THE NS AND THE ENGINEERING NC (V)S:
A comparison of selected engineering subjects within the National Certificate: N2 and N3 and selected programmes of the National Certificate (Vocational)

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Acknowledgements

This research was necessitated by Umalusi's need to find a means to understand the roles played by the National Certificate (NC): N2 and N3 (popularly known as the N-courses) and the NC (V), which are qualifications being offered in FET colleges and to help it to plot a meaningful way forward for both these qualifications since they are currently required to co-exist on the General and Further Education and Training Qualifications Framework. The research was conducted by a small team of five evaluators who were appointed on the grounds of their expertise and their involvement with both qualifications at different levels.

The evaluation instrument used for the project is an adapted version of the *Maintaining Standards* instrument which has a long developmental history in Umalusi's research. The instrument was adapted to answer the new questions which were formulated for the latest research. The adaptations were done by Ms Helen Matshoba and Dr Celia Booyse.

Ms Matshoba and Dr Booyse jointly managed the project under the supervision of Ms Elizabeth Burroughs. They were responsible for much of the editing of the individual reports from the team members. Ms Matshoba compiled the overview report with assistance from Ms Burroughs and Dr Booyse. Within Umalusi, much appreciated administrative support came from Ms Lesego Mgidi.

Appreciation is extended to all who contributed to the success of this project in whatever way.

Umalusi would also like to thank the subject teams for their involvement, dedication and hard work. The project team was composed of:

Mathematics

The analysis for mathematics was conducted by Mr Khwathelani Ashley Sipholi, a mathematics lecturer in the Mathematics, Science and Technology Education department located within the Faculty of Humanities at the Tshwane University of Technology (TUT). He was a lecturer, senior lecturer and Head of Department at various FET colleges before joining the university. He has also been an external moderator for NC (V) Levels 2 – 4 Mathematics for Umalusi since 2008.

Electrical Trade Theory

Due to the analysis workload, the number of subjects to be evaluated and the inclusion of all levels of the NC (V) in the analysis, the analysis of this particular subject was conducted by two evaluators, namely Professor Puramanathan Naidoo and Mr Fred Arends.

Mr Arends compared the N2 Electrical Trade Theory with Electrical Principles and Practice L2, L3 and L4, Electrical Systems and Construction L2, L3 and L4, Workshop Practice L2 and Electrical Workmanship L3 and L4 of the NC (V). An FET college lecturer with more than 20 years of teaching experience in the subject, Mr Arends is currently teaching both the NC (V) and the NC: N2 and N3 Electrical Trade Theory.

The analysis for N3 Electrical Trade Theory in comparison with Electrical Principles and Practice

L2, L3 and L4, Electrical Systems and Construction L2, L3 and L4, Workshop Practice L2 and Electrical Workmanship L3 and L4 of the NC (V) was conducted by Professor Naidoo, an Assistant Professor in the Department of Electrical Engineering at the Mangosuthu University of Technology. Prior to joining higher education, Professor Naidoo worked his way up through the apprentice system, was an instrument mechanic with an N6 Diploma, and has working experience in industry.

Engineering Science

The comparative analysis of NC: N2 and N3 Engineering Science with Engineering Systems Level 2, Materials Technology Level 3 and Applied Engineering Technology Level 4 of the NC (V) was undertaken by Ms Thobile Zulu, an FET college lecturer, who is a subject leader in Mathematics and Engineering Science. Her other responsibilities include being an internal moderator of the examination process at the FET college. She was previously an evaluator for the project that resulted in the research report entitled *Apples and Oranges? A comparison of school and college subjects*.

Engineering Drawing

The comparative analysis of NC: N1, N2 and N3 Engineering Drawing with Engineering Technology Level 2 and Engineering Graphics and Design Level 3 of the NC (V) was conducted by Mr Sarel de Bruin, a Deputy Chief Education Specialist for Engineering Graphics and Design at provincial level. He has 13 years' experience as a teacher and Head of Department for Technical Drawing at various schools. His insight from work done as assistant examiner and examiner for Technical Drawing Paper 1 and 2 at provincial level made him invaluable as part of the writing team that developed the NCS Subject Assessment Guidelines for Engineering Graphics and Design and the Curriculum Assessment Policy Statement (CAPS) for Engineering Graphics and Design.

Mr De Bruin served as chairperson of the Technical Drawing subject committee and subject study group at provincial level, and he was also involved as internal moderator for the National Curriculum Statement (NCS) Engineering Graphics and Design.

Executive Summary

In order to understand and set standards for qualifications that are quality assured and certified by Umalusi, Umalusi evaluates the curricula associated with the subjects which form part of the qualification as well as the accompanying examinations which serve to embody certain aspects of the prescribed standard. Over the past seven years, Umalusi has had to conduct a number of extensive evaluations resulting from the transformation in the education system, which has impacted on the qualifications for which Umalusi is responsible. The one with the most immediate relevance for this research is probably the 2006 report, *Apples and Oranges? A comparison of school and college subjects*, in which Umalusi critically engaged with the relationship between the Senior Certificate and the National Senior Certificate (colleges). In 2008, Umalusi embarked on the *Maintaining Standards* project following the introduction of the National Senior Certificate (NSC), a new qualification replacing the Senior Certificate. In 2009, Umalusi started a comparative evaluation of the NSC and the National Certificate (Vocational) (NC (V), a new qualification introduced in Further Education and Training (FET) colleges in 2007 at Level 2 and which was written for the first time at Level 4 in 2009. In this report the vocational aspect of the NC (V) is compared to the other established offerings in FET colleges, the N-courses.

During the period when the NC (V) was introduced, the old FET college qualifications, the NC: N1–N3, were being phased out. However, in 2010, the Minister for Higher Education and Training decided that some of the NC: N1-N3 programmes, specifically the Engineering Studies programme, should continue to be offered, seemingly as an interim measure. As a result of the return of the NC: N1–N3 engineering courses Umalusi felt that it was important to conduct a curriculum and examination analysis in order to better understand the National Certificate: N1 – N3 that had now been given a new lease of life. It was hoped the research, a comparative evaluation of engineering subjects within the NC (V) and the N-courses, would point to areas of strength and the need for possible improvements within each qualification. An important part of the intent has also been to understand the relationship between the three levels of the NC (V) and the National Certificates: N1 – N3 in a nuanced way – such an understanding could help with issues of recognition for the purpose of articulation, for example.

In conducting the evaluation, Umalusi made every effort to secure the services of subject experts in the specific subjects under investigation. The evaluation instrument that the experts used was divided into two parts: a curriculum analysis and an examination analysis. The teams received thorough training in the application of the instrument. Umalusi also endeavoured to obtain all the relevant policy documents that relate to the curriculum and the assessment of the specific subjects under investigation. The analysis of the documents and the use of the instrument helped in gathering data that could be used to effectively answer the research questions which were considered under the two parts of the instrument.

It is necessary at the outset to note that the two qualifications under investigation were designed differently and were aimed at different demographic groups. The N-courses were designed as post-school qualifications for older learners, often ones who had already been taken up in workplaces, while the NC (V) has been designed mainly for adolescent learners in the 16 – 19 age group, though this is not to negate its potential usefulness for older learners also. The NC (V) is perhaps best seen as a sister qualification to the National Senior Certificate, the school leaving qualification: while the NSC is focused on an academic preparation, the

NC (V) is conceived as a meaningful alternative for young people with greater practical flair and interest. The N-courses for Engineering Studies may form part of a path that leads to an artisan qualification. Between 2007 and 2011, 34 981 people qualified as artisans (Prinsloo 2011). It is worth noting in passing that the NC (V) also has the potential to lead to an artisan qualification due to its design features.

The N-courses for Engineering Studies originally formed part of a path that could lead to an artisan qualification. Indeed, the NC: N2 was determined as the only recognised theoretical component for accessing the trade test. In addition, however, students could, by means of further study and experience in the workplace, gain access to higher education institutions and/or eventually earn the highly prized Government Engineer Ticket. Because the N-courses were intended primarily for people already employed as apprentices, the programmes were offered as small independent modules which could be done part-time or at night, one of the features of the programmes which remains extremely popular with students and employers.

Umalusi's involvement with the N-courses resulted from their becoming accepted alternative subjects for the issuing of either the Senior Certificate or the old National Senior Certificate (colleges) as detailed in the Report 191(2001/08). In order to accept the N-course subjects as bona fide subjects for combination, Umalusi undertook to moderate the papers, quality assure the examinations and standardise the marks, and continues to do so.

What emerges from the curriculum analysis is that, by and large, the NC (V) covers more ground theoretically than do the NC: N2 and N3 combined, which is unsurprising, given that the programme is longer and more comprehensive. The second significant difference is the fact that NC (V) subjects contain substantive opportunities for *skills development*, a feature which was included in the programme precisely because it was recognized that many students undertaking the N-courses no longer have an opportunity to gain on-the-job experience, a prerequisite of the Manpower Training Act, Act 56 of 1981, which requires on-the-job-experience for access to the trade test. Umalusi's evaluators all agree that some workplace experience is needed, for access to the trade test, but argue that this period could be significantly shorter for NC (V) candidates than was the case in the old apprenticeship system, because of the specific focus on the acquisition of practical skills in the structure of the NC (V).

Three of the four subjects evaluated (Mathematics, Engineering Drawing and Engineering Science) do not traditionally have trade tests directly associated with them. However, these subjects play an essential supportive role because they provide the necessary underpinning theory for the trade test. In the NC (V) however, every NC (V) subject, regardless of whether it is a "trade" subject or not, has a practical as well as a theoretical component, thereby providing learners with the opportunity to apply the acquired knowledge and skills. The structure of the NC (V) also provides the possibility of creating education-employment partnerships with industry, which would allow NC (V) learners exposure to the real workplace.

The NC (V) curriculum aims to produce NC (V) learners that are rather better prepared for access to the trade test than in the past, when many N-course learners did not have workplace access and only acquired the theory. As can be seen in the full report, the content, breadth and depth of the curricula of the NC (V) subjects is significantly different from that of the N-courses, taking on as they do the need to provide opportunities for practical skills acquisition (even if this is not always being successfully implemented in colleges as yet).

The analysis of the NC (V) curriculum provides pointers for curriculum reform of the NC: N2–N3 content with regard to Mathematics, Engineering Science and Electrical Trade Theory. However, in the case of the fourth subject, Engineering Drawing, the NC (V) can take some cues from the NC: N1-N3 subject in terms of the packaging of the content.

What emerges from the analysis of the NC: N3 and NC (V) L4 examination of the subjects selected is that the N3 subjects do not have assessment guidelines and that the NC: N3 syllabus, which is the only document that contains information on examination, provides insufficient guidance on how to set the exam paper. The absence of such guidance with regard to the NC: N3 compromises the quality and the standard of the examinations across the various subjects. In comparison, the NC (V) has detailed Subject and Assessment Guidelines. Both these documents provide guidance on the practical assessment and examination. The NC (V) Subject Guidelines provide information on the weighted values of topics in the examination. The Assessment Guidelines provide the suggested distribution of cognitive demands which should be used for setting the final examination papers.

The analysis reveals that the level at which the subjects are assessed in the NC (V) and the N-courses is significantly different. Firstly, the NC (V) has two question papers, a theory and a practical paper, while the NC: N3 has one paper, which is a theory paper. The practical paper of the NC (V), the ISAT, focuses on application and problem-solving, while the theory paper's focus is on knowledge and understanding.

Furthermore, the comparison of the examinations, in terms of the level of difficulty and cognitive demand indicates that, due to insufficient guidance for the setting of the NC: N3 examinations, the four different instructional offerings differed considerably in terms of the spread of levels of difficulty and cognitive demands. In two of the NC: N3 subjects, the analysis, making use of Bloom's revised taxonomy, indicates that not all six levels of cognitive demand are catered for in the examination papers. This is not the case with the NC (V), where there is an acceptable distribution across the various levels of cognitive demand of the four subjects. In one subject, however, the cognitive demands do not correspond at all with the recommendations in the syllabus.

The Engineering Studies programme of the N-courses fulfils a role distinct from that of the NC (V) engineering programmes: they make provision for learners, who are in apprenticeship programmes and who are without a recognised qualification that allows them access to trade testing. These learners attend the theoretical training through the block release system, a mode of instruction not currently catered for in the NC (V) due to its length and assessment design. FET colleges have not innovated to accommodate part-time learners wanting to complete the NC (V) while working. The N-course programmes also cater for part-time learners.

The NC (V) is, however, the only national qualification that provides a vocational educational alternative to those adolescent learners who have already identified an interest in a particular area of work.

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NATED – National Education Department
NC – National Certificate
NC (V) – National Certificate (Vocational)
NQF – National Qualifications Framework
NSC – National Senior Certificate
NTC – National Technical Certificate
FET – Further Education and Training
NCS – National Curriculum Statements
ISAT – Integrated Summative Assessment Task
CAD – Computer-Aided Design

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THE NS AND THE ENGINEERING NATIONAL CERTIFICATE (VOCATIONAL)

A COMPARISON OF SELECTED ENGINEERING SUBJECTS WITHIN THE NATIONAL CERTIFICATE AND SELECTED PROGRAMMES OF THE NC (V)

CHAPTER 1

1.1 BACKGROUND

1.1.1 Introduction

In 2010, Umalusi undertook a comparative evaluation of the curricula of the engineering subjects within the engineering programmes of the N-courses and the related engineering subjects of the NC (V). The research was intended to create an understanding of the relationship between the theoretical component of the NC (V) and the N-course subjects for Engineering Studies. One of the reasons for undertaking the comparison has been, in part, to demonstrate that learners who have completed some or all of the NC (V) engineering subjects are in possession of substantively the same – or more – theoretical knowledge than students who have passed the National Certificate: N2 subjects, which have traditionally provided the only access to the trade test – provided that they are regarded as having had sufficient on-the-job training to have acquired the necessary practical skills. The second important reason for undertaking the comparative research was to better understand the extent and nature of the practical skills that NC (V) students acquire, assuming of course, that the programme is properly taught. Are these skills close to sufficient for students to be reasonably competent in the skills and tested in the trade test? If the practical side of the NC (V) engineering programme is sufficiently rigorous to provide most of the required skills, how much workplace exposure would make good what can only be learned on the job? This was a question Umalusi asked the evaluators to consider during the course of the rigorous curriculum comparison which they undertook.

The National Certificate: N2 is the primary access route to trade testing for artisanship in accordance with Section 13 of the Manpower Training Act, Act No 56 of 1981. The other route is that of Section 28 of the Manpower Training Act, Act 56 of 1981, whereby a candidate can gain access through recognition of experience. In terms of the Skills Development Act, there are currently four pathways through which access to trade testing can be obtained:

- Learnerships – learnerships are offered against registered vocational/occupational qualifications. They have a structured work-experience 16 component and a structured learning component, and are associated with a specific trade, occupation or profession.

- Apprenticeships – apprenticeships are offered against a listed trade and include a trade test; the learner-apprentice must have achieved at least an NC: N2 certificate for access to the trade test.

- Recognition of Prior Learning – Section 28 of the Manpower Training Act.

- Any other learning programme resulting in an occupation or vocational qualification inclusive of prescribed work experience – e. g. the NC (V).
  (Skills Development Amendment Act of 2008, page 18)

With the introduction of the NC (V), it has become necessary to gain an understanding of whether the NC (V) curricula prepare learners sufficiently to be able to access an apprenticeship. Prior to the introduction of the NC (V), the successful completion of the NC: N2 – which was largely theoretical and formally offered in an FET college, and which supposedly included workplace experience gained in a workplace environment – was the standard access route to the trade test.

The NC (V) comprises both practical and theoretical components which are offered formally in the FET college environment, but there is no formal agreement that connects the qualification to apprenticeship programmes, as is the case with the NC: N2. Such a formal acknowledgement in respect of the NC (V) would allow the new qualification to become the conduit it should be into further vocational training and work. This research is thus intended to provide the groundwork to establish a formal relationship between the NC (V) and the NC: N2 in order to allow for policy formulation that will link the NC (V) with the apprenticeship system.

In summary, the evaluation was motivated by Umalusi's need to understand firstly, the extent of the overlap that exists between the curricula of the N-courses and those of the NC (V) as they relate to the theoretical component of the NC (V), and secondly, to determine the comparability of the practical component within the NC (V) with the work experience component of the apprenticeships. The primary intent of the research is to help in determining whether the NC (V) curricula provide the necessary theoretical knowledge to be regarded as comparable to the NC: N2, and whether the practical component justifies a reduced apprenticeship period for NC (V) learners. This report is based on subject reports for the individual subjects that were evaluated. The individual reports will be available as a single report for detailed findings on the individual subjects compared. The report will not be printed but will be made available on the website of Umalusi.

1.1.2 Objectives of the project

The project has the following objectives:

- To conduct a comparative curriculum evaluation between subjects within the engineering programme of the NC (V) and subjects within the engineering programme of the Report 191 (2001/08) National Certificate: N2 and National Certificate: N3 courses, and to determine if the delivery model of the NC (V) curriculum provides hands-on practical training that is similar to that received in on-the-job training in the apprenticeship system.

- To determine whether there are sufficient curriculum overlaps between the NC (V) and the selected N-courses to allow a case to be made for learners with an NC (V) at a certain level to gain access to an apprenticeship programme, and to determine what the necessary content overlap would be to enable such access.

- If the NC (V) content is found to be sufficient, to establish how adequate the NC (V) curricula are in preparing the learner to acquire the necessary skills for an apprenticeship; if on the other hand, the NC (V) is found to be inadequate in developing such skills, to determine what would be needed to make it adequate.

- To establish whether an argument can be made for a reduced apprenticeship period for NC (V) learners given that the NC (V) has a practical component.
- To produce a report that will provide recommendations on how Umalusi needs to deal with the NC (V) with regard to:

  - Duration of the course and possible access to apprenticeships and/or trade test
  - Its comparability with the National Certificate: N2
  - The delivery model
  - The weighting of the practical and theoretical components of the NC (V) subjects
  - Its relationship to the N-courses

1.1.3 How this report links to existing Umalusi research

The 2010 research, commissioned by Umalusi, is an organic extension of work undertaken by Umalusi in the 2009 *Maintaining Standards* project regarding the mapping of the NC (V) as an NQF Level 4 qualification, and uses the evaluation instrument developed and refined in that project. In the research done in 2009, Umalusi evaluated and compared certain subjects in the *National Certificate (Vocational)*, the NC (V), with similar subjects in the NSC (Mathematics, Mathematical Literacy, English First Additional Language and Physical Science). The 2009 research was commissioned in order to ensure a more detailed and sophisticated understanding of both the Level 4 qualifications.

The research resulted in "The 'F' in the NC (V): Benchmarking common subjects in the NSC and the NC (V)" report. Although this research compared engineering subjects within the NC (V) with those within the N-courses, it is, in a manner of speaking, a continuation of "The 'F' in the NC (V)" project. One of the objectives of that research was to determine whether there was sufficient overlap in terms of the curricula and shared standards to allow for subject exemptions between the qualifications for certification purposes especially in respect of the fundamental subjects. This research has a similar objective with regard to the NC (V) and the N-courses in terms of the vocational part of the NC (V) Engineering Studies programme.

1.1.4 Limitations of this study

While Umalusi has chosen FET college lecturers that have experience and knowledge of both the N-courses and the NC (V), the report consists of a set of expert opinions which Umalusi solicited to be able to gain an initial understanding of the relationship between the NC (V) and the N-courses at curriculum level, where some form of informed understanding is required. Notable challenges have been the difficulty of locating expertise and the speed with which the project needed to be undertaken. The study is meant to be fed into the process of strengthening the NC (V) and is therefore not an end in itself.

Curriculum and assessment research is central to Umalusi's work. It has been so since before Umalusi had an official mandate to conduct research. It is through research that Umalusi is able to establish and determine curriculum and assessment standards. It was therefore important for Umalusi to undertake this comparison given the recent discourse regarding the N-courses. The report will assist Umalusi to take an informed position with regard to the N-courses and any future review of the particular evaluated subjects. It will also assist in determining the effectiveness of the NC (V) in preparing learners for potential access to apprenticeship programmes at the selective discretion of the employers, given the practical component of the qualification which was not part of the NC: N2.

1.1.5 The structure of this report

This overview report comprises five chapters. This chapter provides the background to the study. The background sets out the objectives of the study and provides an explanation of how this research links to Umalusi's other research. The limitations of the report are also indicated in this chapter. An overview of the qualifications under investigation together with the selected engineering subjects being evaluated is provided in this section. The section concludes with an outline of the methodology which provides details of the evaluation processes, the research questions and the research instrument.

Chapter 2 provides an outline of the curriculum findings for the various engineering subjects under investigation.

Chapter 3 presents a brief description of the examination findings for the various engineering subjects under investigation.

A case study, which is set out in Chapter 4, became a part of the investigation. The chapter imparts a description of the findings from the case study.

The last chapter draws on the findings to make some recommendations with regard to the curriculum changes with regard to the N-courses' curriculum and related implementation changes with regard to the NC (V), possible recognition of learning/exemption, level of access to an apprenticeship programme in respect of the NC (V) subjects, the role of the N-courses and the role of the NC (V). Several recommendations which are useful in terms of moving the system forward came out of the project which Umalusi hopes the DHET will act upon.

1.2 OVERVIEW OF THE ENGINEERING NC (V)s AND THE ENGINEERING STUDIES OF THE NATIONAL CERTIFICATE: N2 AND N3 PROGRAMMES

1.2.1 An overview of the National Certificate (NC) Instructional Offerings

The National Certificates: N1 – N3 are described in the policy, *Formal technical instructional programmes in the RSA, Report 191 (2001/08)*, which was implemented by FET colleges in 2001 and which replaced the previous NATED 02 - 190, NATED 02 -191 and 190 and 191 reports. The National Certificate instructional offerings, more commonly called the N-courses, are described in two policies known as Report 190 and 191. A careful look at the full range of programmes offered in terms of these policies gives an insight into their intended purposes in the education and training system: firstly, the engineering-specific programmes were intended to support the apprenticeship progammes, and secondly they were supposed to provide meaningful alternatives to the schooling pathway, especially for candidates who did not necessarily excel within the school environment but who did have other talents or interests to pursue.

Because of the target group that the programmes were intended to deal with - often adolescents who had left school as soon as their compulsory commitment was over - there is some overlap between providing additional education and preparing them for the workplace. It is this duality of purpose, especially in the first three of the N programmes (which are regarded as being parallel to Grades 10 – 12), which creates headaches for a neat demarcation of responsibility for them.

The NATED reports were developed in 2000 (Report 190) and 2001 (Report 191), and replaced earlier NATED reports. The one provides the "norms and standards for instructional programmes and the examination and certification thereof in technical college education" (Report 190), while the second report (in two parts) lists and outlines all the instructional offerings from NC: N1 to N6. The offerings are described only in terms of the names of the subjects in the programme, the admission requirements, duration, programme requirements and, in certain cases, promotion requirements.

Report 190 is particularly useful in providing information that illuminates the evolution of the present day situation with regard to the N programmes and provides additional insight into the evolution of the National Certificate (Vocational). It is clear that many of the N programmes were *vocational* in nature, and that these programmes focused on learning that took place primarily in the colleges themselves while yet others were intended as adjuncts to on-the-job, workplace training, and the structure of these N programmes was shorter.

Report 190 explains the admission requirements for the National Instructional programmes, and these requirements provide some indication of the "level of comprehension" (sic) associated with each:

Table 1: National Certificates, associated admission requirements and comprehension levels (Report 190)

Programme	Admission requirement	Duration	SANEP Level
National Certificate (NC): N1	"an appropriate Gr 9 certificate (sic) or an approved introductory programme"	Fulltime: ***One trimester*** (14 weeks) – for occupationally related programmes such as Engineering, Iron and Steel, Chemical Process Control, Coal Mining; ***one semester*** (half year) for Agriculture; ***1 year (orientation)*** for education and arts-related programmes	All instructional offerings at a level of comprehension usually associated with Grade 10 or NC: N1 or a lower level
NC: N2 and National Intermediate Certificate	"an appropriate NC:N1 or an appropriate Gr 10 Certificate (sic) or an equivalent qualification with appropriate instructional offerings"	Fulltime: ***One year*** for many programmes (e.g. classical and contemporary dance, popular music, art, business studies, food services); ***1 trimester*** for others (e.g. Engineering Studies, Poultry Meat Examiner, Iron and Steel, Metalliferous Mining; Water and Waste Water Treatment Practice, Horticulture), and ***a semester*** for yet others (Agriculture)	All instructional offerings at a level of comprehension usually associated with Grade 11 or NC: N2

Programme	Admission requirement	Duration	SANEP Level
NC: N3	"an appropriate NC:N2 or an appropriate Gr 11 Certificate (sic) or an equivalent qualification with appropriate instructional offerings"	Fulltime: ***One year*** for programmes such as Business Studies: Secretarial or Accounting/ administration, clothing production; and a ***trimester*** for Surface Mining, Fertilizer Manufacture, Engineering Studies	All instructional offerings at a level of comprehension usually associated with Grade 12 or NC: N3
NC: N4	"an appropriate NC:N3 or an appropriate Gr 12 Certificate (sic) or an equivalent qualification with appropriate instructional offerings"	Fulltime: ***Semester*** (half year) for most programmes (Tourism, Hair care, Educare, Hospitality and Catering), except for Engineering Studies, Textiles which are once again a ***trimester***.	All instructional offerings at a level of comprehensions usually associated with the first year after Grade 12 or NC: N4
NC: N5	"an appropriate NC:N4 or an equivalent qualification with appropriate instructional offerings"	Fulltime: ***Semester*** for most programmes (Financial Management, Public Management, Legal secretary, Popular Music: Composition); and a ***trimester*** for Engineering Studies, Textiles, and Fertilizer Manufacture	All instructional offerings at a level of comprehensions usually associated with the second year after Grade 12 or NC: N5
NC: N6	"an appropriate NC:N5 or an equivalent qualification with appropriate instructional offerings"	Fulltime: ***Semester*** for most programmes (Business Management, Human Resource Management, Medical Secretary, Hair care, Popular Music: Studio work); and a ***trimester*** for Engineering Studies, Textiles, and Fertilizer Manufacture	All instructional offerings at a level of comprehensions usually associated with the third year after Grade 12 or NC: N6

An analysis of selected programmes indicates the minimum amount of time required in **formal tuition** within the N programmes varied a great deal:

Table 2: Various N-course programmes and their duration (Report 190)

Programme	N1	N2	N3	N4	N5	N6	Total
Business Studies (Accounting/Admin)		1,00	1,00	0,5	0,5	0,5	3,5
Business Studies (Secretarial)			1,00	0,5	0,5	0,5	2,5
Agriculture (Farming Management)	0,5	0,5	0,5	0,5	0,5	0,5	3,0
Mining	0,33	0,33	0,33				1,0
Engineering Studies	0,33	0,33	0,33	0,33	0,33	0,33	2,0
Educare		1,00	1,00	0,5	0,5	0,5	3,5
Art (and Design)	1,00	1,00	1,00	0,5	0,5	0,5	4,5
Music	1,00	1,00	1,00	0,5	0,5	0,5	4,5

This table shows that the amount of formal learning varied considerably across the N programmes: Business Studies programmes allowed for up to 3.5 years of study while the performance-based subjects such as art, music and dance lasted as long as 4.5 years. Educare and Agriculture allowed for between 3 and 3,5 years of formal study.

Engineering Studies across all six certificates caters for a maximum of two years of formal study while the mining programme, which ends at N3, allows for just one year of formal study.

In much of the discussion about the N programmes, Engineering Studies has been somehow regarded as the iconic N programme, while it is clear that Engineering Studies and similar occupationally-related, artisan programmes are far from definitive for the N course programmes as a whole. Their structure as "sandwich" programmes within artisan training/ workplace learning is clear, and the learning in them can only really be presumed to be meaningful if it is located *within* an artisan training programme.

On the other hand, the longer N programmes provide insight into the origins of the NC (V) as a proper vocational qualification as an alternative to the N programmes.

1.2.2 The National Certificate N2 and N3: Engineering Studies

The Report 191 (2001/08) programmes had been implemented in colleges long before the introduction of the NC (V), but, by 2007, they were being phased out to make way for the NC (V). However, the final date for the phasing out of the National Certificates (NC): N1– N3 engineering programmes was deferred indefinitely by Government Notice No 33200 of 17 May 2010. Initially, the amendment allowed for the engineering programme to be extended only to candidates who are indentured by industry. However, the programme has been re-opened to all who wish to enrol (Government Gazette no 33793, Nov 2010). The engineering programmes will thus continue to be offered at FET Colleges according to the conditions set out in the gazettes.

Report 191 (2001/08) lists all the approved programme offerings and describes the programme requirements for technical college education. The subjects are based on a common curriculum which was developed by the National Department of Education. It should, however, be noted that none of the other programmes were brought back and yet they still continue at NC: N4 – N6 level. It must therefore be emphasised that only the Engineering Studies programme was revived; the other programmes at NC: N1 – N3 level have been phased out.

The policy document does not explicitly mention the curriculum underpinning the programme offerings. However, the document indicates that synopses, syllabi/programmes for each instructional offering could be obtained from the department on request. The Department of Education developed a core curriculum per subject to be implemented by all the colleges and these are available through the DHET's Directorate for Examination Administration, Support and Procurement.

With regard to the NC: N2 and N3, there is a single programme named *Engineering Studies*. It contains more than 60 instructional offerings classified into four categories. Category A consists of trade theory or technological instructional offerings. Category B is a mathematics category. Category C is a science category and Category D is a drawing category. The N-course programmes, specifically the trade theory components, were linked to specific trades as the knowledge component of learning in that specific trade offered by FET Colleges. However, there were certain trades which were not recognised by the Manpower Training Act but have come to the fore in recent years. The DHET, through the National Artisan Moderation Body, has embarked on a process of listing new trades which were not previously recognised as trades by the Manpower Training Act. The new trades were included in the process of listing as per Section 26 B of the Skills Development Act. The newly classified occupations have been listed as trades in Government Gazette No 35625 of August 2012. For apprentices, instructional offerings must be selected from each of the four categories, meaning that they must pass four subjects including a compulsory trade theory or technological instructional offering selected from Category A. The choice in Category A is determined by the trade for which the learner is apprenticed. However, non-apprenticed learners can pass any three instructional offerings selected from any of the *three* categories and still be awarded the relevant certificate.

The present comparison entailed Mathematics, from the Mathematics category; Engineering Science from the Science category, Electrical Trade Theory from the Trade Theory category and Engineering Drawing from the Drawing category. The selection criteria for choosing the subjects were based on a number of issues. There had to be a subject from each of the four categories that are required in order to be certified (for apprenticeship purposes); the subject had to be a high enrolment subject; and the subject had to have been quality assured by Umalusi in the past three years.

With regard to the NC: N2 and NC: N3, the subjects are based on a theoretical component only. The practical experience is assumed to be acquired in real workplace environments, at least for those indentured in apprenticeships. For those who are not in workplaces, they have the option of going to a training centre where they acquire the workplace experience in simulation workshops, which are supposed to provide a simulated learning context similar to that of the NC (V), but it is generally understood that the focus at the training centres is more on coaching for the trade test than providing practical experience. It is also worth noting that the duration of the engineering studies programme depended on the mode in which it was delivered. For those learners who were indentured in apprenticeships, it was delivered through a block release system whereby learners would engage in theoretical learning at an FET college for a trimester (about ten weeks of tuition time and two weeks of examination time) then would go back to the workplace for a trimester (the so-called "sandwich model"). If learners accessed the qualification at NC: N1, through the block release system, then it would take eighteen months to complete the NC: N1 to N3. However, the duration differed for those learners who were not indentured and in apprenticeships. They could do the three offerings (NC: N1 – N3) back-to-back in just nine months.

Workplace experience is required if one intends to take a trade test. In most instances, those aspiring to undertake a trade test after completing NC: N2–N3 would have been indentured as apprentices for a time for the purpose of acquiring workplace experience. After successfully passing the trade test, apprentices qualify to be artisans. It should be noted that there is also an alternative route to artisanship known as "effluxion of time", whereby a person, having spent five or so years practising a trade, is deemed to be a proficient artisan.

For the period 2010-2011, 23 517 candidates were registered for trade testing, while the National Growth Path (NGP) target is 30 000 registered artisans by 2015. However, it must be noted that the registration rate is not a guarantee of the number of artisans that the system will produce. Of the 23 517 registered, only 11 778 were certificated as artisans because they successfully completed the trade tests (DHET: 2011 June 07). All those who had registered for the trade tests had already acquired workplace experience, most probably through apprenticeship programmes.

Table 3: National targets for artisan training

Minister's PME Outcome 5 & NSDS III					New Growth Path Economic Development				
10 000 artisans annually by 2014, pass rate from 46% to 60% by 2014					Artisans: 50 000 additional by 2015				
Year	2007-2008	2008-2009	2009-2010	2010-2011	**Year**	2011-2012	2012-2013	2013-2014	2014-2015
Registered	16 193	24 229	26 301	23 517	**Registered**	26 470	27 000	28 000	30 000
Certified	6 030	8 935	8 238	11 778	**Certified**	11 759	14 559	16 200	20 300
Pass rate	N/A	55%	34%	45%	**Pass rate**	50%	55%	65%	70%

Actual NSDS III ***Planned NSDS III***

Table from NAMB Presentation 7 June 2011

The figures in Table 3 represent the number of candidates registered by various Sector Education and Training Authorities (SETAs) and Institute for the National Development of Learnerships, Employment Skills and Labour Assessments (Indlela). The National Artisan Moderation Body is responsible for collating the statistics for registration of candidates for trade testing.

The Department of Education traditionally examined, quality assured and certified the N-courses apart from the NC: N3, which was quality assured and certified by Umalusi. Umalusi became involved with the NC: N3 because of the agreement to allow combinations using the NC: N3 subjects to lead to the Senior Certificate and the National Senior Certificate (colleges), also described in Report 191. Both of these were regarded as Standard Grade matrics.

1.2.3 The National Certificate (Vocational)

The NC (V) is a set of three national vocational qualifications, each a year-long and covering NQF Levels 2 – 4. They are described in the *National Policy Regarding Further Education and Training Programmes: Policy for the National Certificate (Vocational): Qualifications at Levels 2 to 4 on the National Qualifications Framework*. The three single-year qualifications, though each intended to be independent, nevertheless have cumulative intent and the one provides entry into the next qualification.

These qualifications are being offered by public and some private Further Education and Training (FET) colleges. In 2006, the then Minister of Education promulgated the policy on the offering of the NC (V). This qualification was introduced at NC (V) Level 2 in 2007, NC (V) Level 3 in 2008 and at NC (V) Level 4 in 2009. The Level 4 certificate was in its fifth year of existence in 2013.

In the NC (V), learners must take a total of seven subjects, divided into two major components – the fundamentals and the vocational. Three compulsory subjects comprise the fundamental component: a Home Language or First Additional Language which is required to be the language of teaching and learning of the FET College; Mathematics or Mathematics Literacy, and Life Orientation.

The four remaining subjects are selected for the vocational component from one of the following nineteen sub-fields/programmes (as per the 2013 NC(V) matrix of subjects):

- Civil Engineering and Building Construction
- Drawing Office Practice
- Education and Development
- Electrical Infrastructure Construction
- Engineering and Related Design
- Finance, Economics and Accounting
- Management
- Marketing
- Mechatronics
- Office Administration
- Primary Agriculture
- Process Instrumentation
- Process Plant Operations
- Hospitality
- Information Technology and Computer Studies
- Primary Health
- Safety in Society
- Tourism
- Transport and Logistics

Three of the four vocational subjects must be selected from the same sub-field while the fourth subject can be selected from any of the related sub-fields.

The vocational component indicates the specialisation selected for study. For the engineering field, the subjects are selected from Engineering and Related Design; or Civil Engineering and Building Construction; or Electrical Infrastructure Construction; or Mechatronics programmes.

The NC (V) qualification is designed to have a 40% theoretical and a 60% practical component for most of the subjects within the engineering programmes, except for Electrical Practice and Principles, which breaks down into a 60% theoretical and 40% practical component, and Physical Science which has a 50% theoretical and 50% practical component. The theoretical component is offered in classroom environments. The practical component is learned in controlled workshops situated on the premises of the FET colleges. The successful completion of the qualification is based on internal and external assessments of both the theoretical and practical components.

The NC (V) subjects selected for the evaluation were chosen on the basis of their relation to the selected N2 and N3 subjects.

There are clear differences in the design of the N-courses and that of the NC (V). The subject combinations are different. The three NC (V) qualifications, taken together, provide a general education with a strong vocational bias, while the N-courses consist of four theory subjects which must be selected from each of the four categories. Certain trades require specific combinations of subjects for entry into the relevant trade tests, but students are not always properly advised of these requirements at registration, and thus end up with subject combinations which then do not allow them access. This particular shortcoming requires an intervention at both national and college level in order to better counsel would-be students.

Umalusi has quality assured the NC (V) from its inception but the focus falls most intensely on the NC (V) Level 4 because of the financial demands of quality assuring all three qualifications, especially in view of this mandate remaining unfunded. Both Umalusi and the Department of Higher Education and Training have committed themselves to the remediation of this situation.

With regard to certification, Umalusi has until 2012 certified NC (V) Level 4 only, but is committed to certifying all three levels in accordance with the requirements of the policy and in line with the directives governing NC (V) certification.

It is important to note that the present research has evaluated only selected subjects from the engineering programmes. Judging all the NC (V) qualifications based on the findings associated with the programmes based on the engineering studies could be misleading, and an unfair reflection of the other programmes.

The recommendations emanating from the Ministerial Task Team report that reviews the NC (V) qualifications will obviously inform Umalusi's position going forward.

1.3 OVERVIEW OF THE SUBJECTS

The selection of the subjects was based on the N-course subjects with high enrolments. The related NC (V) subjects were identified in relation to the N-course subjects chosen. This section provides a brief overview of the subjects.

1.3.1 National Certificate N2 – N3 subjects

Mathematics, science and drawing form the basis of all engineering trades. In this study, the relevance of these fundamental subjects was assessed. The concepts in mathematics, e.g. calculations for trade-specific topics (Ohm's law in electrical); in science, e.g. principles of trade-specific topics (resistor networks in electrical), and in drawing, e.g. generating layout of engineering systems prior to implementation (component layout and panel wiring in electrical) are common to trade theory in all engineering trades.

Mathematics is not directly a trade subject but the content knowledge and skills in it are applied in other subjects. Mathematics as a discipline serves as a supporting tool and a resource which learners draw on to strengthen conceptual understanding in their different trades. Mathematics in both the NC (V) and the N-courses fulfil the supporting role described above. The second purpose of teaching mathematics is that learners should be able to apply it in their day-to-day lives. The knowledge and skills that enable learners to apply mathematics beyond the classroom are not embedded in the curriculum content that was analysed in the study.

Engineering Science is also not a trade subject that pertains to a specific sub-field. It is rather a supporting subject to all the trades, but especially to mechanical and electrical engineering. In the subject the laws of physics provide the background principles required to understand engineering systems in chemical, mechanical, electrical and civil engineering. The acquisition of generic scientific theory informs the various engineering trades.

Engineering Drawing provides the knowledge and skills required to generate 2, 3 and 4-dimensional representation of physical engineering systems from various projections. The NC: N1/N2/N3 curricula lack certain critical drawing concepts, e.g. graphical drawings, as the primary means of communication in the technological world, various instrument and freehand drawing techniques and skills and the use of CAD (Computer Aided Drawings/ Design) as a method of producing drawings.

Electrical Trade Theory is the only subject in the analysis with direct links to trade testing. The subject focuses on wiring, domestic appliances, lighting, transformers and electromagnetism, among other topics. As a trade theory subject, Electrical Trade Theory is crucial in the preparation for trade testing in the electrical trade.

One of the major shortcomings of the N-courses syllabuses is that they do not provide any subject-specific aims/outcomes. The syllabus is just a list of content topics. Without explicit subject-specific aims/outcomes, it is almost impossible to establish whether the contents of the curriculum do support the subject outcomes.

Table 4: Some of the subjects within the NC: N3 courses arranged by category

Category A	Category B	Category C	Category D
Electrical Trade Theory	Mathematics	Engineering Science	Engineering Drawing
Road Construction Drawing	Motor Workshop Organisation and Administration	Motor Workshop Organisation and Administration	Motor Workshop Organisation and Administration
Radar Trade Theory	Industrial Organisation and Planning	Industrial Organisation and Planning	Industrial Organisation and Planning
Industrial Electronics			Industrial Electronics
Plastic Technology	Industrial Orientation	Industrial Orientation	Industrial Orientation
Refrigeration Technology	Supervision in Industry	Supervision in Industry	Supervision in Industry
Logic Systems	Waste Water Treatment Practice	Logic Systems	Building Drawing
Aluminium Technology		Building Science	Plating and Structural Steel Drawing
Mechano Technology		Industrial Science	Furniture Design
Ferro Alloy Technology			Water Treatment Practice
Tailor's Theory			
Upholstering and Trimming Theory			
Painting and Decorating Theory			
Building and Civil Technology			
Armature Winding Theory			

The list (above), is taken directly from Report 191, and is not arranged in such a way as to provide proper subject-combination guidance to would-be learners: certain conditions apply in the selection of instructional offerings/subjects. Furthermore, the original rationale behind the four categories has been disrupted with a subject such as Motor Workshop Organisation and Administration being placed in what were once the Mathematics, Science and Drawing categories.

According to Report 191 (2001/08), apprenticed learners are required to offer and pass an instructional offering from each of the four categories. Indeed, for certain trades, the choices in the various categories are pre-determined. For non-apprenticed learners, the candidates are also expected to offer one subject from each category, but will nevertheless be issued with a certificate if only three of the four subjects are passed.

Report 191 states that permission has to be obtained for combinations of specific instructional offerings that are outside of the usual combinations specified in the report.

1.3.2 NC (V) subjects

The NC (V) provides well-structured learning with an intensive theoretical component and practical tasks with some trade-specific focus, with some subjects being assessed over the three-year period. The theoretical component is assessed by means of assignments, theoretical tests, a three-hour trial exam and a three-hour final examination. The practical component is assessed by means of several practical tests on various sections and an intense Integrated Summative Assessment Task (ISAT) that could last between four and eight hours.

The purpose of teaching **mathematics** is to produce a person who can confidently apply mathematics in other disciplines and in real life situations. NC (V) Mathematics empowers learners with specific content knowledge and skills necessary for applying mathematical skills in real life situations, in other related subjects, and it lays a solid foundation for further studies in mathematics.

Engineering Systems Level 2, Materials Technology Level 3 and **Applied Engineering Technology Level 4** are science subjects within the NC (V). They are constructed to achieve a balance between theory and hands-on practical knowledge and skills. With regard to Engineering Systems Level 2, the focus is on various systems in machinery or vehicles, including identifying, selecting and preparing components in terms of their pre-operation, operation, control and maintenance. With regard to Material Technology Level 3, the focus is on materials commonly used for the manufacture of components in mechanical engineering which are capable of withstanding stresses, and which allow for innovative engineering design. It also involves properties of the processes used for working with them and their applications. Applied Engineering Technology focuses on evaluation and monitoring of components manufactured for modern technological equipment in the workplace and so allowing new methodologies to be developed.

Engineering Graphics and Design purports to teach internationally acknowledged principles that have both academic and technical applications. The emphasis therefore is on teaching specific, basic knowledge and various drawing techniques and skills so that the students will be able to produce drawings within the contexts of Mechanical Technology, Civil Technology and Electrical Technology.

Electrical Principles and Practice and **Electrical Systems and Construction** allow for the acquisition of trade-specific skills and knowledge so that learners are able to explain how electricity is dealt with in practice. **Workshop Practice level 2** and **Electrical Workmanship Levels 3 – 4** equip learners with the necessary hand-skills, safety awareness and first aid knowledge. Such subjects also assist in the learners' adapting to the technical environment.

Table 5: Subjects within two engineering programmes of the NC (V)

	NC (V) 2	NC (V) 3	NC (V) 4
Fundamental component	English/Afrikaans/ IsiXhosa (First Additional language)	English/Afrikaans/ IsiXhosa (First Additional language)	English/Afrikaans/ IsiXhosa (First Additional language)
	Mathematics **OR** Mathematical Literacy	Mathematics **OR** mathematical Literacy	Mathematics **OR** mathematical Literacy
	Life Orientation	Life Orientation	Life Orientation
Electrical Infrastructure Construction – Compulsory Subjects	Electrical Principles and Practice Electronic Control and Digital Electronics Workshop Practice	Electrical Principles and Practice Electronic Control and Digital Electronics Electrical Workmanship	Electrical Principles and Practice Electronic Control and Digital Electronics Electrical Workmanship
Optional Subjects	Electrical Systems and Construction **OR** Physical Science	Electrical Systems and Construction **OR** Physical Science	Electrical Systems and Construction **OR** Physical Science
Engineering and Related Design – Compulsory Subjects from	Engineering Fundamentals Engineering Systems Engineering Technology	Engineering Graphics and Design Engineering Practice and Maintenance Materials Technology	Applied Engineering Technology Engineering Processes Professional Engineering Practice
Optional Subjects from	Automotive Repair & Maintenance **OR** Engineering Fabrication **OR** Fitting and Turning **OR** Physical Science **OR** Refrigeration Principles **OR** Welding	Automotive Repair & Maintenance **OR** Engineering Fabrication- Boiler making **OR** Engineering Fabrication – Sheet Metal Worker **OR** Fitting and Turning **OR** Physical Science **OR** Refrigeration Practice **OR** Welding	Automotive Repair & Maintenance **OR** Engineering Fabrication – Boiler making **OR** Engineering Fabrication – Sheet Metal Worker **OR** Fitting and Turning **OR** Physical Science **OR** Refrigeration and Air-conditioning Processes **OR** Welding

The subjects in the engineering programmes of the NC (V) and the N-courses have been named differently except for Mathematics. Furthermore, the subjects in the two programmes have been packaged differently in terms of content. The contents of one NC: N2 – N3 subject is sometimes spread across more than one subject in the NC (V) e.g. the contents of NC: N2 – N3 Electrical Trade Theory are found in Electrical Principles and Practice, Electrical Workmanship and Electrical Systems and Construction in the NC (V).

1.4 METHODOLOGY AND APPLICATION OF INSTRUMENT

1.4.1 The evaluation team and processes

The evaluation was conducted by a team of education specialists in the field of engineering. The team consisted of:

- two FET college lecturers

- two university of technology lecturers, and
- one Deputy Chief Education Specialist at a provincial head office.

The evaluation had two parts: a curriculum analysis, which established the breadth and depth of the respective curricula, and then an analysis of a number of examination papers in order to determine the nature and the level of the cognitive demand assumed in the external assessment. The evaluation entailed a comparative analysis of the following related subjects:

Table 6: Selected engineering subjects within the N-courses and the NC (V) compared

NC1 N2 – N3: Engineering	NC (V)
Mathematics	Mathematics Levels 2, 3 and 4
Engineering Science	Engineering Systems Level 2; Material Technology L3; Applied Engineering Technology L4
Engineering Drawing (NC: N1 – N3)	Engineering Technology Levels 2; Engineering Graphics and Design L3
Electrical Trade Theory	Electrical Principles and Practice L2, L3 and L4 Electrical Systems and Construction L2, L3 and L4 Workshop Practice L2 Electrical Workmanship L3 and L4

The Umalusi evaluation teams met for a working session where they were introduced to the project and provided with the necessary documentation. During the first working session, the team dealt with the curriculum evaluation processes and the instrument. The evaluators then worked with the various curricula using the evaluation instrument. The teams met for an additional working session for the examination analysis.

Although the evaluators worked on different subjects, it was necessary to find consensus about the understanding of what is meant by particular concepts such as "content specification, focus and weighting".

1.4.2 Documentation used

Umalusi provided the evaluators with all the documentation needed for the analysis. The evaluators helped to make Umalusi aware in the event that a document had not been issued to them, but which would be necessary for the analysis (see Annexure B).

1.4.3 The research questions

The primary research questions to be answered through the comparative evaluation were:

1. How does the theoretical knowledge base of the NC (V) engineering studies compare with that of the comparable subjects in the National Certificate: N2 and N3? At which point in the NC (V) Levels 2 – 4 can a learner be regarded as having been prepared – in terms of theory – to the same point as a learner who has studied for the NC: N2? Similarly, at which point in the NC (V) Levels 2 – 4 can a learner be regarded as having been prepared – in theory – to the same point as a learner who has studied for the NC: N3?

2. From the analysis of the practical requirements of the NC (V) subjects, and assuming that learners have had good quality practical experience as described in the curriculum, at which point in the NC (V) Levels 2 – 4, would a learner be considered sufficiently prepared

– in terms of practical skills – to access an apprenticeship? In other words, at which point in NC (V) Levels 2 – 4, would the evaluators regard the NC (V) learner as having had sufficient practical experience in the learning environment to be considered to have reached the same level as a person who has had 18 months on-the-job experience, which is the second criterion for access to the trade test?

3. If, in the evaluator's opinion, NC (V) candidates cannot be equated to a person who has had eighteen months of on-the-job experience, what measures would be recommended which would allow institution-based learners to acquire comparable experience?

These research questions were considered under two separate parts of the research instrument, the first part being for the curriculum evaluation, and the second for the exam paper analysis.

1.4.4 The research instrument

The curriculum evaluation instrument required the evaluators to compare and report on a number of significant elements in the curriculum and examination. The elements were drawn from Umalusi's criteria for the development and evaluation of curriculum (Appendix 2, 2008 *Maintaining Standards* report). The instrument was adapted to suit this particular research. The elements, which are itemised below, became the headings for each Umalusi evaluator's report. The specific research questions for the present study (above) were considered under both parts of the research instrument, the first part being for the curriculum evaluation, and the second for the exam paper analysis (see Annexure A).

1.4.4.1 Curriculum analysis

The curriculum analysis focused specifically on content and skill specification and the weighting associated with each in order to establish the core focus in the curricula. The time allocation to deal with the curricula content and the methodology attached to the curricula also received attention.

a. Content specification, focus and weighting
The Umalusi evaluation teams were asked to consider the content and skills of the curricula, with specific reference to their specification, weighting, and focus.

b. Skills specification
The Umalusi evaluators used separate columns for each programme in the tables, indicating which particular skills are specified in the qualification and whether or not the skills are examinable. The teams also assessed the difficulty levels of these skills as being on a difficult, moderate or easy level.

The skills *focus* in the respective curricula was determined by categorising each individual *skill* as *discipline-specific* or as *generic application* or as *every day*. As for the content topics, skills are considered *discipline-specific* when they are specifically applicable to the further study of the particular subject. Skills are described as *generic* when they are relevant to subjects other than the immediate subject being evaluated. They are considered *every day* when they are directly relevant for life outside of the classroom.

c. Duration, knowledge and skills

Keeping in mind the differences in course duration for both the N-courses and the NC (V), the evaluators were required to indicate how well the NC (V) prepares the candidates to be able to access an apprenticeship programme. Given what learners are expected to learn, both in terms of theory and practical application, the evaluators were required to indicate whether the duration of the NC (V) was appropriate, too long or too short and what they would recommend with regard to duration for the whole of the NC (V). The teams also had to give their opinion on whether the NC (V) prepares learners considerably better (or worse) than the trade theory and on-the-job training might have done.

Furthermore, based on the findings and their experience in both the N-courses and the NC (V), the evaluators were required to indicate whether they were of the opinion that the N-courses and the NC (V) are fulfilling similar or distinct roles in the education and training system. They were required to consider whether the two engineering programmes can be seen as having complementary niches, which means that both are necessary to the functioning of further education and training.

With reference to all the responses above, the evaluators were required to make recommendations (in respect of the subject analysed) with regard to NC (V) learners accessing the trade test.

d. Articulation and related matters
The evaluators were required to provide their opinion with regard to the recognition of any of the N-certificates for the purpose of enabling access to NC (V) Levels 2, 3 or 4 and to indicate which N-certificate should articulate with a particular level of the NC (V), should such access be possible.

The evaluators also commented on the retention of the N-certificates programmes rather than their being phased out, as had originally been planned.

e. Concluding ideas, recommendations and opportunities
In the concluding ideas, the evaluation team could add any findings from the investigations in addition to those covered by the research questions.

1.4.4.2 Examination analysis

For the analysis of the examination, the questions were specifically directed to compliance with the requirements as set out in the Assessment Guidelines, the cognitive demands in the papers, the levels of difficulty found in the questions, the format of papers and the use of language in the papers. The evaluators could add any additional points of comparison not covered in the tables to ensure a detailed analysis.
The specific questions for the analysis of the exam papers were:

1. In your opinion, do the NC (V) Level 4 examination papers comply with Subject/ Assessment Guidelines, and do the NC: N3 examination papers comply with the examination requirements as set out in the syllabus? Use the data collected in Columns 3, 4 and 7 in Table 4 of the Excel mapping sheet as reference in your answer.

2. With reference to Table 4 (Columns 3 and 4), calculate the percentage referring to the level of difficulty and the cognitive demand. According to the calculation and your opinion, which cognitive demand is most heavily weighted in the papers, and can the papers therefore be considered as emphasising a particular kind of cognitive demand, or level of difficulty?
3. From the analysis of the November 2009 exams, would you consider the NC (V) Level

4 examination papers to be comparable to the NC: N3 examination papers? If not, what in your opinion distinguishes most significantly between the NC (V) and NC: N3 examination papers? Please answer fully, and base your answer on the facts in the analytical table.

4. In your opinion, could the 2009 NC (V) and NC: N3 examinations be regarded as good models for future examinations, or should their format be critically re-examined immediately? Please make specific suggestions.

5. Please comment on the standard and quality of the NC (V) November 2009 and NC: N3 April and August 2010 final exam papers especially with regard to language level and format of questions.

1.4.5 Case study

The project also entailed a case study which came in response to questions arising in the course of the research. The visit to Highveld was motivated by the knowledge that the company had made a call for learners who have successfully completed or attempted the NC (V) Level 4, amongst other NQF Level 4 qualifications to apply to the company for placement in an apprenticeship programme. This visit created an opportunity for using the company as a case study in terms of determining the comparability of the practical component within the NC (V) in relation to the work experience component of the apprenticeship.

1.5 CONCLUSION

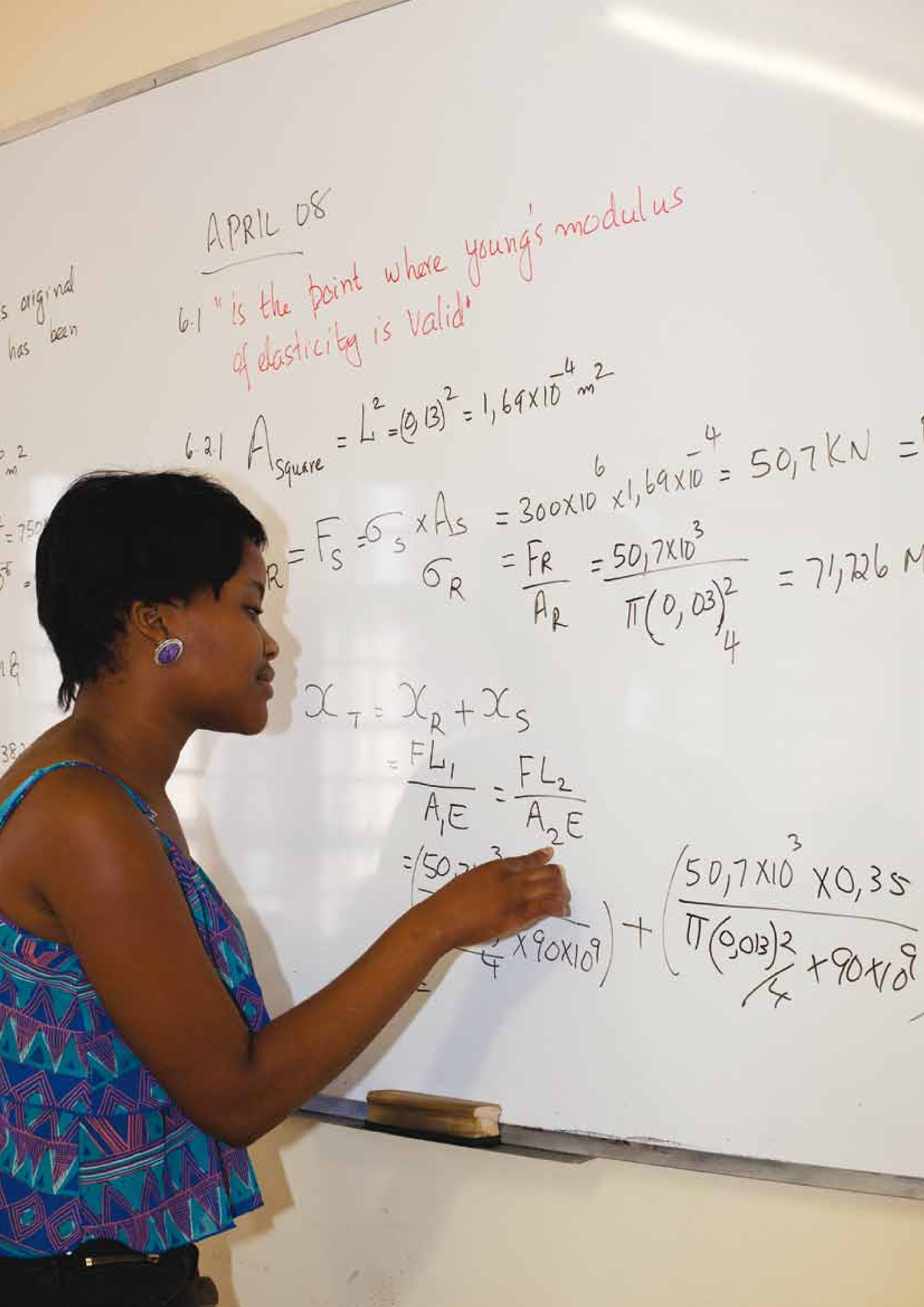
The comparison of the N-course curricula and examinations with those of the NC (V) was undertaken for a number of reasons – the first being to provide information about the similarities and differences between the N-courses and the NC (V), especially in respect of the degree of preparation offered for access to the trade test. But the comparison has been about more than making a case for relaxing the Manpower Training Act requirements, which state that only the NC: N2 provides the knowledge necessary to access the trade test. It has been to foster a better general understanding of the newer qualification in relation to the more commonly understood older part-qualification.

In conducting the evaluation, Umalusi sought the services of subject experts in the specific subjects under investigation and their analysis of the documents and experience in these programmes were used to answer the research questions.

During the investigation, it was understood that the two programmes under investigation are designed differently and are aimed at demographically different groups: the N-courses were designed as post-school programmes for older learners while the NC (V) was designed primarily for adolescent learners, and ought to function as a sister qualification to the National Senior Certificate, that is, as an exit qualification at the end of Basic Education, even if the NC (V) is offered in colleges. The research indicates that the NC (V) also has the potential to prepare learners substantially for study in higher education as well as for an artisan qualification due to its design features. The N-courses for Engineering Studies, on the other hand, have the potential to lead to an artisan qualification.

The return of the N-courses to the FET system, instead of their being phased out as planned, has happened at a point where the NC (V) was just beginning to be understood by the colleges. As a result, the re-introduction is causing difficulties for the newer qualification, because the colleges can turn over many more N-course learners more quickly, and so increase their revenue without the same degree of effort and input that the NC (V) requires, and consequently the colleges are encouraging enrolment in the shorter courses rather than in the larger programmes. The return of the N-courses has been driven by a political imperative and as a part of a strategy to revive artisan training in the face of skills shortages and the need to provide employment opportunities. It has not been a decision based on educational merits particularly as the urgent calls to re-curriculate the N-courses testify.

The decisions which the FET colleges must make are multiple – do they wish to retain the potential to draw in a younger cohort of learners, the 16 –19 year-olds, who wish to finish the last three years of Basic Education in a more vocationally-oriented way? This the colleges could do if they made the necessary adaptations to the way they teach this cohort. Do they wish to offer both the more substantial longer-term and the quick block-release programmes, and if so, how do they adjust their teaching complement to cater for both? Or is the longer-term education of the NC (V) more appropriate to technical schools and would the colleges refer its relocation to properly equipped vocational schools under the Department of Basic Education?


APRIL 08
6.1 "is the point where young's modulus of elasticity is valid"

2.1 INTRODUCTION: CURRICULUM FINDINGS

This section presents a summary of the findings from the curriculum analysis of the various subjects involved in the analysis. The purpose of the findings is to record the differences/ similarities noted between the levels of the N-courses and the NC (V) subjects. The section provides a closer look at the subjects being compared across the two qualifications and at the different levels. The section will discuss the curriculum findings under the headings of:

- Content/skills specification and focus
- Access to trade test after completing NC (V)
- Duration, knowledge and skills
- Weaknesses and strengths of the NC (V) and NC: N2 and N3
- Articulation and related matters

Before proceeding to the comparative analyses, it is necessary to understand how the percentages used in the comparisons have been calculated. For the calculation of the contents/skills mapping used below, the contents/skills of the NC: N2 subject were combined with those of the same subject in NC (V) L2, L3 and L4 to create 100% of the content or skills to be acquired. Similarly, the contents/skills of the NC: N3 subject were combined with those of NC (V) L2 –L4 to make up 100%. In other words, a list of the combined content/skills was drawn up using the content/skills from *both* subjects. Then the contents/skills that only appear in NC: N2 – N3 were identified and calculated as a percentage of the total. Likewise, the contents/skills that only appear in the NC (V) L2/L3/L4 subject were identified and calculated as a percentage of the total. Then the contents/skills that are common to NC: N2–N3 and NC (V) L2 – L4 subjects were identified and calculated as a percentage of the total.

2.2 MATHEMATICS

The analysis of mathematics compared the curriculum documents of NC: N2 and N3 Mathematics with those of NC (V) as detailed in the table below:

Table 7: NC: N2–N3 Mathematics and related NC (V) Mathematics

NC: N2: Engineering	NC (V)
Mathematics	Mathematics Levels 2, 3 and 4
NC: N3: Engineering	**NC (V)**
Mathematics	Mathematics Levels 2, 3 and 4

Mathematics is one of the three compulsory fundamental subjects in the NC (V). However, it should be noted that learners can take either Mathematics or Mathematical Literacy as one of the mathematics fundamentals.

With regard to the National Certificate, for apprentices, a mathematics category subject is also compulsory. For non-apprenticed learners, the mathematics category becomes one of four categories they have to select from. That is, Mathematics then becomes an elective subject.
While this was not the case in all the subjects, for the analysis of Mathematics, a one-on-one comparison was possible because the one subject in the NC: N2–N3 could be compared with

a comparable subject in the NC (V). For the analysis of Mathematics, the Mathematics for NC: N2 was compared with the Mathematics for NC (V) L2, L3 and L4. Then, the Mathematics for NC: N3 was also compared with that of NC (V) L2, L3 and L4.

2.2.1 Content/skills specification and focus

(a) Content/skills mapping between Mathematics NC: N2 and Mathematics NC (V) L2 – L4

The tables below represent the mapping between Mathematics NC: N2 and Mathematics NC (V) L2 – L4.

Table 8: Content/skills mapping between Mathematics NC: N2 and Mathematics NC (V) L2

NC: N2: 10%	Overlap: 31%	NC (V) 2: 59%

NC: N2: 41% of the total	

	NC (V): 90% of the total

Table 9: Content/skills mapping between Mathematics NC: N2 and Mathematics NC (V) L3

NC: N2: 20 %	Overlap: 12%	NC (V) 2: 68%

NC: N2: 32% of total	

	NC (V): 80% of total

Table 10: Content/skills mapping between Mathematics NC: N2 and Mathematics NC (V) L4

NC: N2: 18%	Overlap: 11%	NC (V) 4: 71%

NC: N2: 29% of total	

	NC (V): 82% of total

The tables above reveal that most of the content and skills covered in the NC (V) Levels 2, 3 and 4 curricula are omitted in Mathematics NC: N2 curricula. This indicates that, in terms of content coverage, the NC (V) covers more content than NC: N2. So, for example, while the N2 covers 40% of the entire content covered by NC (V) L2 *and* the NC: N2, NC (V) L2 Mathematics covers 90% of the combined mathematics total. The topics in both N2 and NC (V) curricula play an important supporting role to other trade subjects in terms of conceptual understanding.

(b) Contents/skills mapping between Mathematics NC: N3 and Mathematics NC (V) L2 – L4

The tables below represent the mapping between Mathematics NC: N3 and Mathematics NC (V) L2 – L4.

Table 11: Content/skills mapping between Mathematics NC: N3 and Mathematics NC (V) L2

NC: N3: 38%	Overlap: 27%	NC (V) 35 %
NC: N3: 65% of total		
	NC (V): 62% of total	

Table 12: Content/skills mapping between Mathematics NC: N3 and Mathematics NC (V) L3

NC: N3: 34%	Overlap: 24%	NC (V): 42%
NC: N3: 58% of total		
	NC (V): 66% of total	

Table 13: Content/skills mapping between Mathematics NC: N3 and Mathematics NC (V) L4

NC: N3: 31%	Overlap: 25%	NC (V): 44%
NC: N3: 56% of total		
	NC (V): 69% of total	

Most of the topics above play an important supporting role in enhancing conceptual understanding in different trade subjects.

2.2.2 Access to an apprenticeship programme after completing NC (V)

Although mathematics is not directly assessed in a trade test, it plays an important supporting role regarding other trade test subjects.

2.2.3 Duration, knowledge and skills

The duration of both the NC: N2 and N3 is ten (10) weeks each of theory classes only, whereas the NC (V) programme is effectively a three-year programme containing both theory and practical work. The tables above reveal that the curriculum breadth with regard to content knowledge and skills covered in NC: N2 and N3 curricula are relatively modest in comparison to those in the NC (V). The number of contents and skills covered by each NC (V) subject correspond with the duration of the programme. It is assumed that the duration of the NC (V) programme also provides reasonable time for practical work for the trade subjects, which would help to prepare learners for their trade subjects.

Because of the nature of the subject and its indirect role in preparing learners for access to the trade test, the Mathematics evaluator did not adjudicate on whether the duration, knowledge and skills in NC (V) Mathematics curriculum prepares learners better for the trade test than the trade theory and on-the-job training.

2.2.4 Weaknesses and Strengths of the NC (V) and NC: N2 and N3

Mathematics curricula

In terms of content difficulty level, there is a topic on integration which may be too demanding for NC (V) Level 4, and which should rather be reserved for a higher level. The inclusion of such content also leads to curriculum overload which may also result in a curriculum that is too demanding. Euclidean Geometry appears for the first time at Level 4 and is pitched at the level of Grade 12. In the National Senior certificate, the topic is introduced from Grade 8 and progresses over four years to Grade 12. Learners entering the NC (V) from schooling will have encountered the topic at Grade 8 and 9. If they enter the NC (V) at Level 2, they will only encounter the topic at Level 4 again, which then creates a content gap because the topic at Level 4 is pitched at that level. Nowhere in Levels 2 and 3 is there a continuation of what was taught in Grades 8 and 9 in this topic. The recommendation is that the topic should be introduced at Levels 2 and 3 so that there is a meaningful progression from Grade 9 to NC (V) Level 4.

As for the topic of integration mentioned previously, the recommendation is to revise the curriculum and introduce the basic concepts of integration at Level 3 and bring in more practical application at Level 4. The concepts on integration are perceived as difficult, but essential because they are applicable in other trade subjects. For example, Integration is applicable in Electronic Control and Digital Electronics (ECD) on operational amplifiers when integrating and differentiating amplifiers.

Upon completion of the NC (V) programme, and assuming that the learner has been well taught, he/she is likely to be empowered with the necessary confidence and competence to deal with a variety of mathematical situations requiring mathematical knowledge and skills without being fearful of Mathematics itself. The analysis of the NC (V) curriculum reveals that the curriculum has the potential to empower learners with the specific content knowledge and skills necessary for applying mathematics in real life situations and in other related subjects. It also lays a sound foundation for further studies in Mathematics. In contrast, the NC: N3 Mathematics is limited to empowering learners to use mathematical skills in other N-course-related subjects and lacks the content for applying mathematics in real life situations. The NC (V) Mathematics curriculum contains more content than the NC: N2 and N3 courses, and also has the extended duration required for offering such content.

The NC: N2 and N3 curricula show progression in content and skills between the two levels. The content knowledge and skills in NC: N2 and N3 are highly integrated with other engineering trade subjects. The curricula provide relevant support to these trade subjects for learners to work towards the trade test. However, there is a significant omission from the NC: N2 and N3 with regard to Financial Mathematics. The analysis of the NC: N2 and N3 curricula reveals that they do not make enough provision for the acquisition of such content knowledge and skills. Upon completion, technicians and artisans could become entrepreneurs who may need to plan their personal and business finances. Therefore this omission puts them at a disadvantage as they will not have acquired the necessary skills should they decide to take that path.

2.2.5 Articulation and related matters

NC (V) articulation with NC: N2 and N3

An NC (V) Level 2 learner's mathematical achievement should be transferable to an N3 certificate if required, as very little content that appears in the NC: N2 and N3 has been omitted in the NC (V).
For the same reason, a learner's NC (V) L3 mathematical achievement should be

transferable to an NC: N3 Certificate.

A person who has completed the NC (V) L4 Mathematics is considerably advanced of the Mathematics required in NC: N3. A comparison to the higher N programmes would need to be made to identify the level at which credit transfer could happen.

NC: N2 and NC: N3 Mathematics articulation with the NC (V) curricula

Because of the high percentage of omissions in the two N-course curricula by comparison, no candidate with an NC: N1–N3 can articulate with *any* NC (V) level. It is thus not advisable for a NC: N2 learner to be granted credit for NC (V) Level 3 Mathematics, or for a NC: N3 learner to gain credit for NC (V) Level 4 Mathematics because the omissions in the NC: N2 and N3 curricula would greatly disadvantage them.

The topics, complex number and inverse of functions are covered in NC: N4 and integration starts from NC: N4 to N6. These topics are not included in the NC: N2 and N3 curricula but are covered in the curricula of NC (V) L2 – L4.

Topics such as Financial Mathematics, Linear Programming, Sequence and Series, Euclidean Geometry and Data Handling are not covered in any of the N levels, from N1 to N6, and yet they are very relevant, hence their inclusion in the NC (V) is appropriate.

The inclusion of the above topics that are omitted in the NC: N2 and N3 curricula makes the NC (V) more content rich than the NC: N2 and N3, and perhaps also more demanding than NC: N2 and N3.

2.3 ELECTRICAL TRADE THEORY

The analysis for Electrical Trade Theory compared the curriculum documents of NC: N2 and N3 Electrical Trade Theory with those of NC (V) as detailed in the table below:

Once again, the sum of all the content identified in the curriculum documents formed the total against which the individual subjects were analysed.

Table 14: NC: N2–N3 Electrical Trade Theory and related NC (V) subjects

NC: N2: Engineering Studies	NC (V)
Electrical Trade Theory	Electrical Principles and Practice L2, L3 and L4 Workshop Practice L2 Electrical Workmanship L3 and L4 Electrical Systems and Construction L2, L3 and L4
N3: Engineering Studies	**NC (V)**
Electrical Trade Theory	Electrical Principles and Practice L2, L3 and L4 Workshop Practice L2 Electrical Workmanship L3 and L4 Electrical Systems and Construction L2, L3 and L4

With regard to the Electrical Trade Theory of the NC, learners who are in an apprentice programme must select the relevant compulsory Trade Theory or Technological subject from category A. Electrical Trade theory is a trade subject within category A.

Electrical Principles and Practice L2, L3 and L4, Workshop Practice L2 and Electrical

Workmanship L3 and L4 are *compulsory* NC (V) subjects in the Electrical Infrastructure Construction programme. The compulsory subjects are meant to be taken together and form a constructive progression on essential embedded knowledge, acquired from Level 2 to Level 4. Electrical Systems and Construction (L2, L3 and L4) is an optional subject in the same programme.

2.3.1 Content specification and focus

(a) Content mapping between Electrical Trade Theory NC: N2 and related NC (V) L2 – L4 subjects

The content for Electrical Trade Theory NC: N2 was mapped against Electrical Principles and Practice L2, Electrical Systems and Construction L2 and Workshop Practice of the NC (V). It was then mapped against Electrical Principles and Practice L3, Electrical Systems and Construction L3 and Electrical Workmanship L3 of the NC (V). Finally, Electrical Trade Theory NC: N2 was mapped against Electrical Principles and Practice L4, Electrical Systems and Construction L4 and Electrical Workmanship L4 NC (V), thus enabling comparison across all three levels of the NC (V).

The sum of all the content in the curriculum documents identified in this activity formed the total against which the subjects were analysed: in other words, all this content was taken to be 100% against which the respective subjects were compared.

(b) Content mapping between Electrical Trade Theory NC: N2 and related NC (V) L2 subjects.

In order to calculate the percentage of coverage, the content that only appears for instance in the N2 Electrical Trade Theory was identified and calculated as a percentage of the total. The process was then repeated in order to calculate the amount of content that only appears in the NC (V) L2. Then for the shared content, the content that is common to Electrical Trade Theory NC: N2 and NC (V) L2 subjects, was identified and calculated as a percentage of the total. The list enabled the calculation of content/skills that overlap and content/skills that have been omitted from each curriculum.
The same process was then repeated using the NC (V) Level 3 subjects in order to facilitate the NC: N2 – NC (V) 3 comparison, and then the process was repeated using the NC (V) Level 4 subjects to allow for the NC: N2 – NC (V) 4 comparison.

The tables below represent the mapping between Electrical Trade Theory NC: N2 and the corresponding NC (V) L2 – L4 subjects.

Table 15: Content mapping between Electrical Trade Theory NC: N2 and related NC (V) L2

subjects

NC: N2: 8%	Overlap: 75%	NC (V): 17%
NC: N2: 83% of total		
	NC (V): 92% of total	

Table 16: Content mapping between Electrical Trade Theory NC: N2 and related NC (V) L3 subjects

NC: N2: 5%	Overlap: 75%	NC(V: 20%
NC: N2: 80% of total		
	NC (V): 95% of total	

Table 17: Content mapping between Electrical Trade Theory NC: N2 and related NC (V) L4 subjects

N3: 4%	Overlap: 85%	NC (V): 11%
NC: N2: 89% of total		
	NC (V): 96% of total	

What emerges from the tables above is that the overlap between Electrical Trade Theory NC: N2 and the related NC (V) L2 – L4 subjects is substantial. The content that is covered by the NC: N2 but not covered by the NC (V) is insignificantly small. However, the NC (V) has some new content that is not covered in the NC: N2.

(c) Content mapping between NC: N3 Electrical Trade Theory and related NC (V) L2 – L4 subjects

The mapping process for the content of the Electrical Trade Theory NC: N3 was the same as that used for mapping the NC: N2 Trade Theory against the relevant NC (V) subjects for Levels 2 – 4.

Once again, the sum of all the content in the curriculum documents identified in this activity formed the total against which the subjects were analysed: in other words, all this content was taken to be 100% against which the respective subjects were compared.

(d) Content mapping between Electrical Trade Theory NC: N3 and related NC (V) L2 subjects

The tables below represent the mapping between Electrical Trade Theory NC: N3 and the corresponding NC (V) L2 – L4 subjects.

Table 18: Content mapping between Electrical Trade Theory NC: N3 and related NC (V) L2 subjects

NC: N3: 26%	Overlap: 17%	NC (V): 57%

NC: N3: 43% of total	

	NC (V): 74% of total

Table 19: Content mapping between Electrical Trade Theory NC: N3 and related NC (V) L3 subjects

NC: N3: 30%	Over-lap: 4%	NC (V): 66%

NC: N3: 34% of total	

	NC (V): 70% of total

Table 20: Content mapping between NC: N3 Electrical Trade Theory and related NC (V) L4 subjects

NC: N3: 9%	Overlap: 43%	NC (V): 48%

NC: N3: % 52 of total	

	NC (V): 91% of total

The tables above reveal that, unlike NC: N2 Electrical Trade Theory, the content overlap between NC: N3 Electrical Trade Theory and the related NC (V) subjects is *very small*. The content that appears only in the N3 and has been left out from the NC (V) is also very small. However, the NC (V) has a large amount of new content. The new content has probably been introduced to keep up with global technological advancements. The NC (V) introduces new conceptual content through the introduction of subjects like Workshop Practice, Electrical Systems and Construction and Electrical Workmanship that contain some content that has never been included in the NC: N2 and N3 Electrical Trade Theory. There is an overlap of application skills of certain theoretical content between the two curricula, e.g. the different electrical tests done on electrical AC and DC motors. In the NC: N3 course, these tests are explained theoretically but in the NC (V) course, the tests are explained both theoretically and completed practically.

As Engineering is an applications field, subject contents like Protection and Measuring Testing Instruments; Circuit Diagrams, Drawings and Cabling; Materials and Components; Fault-finding and Testing; and skills such as Wiring and Commissioning a Single-Phase Domestic Installation; Testing and Inspecting 3-phase Domestic Instruments; Designing and Constructing a 3-phase circuit; as well as Soldering and Gas Welding are adequately covered through clear subject and assessment guidelines. This method allows learners to apply their knowledge in the college workshop environment without additional exposure to a training provider or industry, e.g. design, wire, commission and fault-find on single or 3-phase installation under various load conditions.

The curricula of the NC (V) Levels 2 – 4 clearly specify the topics, subject and learning outcomes for each subject, together with prescribed material. So, for example, Electrical Systems and Construction NC (V) L4, one of four vocational subjects at Level 4, has five topics, one of which is "designing and constructing a three-phase circuit". For the subject outcome, "Design and construct a three-phase circuit", there are eight clearly defined learning outcomes:

- Identify symbols (ISO and IEC standard) and components.
- Interpret the task and format a logical plan of action.
- Design a three-phase circuit diagram that will satisfy the requirements.
- Compose a list of components, tools and equipment needed for the construction of the circuit.
- Construct the three-phase circuit using acceptable working procedures and construction methods.
- Evaluate the operational function of the constructed circuit and address any shortcomings.
- Rigorously test the design by applying load tests (if applicable).
- Complete the task by compiling drawings, operating procedures and specifications of the design.

The range which helps to delineate the extent of the outcomes is said to include, but is not limited to identifying electrical symbols (ISO and IEC standard) and components, gathering relevant components and describing the functioning of circuits and components (includes the following components; contactors, protection [fuses, circuit breakers, earth leakage and overload relays], controls [temperature, limits, pressure, level, proximity and time switches], loads [resistive and inductive] and power supplies (maximum 550 volt). Circuits are to be constructed in a simulated environment and tested under supervision.

It must be emphasised that the only "skills" acquired in NC: N3 are "explain", "discuss", "identify", "understand". No practical skills are acquired through the coursework, and their acquisition is entirely dependent on the on-the-job training, which comes after the theoretical training has occurred, and is required by employers. The following are two examples of skills that reinforce knowledge:

- The multimeter – theoretical studies must be supported by practical implementation to allow the learner to take basic current, voltage and resistance readings and derive answers to calculations.

- The electrical motor – theoretical studies must be supported by practical implementation to allow the learner to understand concepts like single and three-phase windings, armature, and to be able to take basic readings and fault-find.

2.3.2 Access to an apprenticeship after completing NC (V)

In the opinion of the evaluators, any learner who has successfully completed the three (compulsory) NC (V) L2 and L3 electrical engineering subjects is more than adequately prepared theoretically to access an apprenticeship which leads into a trade test at the discretion of the employer, because the NC (V) curriculum covers more topics than the NC:

N2 and N3. The amount of content appearing in the NC: N2 and N3 Trade Theory which does not occur in the NC (V) is negligible. It is also probable that the content from the N2 and N3 programmes omitted during the curriculum development for the NC (V) was outdated and irrelevant. The evaluators indicate that the NC (V) Trade Theory topics are also covered in greater depth. The NC (V) learners accessing an apprenticeship after NC (V) L2, or NC (V) L3 or NC (V) L4 would be advantaged because they would already have completed practical training in a simulated workshop environment, which is assessed by an Integrated Summative Assessment Task (ISAT) that serves as an external examination for the practical component.

Furthermore, NC (V) L2, L3 and L4 learners have adequate time to engage with both the theoretical content associated with electrical engineering subjects *and* the practical content due to the duration of the qualification at each level: according to the Subject Guideline, a total of 200 notional hours per year is dedicated to teaching and learning each of the vocational subjects. Ideally, a learner with two years training in the workplace, which equates to the end of NC (V) L3, would have spent 53% of the time doing practical work, which amounts to 212 hours or approximately 42 weeks practical, and 188 hours or 37 weeks theoretical teaching. Since the NC (V) L3 learner covers more theory over a longer period, i.e. three (almost four) times longer than the N courses, a NC (V) L3 learner has more theoretical knowledge and is therefore ready – in terms of the necessary electrical theory – for access to the trade test.

The current minimum of the NC: N2 covers classroom work over three months with no official practical work included. During the year of training in a workplace, three months is spent on formal training at a training provider and the remaining months are spent with on-the-job training. This schedule is followed over the three- to four-year period until the candidate undergoes the trade test.

For the electrical engineering subjects, the analysis also included a comparison of the electrical engineering trade test and the ISAT for Electrical Infrastructure Construction programme. The following three topics at the various NC (V) levels are some of the topics that compare directly with the NC: N3 Electrical Trade Theory curriculum and Electrical Trade Test tasks:

- NC (V) L2: Distinguish between DC, AC, single-phase and three-phase AC supply systems
- NC (V) L3: Fault find on AC and DC systems
- NC (V) L4: Perform a 3-phase motor test.

Since the NC (V) L3 learner spends more time on electrical trade theory and on practical tasks over a longer period, i.e. three times longer than an N-course learner, an NC (V) Level 3 learner will have adequate theoretical and practical exposure, experience and knowledge to be prepared for access to an apprenticeship programme, and, with a trade test preparation course offered by an employer or provider, could acquire an artisan qualification.

2.3.3 Duration, knowledge and skills

The benefit of the duration of the NC (V) at each level is that learners are exposed to more theory and practical work (provided implementation is offered at the required standard). After NC (V) L3, the learners should be more than ready to go to on-the-job practical training which will, at the discretion of the employer, lead to access to trade testing. Indentured for an eighteen-month apprenticeship period, learners could nonetheless be accelerated through

the work programme, based on individual excellent performance.
NC (V) learners should not in any way be seen to be disadvantaged because they have been trained in college workshops. In most instances, apprentices in the workplace are *also* trained in simulated environments in workshops, and so, an environment which is similar to the FET college one. The only difference may be the relative competencies of the trainers and the lecturers offering the subject.

The prescribed duration of the NC: N2 curriculum of one trimester is insufficient to complete the course contents constructively. The NC: N2 is based on teaching technical concepts theoretically in a classroom situation without related practical tasks, but this is so because the programme is meant to serve a specific category of employed learners. The advantage for industry of the NC (V) with its extended duration is that employers are able to offer on-the-job training to the NC (V) learner for a shorter period than the time required by the normal apprentice, who must spend a much longer time with the employer (three to four years) before becoming an artisan. Industry is also relieved of the responsibility of sending the learner to a FET College, as is the case with apprentices. Industry has the advantage of having an adequately skilled learner emerging from the NC (V) electrical engineering programme.

2.3.4 Weaknesses and strengths of the NC (V) and the N-course trade theory subjects

The trade courses offered in an apprenticeship or learnership are well structured with a logbook indicating all the practical training required in a three-year period, with a minimum NC: N2 certificate as a requirement for access to trade testing. In some instances, the learners in apprenticeships are exposed to the practical component of the trade *before* being exposed to the theory.

The NC (V), on the other hand, prepares the learner over a period of three years in classrooms (theory) and simulation workshops (practical). The three core vocational subjects cover most of the field-specific topics as practiced in industry in greater depth than the NC: N3 curriculum, which covers the topics superficially over a very short duration. The duration of the NC (V) in terms of curriculum coverage and mastery of content and skills may be viewed by some as an advantage, and by others as a disadvantage: industry finds it impossible to release apprentices for such a long period.

The NC (V) trade theory curricula are much better structured - and much better assessed – with clear Subject Guidelines and Assessment Guidelines. The Subject Guidelines clearly specify the topics, subject outcomes and learning outcomes. Structured practical tasks support the classroom learning. Apart from weekly workshop/laboratory sessions, there are structured subject- and programme Integrated Summative Assessments Tasks (ISATs) which are externally developed by the Department of Higher Education and Training and externally moderated by Umalusi. The subject- and programme-ISATs cover more than the tasks covered over the three-month college N-course class time each year during the three-year apprenticeship training period. In terms of time, the ISAT tasks, i.e. subject and programme, require more time to complete than the completion of trade test tasks, which require a period of two days.

The NC: N1 – N3 learners have no practical exposure at all during the trimesters that they spend on their theoretical studies, because it is assumed that they receive this experience at work. There are, however, many learners who do the N-courses without being in a workplace at all. The evaluators are of the opinion that since the classroom work covers only theoretical concepts over a three-month period, after which the learner enters industry, they do not yet know the basics, e.g. use of a test meter.

The available NC: N3 syllabus outlines topics only and no clear specifics or guidelines are provided.

2.3.5 Articulation and related matters

2.3.5.1 NC (V) articulation with NC: N2 and N3

The evaluators are of the opinion that a learner with NC (V) L2 and L3 should be granted exemption for the subjects achieved through the NC (V) for access to N2 and N3 and a learner who has completed NC (V) L4 should be exempted from the subjects passed through the NC (V) for access to N4 or a University of Technology.

2.3.5.2 NC: N2 and N3 articulation with the NC (V)

Because of the differences between the N-courses and the NC (V) in respect of the structure of the programmes and the time allocated, the NC (V) should be regarded as a complete mind shift from NC: N1 – N3. The NC (V) curriculum documents include more subjects with more topics and more formal learning outcomes: no justification could be found that would allow credits from the NC: N2 – N3 to be transferred to the NC (V). Although the instructional offerings and the qualifications might seem to serve a similar purpose, they are structured completely differently. In keeping with the transformation agenda in education, the evaluators of Electrical Trade Theory are of the opinion that the NC (V) serves the purpose of preparation either for access to an apprenticeship programme and/or for access to further study in higher education.

2.4 ENGINEERING SCIENCE

The analysis of Engineering Science compared the curriculum documents of NC: N2 and N3 Engineering Science with those of NC (V) as detailed in the table below:

Once again, the sum of all the content identified in the curriculum documents formed the total against which the individual subjects were analysed.

Table 21: NC: N2–N3 Engineering Science and related NC (V) subjects

NC: N2: Engineering Studies	**NC (V)**
Engineering Science N2	Engineering Systems Level 2; Material Technology L3; Applied Engineering Technology L4
NC: N3: Engineering Studies	**NC (V)**
Engineering Science N3	Engineering systems Level 2; Material Technology L3; Applied Engineering Technology L4

The three Engineering subjects within the NC (V) Engineering and Related Design programme are Engineering Systems Level 2, Material Technology Level 3 and Applied Engineering Technology Level 4. They are all compulsory subjects, which are taken alongside other compulsory subjects at their respective levels.

2.4.1 Contents/skills specification and focus

NC: N2 Engineering Science was mapped separately against Engineering Systems L2, Material Technology L3 and Applied Engineering Technology L4 of the NC (V).

Once again, the sum of all the content identified in the curriculum documents formed the total against which the individual subjects were analysed.

(a) Contents/skills mapping between Engineering Science NC: N2 and related NC (V) L2 – L4 subjects

The tables below represent the mapping of content and skills between Engineering Science NC: N2 and the related NC (V) L2 – L4 subjects as mentioned above.

Table 22: Contents/skills mapping between Engineering Science NC: N2 and Engineering Systems L2 of the NC (V)

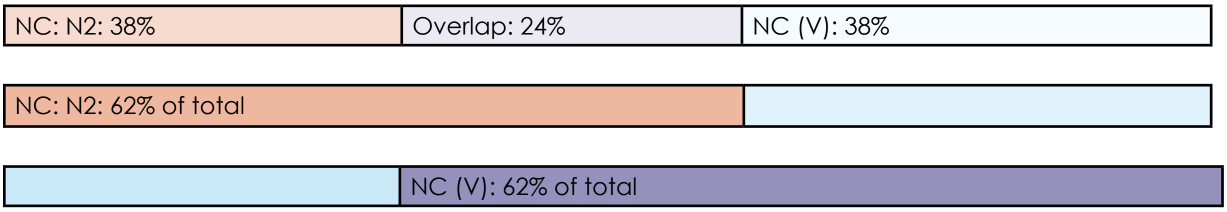


Table 23: Contents/skills mapping between Engineering Science NC: N2 and Materials Technology L3 of the NC (V)

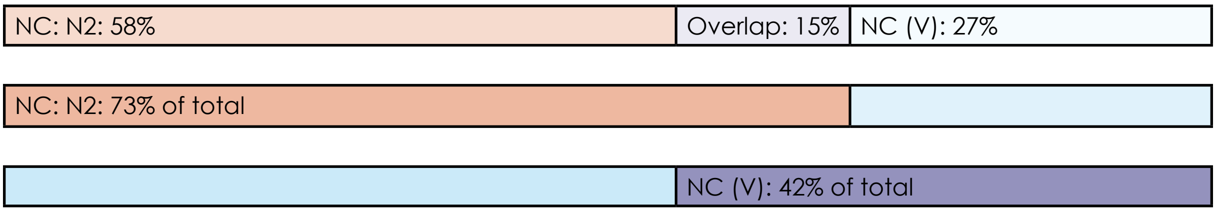
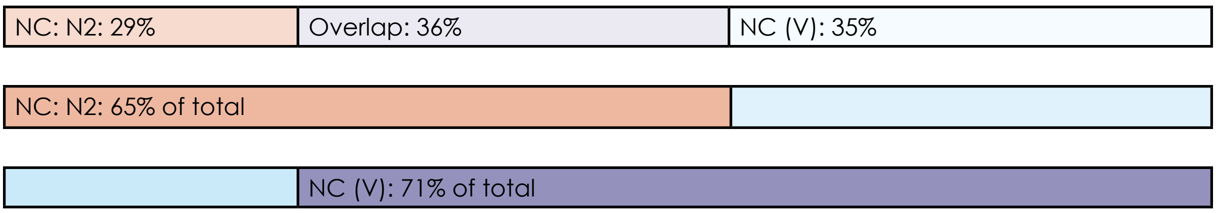


Table 24: Contents/skills mapping between Engineering Science NC: N2 and Applied Engineering Technology L4 of the NC (V)



There is limited common content between Engineering Science NC: N2 and the related NC (V) subjects (between 15% and 36% of the total). Even the topics that do overlap, deal with the same concepts but at different levels in terms of difficulty level and different skills. The concept is similar but the focus is different. For example, In the NC: N2 Engineering Science, students learn about how materials withstand heat and are required to do calculations. On the other hand, the NC (V) content covers process as well as how the processes are executed in practice within the refrigeration cycle. Engineering Science in NC: N2 focuses on calculations that determine speed, force and power while the NC (V) focuses on transmission of power and motion, reducing friction and their application. In the NC (V), the broader vocational/occupational flavour of the subject is emphasised while NC: N2 Engineering

Science simply foregrounds calculations. Most topics in the NC (V) are explained clearly and sequentially to make logical sense to learners, while Engineering Science in NC: N2 deals with topics without providing either the background or the origin of the topic.

(b) Contents/skills mapping between Engineering Science NC: N3 and related NC (V) L2 – L4 subjects

Just as with the NC: N2 Engineering Science comparison, NC: N3 Engineering Science was mapped separately against Engineering Systems L2, Material Technology L3 and Applied Engineering Technology L4 of the NC (V).

Once again, the sum of all the content identified in the curriculum documents formed the total against which the individual subjects were analysed.

The tables that follow represent the mapping between Engineering Science NC: N3 and the related NC (V) L2 – L4 subjects

Table 25: Contents/skills mapping between Engineering Science NC: N3 and Engineering Systems L2 of the NC (V)

NC: N3: 49%	Overlap: 21%	NC (V): 30%

NC: N3: 70% of total	

	NC (V): 51% of total

Table 26: Contents/skills mapping between Engineering Science NC: N3 and Materials Technology L3 of the NC (V)

NC: N3: 67%	Overlap: 22%	NC (V): 11%

N3: 89% of total	

	NC (V): 33% of total

Table 27: Contents/skills mapping between Engineering Science NC: N3 and Applied Engineering Technology L4 of the NC (V)

NC: N3: 35%	Overlap: 33%	NC (V): 32%

NC: N3: 68% of total	

	NC (V): 65% of total

In the NC (V), reference to Engineering Systems is to the system as a whole: the structure of the machine, the specification of the machine, identification of parts and their functions, and the ability to effectively apply actions on the machines. On the other hand, only certain aspects are covered in Engineering Science NC: N2 and N3. For example, on the subject of hydraulic pumps, the NC (V) deals with the whole system from construction, through specification to the different parts of the pump and their functions, as well as their entire application; on the other hand, N3 Engineering Science focuses on calculations associated with fluid pressure and the load that can be lifted. This difference in approach to the subject matter contributes to the omission of sub-topics on NC: N2 and N3 Engineering Science, which implies that the NC (V) learners acquire a greater number of applications than the students studying NC: N2 and N3 Engineering Science do.

The tables provided seem to indicate that the NC: N2 and N3 have more content than the NC (V) L2 – L4, yet some of the content in NC: N2 and N3 that was omitted from the NC (V) might be obsolete content as the N-course curricula have not been updated for a long time.

2.4.2 Access to an apprenticeship after completing NC (V) engineering subjects

The Engineering Science evaluator is of the opinion that, once employed in industry, NC (V) Level 4 learners should normally require eighteen months or less to acquire the necessary on-the-job training. Industry should definitely be encouraged by the DHET and the colleges to find a way of crediting/recognizing some of the practical skills the successful learners have already acquired. In the Engineering Science evaluator's opinion, NC (V) learners ought to have sufficient theory to qualify for on-the-job training, which is strongly complemented by the 60 per cent practical work that is prescribed by the subject guideline.

Another factor to be considered is that the NC (V) L2 – L4 curriculum deals intensively with concepts that are dealt with at NC: N4, N5 and N6 level in the NATED courses. (In this regard it is noteworthy that the N4 – N6 were not part of the analysis, but the information drawn on here comes from experience). Therefore the suggestion is that the NC (V) is pitched at a comparatively high level in relation to the NC: N2 and N3 courses. However, it should also be noted that not all the topics within the NC (V) science subjects are pitched at the *appropriate* level. The inclusion of such content is of great benefit to the learners in terms of acquisition of knowledge and skills, but could be said to lead to curriculum overload, making the curriculum too demanding, and resulting in superficial coverage. The inclusion of such content could be used as motivation to influence the requirements for *access to an apprenticeship programme to be different for NC (V) graduates from those of NC: N2–N3* because these learners have been exposed to advanced content.

2.4.3 Duration, knowledge and skills

Given the nature of the NC (V) Engineering subjects, the evaluator found the duration of three years appropriate for full-time learners, but is of the opinion that the weighting for the practical assessment component ought to be 70 % of the 200 hours allocated for teaching and learning for each year, as this would give learners sufficient time to acquire the necessary practical skills.

2.4.4 Weaknesses and strengths of the NC (V) and the N-courses

The vocational science subjects evaluated within the NC (V) curriculum (which excluded Physical Science) integrate academic knowledge (theory) with practical skills and the values specific to each vocational area. They produce learners who are multi-skilled because the programmes are designed to be of a general vocational nature and to cater for all the sectors of the engineering science field in as far as acquiring theoretical and practical skills are concerned. Furthermore, the NC (V) engineering curriculum is based on the latest trends and developments in the industry and commercial sectors, which broadens the knowledge of learners in the changing and challenging world of work.
A notable challenge with the intended curricula of the three evaluated NC (V) subjects

(Engineering Systems, Materials Technology and Applied Engineering Technology) is that they are currently too long and too demanding. A difficulty has been that the subjects introduced new content, for which the lecturers did not receive thorough training before implementation. Furthermore, the process of curriculum development for the NC (V) did not provide an opportunity for piloting before implementation. Piloting would have identified potential challenges and led to a more tried-and-tested curriculum.

The evaluator is of the opinion that the NC (V) curricula require high levels of cognitive ability, and that learners with mixed abilities are therefore likely to experience a variety of challenges. Furthermore, the subjects are resource-intensive (physical, human, capital) and many FET colleges are not sufficiently resourced to be able to implement the engineering curriculum effectively. The NC (V) needs well-qualified people to teach both the practical and theoretical components of the subjects effectively, a challenge for the colleges because they must ensure that they have employed sufficiently trained staff for both the practical and theory if they are to ensure decent delivery.

With regard to the NC: N2 and N3 Engineering Science, the content topics are poorly sequenced and frequently presented as separate entities. This makes it difficult for learners to follow and understand. Furthermore, the content is old and has not been reviewed for a long time.

2.4.5 Articulation and related matters

While the analysis shows that the overlap of content between NC: N2 and the engineering subjects is only between 15% and 36%, and between 21% and 33% for the NC: N3 and the NC (V) subjects, the NC (V) introduces new, up-to-date content. The amount of new content that is introduced in the NC (V) subjects ranges between 27% and 38% for the N2 comparison and between 11% and 32%. It may be that the content that has been left out from the NC: N2 and NC: N3 is content that had become obsolete. Some of the new content that has been included in the NC (V) subjects is content that is also included in the NC: N4 – N6 subjects. Because of the additional new content in the NC (V) and the practical component, it is not advisable for those learners who have successfully completed the NC: N2 to transfer to NC (V) Level 3 or for those learners who have successfully completed the NC: N3 to transfer to the NC (V) Level 4.

The qualification was designed to articulate with HE qualifications as stated in its purpose: "The National Certificate (Vocational) at Level 4 on the NQF enables students to acquire the necessary knowledge, practical skills, applied competence and understanding required for employment in a particular occupation or trade, or class of occupations or trades or entrance into Higher Education" (Department of Education, 2006: 82). The content of the NC (V) subjects was designed with the purpose of the qualification in mind. The duration of the qualification, the amount of content in the subjects, its delivery model and the skills and knowledge that are expected to be acquired should enable further learning opportunities and articulation into higher education, as set out by Higher Education, in Government Gazette No 32743 of 26 November 2009.

Currently, an NC: N3 learner cannot articulate directly with higher education qualifications at NQF Level 5 and Level 6 irrespective of their performance at NC: N3 level. First, they have to go through NC: N4 and with a pass in Maths and Engineering Science at NC: N4 level, they can then gain access into a University of Technology. NC: N4 – N6 were also directed at those learners who did not meet the entry requirements of higher education because of poor results. These courses also served as orientation courses to those students with intentions of progressing to higher education qualifications.

2.5 ENGINEERING DRAWING

The investigation into the standing of the subject, Engineering Drawing, compared the curricula of NC: N1, N2 and N3 Engineering Drawing with two of the NC (V) subjects as detailed in the table below.

Once again, the sum of all the content identified in the curriculum documents formed the total against which the individual subjects were analysed.

Table 28: NC: N1–N3 Engineering Drawing and related NC (V) subjects

NC: N1: Engineering Studies	**NC (V)**
Engineering Drawing N1	Engineering Technology L2 Engineering Graphics and Design L3 (EGD)..
NC: N2: Engineering Studies	**NC (V)**
Engineering Drawing N2	Engineering Technology L2 Engineering Graphics and Design L3 (EGD).
NC: N3: Engineering Studies	**NC (V)**
Engineering Drawing N3	Engineering Technology L2 Engineering Graphics and Design L3 (EGD).

Engineering Drawing falls within Category D of the Engineering Studies programme of NC: N2 and N3. Category D is one of the three compulsory categories from which apprentices must select a subject. However, for non-apprenticed students, Category D is one of four categories from which learners select three subjects. The three subjects cannot be selected from the same category but from any of the four categories.

Engineering Technology Level 2 and Engineering Graphics and Design Level 3 are compulsory subjects in the NC (V) Engineering and Related Design programme. Once again, the sum of all the content in the curriculum documents for this subject in both the NC (V) and the N-courses formed the total against which the individual subjects were compared.

2.5.1 Contents/skills specification and focus

NC: N1 Engineering Drawing was mapped against the content and skills found in Engineering Technology L2 and Engineering Graphics and Design L3 of the NC (V). The same process was then repeated with NC: N2 Engineering drawing, and then with Engineering Drawing in NC: N3.

Once again, the sum of all the content identified in the curriculum documents formed the total against which the individual subjects were analysed.

(a) Contents/skills mapping between Engineering Drawing NC: N1 and related NC (V) L2 and L3 subjects

Table 29: Contents/skills mapping between Engineering Drawing NC: N1 and related NC (V)

L2 and L3 subjects

NC: N1: 41 %	Overlap: 22 %	NC (V): 37 %

NC: N1: 63% of total	

	NC (V): 59% of total

(b) Contents/Skills mapping between Engineering Drawing NC: N2 and related NC (V) L2 and L3 subjects

Table 30: Content/skills mapping between Engineering Drawing NC: N2 and related NC (V) L2 and L3 subjects

NC: N2: 48 %	Overlap: 16 %	NC (V): 36 %

NC: N2: 64% of total	

	NC (V): 52% of total

(c) Contents/Skills mapping between Engineering Drawing NC: N3 and related NC (V) L2 and L3 subjects

Table 31: Contents/skills mapping between Engineering Drawing NC: N3 and related NC (V) L2 and L3 subjects

NC: N3: 21 %	Overlap: 21%	NC (V): 58 %

NC: N3: 42% of total	

	NC (V): 79% of total

Drawing provides the knowledge and skills to generate 2, 3 and 4-dimensional representations of physical engineering systems from various projections. The NC: N1- N3 curricula lack certain critical drawing concepts, e.g. graphical drawings as the primary means of communication in the technological world, various instrument and freehand drawing techniques and skills and the implementation of CAD (Computer Aided Drawings/ Design) as a method of producing drawings.

The content/skills comparison in the tables provided also indicate that substantial amounts of the NC: N1-N3 Engineering Drawing content was omitted from the NC (V) drawing subjects. The content omitted from the NC (V) would introduce novice learners to the subject.

2.5.2 Access to an apprenticeship after completing the NC (V) drawing subjects

Engineering Drawing is not a direct trade subject. Although it is clear that most of the contents/skills for NC (V) L3 were written to be pitched at the same level as the content for NC: N3, a NC (V) L3 learner is only partially prepared to successfully complete the NC: N2 curriculum, given the fact that almost half of the NC: N2 content (48%) has been omitted from the NC (V).

However, a period of eighteen months' "full-time" study during the NC (V) would be sufficient for a learner to master all the drawing skills required to successfully apply the knowledge to different types of drawings, provided these were incorporated into the curriculum. Mastering all the drawing skills would take between two and three years within the "part-time" environment of the college.

Therefore, because the curriculum for Engineering Graphics and Design is inadequate, not even an NC (V) L4 learner would be sufficiently prepared to compete in respect of drawing-related skills with a candidate who has completed an eighteen-month "full-time" on-the-job training period after attaining NC: N2–N3.

2.5.3 Duration of the subject

The evaluator considers the duration of the NC (V) Engineering Graphics and Design to be too short. It is recommended that, as with the "old" N-courses, a dedicated drawing subject, Engineering Graphics and Design, be included for NC (V) Levels 2, 3 *and* 4. This move would also align the NC (V) with the developmental process that is currently very successfully implemented in the FET schools' curriculum for Engineering Graphics and Design.

2.5.4 Weaknesses and strengths of the N-courses

As Engineering Drawing is a knowledge- as well as an application- and skills-based subject, the strength of the N-courses lay in the fact that a dedicated drawing subject was included in the NC: N1, N2 and N3 courses. The subject provided multiple opportunities for learners to acquire the required knowledge and skills at the different levels at which the subject was offered. The N-courses can, however, also be strengthened by the introduction of graphical drawings, various instrument- and freehand-drawing techniques and skills, and the use of CAD as a method of producing drawings.

2.5.5 Articulation and related matters

Regarding articulation between the N-courses for drawing and the NC (V), it is recommended that all the N-certificates for Engineering Drawing should be recognized as:

- NC: N1 and N2 Engineering Drawing for entry into NC (V) L3 Engineering Graphics and Design, and
- NC: N3, on condition that a CAD training course has also been completed, for entry into any NC (V) L4 engineering (technological) course.

If a dedicated drawing subject could, as already recommended, be implemented for NC (V) Levels 2, 3 and 4, the NC: N2 fundamentals for drawings should be retained as the focus of the L2 course. However, the L3 and L4 courses should contain the most relevant content, which must include Computer Aided Design (CAD), from the NC: N2, NC: N3 and the NC (V) L3 courses.

2.6 CONCLUSION

In conclusion, what emerges from this section is that, by and large, the NC (V) covers more ground theoretically than do the NC: N2 and N3, which is unsurprising, given that the programme is longer and more comprehensive. The second significant difference is the fact that NC (V) subjects contain substantive opportunities for skills development, a feature which was included precisely because it was recognized that many students undertaking the N-courses did not have on-the-job experience. The evaluators all agreed that some workplace experience is necessary, but they argued that this could be significantly shorter because of the focus on the acquisition of practical skills in the NC (V). On-the-job experience could be gained, through the SETA-college partnerships, by using the model that was used by the Industry Training Boards (ITBs). Previously the ITBs "approved" the college workshops which meant that time spent in the college workshops was accepted as equivalent to time on the job. This was in part because the college work was structured by means of a logbook – an idea which should be taken up in the NC (V) if it hasn't been already.

Three of the four evaluated subjects (Mathematics, Engineering Drawing and Engineering Science) do not traditionally have trade tests associated with them. However, these subjects play an essential supportive role because they provide the necessary underpinning theory. In this sense, they are different from the NC (V) subjects, because every NC (V) subject, regardless of whether it is a trade subject or not, has a practical as well as a theoretical component, thereby providing learners with the opportunity to apply the knowledge and skills learned. The structure also provides an opportunity to create education-employment partnerships with industry where NC (V) learners can be exposed to the real workplace in instances where such opportunities are possible, even if it is only for work-shadowing to start with.

The NC (V) curriculum aims to produce learners who are well prepared to access apprenticeship programmes. This aim is evident in the content, breadth and depth of the curricula of the NC (V) subjects.

The NC (V) should provide pointers for curriculum reform for the N-course content with regard to Mathematics, Engineering Science and Electrical Trade Theory. However, in the case of Engineering Drawing, the NC (V) ought to take its cues from the N-course subject in terms of the packaging of the content.

CHAPTER 3

3.1 EXAMINATION FINDINGS

The examination analysis compared the NC: N3 and NC (V) Level 4 final examinations. The final question papers and their memoranda for the November 2009 NC (V) exams and the April and August 2010 N3 exams were compared. The instrument used was developed to address issues of cognitive demand and the level of difficulty found in the questions. The concluding questions of the evaluation were specifically directed to compliance with the requirements as set out in the Assessment Guidelines, the cognitive demands in the papers, the levels of difficulty found in the questions, the format of papers and the use of language in the papers. All these matters are routinely addressed in the external moderators' reports. The evaluators were free to add any additional points of comparison not covered in the tables to ensure a detailed analysis.

The purpose of the exam analysis was to establish the comparability of the examinations in terms of levels of difficulty and cognitive demand.

3.1.1 Mathematics

For the examination analysis, the April and August 2010 examination papers and memoranda for Mathematics NC: N3 were compared with those of Mathematics NC (V) L4 for 2009.

The analysis indicates that the Mathematics NC: N3 and NC (V) L4 examinations have some aspects in common:

- Technical aspects of the paper, graphs and other illustrations in all the question papers are clear and of good quality.
- The terminology and mathematical concepts are correctly used and are at an appropriate level for the students, provided those concepts have been properly taught.
- Questions in both NC: N3 and NC (V) examinations provide opportunities for learners to translate from verbal to symbolic form, which is one of the critical outcomes in Mathematics. (See for example questions 2.5 in the N3 April 2010 examination paper and 1.3 in paper 1 of NC (V) Level 4 in the November 2009 examination paper, reproduced over the page.)

April 2010 Mathematics N3 examination paper, example

2.5 The square of a natural number is four more than two times another natural number. The second number is two less than three times the first number. Determine the two natural numbers algebraically.

(DoE, 2010)

November 2009 Mathematics NC (V) Level 4, paper 1, example

1.3 A group of students intend selling x hamburgers and y chicken burgers at a soccer match. They have meat for 300 hamburgers and 400 chicken burgers at most. Each burger is sold in a polystyrene container, of which 500 are available. The students suspect that hamburgers will be at most twice as popular as the chicken burgers.

1.3.1 Two of the constraints are $x \geq 0$ and $y \geq 0$. Write down FOUR other constraints in respect of the above information in terms of x and y. *(4)*

1.3.2 Using a scale of 1 cm = 100 burgers, represent the inequalities graphically and indicate the feasible region. *(5)*

1.3.3 The students make a profit of R4,50 on each hamburger sold and R3,00 on each chicken burger sold. Write the equation that represents the total profit in terms of x and y. *(1)*

1.3.4 Use the search line method to determine how many of each burger should be sold to obtain the maximum profit. Hence determine the maximum profit. *(3)*

(DoE, 2009)

- Even though the content covered by these examination papers is different, each paper covers the content prescribed by the respective curriculum, except for a question on "definite integral" in NC (V) Level 4 (see Question 3.2 in November 2009 Paper 1). Both the Level 4 Subject- and Assessment Guidelines are silent about "definite integrals", but do refer to "area under a curve". Because, for one to calculate the area under a curve, one needs the knowledge of definite integrals, it should be specified in the policy documents along with the other concepts listed.

November 2009 Mathematics NC (V) Level 4, Paper 1, example

3.2 Evaluate $\int_{3}^{5} (-x^2 + 8x)\,dx$

(2)

(DoE) 2009

- The marking memoranda are accurate and correspond to the questions in the question papers.

In the N3 examinations, questions largely demand application of previously learned procedures to solve mathematical tasks as well as analysis and problem-solving.

Tables 32 – 35 show how questions are distributed according to different levels of cognitive demand and the levels of difficulty for NC: N3 Mathematics April and August exam papers, and the NC (V) Mathematics Paper 1 and Paper 2 of the November 2009 Level 4 examinations.

Table 32: Levels of cognitive demand for April 2010 NC: N3 Paper and November 2009 NC (V) Level 4 Mathematics Paper 1

Levels of cognitive demand	Maths NC (V) L4, Paper 1	Maths NC: N3		**Levels of difficulty**	Maths NC (V) L4, Paper 1	Maths NC: N3
Conceptual Knowledge	2%	0%		Easy	20%	15%
Comprehension	5%	6%		Moderate	60%	54%
Application	63%	67%		Difficult	20%	31%
Analysis & Problem Solving	23%	27%				
Evaluation & Synthesis	7%	0%				

Table 33: Levels of cognitive demand for April 2010 NC: N3 Paper and November 2009 NC (V) Mathematics, Paper 2

Levels of cognitive demand	Maths NC (V) L4 Paper 2	Maths NC: N3		**Levels of difficulty**	Maths NC (V) L4 Paper 2	Maths NC: N3
Conceptual Knowledge	4%	0%		Easy	48%	15%
Comprehension	5%	6%		Moderate	18%	54%
Application	59%	67%		Difficult	34%	31%
Analysis & Problem Solving	31%	27%				
Evaluation & Synthesis	1%	0%				

Table 34: Levels of cognitive demands for August 2010 NC: N3 Paper and November 2009 NC (V) Mathematics, Paper 1

Levels of cognitive demand	Maths NC (V) L4 Paper 1	Maths NC: N3		**Levels of difficulty**	Maths NC (V) L4 Paper 1	Maths NC: N3
Conceptual Knowledge	2%	0%		Easy	20%	10%
Comprehension	5%	9%		Moderate	60%	59%
Application	63%	64%		Difficult	20%	31%
Analysis & Problem Solving	23%	27%				
Evaluation & Synthesis	7%	0%				

Table 35: Levels of cognitive demands for August 2010 NC: N3 Paper and November 2009 NC (V) Maths Paper 2

Levels of cognitive demand	Maths NC (V) L4 Paper 2	Maths NC: N3		**Levels of difficulty**	Maths NC (V) L4 Paper 2	Maths NC: N3
Conceptual Knowledge	4%	0%		Easy	48%	10%
Comprehension	5%	9%		Moderate	18%	59%
Application	59%	64%		Difficult	34%	31%
Analysis & Problem Solving	31%	27%				
Evaluation & Synthesis	1%	0%				

IIt is evident from Tables 32 – 35 that the NC: N3 papers covered mainly three levels of cognitive demand (comprehension, application, analysis and problem solving) as outlined in Bloom's revised taxonomy (2001). The spread of questions, indicated above, did not cover conceptual knowledge nor evaluation and synthesis. Evaluation and synthesis, the highest level of cognitive demand in the taxonomy, are not assessed significantly in both NC: N3 and N(C)V examinations. In other words, the analysis suggests that the papers are presently targeting the average ability in terms of thinking skills.

The analysis also indicates that the spread of questions across the levels of cognitive demand shows that the NC: N3 papers did not comply with the requirements as prescribed in the NC: N3 syllabus for Mathematics (DoE, 1994). The syllabus requires questions in examination papers to cover reproduction (i.e. conceptual knowledge and comprehension/recall), application, analysis and evaluation in the ratio: 40%, 25%, 20% and 15% of the total questions respectively. Questions assessing the conceptual knowledge and comprehension in Tables 32 – 35, assess what the NC: N3 syllabus calls "reproduction": questions assessing this level should count about 40% of the question paper, but range between 6% and 9% of the total. Tables 32 – 35 also indicate that 64% of the questions assessed application of knowledge, which is much more than the 25% prescribed by the syllabus: it is likely that, while appearing to be in the form of application of knowledge, these questions are sufficiently well rehearsed to be "reproduction" rather than a genuine application of knowledge acquired. According to the syllabus, evaluation questions should count about 15% of the questions. The papers analysed did not include any questions assessing evaluation and synthesis. The April and August question papers resemble each other regarding structure, concepts assessed, mark allocation and level of difficulty.

Tables 32 – 35 also show how questions were spread according to level of difficulty per cognitive level. Questions were also categorised according to whether they were easy, moderate or difficult. The classification then assisted in determining the overall difficulty level of a paper. The April and August NC: N3 papers lean heavily towards moderately difficult (59,4%) and difficult (31,2%) questions, but these are spread across three cognitive demands, namely comprehension, application as well as analysis and problem-solving, without any of the questions assessing either evaluation or synthesis.

Tasks in the NC: N3 examination papers are not contextualized: all the questions in the two papers are characterized by the action verbs *factorise*, *simplify, solve, determine, calculate, sketch* and *prove*, making it evident that the questions are textbook-like. This way of setting questions is out of step with current assessment practice. This practice of setting examination papers cannot be regarded as a good model for future examinations. In addition, the high level of similarity between the question-types set in the two papers would mean that even "difficult" questions will have been rehearsed in preparation, and so, would no longer really be classifiable as "difficult".

The NC (V) examinations differ from those of the NC: N3 in that questions largely focus on the *application* of mathematical concepts in real life, a situation which allows creative responses from the candidate. In the November 2009 examination, papers included questions of various types that required data responses, paragraphs, dealing with real-life scenarios and real-life problem solving (see for example, Paper 1, Q 4.1, and Paper 2, Q 4.1 and 4.2 below).

Nov 2009 Mathematics NC (V) Level 4, paper 1, example

4.1 As a manager in a factory you have observed 10 workers on the shop floor, timing how long it takes each of them to assemble a product. It was possible to match these times with the length of the workers' experience. The results obtained are shown below.

EMPLOYEE	***EXPERIENCE*** x ***(IN MONTHS)***	***TIME*** y ***(MINUTES)***
A	2	27
B	5	26
C	3	30
D	8	20
E	5	22
F	9	20
G	12	16
H	16	15
I	1	30
J	6	19

4.1.1 Construct a scatter plot for the above data with the employees' experience on the horizontal axis and the time to assemble the product on the vertical axis. *(6)*

4.1.2 Find the sample regression equation by the method of least squares. *(8)*

4.1.3 Predict the time it would take an employee with 4 months' experience to assemble the product. *(2)*

(DoE: 2009)

Nov 2009 Mathematics NC (V) Level 4, paper 2

4.1 A person earns a basic salary of R92 508 per annum. She is required to contribute 1% of her salary towards the Unemployment Insurance Fund (UIF). Her employer is also expected to contribute a further 1% of her salary towards UIF. Calculate the total monthly contribution towards UIF. *(3)*

4.2 The table below shows the rates at which tax was levied in South Africa for the 2008 tax year. Thobile, who is 42 years old, earned a gross salary R10 890,00 per month (before the tax). She also received a bonus of R11 200,00 in December. Thobile did not earn any interest from investments during the tax year.

Rates applicable to individuals	
Taxable Income	***Rates of tax***
R0 – R122 000	*18% of every R1*
R122 000 – R195 000	*R21 960 + 25% of the amount over R122 000*
R195 000 – R270 000	*R40 210 + 30% of the amount over R195 000*
R270 000 – R380 000	*R62 710 + 35% of the amount over R270 000*
R380 000 – R490 000	*R101 210 + 38% of the amount over R 380 000*
R490 000 and over	*R143 010 + 40% of the amount over R490 000*

Use this information and the table to answer the following questions.

Tax Rebates:

Primary rebate R7 200

Additional rebate (for persons 65 years and older) R4 500

Exemptions:

Annual exemption on interest earned for individuals younger than 65 years R19 000

Annual exemption on interest earned for individuals older than 65 years R19 000

[SOUTH AFRICAN REVENUE SERVICE (SARS) 2007/2008]

4.2.1 Calculate Thobile's total earnings per annum including the bonus. *(2)*

4.2.2 Calculate the after-tax income per month that Thobile earned if tax on her bonus was deducted on a monthly basis. *(4)*

4.2.3 Why did Thobile want the tax on her bonus to de deducted on a monthly basis? *(1)*

(DoE, 2009)

Such NC (V) questions represent the latest development in the assessment and teaching and learning of the knowledge field, and call for the candidates writing these papers to be analytical and innovative when answering questions. This way of setting questions is regarded as a good model for future examinations.

For the NC (V), the Assessment Guidelines for Mathematics (DoE, 2007:15) require questions in an examination question paper to assess different levels of cognitive demand. It stipulates that questions assessing knowledge and comprehension should have a weighting of approximately 25% of the total marks, application approximately 50% of the total marks and analysis, synthesis and evaluation should comprise approximately 25% of the total marks. Tables 32 – 35 show that questions assessing knowledge and comprehension in Paper 1 and Paper 2 are worth 7% and 9% of the marks respectively. This distribution is not in compliance with the Assessment Guidelines for Mathematics, which stipulates that 25% of the marks should be for knowledge and comprehension (DoE, 2007:15). Similarly the distribution of 84% and 90% for applications and analysis and problem solving for Paper 1 and Paper 2 respectively is not in compliance with the Assessment Guidelines. The papers assume that learners can operate at a high level of cognitive demand. For those learners who are not able to operate at such a level, it might be difficult to pass the papers.

As explained in the preceding paragraphs, the NC (V) Assessment Guidelines expect a distribution of questions in terms of cognitive levels as outlined in the Assessment Guidelines. As illustrated by the sample questions above, the NC (V) papers require students to display some level of reasoning and innovation. Although papers did not comply with the prescribed distribution of questions across the different levels of cognitive demands, the layout, the format, and the quality of these Mathematics NC (V) Level 4 papers are of an appropriate standard in accordance with both the Subject Guideline and the Assessment Guidelines (DoE, 2007).

If the NC: N3 and NC (V) exam papers are compared, the difference in terms of the distribution of cognitive demands become evident. The NC: N3 papers covered three levels of cognitive demand (comprehension, application, analysis and problem solving) whilst the NC (V) questions were spread across the combined suggested lower, middle and higher order demand as suggested by the Assessment Guidelines. The NC: N3 questions did not cover some of the cognitive demands especially the Conceptual Knowledge and Evaluation and Synthesis questions.

From experience as an external moderator for Mathematics, the evaluator indicated that Level 4 students struggle to answer questions on Euclidean geometry. This section is covered *only* in NC (V) Level 4. The recommendation is that the topic be started at lower levels to give students some background to the concepts. The topic on complex numbers is covered in both Level 3 and Level 4. In Level 3, it is assessed in Paper 1 and in Level 4 in Paper 2. The suggestion is that in Level 4 the section be assessed in Paper 1 for consistency.

The Learning Outcomes (LOs) and the Assessment Standards in the NC (V) curriculum do not always explicitly mention the content range and depth (see for example Level 4 Subject Guideline, topic 5.2, where the LO says only "find anti-derivatives and integrals by using rules and simplifications correctly"). It is highly likely that these skills may not be explicitly taught.

3.1.2 Electrical Trade Theory

For the examination analysis, the examination papers and memoranda of the April and August 2010 N3 Electrical Trade Theory were compared to the November 2009 NC (V) L4 question papers for Electrical Principles and Practice, Electrical Systems and Construction, and Electrical Workmanship.

The investigation of specific practical tasks also required reference to the Integrated Summative Assessment Task (ISAT) per subject at NC (V) Levels 3 and 4, and the Electrical Trade Test. The subject ISAT at NC (V) Level 3 and Level 4, and the Electrical Trade Test for specific practical tasks are comparable. The broad topics in the trade test are broken up into detailed tasks in the ISAT. Although the trade test topics are broken up during the actual training, *there is no national standard* in terms of how the tasks are covered, as the process varies from provider to provider and industry to industry.

The ISAT, on the other hand, is a structured learning process with standard guidelines and marking rubrics, thus providing clear guidance to the teacher around administering the assessment. It should be noted that the NC (V) Level 4 ISAT tasks compare well with the trade test tasks.

Tables 36 to 42 show how questions were distributed according to different levels of cognitive demand and the levels of difficulty for the April and August 2010 N3 Electrical Trade Theory papers and the 2009 November NC (V) L 4 Electrical Principles and Practice, Electrical Systems and Construction and Electrical Workmanship papers.

Table 36: Cognitive demands and levels of difficulty – the April 2010 NC: N3 Electrical Trade Theory and the Nov 2009 NC (V) Electrical Principles and Practice (EPP) L4 papers

Cognitive demand	EPP L4	Electrical Trade Theory NC: N3		**Levels of difficulty**	EPP L4	Electrical Trade Theory NC: N3
Conceptual Knowledge	21%	20%		Easy	30%	24%
Comprehension	30%	32%		Moderate	55%	44%
Application	27%	4%		Difficult	15%	32%
Analysis & Problem Solving	12%	24%				
Evaluation & Synthesis	10%	20%				

Table 37: Cognitive demands and levels of difficulty – the April 2010 NC: N3 Electrical Trade Theory and the Nov 2009 NC (V) Electrical Systems and Construction L4 (ESC)

Cognitive demand	ESC	Electrical Trade Theory NC: N3		**Levels of difficulty**	ESC	Electrical Trade Theory NC: N3
Conceptual Knowledge	24%	20%		Easy	38%	24%
Comprehension	36%	32%		Moderate	38%	44%
Application	16%	4%		Difficult	24%	32%
Analysis & Problem Solving	8%	24%				
Evaluation & Synthesis	16%	20%				

Table 38: Cognitive demands and levels of difficulty – the April 2010 NC: N3 Electrical Trade Theory and the Nov 2009 NC (V) Electrical Workmanship L4 (EW) papers

Cognitive demand	EW	Electrical Trade Theory N3		**Levels of difficulty**	EW	Electrical Trade Theory N3
Conceptual Knowledge	20%	20%		Easy	33%	24%
Comprehension	18%	32%		Moderate	37%	44%
Application	40%	4%		Difficult	30%	32%
Analysis & Problem Solving	8%	24%				
Evaluation & Synthesis	14%	20%				

Table 39: Cognitive demands and levels of difficulty – the Aug 2010 NC: N3 Electrical Trade Theory and the Nov 2009 NC (V) Electrical Principles and Practice L4 papers

Cognitive demand	EPP L4	Electrical Trade Theory NC: N3		**Degree of difficulty**	EPP L4	Electrical Trade Theory NC: N3
Conceptual Knowledge	21%	23%		Easy	30%	54%
Comprehension	30%	42%		Moderate	55%	31%
Application	27%	4%		Difficult	15%	15%
Analysis & Problem Solving	12%	27%				
Evaluation & Synthesis	10%	4%				

Table 40: Cognitive demands and levels of difficulty – the Aug 2010 N3 Electrical Trade Theory and the Nov 2009 NC (V) Electrical Systems and Construction L4 papers

Cognitive demand	NC: ESC L4	Electrical Trade Theory N3		**Degree of difficulty**	ESC L4	Electrical Trade Theory NC: N3
Conceptual Knowledge	24%	23%		Easy	38%	54%
Comprehension	36%	42%		Moderate	38%	31%
Application	16%	4%		Difficult	24%	15%
Analysis & Problem Solving	8%	27%				
Evaluation & Synthesis	16%	4%				

Table 41: Cognitive demands and levels of difficulty – Aug 2010 NC: N3 Electrical Trade Theory and the Nov 2009 NC (V) Electrical Workmanship L4 papers

Cognitive demand	EW L4	Electrical Trade Theory NC: N3		**Degree of difficulty**	EW L4	Electrical Trade Theory NC: N3
Conceptual Knowledge	20%	23%		Easy	33%	54%
Comprehension	18%	42%		Moderate	37%	31%
Application	40%	4%		Difficult	30%	15%
Analysis & Problem Solving	8%	27%				
Evaluation & Synthesis	14%	4%				

Table 42: Cognitive demands and levels of difficulty – Nov 2009 NC (V) ISAT and the Electrical Trade Test

Cognitive demand	ISAT L4	Electrical Trade Test		**Degree of difficulty**	ISAT L4	Electrical Trade Test
Conceptual Knowledge	25%	8%		Easy	24%	17%
Comprehension	12%	33%		Moderate	38%	58%
Application	13%	17%		Difficult	38%	25%
Analysis & Problem Solving	25%	17%				
Evaluation & Synthesis	25%	25%				

The analysis in tables 36 – 42 indicates that, in terms of the spread of the level of difficulty, the N3 papers and the NC (V) papers are comparable in that difficult questions in the NC (V) L4 range between 15% and 30% of the marks while the difficult questions in the NC: N3 range between 15% and 32% of the marks. However, in terms of easy questions the NC: N3 has more easy questions. Easy questions in the N3 range from between 24% and 54% of the marks, while in the NC (V) L4 easy questions account for between 30% and 38% of the marks. One can therefore infer that it is easier to pass the N3 than it is to pass the NC (V). Yet, if one looks at the combined easy and medium-difficulty questions, which range between 70% and 85% of the marks for the NC (V), and 68% and 85% of the marks for the NC: N3, the papers become comparable.

In terms of the cognitive demands of the papers as detailed in tables 36 - 42, what emerges is that the NC (V) papers had instances where they had fewer questions at certain levels of demand than the NC: N3. For example, at the comprehension level, the questions ranged between 18% and 24% of the marks for the NC (V), and between 32% and 42% of the marks for the NC: N3. At the analysis level, the questions ranged between 8% – 12% of the marks for the NC (V) and between 24% and 27% of the marks for the NC: N3. In the same vein, the NC: N3 papers had, in some instances, fewer questions at certain levels of demand than did the NC (V), for example, at the level of application, the questions ranged between 16% and 40% of the marks for the NC (V) and only 4% of the marks for the NC: N3. However, in some instances, the papers were comparable for example, at the conceptual knowledge level; both papers are comparable with questions ranging between 20% and 24% of the marks for the NC (V) and 20% and 23% of the marks for the NC: N3 levels.

The papers were *not* in compliance with the Subject Guidelines in terms of the distribution of questions according to cognitive demands. The Electrical Systems and Construction L4 of the NC (V) paper did not comply in terms of all the cognitive demands while the other papers (Electrical Workmanship and Electrical Systems and Construction) complied in some cases and did not comply in others.

In terms of the suggested spread of cognitive demands for Electrical Trade Theory NC: N3, the syllabus does not provide any guidance, therefore it is impossible to indicate whether the paper was in compliance or not.

The examinations of the subjects in the different qualifications used different typologies for the distribution of cognitive demands. The distribution of the cognitive demands used for the NC (V) examinations is a three-level typology which is based on Bloom's Taxonomy while the NC: N3 examination papers were based on another taxonomy which is nevertheless a three-level typology. The typologies used are summarised as:

Table 43: Typology for levels of cognitive demands: The NC (V) L4 examination papers and the NC: N3 examination

NC (V) Electrical Principles and Practice	NC (V) Electrical Workmanship	NC (V) Electrical Systems and Construction	N3: Electrical Trade Theory
Conceptual knowledge and comprehension	Conceptual knowledge and comprehension	Conceptual knowledge and comprehension	Knowledge
Application	Application	Application	Application
Analysis, Synthesis and Evaluation	Analysis, Synthesis and Evaluation	Analysis, Synthesis and Evaluation	Evaluation

It is clear from Table 43 that for the examination of the Electrical Trade Theory of the NC: N3, the learners were required to operate at a different level of cognition in comparison to the NC (V) learners. The low-order thinking questions of the NC: N3 are knowledge questions and for the NC (V) they are conceptual knowledge and comprehension questions. The higher order thinking questions for the NC: N3 are only evaluation questions while the NC (V) combines analysis, synthesis and evaluation questions.

3.1.3 Engineering Science

For the examination analysis, the examination papers and memoranda of April and August 2010 for Engineering Science N3 were compared with those of Applied Engineering Technology NC (V) L4 for 2009. The analysis also entailed the analysis of the programme ISAT for 2009, which is the practical external examination for Engineering and Related Design at L4.

The analysis indicated that the 2009 NC (V) Applied Engineering Technology L4 examination paper complied with Subject and Assessment Guidelines with regard to the weighted value of topics. It is worth noting that no examination guideline was prescribed for the NC (V). The Assessment Guidelines provide broad information on assessment while the Examination Guidelines have as their main focus the minimum content that every learner should cover to be able to meet the minimum requirements of passing the examination.

Even though the examination paper complied with the Subject and Assessment Guidelines in terms of the weighted values of topics, it is *not* a good model for future exams because of an unfair allocation of marks and time, which did not always match the amount of effort required from the learners in answering the question. The marks allocated (to the question reproduced below) were too few given the time and effort required to answer the question. A lot of skill is involved because a shear diagram needs to be scaled down accurately, which is a difficult task requiring application and in order to draw bending moments, calculations have to be done first.

Applied Engineering Technology NC (V) L4 2009 November example

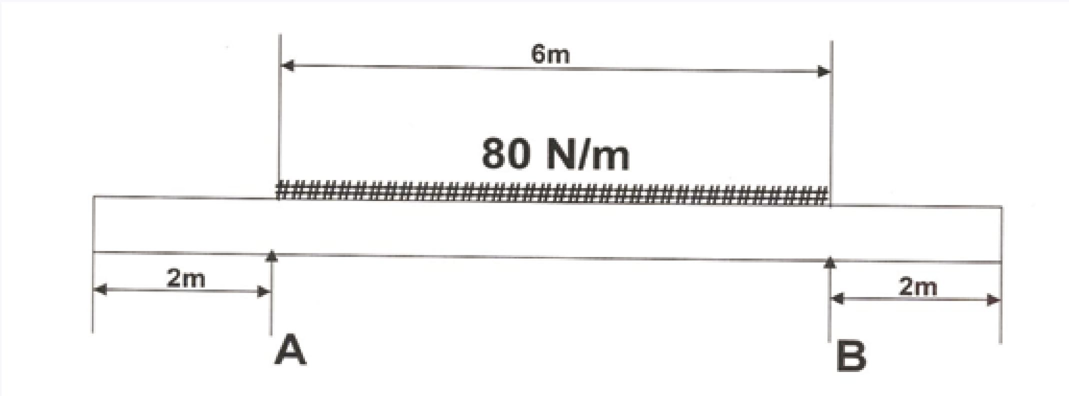


FIGURE 1: Shear force and bending moment diagram

Draw the shear force and bending moment diagrams for the beam shown in FIGURE 1.

(6)

(DoE: 2009)

The same question also appeared in the N3 Engineering Science April 2010 exam paper. A similar question was asked and yet allocated the same marks although the question in that paper required only the shear force diagram.

Engineering Science N3 April 2010 example

3.1.2 Draw the shear force diagram for the beam shown in FIGURE 2, using a suitable scale.
Show all the main values on the diagram.

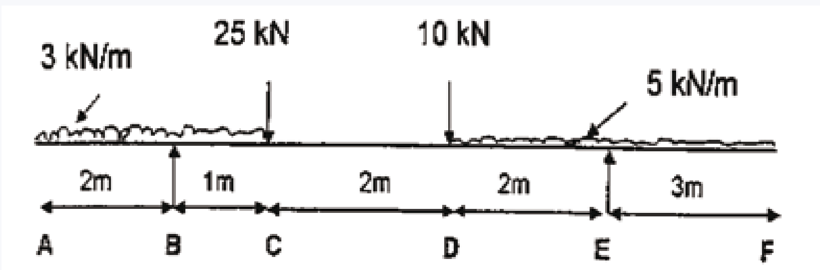


FIGURE 2: Shear force diagram *(6)*

(DoE: 2010)

With regard to the N3 Engineering Science, apart from the syllabus, there are no formal documents stipulating requirements to be followed in setting examinations. Only the old syllabus is available, which stipulates the weighted value of the topics in the exams with no regard at all for overall standard, coverage, and quality. The weighted value of topics also provides an indication of the teaching time that should be spent on each topic. In terms of the weighted values of topics in the examination, they were not in accordance with what is specified in the syllabus. Scanning through the other previous question papers and even the 2010 August Engineering Science N3 revealed that most of them did not comply with this requirement.

Tables 44 and 45 show how questions were distributed according to different levels of cognitive demands and the levels of difficulty for N3 Engineering Science April and August 2010 papers and NC (V) Applied Engineering Technology L4 2009 November paper.

Table 44: Cognitive demands and levels of difficulty – Nov 2009 NC (V) Applied Engineering Technology L4 and April 2010 N3 Engineering Science

Levels of cognitive demand	AET L4	Electrical Science N3		**Levels of difficulty**	AET L4	Electrical Science N3
Conceptual Knowledge	31%	18%		Easy	32%	33%
Comprehension	44%	1%		Moderate	62%	45%
Application	15%	9%		Difficult	6%	22%
Analysis & Problem Solving	6%	70%				
Evaluation & Synthesis	4%	2%				

Table 45: Cognitive demands and levels of difficulty – Nov 2009 NC (V) Applied Engineering Technology L4 and Aug 2010 N3 Engineering Science

Levels of cognitive demand	AET L4	Electrical Science N3		**Levels of difficulty**	AET L4	Electrical Science N3
Conceptual Knowledge	31%	17%		Easy	32%	51%
Comprehension	44%	1%		Moderate	62%	29%
Application	15%	10%		Difficult	6%	20%
Analysis & Problem Solving	6%	70%				
Evaluation & Synthesis	4%	2%				

With regard to the N3 Engineering Science, the analysis indicates that the exam paper is out of 101 marks while the marking guidelines indicate 100 marks. The reason is that, in Question 1.6 on the paper, the mark allocation is 2 marks, and in the marking guideline it is allocated 1 mark. The cognitive demand is not distributed in accordance with the syllabus recommendations. The spread of questions across the levels of cognitive demands shows that the NC: N3 papers did not comply with the requirements as prescribed in the NC: N3 syllabus for Engineering Science (DoE, 1994). The syllabus requires questions in a paper to cover 40% of the marks at the level of reproducing (i.e. conceptual knowledge and comprehension/ recall), 25% of the marks at the level of application, 20% of the marks at the level of analysis and 15% of the marks at the level of evaluation.

The question paper tested more analysis and problem- solving than other levels of cognitive demands such as conceptual knowledge, comprehension and evaluation and synthesis. In Question 1, instead of a specific topic, the question is about the theory of the whole syllabus.

Questions 1.1; 1.3 and 1.5 are posed as "state" questions, which are ambiguous, and it is unclear what the question requires as a response, whether to mention, define, discuss or recall. Most questions are of the conceptual knowledge type, which requires definitions, laws, advantages and disadvantage. Question 1.8 is the only question demanding actual comprehension.

The two NC: N3 papers analysed had between 33% and 51% of the marks allocated to easy questions and between 20% - 22% of the marks allocated to difficult questions.

With regard to the 2009 NC (V) Applied Engineering Technology (AET) L4 exam paper, the paper did not comply with the distribution of cognitive demands as stated in the Assessment Guidelines of the Department of Education (2007:160). The paper had 75% of the marks as conceptual knowledge and comprehension questions, instead of the required 40% of the marks. The application level, which was supposed to have 50% of the marks, had only 15% of the marks allocated to application questions. That is problematic because Applied Engineering Technology by its nature is supposed to be an application subject, and learners need to be engaged with more questions at that level.

The NC (V) paper had fewer easy questions at 32% of the marks and fewer difficult questions at only 6% of the marks. The bulk of the questions were at the moderate level. It can therefore be concluded that the paper was of a moderate level of difficulty. With such a few difficult questions, the paper is consequently not a challenging paper for gifted learners.

If one compares the NC: N3 papers with the NC (V) papers in terms of levels of difficulty, one comes to the conclusion that the NC (V) papers analysed are potentially easier to pass than the N3 papers which had 20% and 22% of the marks allocated to difficult questions compared to the NC (V) which had only 6% of the marks allocated to difficult questions.

If one compares the N3 papers and the NC (V) papers in terms of the distribution of cognitive demands, one can conclude that the N3 had more application and Problem-Solving questions, which may account for the number of difficult questions in the paper. On the other hand the NC (V) had very few application and problem- solving questions, which may account for the lack of difficult questions in the paper. However, it should also be noted that the distribution of cognitive demands with regard to the N3 paper was not spread in accordance with the syllabus requirements, because 70% of the marks was allocated to analysis and problem-solving questions with only 2% of the marks allocated to questions of a conceptual nature.

The practical paper (ISAT 2009)

The Integrated Summative Assessment Task (ISAT) is a compulsory part of practical assessment for the NC (V) that has to be completed by every learner, either in phases during the year or as a practical examination at the end of the year. The ISAT goes through the quality assurance processes associated with all externally examined subjects. There are two kinds of ISATs, one at subject level and one at programme level. The ISAT that was analysed is a programme ISAT.

The 2009 ISAT covered all the topics of the curriculum with the spread of cognitive demand fairly distributed. The level of difficulty was skewed to 75% difficult, 16% medium and 9% easy of the marks. Unfortunately, there is no guide for the ISAT stipulating the cognitive demands and the levels of difficulty which would determine compliance.

Table 46: NC (V) ISAT 2009 Cognitive demands and levels of difficulty

Level of cognitive demand		Levels of difficulty	
Conceptual knowledge	0%	Easy	9%
Comprehension	24%	Moderate	16%
Application	40%	Difficult	75%
Analysis & problem solving	28%		
Evaluation & synthesis	8%		

In summary, in all the question papers analysed, the language level was appropriate and the subject terminology was correctly used. There is no grammatical confusion and sentences are well structured. The format of the question papers is user friendly and easy to read and comprehend.

The NATED exams in some subjects have become highly predictable because of the need to set three exams in a year, in which certain chapters have three questions that may be asked in three trimesters, i.e. it becomes a norm that if any of the questions is asked in that trimester, two are left out for the remaining trimesters. This shows how easily questions can become predictable.

When comparing the NC (V) and N3 exam papers, it is clear that the levels at which the subjects were assessed in the two programmes were significantly different. Firstly, the NC (V) has two question papers, a theory and a practical paper, while the N3 has one paper. The practical paper (ISAT) leans towards application and problem-solving, while the theory paper leans towards knowledge and understanding. The N3 paper leans towards application and problem solving as well, but neglected the other cognitive demands as indicated above. The N-courses do not have examination guidelines and the N3 syllabus provides insufficient guidance on how to set exam papers.

3.1.4 Engineering Drawing

The examination analysis entailed a comparative analysis of Engineering Drawing N3 examination papers and memoranda for April 2010 and August 2010 and the 2009 NC (V) Engineering Graphics and Design L3 examination papers and memoranda.

As Engineering Graphics and Design is offered only as an NC (V) L3 subject, there are no NC (V) L4 question papers for Engineering Drawings. However, it is clear that the Engineering Graphics and Design NC (V) L3 papers are intended to be pitched at the N3 level.

Although the general standard and quality of the language used in all the examination papers is acceptable and would not have had any negative impact on the candidates, there are concerns regarding the language used.

Table 47: Cognitive demands and levels of difficulty – Nov 2009 Engineering Graphics and Related Design L3 Paper 1, and April 2010 N3 Engineering Drawing

Levels of cognitive demands	Engineering Drawing N3	EGD L3 Paper 1		**Levels of difficulty**	Engineering Drawing N3	EGD L3 Paper 1
Conceptual Knowledge	0%	0%		Easy	31%	0%
Comprehension	0%	0%		Moderate	44%	100%
Application	75%	100%		Difficult	25%	0%
Analysis & Problem Solving	25%	0%				
Evaluation & Synthesis	0%	0%				

Table 48: Cognitive demands and levels of difficulty – Nov 2009 Engineering Graphics and Related Design L3 Paper 2, and April 2010 N3 Engineering Drawing

Levels of cognitive demands	Engineering Drawing N3	EGD L3 Paper 2		**Levels of difficulty**	Engineering Drawing N3	EGD L3 Paper 2
Conceptual Knowledge	0%	0%		Easy	31%	38%
Comprehension	0%	0%		Moderate	44%	62%
Application	75%	65%		Difficult	25%	0%
Analysis & Problem Solving	25%	35%				
Evaluation & Synthesis	0%	0%				

Table 49: Cognitive demands and levels of difficulty – Nov 2009 NC (V) Engineering Graphics and Related Design L3 Paper 1, and August 2010 N3 Engineering Drawing

Levels of cognitive demands	Engineering Drawing N3	EGD L3		**Levels of difficulty**	Engineering Drawing N3	EGD L3 Paper 2
Conceptual Knowledge	0%	0%		Easy	31%	0%
Comprehension	0%	0%		Moderate	44%	100%
Application	75%	100%		Difficult	25%	0%
Analysis & Problem Solving	25%	0%				
Evaluation & Synthesis	0%	0%				

Table 50: Cognitive demands and levels of difficulty – Nov 2009 NC (V) Engineering Graphics and Related Design L3 Paper 2 and August 2010 N 3 Engineering Drawing

Levels of cognitive demands	Engineering Drawing N3	EGD L3		**Levels of difficulty**	Engineering Drawing N3	EGD L3 Paper 2
Conceptual Knowledge	0%	0%		Easy	31%	38%
Comprehension	0%	0%		Moderate	44%	62%
Application	75%	65%		Difficult	25%	0%
Analysis & Problem Solving	25%	35%				
Evaluation & Synthesis	0%	0%				

It is clear that application is the most favoured cognitive demand in all the question papers. However, it is clear that the Engineering Graphics and Design NC (V) L3 papers were intended to be pitched at the N3 level. The analysis of the levels of difficulty however indicates that the levels of the NC (V) L3 papers are of a much lower level of difficulty than the N3 papers.

It is, however, worth noting that the standard, format and quality of all the question papers analysed, although acceptable, are not comparable with the standard, format and quality of the FET schools examination papers, a conclusion not drawn from any formal analysis but from the evaluator's experience. The drawings are of a poor quality and not acceptable, the most noteworthy examples being the CAD generated drawings in the November 2009 NC (V) Engineering Graphics and Design NQF Level 3 Second Paper.

In order to create format templates that would simulate the high standard of the FET schools papers, it is suggested that the assistance of the FET schools' NSC examination panel should be requested to create such templates. The FET schools' NSC examination panel would also be able to assist in ensuring that drawings of future NC (V) papers would be of an acceptable standard.

The other major concern is the indication and allocation of marks. Although marks are indicated with all the questions of the Engineering Drawing N3 examination papers, there is no clear correlation between the mark indicated on the question paper and the mark allocation of the memorandum. This means that the candidates do not have a clear indication of all the assessment criteria.

The allocation of the marks for N3 is cause for concern. The marking guidelines simply state "CORRECTNESS". As there are no marks indicated on the drawings of the marking guidelines, there is no clear indication as to how the marks for the "CORRECTNESS" should be allocated. This means that the mark for "CORRECTNESS" is open to interpretation, which means that each marker could allocate marks differently.

Engineering Drawing N3 April 2010 examples

The question:

2.1 A full-sectional front view on cutting plane X-X *(10)*

2.2 A full-sectional top view on cutting plane Y-Y *(10)*

The marking guideline (mark allocation):

Correctness:

FSFV:	*6%*
FSTV:	*6%*
Linework:	*4%*
Accuracy:	*4%*
Total:	*20%*

(DoE: 2010)

What emerges from the NC: N3 and NC (V) L4 examination analysis of the selected subjects is that the NC: N3 subjects do not have Assessment Guidelines and the NC: N3 syllabus, which is the only document containing information on examinations, provides insufficient guidance on how to set the exam papers. The absence of such guidance with regard to the NC: N3 compromises the quality and the standard of the examinations across the various subjects. In comparison, the NC (V) has detailed Subject and Assessment Guidelines. Both these documents provide guidance on the practical assessment and examination. The Subject Guidelines provide information on the weighted values of topics in the examination. The Assessment Guidelines provide the suggested distribution of cognitive demands which should be used for the setting of the final examination papers.

The analysis reveals that the levels at which the subjects are assessed in the two programmes are significantly different. Firstly, the NC (V) has two question papers, a theory and a practical paper, while the NC: N3 has one paper, which is a theory paper. The practical paper of the NC (V), the ISAT, focuses on application and problem solving, while the focus of the theory paper is on knowledge and understanding.

Furthermore, the comparability of the examinations in terms of the levels of difficulty and cognitive demands indicates that because of the lack of sufficient guidance in the examinations of the NC: N3, the analysis of the subjects within the N3 came to different findings in terms of both the spread of levels of difficulty and the cognitive demands assessed. In two of the NC: N3 subjects, the analysis, making use of Bloom's revised taxonomy, indicates that not all six levels of cognitive demand are catered for in the examination papers, which is not the case with the NC (V) where there is an acceptable distribution across the various levels of cognitive demand of the subjects. However, in three of the subjects (Mathematics, Electrical Systems and Construction, Applied Engineering Technology and Engineering Graphics and Related Design), the cognitive demands examined do not correspond with the recommendations in the guidelines.


TRAIN

CHAPTER 4

4.1 HIGHVELD STEEL AND VANADIUM (EVRAZ): A CASE STUDY

The involvement of Highveld in this investigation was motivated by the realization that IN 2010, the company had placed an advertisement in which it was inviting learners who have successfully completed the NC (V) Level 4 qualification (among a number of other NQF Level 4 qualifications which would be recognized) to apply to the company for placement in an apprenticeship programme. The company, on which Highveld Steel and Vanadium Corporation Limited (Highveld) was founded, was established in 1957, when Minerals Engineering of Colorado built a plant in eMalahleni (previously called Witbank) to produce 1.4 million kilograms of vanadium pentoxide a year. Its expansion over the years, the global interest in the company and its established training facilities and apprenticeship offerings, make this company an invaluable source of information regarding the industry's involvement in the vocational sector.

Members of the QCC unit visited the training centre of Highveld Steel and Vanadium (Ltd) on the 19th October 2010 and again on the 16th November 2010. The purpose of the visits was to gain an understanding of how the company handled the training of NC (V) graduates who have been indentured in apprenticeship programmes in comparison to learners who have successfully completed the N3 Engineering Studies Programme.

Meetings and interviews were held with the apprentices, the training facilitators and the head of the training centre. It was envisaged that the visits would create an opportunity to use the company as a case study in terms of determining the comparability of the practical component within the NC (V), to the work experience component of the apprenticeship. Furthermore, it was felt the visits would assist in determining the differences/similarities of skills between NC (V) graduates and NC graduates, given the differences of the NC and the NC (V).

4.2 FINDINGS FROM THE CASE STUDY

4.2.1 Access to an apprenticeship programme for NC (V) graduates at Evraz Highveld

Currently, the company is accredited by Manufacturing, Engineering and Related Services Sector Education and Training Authority (Manufacturing, Engineering and Related Services SETA (merSETA) to offer five trades, which are Electrical, Millwright, Boilermaking, Instrumentation, and Fitting and Turning. The company has, since July 2010, been able to recruit ten NC (V) graduates who have been indentured into the apprenticeship programmes.

The intention was to put the ten NC (V) graduates through an accelerated programme of three months, although the normal programme usually takes six months. The graduates performed well on a diagnostic test, which is theoretical and which is used as an indicator of whether they are prepared to proceed to the practical. However, as the practical training proceeded, it was discovered that most of the NC (V) learners lacked some knowledge within the field and the company therefore extended their apprenticeship programme by another three months. As things stood then, access to trade testing was going to be based on the performance of the individual apprentices: the company will make a decision on the readiness of the apprentice based on performance of each individual apprentice. As it is, the quality of the learners they have presently suggests that although some of them may have the general required vocational background, they nevertheless need workplace exposure which will then prepare them for taking the trade test.

It was noted that the different NC (V) graduates from different FET colleges were at different levels in terms of the acquisition of knowledge and skills. The trainers noted an evident lack of a common standard among colleges in the implementation of the NC (V).

Another significant finding was the readiness of industry to engage with NC (V) graduates, which then dispels the assumption that industry is not receptive to the qualification. The company is even willing to form education-employment partnerships with the FET College in the area. Through the partnerships, the practical component of the NC (V) can be complemented with real work experience that will assist to produce graduates that are ready and prepared for accelerated apprenticeship programmes. Further study in this regard will reveal if indeed such a partnership will benefit the NC (V) graduates in terms of the acquisition of knowledge and skills and produce NC (V) graduates that are much better prepared for accessing an accelerated apprenticeship programme.

4.2.2 Collaboration with FET colleges

The difficulty of developing collaboration with FET colleges came under discussion during the meeting between Umalusi staff members, the head of training facilities at Evraz Highveld Steel and Vanadium and the training instructors at the training facility.

The company raised concerns about the lack of collaboration with the FET College which is located in the vicinity of the company. Although the company had expressed its willingness to assist and collaborate with the college, no response in this regard came back to Highveld Steel and Vanadium. The lack of collaboration makes it difficult for the company to harvest suitably-trained candidates from the college that meet their needs. The lack of collaboration also impacts on the kind of product that the college produces. Collaboration between the FET College and neighbouring industries would ensure that the FET College better meets the needs of those companies likely to employ their graduates. Collaboration would also mean that the company would make their facilities available for the ISAT, which did happen once in the past, through the initiative of the company.

All the apprentices interviewed came from areas outside Emalahleni.

4.2.3 Comparability between the practical component and work experience

During the site visit at the Highveld Steel and Vanadium premises, Umalusi representatives learned that the well-resourced workshops are used by the apprentices during the initial stages of their training. Only after having successfully gone through the simulated workshop environments are they allowed to proceed to do in-plant training. Safety and security measures are highly prioritized and practised in the workshops as preparation for work in the plant.

The fact that the NATED subjects have no formal practical tasks to support the respective sections in each subject as the learning process progresses is a major drawback. The practical component, in this case, the hands-on work experience and dedicated practical training, is in keeping with industry requirements because the employer determines and pays for it. The learner, in this case, is prepared for a specific industry, in a specific trade that benefits both the industry and the learner. So, while the NC (V) has a practical component, the NC (V) graduates indentured in the apprenticeship programmes were found to be at different levels in terms of acquisition of practical skills and knowledge. The problem seems to be with the lack of consistent standards in the implementation of the NC (V) curriculum: there was, however, one particular apprentice who was regarded as being at an acceptable level in terms of acquisition of knowledge and skills achieved through the NC (V) alone. Therefore, while it was not easy to come to any findings in terms of the comparability of the practical component and work experience, one can indicate that if the standard of implementation is at the required level, the NC (V) has the potential to produce graduates that can compare most favourably with those that came through the block release system.

CHAPTER 5

5.1 RECOMMENDATIONS

In this chapter, the co-existence of the NC (V) and the N – courses is considered in view of their history and present developments, and suggests some possible ways forward in the post-compulsory school environment. Once the larger picture is established, the findings regarding the strengthening of the curricula are provided as a set of recommendations.

5.2 THE NC (V) AND THE N –COURSES IN THE POST-COMPULSORY SCHOOL ENVIRONMENT

An analysis of the range of National Certificate: N1 – N3 programmes indicates that the genesis of the NC (V) owes a great deal to the NATED 190/191 instructional offerings, even while its relationship to the NSC (colleges) is very clear. The NC (V) inherits the practical part of its structure – within the colleges – from the N-courses, and it is clear from the NATED reports that the programmes being offered in the colleges were also intended for young people with a practical bent, who might have left school once the compulsory years were over. In other words, they were not necessarily designed for older learners or adults, even if these have become the traditional target groups for colleges.

In some senses an exception, the engineering N-courses may have had their practical component offered, by means of an apprenticeship, in the workplace, but this was ultimately not true for all students who enrolled to do the engineering N-courses. The structure of the NC (V) also looked to strengthen the academic/ fundamental aspect of the old National Senior Certificate offered in colleges, as well as the Senior Certificate, gained in colleges by combining Senior Certificate subjects with NC: N3 subjects. The fact that the N-courses were being phased out was a strong indication that the NC (V) would in time replace them altogether. In addition, the three times one year structure for the NC (V) was also clearly intended to allow for periods of study interspersed with being out in the workplace if so required.

In addition, the refurbishment (re-capitalisation) of the FET colleges in advance of the introduction of the NC (V) coincided with the neglect of the technical schools, and so it seems clear that the colleges were intended to become the locus of vocational learning (and for a great number of young people) while the schools would concentrate on the more academic side of education.

The potential usefulness of the one-year structure for the NC (V) at NQF Levels 2 – 4 was confounded by the admirable intent to ensure integrated assessment of the theory and the practical, which has meant that both the internal and the external assessment assess both theory and practice and report on both aspects with a single mark. The possibility of assessing and reporting on the practical and theory separately has the potential to allow for a modularised approach to the qualifications which could allow for part-time candidates to enrol for parts of the qualification on a trimester or semester basis, thus harnessing the single most appealing aspect of the N-courses, their model of delivery.

The separation of the assessment and reporting of the theory and practical, well handled, could happen without the loss of the interconnectedness of the two components, but would allow for the theory to be offered on a part-time basis. Further developments, such as the formal accreditation of the college workshops (and the concomitant rise in standard that it would presuppose) by the SETAs/Quality Council for Trades and Occupations, could mean that the student's time doing practical work could gain better formal recognition than is currently the case.

When the Minister of Higher Education and Training stayed the demise of the N-courses, the only ones allowed to continue were the short trimester ones associated with engineering studies. What had happened during the period of their phasing out was that certain of the engineering SETAs such as Chemical Industries Education and Training Authority (CHIETA), MerSETA and the Mining Qualifications Authority (MQA), went ahead and created modernised versions of the N-courses to suit their own purposes, and which in the event, have become the theory component of the three-part qualification structure envisaged for the trades. These versions, usually offered in industry facilities accredited by the SETAs, have frequently replaced the superannuated offerings in the colleges, and are certified by the SETAs themselves. This matter is being carefully considered by the National Artisan Moderating Body (NAMB) which is somewhat concerned that this move has created more than one standard for subjects which should have a national standard.

It is clear that, while consideration was given to the content of the N-course subjects in the development of the related NC (V) subjects, the curriculum developers were intent on modernising and strengthening the new curricula (sometimes too ambitiously) and ensuring that the NC (V) learners also had opportunities to acquire a range of workplace skills at the same time. So, while there is overlap, the newer curricula tend to point the way – that is, with the notable exception of Engineering Drawing, where the evaluator felt that certain valuable basics present in the N-course drawing subject needed to be re-considered for inclusion into an extended drawing subject for the NC (V). An alignment of the N-course theory with that of the NC (V) would allow part-time learners to be studying towards the powerful new qualification which, despite initial uncertainty, is starting to gain traction in the marketplace.

The versions of the N-courses that already form part of the occupational qualifications that will ultimately reside under the QCTO should be aligned to one another through the efforts of NAMB, and the possibilities of recognition and/or articulation remain a constant discussion between the NC (V) and the theory components of the occupational qualifications.

What this would ultimately mean is that the N-courses as we now know them would cease to exist: part-time students would enrol for the theory (or practical) components of the NC (V) at a particular level at colleges, or, if they are indentured apprentices, be able to offer the theory component associated with the occupational qualification for which they have signed up.

Different modes of delivery may be one – but certainly not the only – means of separating younger NC (V) students from older ones. The difficulty posed by having students of different ages in the classroom has repeatedly been cited as a challenge in the implementation of the qualifications. Delivery models could include having semester programmes (or trimester where this is possible) run concurrently with the standard NC (V) programme for adolescents. A programme which exclusively focuses on the vocational component for those who have achieved satisfactory exemption of the fundamentals would allow for a shorter period of learning – and a minimum of repetition in the system. The Department of Higher Education and Training ought to work pro-actively in guiding the FET colleges to diversify the ways in which they offer this flagship qualification. The colleges on their own cannot make these decisions without some positive indications from the DHET as they have funding implications and assessment implications which would impact on the entire system.

One of the delivery options, this time outside of the colleges, would be to revitalise the neglected technical schools and to locate the NC (V) there for adolescent learners. This scenario would mean that both the DBE and the DHET would be responsible for the qualification, and that Umalusi would potentially need to quality assure its delivery and assessment in both colleges and the technical/vocational schools. This option may mean that many more young people of school-going age would access the NC (V): it seems that many parents hesitate to send their children to college after Grade 8, feeling that they are too young to enter such an educational environment.

While the shape that the post-school environment will take on remains unclear, the turbulence caused by re-introducing the N-course programmes just as the NC (V) was starting to take hold has complicated the way forward. In many colleges, the N-courses are regarded as bringing in the bread and butter – they have been in the system a long time, therefore are familiar and easy to teach; they are short and one can get large numbers going through the system and paying. No consideration has seriously been given to the efficacy of the offerings and whether they serve the students achieving the National Certificate: N2 and the National Certificate: N3 in gaining access to the workplace. It is this latter issue which puts a question mark over the usefulness of these offerings as a smart solution to the challenge of servicing the needs of the so-called Not in Employment, Education or Training (NEET) group, who are not in employment, education or training. And it was presumably to cater for this group that the N-courses were so rapidly re-introduced. (Nor, it must be said, can the NC (V) address the needs of that group, at least without the changes sketched above.)

One of the limitations of this research is that the usefulness of the N-courses *in relation to the needs of apprentices and successful artisans* has not been evaluated. This is an undertaking that lies more appropriately in the realm of the Quality Council for Trades and Occupations. Nevertheless, by using evaluators deeply embedded in both the NATED and NC (V) systems, some observations have been possible about the relationship between the existing N-courses and the NC (V) engineering programmes.

5.3 CURRICULUM CHANGES WITH REGARD TO THE N-COURSES

In most of the subjects evaluated, the evaluation suggests that there is a significant amount of new content in the NC (V) subjects, except for the NC (V) Engineering Graphics and Design, which contains less content than the N3 Engineering Drawing. If the N-courses are to serve a useful function, then both the structure and content of the syllabuses will need to be reviewed in order to update them.

The syllabuses of the NC: N2 and NC: N3 need to be more detailed because currently they do not provide sufficient guidance to the lecturers in terms of content depth and breadth or assessment. The syllabus only provides content in the form of topics. Therefore the syllabus needs to be better structured so that there are clear subject objectives that are achieved through clearly specified outcomes which will help to define the breadth and depth of the content to be covered.

The content will also need to be more conceptually demanding because currently most of the content is dealt with at cognitively lower levels. For example, the outcomes for the N-course exams appear to be confined to recall, the description of undertaking of routine procedures and solving problems which are familiar to the students, and which are therefore less problem-solving in nature and more recall-like. The exams have also become quite predictable because there are three exams per year to cover the very minimal content, and as such they are far much easier to pass than those of the NC (V). Furthermore, there needs to be guidance for the lecturers in the form of Examination/Assessment Guidelines because the lack of such documents compromises the standard and quality of the assessment and examinations.

Recommendation 1: The much called-for re-curriculation of the N-course syllabi is needed not only to update the content of the courses, but also to provide specified objectives or outcomes for each curriculum to guide the teaching, learning and assessment. In doing so, the assessment model needs to be revivified to ensure that the exams become more varied and genuinely testing of people's understanding.

5.4 CURRICULUM AND RELATED IMPLEMENTATION CHANGES WITH REGARD TO THE NC (V)

In those NC (V) subjects that were found to have more content than the N-courses subjects, some of the content was pitched at a level that contributes to the NC (V) curriculum overload, and which made the curriculum too demanding to teach and learn. The analysis indicates that some content that appears in Mathematics NC (V) L4, Engineering Systems NC (V) L2, Materials Technology NC (V) L3 and Applied Engineering Technology NC (V) L4 appears at NC: N4 to NC: N6 Level, and ought to be reconsidered and probably removed.

Furthermore, the three subjects that correspond to Engineering Science should be designed in such a manner that they become consistent in terms of sequencing and progression of content and skills in order to form a more unified, cohesive learning programme.

While a very small percentage of gifted learners, who are focused, have a good understanding of what NC (V) entails, the NC (V) appears difficult for the majority of learners to achieve. For example, the NC (V) at Level 2 is pitched at a high level for those learners interacting with vocational subjects for the first time.

To ensure that the practical component is given its due in the NC (V), a proper practical and theoretical timetable for NC (V) must be designed and implemented from the highest authority, the Department of Higher Education and Training (DHET). Such a timetable for the practical will ensure that time is given to the practical training; it should not be left to the individual lecturers to decide when the practical training should take place, and how much of it there is.

Appropriately qualified lecturers should be used to conduct the practical training. If qualified lecturers cannot be found, then appropriate training must be given to the available lecturers. All the lecturers responsible for teaching engineering subjects should form communities of practice (including local industry as a stakeholder) and meet regularly to discuss the inter-relationship between the core subjects and any new developments that might affect the content. The involvement and collaboration with industry is critical. The colleges should tap into the expert knowledge and experience of industry experts for the purposes of improving the workshops so that they are relevant in meeting the needs of industry. Ideas can be exchanged between different colleges nationally on the same subjects.

With regard to Engineering Drawing and Engineering Graphics and Design, the recommendation is for a dedicated drawing subject that could be implemented for all three levels (L2, L3 and L4) of the NC (V). The NC (V) L2 course should retain the NC: N1 and NC: N2 fundamentals for drawings as the focus and the NC (V) L3 course should contain all the relevant content from the NC: N2 and NC: N3. Computer Aided Design (CAD) must also be included in the N1 – N3 courses in the event that re-curriculation does occur.

Recommendation 2: With regard to Engineering Drawing and Engineering Graphics and Design, a dedicated drawing subject should be implemented for all three levels (L2, L3 and L4) of the NC (V). The NC (V) L2 course should retain the NC: N1 and NC: N2 fundamentals for drawings as the focus and the NC (V) L3 course should contain all the relevant content from the NC: N2 and NC: N3. Computer Aided Design (CAD) must also be included in the N1 – N3 courses.

Recommendation 3: Some content in Mathematics NC (V) L4, Engineering Systems NC (V) L2, Materials Technology NC (V) L3 and Applied Engineering Technology NC (V) L4 appears to have been drawn down into the NC (V) from NC: N4 – NC: N6 Level. A review of the individual curriculum for each of these subjects, preferably done with established experts from industry and the SETA processes as well as experienced college staff, should evaluate the extent and nature of the content and remove whatever is inappropriate.

5.5 POSSIBLE RECOGNITION OF LEARNING/EXEMPTION

In connection with the three NC: N3 subjects: Mathematics, Engineering Science and Electrical Trade Theory, it was noted that much of the NC (V) content is omitted from the N2-N3. In other words, the NC (V) contains a lot of new content that is not in NC: N2-NC: N3, which is not surprising given the duration of the qualification at each level. In addition, the NC (V) content is also better specified than that of the N2-N3, which should ideally make clear what is required for the delivery of the NC (V) curriculum. As a result of this additional content, it is not advisable to condone the transfer of an NC: N2 learner to NC (V) Level 3, or for an N3 learner to transfer to NC (V) Level 4, because they will almost certainly be disadvantaged because of the omissions in the NC: N2 and NC: N3.

Furthermore, the NC (V) was designed to have both a practical and a theoretical component whereas the N courses were designed to have only a theoretical component. As a result it is not advisable for a learner to transfer from the N courses to the NC (V) at any level because they will not be able to make up for the practical component which is not part of the N courses, unless of course, they have gained the necessary practical experience in the workplace. However, with the exception of Engineering Drawing and the related NC (V) subjects, an NC (V) L2 learner could be exempted from NC: N2, and an NC (V) L3 learner could be exempted from NC: N2 and NC: N3 because very little NC: N2 and NC: N3 content has been omitted in the NC (V).

Recommendation 4: No candidate with an N-certificate at NC: N1 – NC: N3, based only on the knowledge so acquired, can reasonably be expected to gain access to and succeed at any NC (V) level.

However, with the exception of Engineering Drawing and the related NC (V) subjects, an NC (V) L2 learner can be exempted from N2 and an NC (V) L3 learner can be exempted from N2 and N3 because very little content that appears in the NC: N2 and NC: N3 has been omitted in the NC (V).

Recommendation 5: For the N3 Engineering Drawing, however, the recommendation is:

All the N-certificates for Engineering Drawing should be recognized as:

- NC: N1 and NC: N2 for entry into Engineering Graphics and Design Level 3
- NC: N3, on condition that a CAD training course has also been completed, for any Level 4 Engineering (Technological) drawing subject.

5.6 LEVEL OF ACCESS TO APPRENTICESHIPS IN RESPECT OF THE NC (V) SUBJECTS

Three of the subjects evaluated are not directly trade subjects (Mathematics, Engineering Science and Engineering Drawing). The only subject which is a trade subject is Electrical Trade Theory. Therefore the recommendations in this section apply only to the subjects relating to Electrical Trade Theory which are Electrical Principles and Practice L2 – L4, Electrical Systems and Construction L2 – L4, Workshop Practice and Electrical Workmanship L3 and L4.

Given the weightings in internal assessment for the theoretical and practical components, the implication is that the bulk of the 200 hours of teaching and learning time per level should be spent on the practical component. The practical component therefore makes up a large part of the qualification in most of the vocational subjects within the engineering programmes. Upon completion of the qualification, a learner who has been through all three levels of the NC (V) shall have effectively spent 360 hours of teaching and learning time on the practical component of one vocational subject and 240 hours of teaching and learning time on the theory of the same vocational subject. The practical component of the qualification is externally moderated and examined according to Umalusi's quality assurance mechanisms.

Furthermore, NC (V) learners spend much more time on the theory than NC: N2–NC: N3 learners who spend only about 10 weeks on theory. An NC (V) Level 2 graduate will have spent about 80 hours of teaching and learning time on one vocational subject. That is far better preparation in comparison to that provided by NC: N2–NC: N3 subjects, where learners effectively have about three weeks of teaching and learning time per vocational subject. Furthermore, the analysis indicates that the longer duration of the NC (V) is also evident in the breadth of the contents as contained in the curricula of the various vocational subjects within the engineering programmes of the NC (V) in comparison to those of the engineering subjects within the NC: N2–:NC N3: Engineering Studies.

The Skills Development Amendment Act, Act No 20 of 2008, states that for a vocational qualification to be recognised for undergoing a trade test, the qualification should be "inclusive of prescribed work experience".

Based on the information above it is recommended that formal recognition be given of the duration spent on the practical component of the NC (V) for the purpose of reducing time spent acquiring on-the-job training for the purpose of gaining access to trade testing and acquiring an artisanship qualification.

Recommendation 6: Assuming that the quality of implementation of the NC (V) improves in colleges, the time spent on the practical component in the NC (V) programmes should be recognized and help to reduce the amount of time required for on-the-job training. This could certainly happen if the SETAs, through the QCTO, were to accredit, and so recognise, the college workshops, as once was the case with the Industry Training Boards (ITBs).

5.7 THE ROLE OF THE N-COURSES

The N-courses were traditionally a vehicle to accommodate those learners who could not afford to go to universities or whose academic achievement was such that they did not qualify for university entry but who could be absorbed by industries after they successfully completed the N2.

The N-course programmes were in the process of being phased out, when in May 2010, the Minister of Higher Education and Training reversed the decision and declared that the National Certificates N1 – N3 were granted extension in terms of Gazette 33200. Their extension, just before they were completely phased out, is a belated recognition that the N-courses serve a different purpose to the one served by the much bigger NC (V). This gazette also re-opened the N-courses, which are offered on a block release system, to the general populace rather than just to indentured apprentices. The N-course programmes thus also cater for part-time learners, which remains a challenge with regard to the delivery of the NC (V), because FET colleges do not yet accommodate part-time learners, particularly those who want to complete the NC (V) while working.

5.8 THE RELATIONSHIP BETWEEN THE N1 – N3 AND N4 – N6

The N1-N3 offer the only direct throughput to the N4 – N6 programmes. The N4-N6 programmes will cease to exist without a steady throughput of learners from the N1 – N3 programmes (unless articulation from the NC (V) is developed).

Recommendation 7: A revitalised set of N-course subjects are a prerequisite for supporting the knowledge component of the engineering occupational qualifications, and can provide an institutional learning opportunity that supplements on-the-job training, and should therefore be put in place. It is possible that the re-curriculation process could bring the N-courses closer to the theory components of the NC (V) which might then allow for greater flexibility and better articulation in the FET system.

Recommendation 8: Better career guidance is required at colleges regarding suitable combinations of N-course subjects: many students are not advised or poorly advised at best, and choose subject combinations which are not considered attractive by prospective employers, and which also do not allow them to access the trade test.

Recommendation 9: The trajectory for the engineering programmes of the N courses, if they are well offered and offered as intended, is into the workplace, into an engineering or manufacturing environment. The N-courses should therefore only be accessible to people who are in employment as was originally the case. These are people who only require the knowledge component of their trade. The trimester structure for the Engineering Studies presumably was developed with the idea in mind that the candidates were meaningfully occupied for the remaining two-thirds of the year – a reality which frequently does not transpire. Instead candidates end up with N3, having studied full-time for a year, but with no commensurate experience to back it up. (It was to give candidates such as these opportunities to acquire practical knowledge and skills that the NC (V) was developed). Hence, the reporting of the NC (V) could then be structured such that the practical mark and theoretical mark are recorded separately. Such separate reporting on the practical and theoretical components will enable those learners who are already in employment/ apprenticeships to just enrol for the theory of the NC (V) and for those learners who are outside of employment to get both the theory and practical exposure through the NC (V).

The N-certificates should only be retained if the delivery model of the NC (V) cannot be made flexible such that it accommodates the following learners:

- Those learners who were unable to complete a particular NC (V) level, and who are in employment and yet want to complete the qualification;
- Those learners who are in apprenticeship/employment and want to achieve the qualification through a block release system.

5.9 THE ROLE OF THE NC (V)

The NC (V) Engineering Studies differs significantly from its NC: N1 – NC: N3 counterpart in that the formal learning for the NC (V) takes three years as opposed to the one. What the NC (V) offers is almost two years of practical and just over one year of theory (assuming it is being offered as intended). While cautious recognition for the value of NC (V) graduates is starting to emerge, others are concerned that it is for instance, too long or too academic and therefore inaccessible to those who did the N Engineering Studies courses previously.

The NC (V) is not only based on the Engineering programmes. It should be remembered that the NC (V) was intended to respond to the fact that the N-courses on their own did not necessarily mean that successful candidates gained employment. The NC (V) was thus designed to provide both a more substantive theoretical base as well as ample opportunity to gain practical experience, even if it were in workshops and practicum rooms rather than in the workplace with the intention that successful NC (V) learners would be much more highly employable than learners exposed only to the theory in the N-course programmes.

Nevertheless, this research has indicated that, implementation challenges aside, the NC (V) could be strengthened through the review of curricula for the engineering subjects along the lines indicated in the subject chapters of this report.

Umalusi advised the Department of Higher Education and Training regarding credit transfer for certain subjects from the NSC to the NC (V), which would allow successful school-leavers to be exempted from the fundamentals, allowing them to focus on the vocational subjects. This, in effect, would allow colleges to provide an alternative form of delivery for that cohort of learners, which could be much quicker than the full three years it now takes. Such an alternative might also fit in with some form of block release system.

Recommendation 10: The DHET should strongly advise the colleges to provide an alternative programme for candidates who have been exempted from the fundamental subjects. Currently students who have recognition for their NSC subjects simply have free periods. Here is an ideal opportunity for creating the accelerated form of the NC (V) that the colleges were keen to re-introduce.

Recommendation11: During the review of the NC (V) engineering curricula, the possibilities of having an introductory NC (V) Level 1 (or General Education and Training Certificate for Adults (GETCA) serving much the same purpose) and/or a Level 5 option should be considered. Both ideas have been mooted, but the need for one or both possibilities would need to be interrogated while the progression of knowledge and skill for each of the subjects is carefully considered.

Umalusi, however, proposes that the subjects should be revised sequentially working from the ones that need most fixing gradually back to the ones which need the least attention. *Under no circumstances* should all the NC (V) engineering subjects be reviewed simultaneously.

5.10 ARTICULATION BETWEEN THE NC (V) AND OTHER QUALIFICATIONS

a) NSC and NC (V)

Umalusi researched the relationship between the fundamental subjects in the NSC and the NC (V), and, though it is not part of this research, one of the recommendations from that report was that credit transfer between the NC (V) and the NSC for the evaluated subjects be allowed. The department has not yet fully implemented this recommendation. Umalusi made the recommendation in 2010 and the DHET circular was issued in 2012, and yet the DHET has not provided any guidance with issues of how the NC (V) can then be accelerated for those learners who have had the CAT (See recommendation 10 above).

Umalusi is finalising the Life Orientation project which considers the possibility of articulation between Life Orientation in the NC (V) and in the NSC. A comparative curriculum analysis was conducted, which reveals lessons for the NSC as well.

b) NC (V) and N-courses

With small changes to the structure of assessment it will be possible to report separately on the practical and the theory, if that were so, it would be so that the theory of the N-courses could be replaced by that of the NC (V). Alternatively, if one had workshops formally recognised by the SETAs as was the case with the old ITBs in the colleges, then a strengthened practical component could gain greater recognition, particularly if colleges are persuaded of the importance of co-operating with local industries.

c) NC (V) and Higher Education

The DHET regulated the admission requirements for the NC (V). Indeed the requirements for the NC (V) are more stringent that those of the NSC. There has never been any explanation as to the reasons. It is clearly not fair for the NC (V) students to have a standard that is higher than that of the NCS. There is a need for the requirements to be reviewed.

5.11 CONCLUSION

This evaluation entailed the analysis of four subjects, three of which are not trade tested because they do not relate to any specific trade. However, these subjects are significant in terms of providing some basic theoretical support in Mathematics, Science and Drawing towards preparation for trade testing in a number of trades. In some instances, industry will indenture apprentices on the basis that they have passed these subjects only, even though they do not have a specific trade subject (e.g. Mining Qualifications Authority requirements). Therefore, even if these subjects are not coupled to a trade test, they play a significant role in terms of providing the knowledge required for learners to succeed in an apprenticeship programme.

While the analysis revealed that the NC (V) curriculum is better organized and more substantive than the NC: N2– NC: N3 courses in three of the evaluated NC: N2 – NC: N3 subjects, the challenges noted in the NC (V) curriculum include curriculum overload. Overloading may lead to superficial coverage of the content. While the N4–N6 were not under investigation, the evaluators, because of their experience, noted that content from the N4–N6 is included in the NC (V). A further comparison between NC (V) and the N4–N6 would help to establish the extent of the overlap, and its effect on the higher levels of the NC (V) qualifications.

The high failure rate, even though not a focus in this investigation, may in part be a result of content overload, and the inclusion of content that is beyond the level of the intended target group. The NC (V) can be strengthened by ensuring that the content that is contained in the curriculum is at the right level for the intended target group and is also pruned to ensure that coverage occurs at a more appropriate depth. Such revision would help produce learners that are knowledgeable and sufficiently skilled to meet the demands of industry, and are able to engage in lifelong learning. It is worth mentioning in conclusion that the pass rates for 2010 have improved somewhat. The figures indicate that in 2009 there were about 500 certified NC (V) L4 candidates and that figure doubled to 1 000 in 2010. Even though the figure does not reflect a great record, a 100% increase nevertheless suggests that the colleges are beginning to understand the NC (V) and are teaching it better.

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Annexure A

The Evaluation Instrument

Section 1: Mapping Instrument – Curriculum Analysis

1. Content Specification

1. In Table 1: Identify *all* the major content areas represented in the different curricula and list these in Column 1. After naming each area/ sub-area of content, in the same column, estimate the apparent cognitive complexity level of each area/ sub-area of content, as *difficult, moderate*, or *easy*. Use the degree to which the content is abstract, theoretical, and based on disciplinary-specific knowledge that cannot easily be learned outside a school context, to estimate this degree of difficulty.
2. Indicate whether the content specified is covered in each curriculum in the columns marked "**Specified**" with a **Y** for "yes" and an **N** for "no" (Please indicate where it is specified, namely a particular curriculum).
3. Indicate whether the content specified forms part of examinable content in the final exam. Enter an **E** for "Examinable" and an **N** for "Not examinable" in the boxes marked "**Examinable**".

Table 1: Table for recording analysis of content

SUBJECT	
Full bibliographical details of curriculum documents	**#**
	1
	2

1. Content required	CONTENT DETAILS					N1		N2		N3		NC (V) L2		NC (V) L3		NC (V) L4	
List all content described in the curriculum documents here (include document and page references please)	Document #	Page	Easy	Medium	Difficult	Specified	Examinable	Specified	Examinable	Specified	Examinable	Specified	Examinable	Specified	Examinable	Specified	Examinable
(add as many rows as are needed)	1																
	8																
	3																
Totals																	
% Discipline-specific curriculum content																	
% Curriculum content that is general information																	

2. Skills specification

1. In the table below, list all the skills that have been specified in the curriculum and make a complete list of these skills in Column 1 of the table immediately below. In so doing, estimate and place each skill under the most likely *type of cognitive demand* required.
2. In the table classify skills as either discipline-specific and required for a single subject only; as generic cross-cutting skills useful for more than one subject; or as everyday skills

required by school leavers in order to cope with everyday living (please note that the generality of skills does not imply that they are easy: they may be cognitively demanding, but general). Once you have rated all the skill areas, please make a global judgment as to how many skills are subject-specific, how many are relevant to several subjects, and how many are general.

Table 2: Table for recording analysis of skills

Skills specified	SKILL DETAILS			NC (V) L2			NC (V) L3			NC (V) L4			N2			NC (V) L2			NC (V) L3			NC (V) L4			N-3		
List all skills described (1.4=yellow; 1.5=blue; 1.6=green) (include document and page references please)	**Document #**	**Page**	**Easy**	**Discipline %**	**Generic %**	**Everyday Application %**	**Discipline %**	**Generic %**	**Everyday Application %**	**Discipline %**	**Generic %**	**Everyday Application %**	**Discipline %**	**Generic %**	**Everyday Application %**	**Discipline %**	**Generic %**	**Everyday Application %**	**Discipline %**	**Generic %**	**Everyday Application %**	**Discipline %**	**Generic %**	**Everyday Application %**	**Discipline %**	**Generic %**	**Everyday Application %**
E.g. Add 3-digit numbers (basic)	1		B																								
E.g. Multiply 3 algebraic terms (application-familiar)	1		A F																								
E.g. Integrate the square root (application-new)	3		A n																								
Etc.																											
Totals																											
% Discipline (subject)-specific skill																											
% Generic cross-cutting skills																											
% Everyday application																											

3. Concluding tasks

1. With reference to Table 1:
   (a) List all the content/elements that are overlapping between the N2 and the NC (V)
   (b) Estimate the percentage of content overlap between the N2 and the NC (V) subjects.
   (c) Looking at the content overlap between the N2 and the NC (V) subjects, mention and describe the content that is lacking in the different curricula.
   (d) List all the content/elements that are overlapping between the N3 and the NC (V).
   (e) Estimate the percentage of content overlap between the N3 and the NC (V) subjects.
   (f) Looking at the content overlap between the N3 and the NC (V) subjects, mention and describe the content that is lacking in the different curricula.

2. With reference to Table 2:
   (a) List the skills that are overlapping between the N2 and the NC (V).
   (b) Estimate the percentage of overlap in skills between the N2 and the NC (V) subjects
   (c) Looking at the overlap in skills, mention and describe the skills that are lacking between N2 and NC (V)
   (d) List the skills that are overlapping between the N3 and the NC (V).
   (e) Estimate the percentage of overlap in skills between the N 3 and NC (V) subjects
   (f) Looking at the overlap in skills, mention and describe the skills that are lacking between N 2 and NC (V)
3. With reference to Table 1, Content details/ level:
   (a) Which of the curricula tends to be easier and which tends to be most demanding? Please motivate.
   (b) In your opinion, is there notable content of **even demand** duplicated in the NC (V) subjects? If so please provide examples of such.
4. With reference to Table 2:
   (a) In your opinion, are the analysed curricula significantly different? Please provide motivation for your answer.
   (b) Which curriculum carries the highest percentage of discipline matter?
5. Based on the data collected:
   (a) Do the NC (V) subjects that correspond to the N2 subjects sufficiently prepare candidates for trade testing?
   (b) Do the NC (V) subjects that correspond to the N3 subjects sufficiently prepare candidates for trade testing?
   (c) In your opinion, which NC (V) level is the most appropriate in terms of preparation for access to trade testing?
6. Keeping in mind the duration of the NC (V) at each level in comparison to that of the N2 and N3, and the inclusion of both theoretical and practical components and several assessment opportunities provided by the NC (V), in your opinion, does the NC (V) prepare the candidates well to be able to access trade testing? Please motivate your answer.
7. With reference to your answers in questions 4, 5(a) and (b) and 6, what would your recommendation be with regard to access to trade testing NC (V)?
8. Please comment on whether you think the instrument was useful in assisting you with the comparison of the various curricula. Please motivate for your answer.

Section 2: Comparative Analysis – Examination Analysis

For completing Exam Analysis Table:

1. Closely analyse the 2009 NC (V) examination papers for your subject, and report on the following per question (or per subsection of the question, whichever is the smaller of the units):
   - Please enter the **exam paper** code at the top of each table (indicate in abbreviated form, the subject, paper number (1, 2, 3), and the date of the paper;
   - In Column 1 (the "item" column) of the **Exam Analysis Table** please place the **question, or the subsection** of the question, (if, in your opinion, one or more subsections of a question could stand independently, please treat it as a separate item in the table);
   - In Column 2 marked **"max" (for maximum mark)**, enter the mark for that item;
   - In Column 3, enter the **type of cognitive demand** and level of **cognitive difficulty** in Column 4, using the typology on the next page as based on Bloom's Revised Taxonomy (2001):

Type of Cognitive Demand	Level of Difficulty	Explanation and examples of level
Conceptual knowledge - Recall and recite knowledge - Define and describe - Identify, label, select, locate information - Estimation; appropriate rounding of numbers - Theorems - Straight recall - Identifying from data sheet - Know and use of appropriate vocabulary - Knowledge and use of formulae	**Easy**	Very simple recall, State a simple law or equation; Recognize content in MCQ; For instance: Read information directly from a table (e.g. the time that bus number 1234 departs from the terminal).
	Moderate	Medium content, learnt diagrams For instance: Know and use appropriate vocabulary such as equation, formula, bar graph, pie chart, Cartesian plane, table of values, mean, median and mode.
	Difficult	Recall complex content For instance: Know and use formulae such as the area of a rectangle, a triangle and a circle where each of the required dimensions is available.
Comprehension - Understanding of previously acquired information in a familiar context, - Regarding information gathering: change or match information, - Regarding use of knowledge: distinguish between aspects, compare and predict, defend and explain	**Easy**	Simple relationships; simple explanations; 1 step answers; derivation of units
	Moderate	Counter-intuitive relationships; Qualitative proportional reasoning; more complex relationships or explanations; 2 steps to arrive at answer, simple applications; interpretation of realistic diagrams
	Difficult	Identify principles which apply in a novel context; explaining complex reasoning involving synthesis, critical argument; novel or abstract contexts etc.
Application - Interpret and apply knowledge; - Choose, collect and do basic classification of information; - Modify existing by making use of the existing knowledge; - Using well-known procedures (The required procedure is, however, not immediately obvious from the way the problem is posed.) - Candidates to decide for instance on the most appropriate procedure to solve the solution to the question and may have to perform one or more preliminary calculations before determining a solution. - Select the most appropriate data from the options - Decide on the best way to represent data to create a particular impression.	**Easy**	Perform well-known procedures in familiar contexts. Learners know what procedure is required to solve the problem from the way the problem is posed. All of the information required is immediately available to the candidate.
	Moderate	Draw for instance data graphs for provided data; Draw algebraic graphs for given equations. Accuracy
	Difficult	Measure for instance dimension such as length, time and weight using appropriate measuring instruments sensitive to levels of ^^^^

Type of Cognitive Demand	Level of Difficulty	Explanation and examples of level
Analysis & Problem-solving - Analysis of information in a new or unfamiliar context; - Examine and differentiate; - Distinguish to find the most appropriate; - Research and investigate information - Solving non-routine, unseen problems by demonstrating higher level understanding and cognitive processes - Interpreting and extrapolating from solutions obtained by solving problems based in unfamiliar contexts - Using higher level cognitive skills and reasoning to solve non-routine problems - Being able to break down a problem into its constituent parts identifying what is required to be solved and then using appropriate methods in solving the problem - Non-routine problems based on real contexts	**Easy**	Simple procedure (e.g. plug into formula with only one unknown; no extraneous information; known or practiced context; simple chemical equation)
	Moderate	Solving non-routine, unseen problems by demonstrating higher level understanding and cognitive processes For instance: Sketch graphs; construction or interpretation of schematic diagrams; problems with 2 or more steps; basic logic leaps; proportional reasoning; interpretation of table of data; acid-base or redox equation
	Difficult	Complex abstract representation; combination of concepts across sub-fields; Interpreting and extrapolating from solutions obtained by solving problems based in unfamiliar contexts Using higher level cognitive skills and reasoning to solve non-routine problems Being able to break down a problem into its constituent parts – identifying what is required to be solved and then using appropriate methods in solving the problem
Evaluation & Synthesis - Making judgment (evaluate), critique, and recommend by considering all material available; - Weigh possibilities and do recommendations - Construct new; - Synthesise, create or find innovative solution; - Formulate new ideas	**Easy**	Opinion, giving general critique
	Moderate	Substantiated opinion Critique solutions to problems and statements about situations made by others.
	Difficult	Generalise patterns observed in situations, make predictions based on these patterns and/or other evidence and determine conditions that will lead to desired outcomes. Working with complex problems involving insight and logic-leaps; formulating new equations (using all unknowns; creating new solutions to problems; redesign)

Exam Analysis Table: Analysis of NC (V) Level 4 examination papers

e.g. Mathematics P1	C2	C3	C4	C5	C6	C7	C8
Item	Max	Type of cognitive demand	Level of Difficulty	Content/ skill/ topic	Comment	NC (V) L4 assessment standard	NC (V) PAPER
eg.1.1.1	2						
eg.1.1.2	2						
e.g.1.1.3	2						
eg.1.1.4	2						
eg.1.1.5	2						
…	1						
5.3.1	3						
5.3.2	4						
TOTAL	150						
Qu 1	50			% BE; BM; BD			
Qu 2	25			% CE; CM; CD			
Qu 3	25			% PE; PM; PD			
Qu 4	25						
Qu 5	25						
Total	150						

(Please note: Add as many rows as are needed)

Concluding tasks

Once you have completed the analyses of the 2009 final NC (V) papers, please submit a written report with full responses to the questions that follow. Please answer fully, and provide evidence for all of your answers based on countable facts from the tables for your analysis.

1. In your opinion, do the 2009 exam papers comply with the Subject Assessment Guidelines (SAG)? Use your findings from Column 3 and 4 in the **Exam Analysis Table** as reference in your answer. Refer to both DoE and IEB exam papers. (Maximum number of words: 300).
2. From your analysis of the 2008 and 2009 final papers, are these examinations, in your opinion, roughly of a comparable standard? Please motivate and provide evidence for your position especially when you find that there are large discrepancies in the standards of these exams (maximum number of words: 300).
3. In your opinion, are the 2008/9 final papers themselves a good model for future examinations, or should their format be critically re-examined immediately? Please make specific suggestions (maximum number of words: 300).

Documentation used

Umalusi provided the following documentation for the curriculum analysis:

Electrical Trade Theory/Electrical Systems and Construction/ Electrical Principles and Practice/Workshop Practice/Electrical Workmanship

- Electrical Systems and Construction Subject Guideline Level 2
- Electrical Systems and Construction Subject Guideline Level 3
- Electrical Systems and Construction Subject Guideline Level 4
- Electrical Principles and Practice Subject Guidelines Level 2
- Electrical Principles and Practice Subject Guidelines Level 3
- Electrical Principles and Practice Subject Guidelines Level 4
- Workshop Practice Subject Guidelines Level 2
- Electrical Workmanship Subject Guidelines Level 3
- Electrical Workmanship Subject Guidelines Level 4
- Electrical Trade Theory N2 Syllabus
- Electrical Trade Theory N3 Syllabus

Engineering Science/Engineering Systems/Materials Technology/ Applied Engineering Technology

- Engineering Systems Level 2 Subject Guidelines
- Materials Technology Level 3 Subject Guidelines
- Applied Engineering Technology Level 4 Subject Guidelines
- Engineering Science Syllabus N2
- Engineering Science Syllabus N3

Mathematics

- Mathematics Subject Guideline Level 2
- Mathematics Subject Guideline Level 3
- Mathematics Syllabus N2
- Mathematics Syllabus N3

Engineering Drawing/Engineering Technology/Engineering Graphics Design

- Engineering Technology Subject Guidelines Level 2
- Engineering Technology Assessment Guidelines Level 2
- Engineering Graphics and Design Subject Guideline Level 3
- Engineering Graphics and Design Assessment Guideline Level 3
- Engineering drawing – syllabus N1
- Engineering drawing – syllabus N2
- Engineering drawing – syllabus N3

The most recent version of each of these curriculum documents was consulted for each subject

The following documentation was considered for the exam paper analyses:

Electrical Trade Theory/Electrical Systems and Construction/Electrical Principles and Practice/ Workshop Practice/Electrical Workmanship

- Electrical Systems and Construction Assessment Guideline Level 4
- Electrical Systems and Construction Level 4 Question Paper 2009 November
- Electrical Systems and Construction Level 4 Memorandum 2009 November
- Electrical Principles and Practice Assessment Guidelines Level 4
- Electrical Principles and Practice Level 4 Question Paper 2009 November
- Electrical Principles and Practice Level 4 Memorandum 2009 November
- Electrical Workmanship Assessment Guidelines Level 4
- Electrical Workmanship Level 4 Question Paper 2009 November
- Electrical Workmanship Level 4 Memorandum 2009 November
- Electrical Trade Theory Question Paper 2010 April
- Electrical Trade Theory Memorandum 2010 April
- Electrical Trade Theory Question Paper 2010 August
- Electrical Trade Theory Memorandum 2010 August

Engineering Science/Engineering Systems/Materials Technology/Applied Engineering Technology

- Applied Engineering Technology Assessment Guidelines Level 4
- Applied Engineering Technology Level 4 Question Paper 2009 November
- Applied Engineering Technology Level 4 Memorandum 2009 November
- Engineering Science N3 Question Paper 2010 April
- Engineering Science N3 Memorandum 2010 April
- Engineering Science N3 Question Paper 2010 August
- Engineering Science N3 Memorandum 2010 August

Mathematics

- Mathematics Subject Guideline Level 4
- Mathematics L4 Question Paper 2009 November
- Mathematics L4 Memorandum 2009 November
- Mathematics N3 Question Paper 2010 April
- Mathematics N3 Memorandum 2010 April
- Mathematics N3 Question Paper 2010 August
- Mathematics N3 Memorandum 2010 Augustt

Engineering Drawing/Engineering Technology/Engineering Graphics Design

- Engineering Technology Assessment Guidelines Level 2
- Engineering Technology Level 2 Question Paper 2009 November
- Engineering Technology Level 2 Memorandum 2009 November
- Engineering Graphics Design Assessment Guidelines Level 3
- Engineering Graphics Design Level 3 Question Paper 2009 November
- Engineering Graphics Design Level 3 Memorandum 2009 November
- Engineering Drawing N3 Question Paper 2010 April
- Engineering Drawing N3 Memorandum 2010 April
- Engineering Drawing N3 Question Paper 2010 August
- Engineering Drawing N3 Memorandum 2010 August

MATHEMATICS

(a) Content/skills mapping between Mathematics N2 and Mathematics NC (V) L2 – L4

The following six topics are covered in the N2 only and excluded in the NC (V) L2 to L4 curricula:

- Simplifying logarithmic expressions using logarithmic laws
- Solving logarithmic equation
- Exponential equation with common factors and in the form $5^{3x+6} = 1$
- Manipulating technical formulae using logarithmic laws
- Angular velocity and peripheral velocity
- Calculating heights and distances using trigonometric ratios

The following topics are covered in NC (V) L2 to L4 curriculum but excluded in the N2 curriculum:

- Converting terminating and recurring decimals (rational numbers).
- Converting surds to rational numbers
- Exponential equations which can be converted to quadratic equations
- Solving quadratic equations by completion of a square
- Arithmetic progression, sequence and series
- Complex numbers: standard and polar form; applying basic operations on complex numbers
- Representing complex numbers in Argand diagram
- Applying De Moivre's theorem
- Applying complex numbers to solve equations with imaginary numbers and in real life context
- Solving algebraic inequalities
- Average rate of change of a function between two values of independent variables
- Mathematical modelling
- Limits and rules of differentiation
- Derivative from first principles
- Application of differentiation
- Integration and anti-derivatives
- Determining area under a curve by means of integration
- Inverse functions of linear, parabola and exponential functions
- Properties of geometric shapes
- Proving and applying similarities and congruency of triangles
- Transformation of geometric figures
- Geometry of a circle
- Euclidian geometry
- Solving, constructing and interpreting geometric and trigonometric models
- Calculating angles of elevation and depression using trigonometric function
- Personal finances and household budgets: income and expenditure
- Determining simple and compound interests
- Organizing business finances
- Taxation, inflation and interest rates
- Measures of central tendency and dispersion in invariable numerical data
- Analyse and interpret data using bar graphs, histograms, frequency polygons, pie charts, line and broken line graphs
- Using experiments, simulations, and probability distribution to set and explore probability model

The following main topics overlap in the N2 and NC (V) L2 – L4 curricula:

- Deriving and applying exponential laws
- Solving linear, quadratic and exponential equations including manipulation of technical formulae
- Algebraic functions that include linear, parabola, hyperbola, exponential as well as trigonometric functions
- Perimeter, area and volume of right pyramids, cones, spheres and cylinders
- Trigonometric ratios and identities, solving right-angled triangles well as producing a proof

(b) Contents/skills mapping between Mathematics N3 and Mathematics NC (V) L2 – L4

The following topics are omitted in the NC (V) Levels 2 – 4 curriculum but appear in the N3 curriculum:

- Solving equations with surds
- Manipulating technical formulae using logarithmic laws

The following important topics are omitted in N3 curriculum but appear in the NC (V) Levels 2 - 4 curricula:

- Converting terminating and recurring decimals (rational numbers)
- Arithmetic progression, sequence and series
- Complex numbers; linear programming
- Integration and anti-derivatives
- Inverse functions of linear, parabola and exponential functions
- Properties of geometric shapes
- Proving and applying similarities and congruency of triangles
- Transformation of geometric figures
- Euclidian geometry
- Solving, constructing and interpreting geometric and trigonometric models;
- Financial Mathematics
- Taxation, inflation and interest rates
- Data handling; as well as
- Using experiments, simulations, and probability distribution to set and explore probability models

Several topics overlap between the N3 and the NC (V) Levels 2 – 4 curricula. They include:

- Applying exponential laws
- Exponential equations
- Solving quadratic equations
- Manipulating technical formulae
- Factorization up to third degree expressions
- Limits and rules of differentiation
- Determining equation of a tangent to the curve
- Geometry of a circle
- Trigonometric ratios and identities
- Solving right-angled triangles; and trigonometric equations

ELECTRICAL TRADE THEORY

(a) Content mapping between Electrical Trade Theory N2 and related NC (V) L2 – L4 subjects

The following important topics are omitted in N2 curriculum but appear in the NC (V) L2 – L4 curricula:

- Safety regulations
- First Aid Procedures
- Lifting techniques
- Soldering and gas welding
- Knowledge of safety signs and procedures
- Accident reporting
- Design and construct a three-phase circuit
- Construct a three-phase medium voltage overhead supply to domestic houses
- Fault-finding, repair and maintain three-phase voltage electrical circuits
- Tools and Equipment use
- Worksite Procedures, Lifting Techniques and Trainee Regulations
- Repair and maintenance
- Fault-finding on alternating current (AC) and direct current (DC) systems
- Operate on low voltage networks
- Test and inspect a three-phase industrial/commercial installation
- Soldering and Trade Practices
- Gas welding
- Trade Practices

The following topics are omitted in the NC (V) L2 – L4 curriculum but appear in the N2 curriculum:

- Electronics
- Earthing

Content overlap between Electrical Trade Theory N2 and related NC (V) L2 subjects

- Conductors and Cables
- Switchgear
- Contactors and Relays
- Direct Current Machines
- Alternating Current Machines and Motor Starters
- Protection
- Measuring Instruments
- Transformer
- Earthing and Protection
- Measuring Instruments and transformers
- Operating low voltages
- Fault finding on AC circuits (Current Machines)
- Alternating Current Machines and Motor Starters
- Testing and measuring equipment
- Alternating Current
- Machines and Motor Starters

(b) Content mapping between N3 Electrical Trade Theory and related NC (V) L2 – L4 subjects

The following topics are omitted in N3 curriculum but appear in the NC (V) L2 – L4 curricula:

- Electrical and Magnetic Theory
- DC and AC Circuits
- Protection and Measuring Testing Instruments
- Circuit Diagrams, Drawings and cabling
- Materials and Components
- Basic Electrical Circuits and Systems
- Wire Ways and Low Voltage Cables
- Electric Machines
- Fault-finding and Testing
- Protection and Measuring Instruments
- Tools and Equipment Use
- Worksite Procedures, Lifting Techniques and Trainee
- Soldering and Gas Welding
- Materials, components and interpreting electrical drawings
- Circuit diagrams and electric machines
- Wire and commission a single-phase domestic installation
- Test and inspect phase domestic instruments
- Fault-finding on alternating current(AC) and direct current (DC) systems
- Operate on low voltage networks
- Maintain lighting systems and demonstrate an understanding of energy efficiency
- Trade Practices
- Testing and measuring equipment
- Repair and maintenance
- Installations
- Fundamentals of electricity
- Generation and supply of electricity
- Earthing and load balancing
- Electrical Infrastructure
- Design and construct a three-phase circuit
- Construct a Three-Phase Medium Voltage Overhead Supply to domestic houses
- Test and inspect a three-phase industrial/commercial installation
- Fault-find, repair and maintain three-phase voltage electric circuits
- Typical electrical installations
- Electrical machines and control gear
- Electrical Entrepreneurship/Safety and First Aid

The following topics are omitted in the NC (V) L2 – L4 curriculum but appear in the N3 curriculum:

- Principles of circuit breakers
- Domestic Appliances
- Lighting
- Transformers
- Motors and allied equipment
- Silicon and germanium diodes
- Safety Precautions

Content overlap between Electrical Trade Theory N3 and related NC (V) L2-L4 subjects

- Safety and Regulations
- First Aid
- Alternating Current and voltage
- Motor/generator/alternator principles
- Illumination
- Low voltage transformers and switchgear

ENGINEERING SCIENCE

(a) Contents/Skills mapping between Engineering Science N2 and related NC (V) L2–L4 subjects

The following important topics are omitted in Engineering Science N2 curriculum but appear in the NC (V) Levels 2 – L4 curricula:

- Identify safety measures to be observed when dealing with different engineering systems
- Discuss the implications of non-adherence to safety measures as stipulated by the manufacturers
- Identify consumables needed to care for and maintain
- Discuss safety precautions to be observed when dealing with equipment of simple control systems
- Identify equipment with simple control system and list the functions of equipment
- Discuss the implications of non-conforming with the manufacturer's specifications when operating the equipment with simple control systems
- Draft a plan of operation
- Adjust settings of, start and operate equipment
- Monitor and adjust the process as required
- Care for and maintain equipment with simple control systems
- Start the equipment after maintenance
- Compile a post-maintenance report and submit it to the supervisor or assessor
- Perform a pre-operational inspection on machinery or equipment.
- Plan a routine maintenance
- Prepare machinery or equipment for routine maintenance
- Discuss safety precautions with regard to maintenance
- Isolate machinery or equipment for routine maintenance
- Perform routine maintenance
- Start the machine or equipment
- Write a post-maintenance report
- Explain ferrous metals, their composition and characteristics
- Differentiate and classify the types and grades of ferrous metals according to the characteristics
- Explain non-ferrous metals, their composition and characteristics
- Explain and describe the fabrication process of non-ferrous metals
- Describe the benefit of alloying elements in metals
- Explain the types and applications of non-metals
- Describe the various processes of manufacturing steel
- Identify the differences in ferrous metal processing
- Practical evaluate properties of materials through testing
- Define, describe and calculate momentum

- Interpret testing results by analyses
- Draw up a report on the testing results
- Identify and describe the use of plain bearings and roller bearings
- Describe and explain the use of seals
- Explain the refrigeration cycle
- Explain the operation of a domestic refrigerator
- Explain and perform safety checks on mechanical equipment
- Describe safety procedures involved during the usage of mechanical equipment
- Carry out a diagnostic analysis on mechanical equipment and report the findings
- Ensure safety in work practices when working in the vicinity of mechanical equipment
- Design prototype with new and different technological impact, considering a range of factors
- Interpret the prototype, its constructional design and relevancy to the point of application
- Test and evaluate the prototype and make any necessary modifications
- Apply new design concepts onto an illustrative plan
- Interpret illustrations and create a new prototype design
- Examine the prototype for comparisons of previous design faults
- Check all specifications, their corrections and identify them in the prototype upgrade
- Assimilate operating conditions for prototype, recording test results
- Field test prototype for operational expectations
- Check prototype against design specifications and analyse results
- Explain control systems in terms of their component interactions
- Describe components in terms of requirements
- Identify the causes of the problem
- Select the form of a control system and justify components
- Include the control system components and structure, material/s,
- Apply the prototype according to organisational requirements

The following topics are omitted in the NC (V) L2 – L4 curriculum but appear in the Engineering Science N2 curriculum:

- Plot the displacement/time and velocity/time graphs
- Define, determine graphically and resolve the parallelogram of forces, resultant and equilibrant
- Describe, draw a sketch and calculate the mechanical advantages of lifting machines
- Explain the meaning of resistivity of a conductor and perform calculation
- Resolve a force analytically and graphically
- List the advantages and disadvantages of friction as well as applications of friction in practice
- Define and distinguish between heat and temperature
- Describe specific heat capacity and calculate heat gain and heat lost
- Apply the law of conservation of heat
- Define and calculate heat value of a fuel and the efficiency
- Define and calculate the coefficient of linear expansion
- Name the applications, advantages and disadvantages of steam, sketch the
- graph that illustrate the changes of steam and calculate the steam properties
- Explain electron transfer
- Explain the electrolyte process
- Plot force/distance and determine from the graph the average force
- Explain the meaning of resistivity of a conductor and perform calculation
- Distinguish between distance and displacement, and between speed and velocity, and

brief describe each of these concepts

- Describe the moment of a force and the law of moments
- Define potential and kinetic energy, formulate the law of conservation of energy
- Derive, manipulate and apply the law
- Define work, power and efficiency
- Calculate work done and power required against resistance on a horizontal plane, on an inclined plane and work done by torque
- Differentiate between mechanical drives and lifting Machine (gear drives, belt drive and chain drives
- Describe the principle of hydraulics machine, draw a diagram and calculate
- Discuss and calculate the effect of resistance on electricity
- Describe the structure of the atom

Content overlap between Engineering Science N2 and related NC (V) L2 – L4 subjects

- Identify and discuss various engineering systems and their functions (electrical; electronic; mechanical; hydraulic, pneumatic etc)
- Identify a variety of engineering system applications and discuss the functions of each system's application (e.g. gears, trains and brake system)
- Prepare and set up an engineering systems application for operation
- Define a variety of output by means of calculation
- Demonstrate knowledge of heat treatment
- Explain the principles of mechanical engineering
- Explain motion in engineering design
- Evaluate surface finishes involving sliding motion and consider alternatives to reduce friction
- Explain the inertia effect as a result of mass and its resistance to motion resulting in the force required for motion
- Consider the mass of matter with reference to its direct relationship to friction and the force required for
- Demonstrate knowledge and understanding of the operating principles of mechanical components used in the engineering related design industry
- Identify and explain the working and the use the five general classifications in pump technology
- Explaining terminology related to pump technology
- Describe and explain the use of hydraulic, pneumatic valves and couplings
- Describe the reasons for the use of different driving transmissions
- Interpret, draw and make calculations of a minimally engineered, supported structure capable of bearing a point and/or distributed load
- Apply calculations and their representation in the prototype design
- Functionally dependent mechanisms are incorporated into a prototype of a technological solution
- Explain the dependency of components that are linked in order to produce motion
- Describe examples of dependency to produce a prototype
- Illustrate diagrammatically the different control systems
- Identify and describe the control system diagrammatically
- Use the diagram to construct a control system
- Mechanical drives and lifting Machine (gear drives, belt drive and chain drives
- Describe and calculate the static, kinetic friction and coefficients of friction
- Describe the effect of lubricants on friction

- Describe and illustrate by means of a sketches the meaning of electromagnetic induction (mutual and self-induction)

(b) Contents/skills mapping between Engineering Science N3 and related NC (V) L2 – L4 subjects

The following important topics are omitted in Engineering Science N3 curriculum but appear in the NC (V) Levels 2 – L4 curricula:

- Identify safety measures to be observed when dealing with different engineering systems
- Discuss the implications of non-adherence to safety measures as stipulated by the manufacturers
- Identify consumables needed to care for and maintain
- Identify equipment with simple control system and List the functions of equipment
- Discuss safety precautions to be observed when dealing with equipment of simple control systems
- Discuss the implications of non-conformant with the manufacturer's specifications when operating the equipment with simple control systems
- Draft a plan of operation
- Adjust settings of, start and operate equipment
- Monitor and adjust the process as required
- Care for and maintain equipment with simple control systems
- Start the equipment after maintenance
- Compile a post-maintenance report and submit it to the supervisor or assessor
- Plan a routine maintenance
- Perform a pre-operational inspection on machinery or equipment
- Prepare machinery or equipment for routine maintenance
- Discuss safety precautions with regard to maintenance
- Isolate machinery or equipment for routine maintenance
- Perform routine maintenance
- Start the machine or equipment
- Write a post-maintenance report
- Describe the various processes of manufacturing steel
- Describe the benefit of alloying elements in metal
- Practical evaluate properties of materials through testing
- Interpret testing results by analyses
- Draw up a report on the testing results
- Identify the differences in ferrous metal processing
- Identify and describe the use of plain bearings and roller bearings
- Describe and explain the use of seals
- Explain the refrigeration cycle
- Explain the operation of a domestic refrigerator
- Explain and perform safety checks on mechanical equipment
- Describe safety procedures involved during the usage of mechanical equipment
- Carry out a diagnostic analysis on mechanical equipment and report the findings
- Ensure safety in work practices when working in the vicinity of mechanical equipment.
- Design prototype with new and different technological impact, considering a range of factors
- Interpret the prototype, its constructional design and relevancy to the point of application
- Test and evaluate the prototype and make any necessary modifications

- Explain the dependency of components that are linked in order to produce motion
- Describe examples of dependency to produce a proto type
- Apply new design concepts onto an illustrative plan
- Interpret illustrations and create a new prototype design
- Examine the prototype for comparisons of previous design faults
- Check all specifications, their corrections and identify them in the prototype upgrade
- Assimilate operating conditions for prototype, recording test results
- Field test prototype for operational expectations.
- Check prototype against design specifications and analyze results
- Explain control systems in terms of their component interactions
- Describe components in terms of requirements
- Identify the causes of the problem.
- Select the form of a control system and justify components
- Include the control system components and structure, material/s,
- Test and evaluate the prototype and make any necessary modifications
- Apply the prototype according to organizational requirements

The following topics are omitted in the NC (V) L2 – L4 curriculum but appear in the Engineering Science N3 curriculum:

- Express the relation between force, mass and acceleration
- Derive the formula and apply the formula
- Distinguish between balanced and unbalance force
- Define, describe and calculate momentum
- Define, determine graphically and resolve the parallelogram of forces, resultant and equilibrant
- Calculate the reactions at the supports of beams subject to point loads, distributed loads and combinations
- Draw, according to scale, of a beam showing all loads and supports and a shear force diagrams determining the maximum and minimum shear forces
- Describe what equilibrium, equilibrant, resultant and triangle of forces mean
- Resolve a force analytically and graphically
- Represent by means of a diagram a roof truss supported at two points
- Determine analytically or graphically the nature and magnitude of the forces in the different frame parts
- Describe and calculate the static, kinetic friction and coefficients of friction
- List the advantages and disadvantages of friction as well as applications of friction in practice.
- Describe the effect of lubricants on friction.
- Calculate the forces acting on bodies on horizontal and inclined planes taking friction into consideration
- Describe specific heat capacity and calculate heat gain and heat lost
- Apply the law of conservation of heat
- Define and calculate heat value of a fuel and the efficiency
- Define and calculate the coefficient of linear and area expansion
- Name the applications, advantages and disadvantages of steam, sketch the graph that illustrate the changes of steam and calculate the steam properties
- Describe the electrochemical equivalent
- Formulate Faraday's law, apply the principles and calculate
- Explain by means of illustration the magnetic effect of electric current
- Make a label sketch of a transformer and explain the operation
- Describe element and matter
- Name the component elements of alloys and compounds
- Explain the structure of periodic table

- Briefly explain and identify well known metals and non-metals
- Describe the structure of the atom
- Explain the electrolyte process
- Describe oxidation, reduction and corrosion
- Name precautionary measures which can be implemented to combat corrosion
- Describe velocity and acceleration.
- Express the relation between force, mass and acceleration
- Define potential and kinetic energy, formulate the law of conservation of energy
- Calculate the reactions at the supports of beams subject to point loads, distributed loads and combinations
- Resolve a force analytically and graphically
- Describe the principle of hydraulics machine, draw a diagram and calculate
- Describe the effect on the potential difference, current and resistance of an electric circuit on series and parallel connection
- Derive the formula and do manipulation
- Calculate work done, power and work done by torque
- Mechanical drives and lifting machine (belt drives)
- Describe the moment of a force and the law of moments
- Formulate Joule's law, apply the principles and calculate
- Define direct and alternating current and their characteristics

Content overlap between Engineering Science N3 and related NC (V) L2 – L4 subjects

- Identify and discuss various engineering systems and their functions (electrical; electronic; mechanical; etc)
- Prepare and set up an engineering systems application for operation
- Define a variety of output by means of calculation
- Identify a variety of engineering system applications and discuss the functions of each system's application (e.g. gears, trains and brake system)
- Explain ferrous metals, their composition and characteristics
- Differentiate and classify the types and grades of ferrous metals according to the characteristics
- Explain non-ferrous metals, their composition and characteristics
- Explain and describe the fabrication process of non-ferrous metals
- Explain the types and applications of non-metals
- Demonstrate knowledge of heat treatment
- Describe specific heat capacity and calculate heat gain and heat lost
- Apply the law of conservation of heat
- Define and calculate the coefficient of linear and area expansion
- Name the component elements of alloys and compounds
- Briefly explain and identify well known metals and non-metals
- Explain the electrolyte process
- Explain the principles of Mechanical Engineering
- Explain motion in engineering design
- Evaluate surface finishes involving sliding motion and consider alternatives to reduce friction
- Explain the inertia effect as a result of mass and its resistance to motion resulting in the force required for motion
- Consider the mass of matter with reference to its direct relationship to friction and the force required for
- Demonstrate knowledge and understanding of the operating principles of mechanical components used in the engineering related design industry

- Identify and explain the working and the use the five general classifications in pump technology
- Explaining the following terminology related to pump technology
- Describe and explain the use of hydraulic, pneumatic valves and couplings

ENGINEERING DRAWING

(a) Contents/Skills mapping between Engineering Drawing N1 and related NC (V) L2 and L3 subjects

The following topics are omitted in N1 – N3 curriculum but appear in the NC (V) Levels 2 and L3 curricula:

- Explaining the function and purpose of drawings in terms of principles and practices
- Knowledge and skills applied to interpret drawings
- The planning of drawings to maximize page space
- Drawing border lines
- Development by the parallel line method
- Development by the radial line method
- Development by triangulation
- Preparing the computer environment and plan Computer Aided Drawing/Design (CAD) scale production drawing
- Produce scale production drawings to line stage using a CAD program
- Complete and verify CAD scale production drawings
- Print CAD scale production drawings and manage files

The following topics are omitted in the NC (V) L2 and L3 curriculum but appear in the N1 – N3 curriculum:

- Identify, use and take care of drawing instruments
- Identify and use line types
- Printing (writing) in free-hand
- Free-hand drawings
- Geometrical constructions
- Drawing regular polygons with drawing instruments
- Drawing the first-angle projection symbol
- Draw oblique views according to the cabinet method
- Draw isometric views that includes non-isometric lines
- Orthographic projections of geometrical solids
- Construct hexagonal bolts, nuts, studs and drilled holes
- Draw in free-hand other types of fasteners
- Identify and draw in free-hand types of welding joints
- Apply specific welding symbols
- Interpret and indicate supplementary symbols
- Draw representation of metric screw threads
- Explain terminology applicable to screw threads
- Draw the basic machining symbols
- Identify and use symbols for removal and not machining
- Read and apply surface texture symbols
- Specifying a production method
- Draw isometric views that includes non-isometric lines, circles and hidden detail
- Draw the third-angle projection symbol

- Draw given views and insert the curve on interpenetration of T-ends, fork ends and rod-ends
- Draw free-hand views of engineering components
- The inclusion of fastening devices, instructional notes, surface texture symbols and limits and fits (tolerances) on sectional drawings of machine parts
- The inclusion of fastening devices on assembly drawings
- The inclusion of fastening devices, instructional notes, surface texture symbols and limits and fits (tolerances) on detailed drawings

The following topics overlap between Engineering Drawing N1–N3 and related NC (V) L2 and L3 subjects

- Drawing terminology, abbreviation & CAD
- Reproduction drawings
- First–angle orthographic projection
- Sectional drawing of single (simple) items
- General engineering drawing terms
- First–angle orthographic projection
- Third–angle orthographic projection
- Interpenetration: Draw given views and insert the curve of interpenetration of pipes and prisms
- Draw given views and insert the curve of interpenetration of pipes and prisms
- Draw non -, full -, or partially sectioned views of castings or multi-part objects(assemblies)
- Isometric projection

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