninates is that the idea of 'applied' theory, as a contextualised selection of factual, conceptual and procedural knowledge, may well be achieved at the level of the intended curriculum, only to be scuppered by insufficient teaching time and/or examination questions that focus mainly on rehearsed procedural problem solving. Here we thus see the effect of a proceduralising curriculum move in the direction of the everyday world of practice.

These are the issues addressed in the final section, where we use the conceptual tools set out in the paper to consider possible options for the practical assessment of school and college subjects.

Towards a framework for the quality assurance of practical subjects and/or the practical component of subjects

Conceptual tools

The purpose of the conceptual framework developed in this paper has been to give us a set of tools with which to consider the assessment and quality assurance of practical subjects and/or the practical component of subjects. We briefly summarise the 'knowledge' tool and the 'practice' tool and then turn to the question of their combination.

A foundational assumption is that practice cannot be considered in the absence of knowledge (theory). In answering the question about what counts as practice, there is always an accompanying question about what counts as knowledge.

1. Knowledge

Knowledge categories (from Bloom's revised taxonomy
Factual knowledge
Conceptual knowledge
Procedural knowledge

These knowledge categories combine (in Gamble's model) as:

- *'Applied' theory*: factual + procedural knowledge
  The logic of 'applied' theory is sequential (step-by-step)
- *'Pure' theory:* factual + conceptual knowledge
  The logic of 'pure' theory is relational/connective

Associated cognitive processes (Bloom's revised taxonomy)

- Factual knowledge: Remember (recognise, identify, recall, retrieve)
- Conceptual knowledge: Understand (explain, compare, interpret, exemplify, classify, summarise, infer)
- Procedural knowledge: Apply (execute, implement, use, carry out)

2. Practice

Forms of practice, with Bloom's revised taxonomy of equivalent cognitive dimension indicated in brackets)	
Doing	(Applying - carrying out a procedure in a given situation)
Making	(Analysing – breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose)
Creating	(Creating - putting elements together to form a novel coherent whole or to make an original product)

Other key words for ***applying***: execute implement, carry out, use

Other key words for ***analysing***: differentiate, distinguish, select, organise, determine how elements fit into a structure.

Other key words for ***creating***: generate, plan, produce, design, construct

[When referring to an original piece of writing Kratwohl (2002, 217) classifies writing under 'produce', as a process within 'create'.]

Using the tools to create knowledge-practice combinations

In accordance with the logic developed in the paper, knowledge-practice combine in four possible ways.

Everyday contextual coherence

Knowledge	**Practice**
Factual (naming of parts)	**Doing:** discrete task performance in everyday life situations, with no necessary relation between segments of practice in everyday life. Evaluative criteria: 1. Correctness/accuracy 2. Dexterity (time taken)

Tacit conceptual coherence

Knowledge	Practice
Factual (naming of parts)	**Making**: reproducing a part-whole relation Evaluative criteria: 1. Organisation of 'parts' into a 'whole' 2. Presentation of the 'whole'

Theorised contextual coherence

Knowledge	Practice
Factual Procedural	**Making**: reproducing a part-whole relation through making - and able to describe the sequential logic. Evaluative criteria: 1. Organisation of 'parts' into a 'whole' 2. Presentation of the 'whole' 3. Giving a rationale for practice in terms of sequential logic

Contextualised conceptual coherence

Knowledge	Practice
Factual (Procedural) Conceptual	Creating : connecting parts to whole in a novel way to make a new coherent whole and able to describe the logic both relationally (and sequentially) Evaluative criteria: 1. Conceptualising 'parts' into a new 'whole' 2. Giving a rationale for practice in terms of relational or connective logic

In the above combinations conceptual knowledge, as the basis of understanding, may or may not include an understanding of procedural knowledge, since it is by no means inevitable that the two forms of knowledge should be separated. Principles are often acquired through procedures although, as we have seen, procedures can also be taught sequentially without reference to principles. The important point is that conceptual knowledge is not reduced to procedures. Procedures, if and when they are taught always stand in the service of helping the student to grasp an abstract law, rule or principle.

What we have here are gradations of Muller's original idea of conceptual and contextual coherence. In the theory-practice curriculum both forms of coherence manifest in restricted and elaborated form[5]. We can represent this in the following schema:

[5] The terms 'restricted' and 'elaborated' are borrowed from the work of the sociologist Basil Bernstein (2000), as are the terms 'selection', 'sequence', 'pace' and 'evaluative criteria', to achieve theoretical consistency

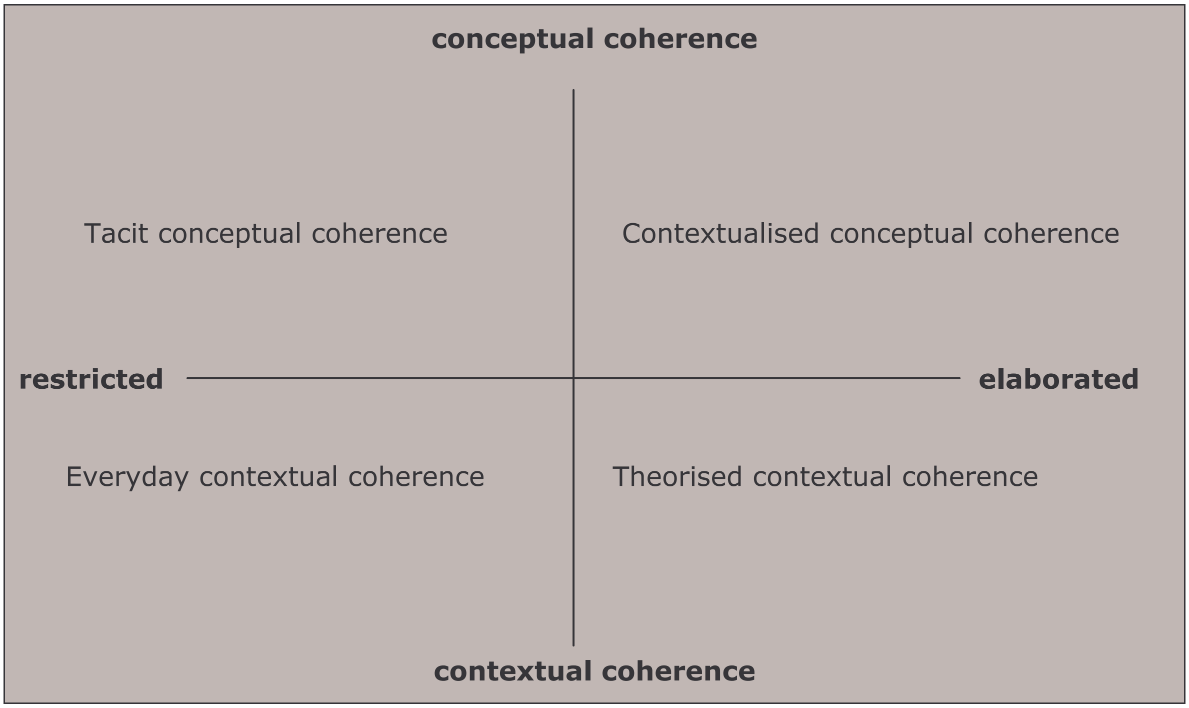


Figure 8: Gradations of curriculum coherence in a theory-practice curriculum

On the left-hand side we see two forms of untheorised practice, with the position reversed on the right-hand side, where practice is always knowledge-based, although drawing on different forms of knowledge.

Current specifications of cognitive distribution in school and FET college subjects with a practical component

Gradations of curriculum coherence imply that practical subjects or the practical component of subjects can be graded in terms of the kind of knowledge-base on which the practice is based. If we turn to the Assessment Guidelines issued for subjects with a practical component we see how this translates into assessment stipulation:

In the example of assessment guidelines for practical school subjects, the categories refer to the original Bloom's taxonomy, elaborated through specification of progression in 'thinking skills' (see below).

Table X: NCS Subject assessment guidelines: Business Studies - Grades 10 -12 (January 2008)

Knowledge and Comprehension Original Bloom levels 1 & 2	Basic thinking skills (e.g. factual recall, low-level application and low-level comprehension)	30%
Application and Analysis Original Bloom levels 3 & 4	Moderately high thinking skills (e.g. more advanced application, interpretation and low-level analysis)	50%
Synthesis and Evaluation Original Bloom Levels 5 & 6	Higher-order thinking skills (e.g. advanced analytical skills, synthesis and evaluation)	20%

However, given that the emphasis is on skill (cognitive process) rather than on knowledge, we cannot judge from this table what the knowledge base is to which the 'cognitive skills' relate.

Still using the original Bloom's taxonomy, the assessment guidelines for FET college subjects distributes cognitive application somewhat differently. 'Application' is specified as a category on its own, with the higher-order cognitive dimensions of analysis, synthesis and evaluation specified as a separate category.

Table X: NC(V) Assessment Guidelines: Programme Office Administration NQF levels 2 - 4

SUBJECT	KNOWLEDGE AND COMPREHENSION	APPLICATION	ANALYSIS, SYNTHESIS AND EVALUATION
Fundamental subjects			
English 1st Add Language (Level 2)	60%	30%	10%
English 1st Add Language (Level 3)	30%	40%	30%
English 1st Add Language (Level 4)	20%	40%	40%
Life orientation (Level 2)	70%	25%	5%
Life orientation (Level 3)	55%	35%	10%
Life orientation (level 4)	40%	40%	20%
Vocational subjects			
Business Practice (L2-4)	40%	40%	20%
Office Practice (L2-4)	40%	40%	20%
Office Data Proccessing (L2-4)	10%	80%	10%
Applied Accounting (L2-4)	40%	40%	20%

Assessment guidelines for Mathematical Literacy differ from the others, in that there are both content and cognitive dimension stipulations, although no variation between different NQF levels.

Table X: Mathematical Literacy – NQF levels 2 - 4

Content stipulation	Numbers	Patterns & relationships	Finances	Space, shape & orientation	Information communicated
NQF Levels 2 - 4	20%	20%	20%	20%	20%

Cognitive dimension	Knowing	Applying routine procedures in familiar contexts	Applying multi-step procedures in a variety of contexts	Reasoning and reflecting
NQF Levels 2 - 4	30%	30%	20%	20%

A number of patterns emerge from these ways of stipulating the requirements of FET college external examinations that contain practical components:

Foundational subjects

- *English* shows a progression from 'knowledge and understanding' to higher-order cognitive processes over the three years of the qualification, as well as an increase in the application component at NQF levels 3 and 4.
- *Mathematical Literacy* specifies content distribution and distinguishes between two forms of application, but does not vary the distribution pattern over the three years.
- *Life Orientation* places a strong emphasis on 'knowledge and comprehension' in the first year. This emphasis decreases gradually, with a concomitant increase in the other two categories.

Vocational subjects

- Apart from one subject which has a very strong emphasis on 'application', the other three subjects show an equal distribution between 'knowledge and comprehension' and 'application' over the three years of the qualification. There is less emphasis on 'analysis, synthesis and evaluation' in these subjects.

Like in the school subject specification, there is no indication in the FET college specification of what counts as knowledge (apart from in Mathematical Literacy). Bearing in mind the Umalusi case study results, one could probably surmise that the knowledge component consists mainly of 'recall of factual or procedural knowledge'.

Similarly, apart from in Mathematical Literacy, there is no differentiation between different forms of ‘application’. Both these omissions could be regarded as limitations in terms of in-depth quality assurance.

A suggested way forward

Any guideline should be straight-forward and easily understood, otherwise it undermines exactly what it is trying to promote. In the interests of simplicity, it is tempting to suggest the route taken by the science evaluators in the Umalusi case study. They specify only three main categories (factual recall; understanding of concepts and principles; problem solving), with two or three levels of cognitive challenge included in each category. However, the strong emphasis on practice which characterises the school and college subjects which Umalusi must quality assure, calls for a different kind of specification.

Given that both schools and colleges are already familiar with the categories in the original Bloom’s taxonomy it makes sense to suggest use Bloom’s revised taxonomy as the basis for a grid that captures different kinds of knowledge and practice. The example that follows illustrates this approach.

Knowledge	**Facts/terminology**	**Procedures and rules**		**Concepts and principles**
Practice	**Single-task performance** Single tasks according to criteria of correctness and time taken.	**Multiple-task performance** Connecting tasks into whole sequences, according to criteria of correctness and time taken.	**Rehearsed problem solving** Connecting tasks into whole sequences and able to explain grounds for action.	**Novel problem solving** Creating new, unrehearsed task sequences and able to explain the reasoning.

The words may not yet be the appropriate ones but it is easy to see how the grid allows for both knowledge and practice progression. For example:

Grade 10/NQF Level 2:

<table>
<tr><th>KNOWLEDGE</th><th>Facts/terminology</th><th colspan="2">Procedures and rules</th><th colspan="2">Concepts and principles</th></tr>
<tr><td></td><td>50%</td><td colspan="2">40%</td><td colspan="2">10%</td></tr>
<tr><th>PRACTICE</th><th>Single-task performance</th><th>Multiple-task performance</th><th colspan="2">Rehearsed problem solving</th><th>Novel problem solving</th></tr>
<tr><td></td><td>60%</td><td>20%</td><td colspan="2">20%</td><td></td></tr>
</table>

Grade 11/NQF Level 3:

<table>
<tr><th>KNOWLEDGE</th><th>Facts/terminology</th><th colspan="2">Procedures and rules</th><th colspan="2">Concepts and principles</th></tr>
<tr><td></td><td>30%</td><td colspan="2">50%</td><td colspan="2">20%</td></tr>
<tr><th>PRACTICE</th><th>Single-task performance</th><th>Multiple-task performance</th><th colspan="2">Rehearsed problem solving</th><th>Novel problem solving</th></tr>
<tr><td></td><td>20%</td><td>20%</td><td colspan="2">40%</td><td>20%</td></tr>
</table>

Grade 12/NQF Level 4:

<table>
<tr><th>KNOWLEDGE</th><th>Facts/terminology</th><th colspan="2">Procedures and rules</th><th colspan="2">Concepts and principles</th></tr>
<tr><td></td><td>10%</td><td colspan="2">40%</td><td colspan="2">50%</td></tr>
<tr><th>PRACTICE</th><th>Single-task performance</th><th>Multiple-task performance</th><th colspan="2">Rehearsed problem solving</th><th>Novel problem solving</th></tr>
<tr><td></td><td></td><td>10%</td><td colspan="2">30%</td><td>60%</td></tr>
</table>

Knowledge distribution depends on a subject's knowledge base. Some subjects may only have a factual and procedural 'applied theory' knowledge base, in which case these categories would be the main focus. In other subjects 'applied theory' may consist of selections of factual + procedural + conceptual knowledge.

Specifications, such as those exemplified above, avoid a situation where the 'knowledge and comprehension' category refers mostly to factual recall; or, where the 'analysis, synthesis and evaluation' category refers mostly to rehearsed problem-solving. It encourages progression in the practical component of subjects that is not possible in 'application' as a single category.

Conclusion

This paper has attempted to show how rules of combination, in terms of selection, sequencing and pacing construct different permutations of the 'theory-practice' combination in the vocational and professional curriculum. The conceptual language developed enables more finely-grained interpretations of terms such as theory (knowledge) and practice. If the proposed way forward is adopted it will go a long way towards moving Umalusi's quality assurance practice from the monitoring of procedural compliance towards addressing the form taken by both 'knowledge' and 'practice'. This is not to say that there should be no measures for ascertaining procedural compliance but rather that, on its own, procedural compliance cannot assure quality.

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