

Assessment of Learning Outcomes

Engineering Subject Centre Guide **Assessment of Learning Outcomes**

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Authorship

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This Guide has been written to support you with the Assessment of Learning Outcomes. It describes a variety of methods and approaches you might wish to consider, however, please note that, these are offered as a guide only and are not prescribed by the Engineering Council UK

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Section 1 - Introduction

Benchmarks, frameworks and outcomes standards

With a move to mass Higher Education, and the associated need for transparency and the assurance of quality, a number of initiatives have led to attempts to provide a transparent, understandable description of the abilities that should be apparent in graduate engineers. The Quality Assurance Agency (QAA) sponsored the development of Subject Benchmark Statements in all Engineering subjects and the Higher Education Funding Council (HEFCE) sponsored the development of the Qualifications Framework. At the same time, the Engineering Council UK (ECUK) developed its own Graduate Outcomes standard. The most recent version of this standard is described in the EC UK's publication 'The Accreditation of Higher Education Programmes' (May 2004). The publication states:

'Under the United Kingdom Standard for Professional Engineering Competence (UK-SPEC), the decision whether to accredit a programme will be made on the basis of the programme delivering the Learning outcomes which the professional institution has specified. Those outcomes will be derived from the generic output standards for accredited degree programmes adopted by Engineering Council and set out in [the document].'

Following the publication of the UK SPEC, ECUK, EPC and the Engineering Subject Centre jointly approached QAA about the need to align the Engineering Benchmark Statement and the UK SPEC. A revised Engineering Benchmark Statement was published in 2006 with the UK-SPEC adopted as the subject benchmark statement standard. Another important feature of this second edition subject benchmark statement is the bringing together of the honours and integrated master's awards (MEng), as the MEng statement was originally published as a separate annex in 2002.

<http://www.qaa.ac.uk/academicinfrastructure/benchmark/statements/Engineering06.asp#p1>

Why seek accreditation?

Clearly, if a programme is to attract funding from HEFCE, then it must satisfy the QAA standards and fall within the qualifications framework. However, accreditation of degree programmes by recognized professional and statutory bodies has long given additional standing to them, and increasingly, the advantages of independent professional accreditation are being recognized internationally. Finally, professional accreditation is recognized as an important way of demonstrating that the programmes concerned are likely to meet QAA standards.

What does the UK-SPEC output standard look like?

The output standard for accredited engineering programmes encompasses two different categories of learning outcomes. The first is general in nature, and applies to all types of programme. The second category is more specific. However, the two categories are inter-related, with the general learning outcomes being embodied to a greater or lesser extent within the various specific outcomes¹.

¹ The UK-SPEC is given in appendix 1 of this chapter. Throughout the guide, we will use the terms Generic outcomes to refer to the first category (four fields), Specific Outcomes to refer to the (five) fields encompassing the second category, and Detailed Specific Outcomes to refer to the (26) bullet points which appear as sub statements of the Specific Outcomes.

The UK-SPEC Output Standards for Accredited Engineering Programmes

General Learning Outcomes	Specific Learning Outcomes	Number of Detailed Specific Learning Outcomes
Knowledge and Understanding	Underpinning science, mathematics, and associated engineering disciplines, as defined by the relevant engineering institution	3
Intellectual Abilities	Engineering Analysis	4
Practical skills	Design	6 (plus an introductory statement)
General transferable skills	Economic, social, and environmental context	5
	Engineering practice	8

Engineering practice

Finally, it should be noted that this guide is intended for Engineering programmes, although it does draw upon other subjects from time to time. Much good practice exists beyond Engineering, and engineering practice often utilizes design solutions developed in other areas, so this is good engineering practice. Further, engineers are committed to developing 'good' solutions to problems or to 'good' designs. This recognizes that there is not always a 'correct' solution, approach or design, but there are often several options and an engineer will make the 'best' choices available. In this guide, you will find several design concepts, suggestions and ideas. It is for the reader to determine which may be useful to them and which they might wish to adopt or adapt to their own situation. The reader will also find other published material which may propose conflicting solutions or ideas. Again, it is for the reader to evaluate these proposals and to adopt those which best suit their own situation.

Section 2 - Designing a Programme of study

Where do you begin?

It is important to gather together any resource you may have before starting to describe a programme of study. These resources may include:

- The QAA subject benchmark statements
- The Higher Education Qualifications Framework
- The UK-SPEC accreditation document
- The Qualifications and Curriculum Authority (QCA) National Qualifications Framework level descriptors
- Other examples of programme specifications
- Previous documentation relating to the programme you may be replacing

Top-down and bottom-up design

There are (at least) two approaches which are commonly taken when designing a programme. In a bottom-up approach, the designers consider what knowledge, skills and abilities the students bring with them to the programme of study. This has become more difficult with a move to mass higher education and its associated expansion of routes to entry. Many Higher Education Institutions are developing on-entry profiling systems designed, not to assess students directly, but to help them to identify their skills, abilities and learning concerns. This can lead to the maintenance of student learning logs or 'Personal Development Portfolios'. The design team then determines which areas of curriculum are appropriate starting points for study and then build a programme from the bottom-up.

There are advantages to bottom-up design. The learning environment begins to look like a traditional apprenticeship scheme, in which the students can progress through the programme at their own pace, ensuring they are prepared for the next stage of learning. Additionally, this approach allows the student to choose their route through a programme (as they are working from the bottom-up). The key disadvantage is that it is difficult to make explicit statements about the programme learning outcomes that a student completing the programme would be expected to be able to demonstrate.

Top-down programme design

With this approach, the designers begin by describing the graduate outcomes of the programme. It is useful here to refer to the programme outcomes as prescribed in the UK-SPEC General Learning Outcomes (which also match the QAA guidelines):

- Knowledge and Understanding
- Intellectual Abilities
- Practical skills
- General transferable skills

The first outcome field describes the essential concepts, theories and principles of the engineering discipline, and its underpinning science and mathematics. It might also include the wider multi-disciplinary engineering, social, environmental, ethical and commercial considerations involved in the particular engineering context. This establishes the branch of engineering of interest to the programme of study. The other three outcome fields describe more general graduate and professional abilities and skills, although the outcomes addressed under 'Practical skills' may necessarily include specific subject-related skills. However, the designer needs to achieve a balance between over-specifying skill in using particular equipment or executing processes on the one hand, which may constrain the subject, and being too vague on the other which loses the focus of the subject.

A very useful approach at this stage would be to consider the detailed specific outcomes in the UK-SPEC and identify which of these would fit into each of the four general outcomes fields. For example, the detailed outcome *'identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques'* (in Engineering Analysis) could form a programme outcome within the *'Intellectual Abilities'* field.

From here, the final year curriculum is mapped out before considering the necessary underpinning curriculum at level two and so on. Good practice here is to consider not only the curriculum areas of study but also the intellectual, practical and transferable skills to be developed and assessed at each level (using the level descriptors to establish a standard for each level of study).

Programme specification template

The main fields of a typical Programme Specification Template are shown in Table 1.

Field 7 refers to the resources discussed in the first paragraph of this chapter. Field 10 shows a table which allows the designer to specify the programme outcomes under the four fields discussed (on the left column). Field 11 describes the teaching, learning and assessment methods employed. Before going on to design the modules, the programme outcomes need to be matched with appropriate teaching, learning and assessment methods. This is by no means easy, and is the subject of later chapters in the guide, but the key concept here is that assessment methods that assess the students' knowledge of a subject may not be appropriate for assessing their intellectual or practical skills.

Fields 12 to 14 allow the designer to determine the modules that will be necessary to complete the programme. It is very easy for designers to 'give way' to the aspirations of other stakeholders in the programme and to 'allow' them to include 'their' module, but this tendency should be resisted. Modules should only be included in the programme if they contribute effectively to either the curriculum area or to the programme outcomes. If they are essential contributions, then they should be core modules, otherwise they may be options. Having determined an **outline** description of the modules to be included at each level of the programme (field 12), the module designers then establish the **detailed** module outcomes to be developed and assessed (at the appropriate level) and these are listed in field 13. This allows the programme designer (and verifying or validating bodies) to check that the module outcomes together allow the student to achieve and demonstrate all of the programme outcomes.

NOTE

In an outcomes environment, it is essential for a student to demonstrate all of the programme outcomes (at threshold level – see later) in order to achieve the degree. This is assured only if there is clear mapping of module outcomes to programme outcomes. That is to say that it is the module learning outcomes that are assessed, so the programme must be designed in such a way that if the module learning outcomes are demonstrated, then the programme outcomes are assured.

Table 1 – The major fields in a Programme Specification Template

1. Title of programme:	
2. Awarding institution:	
3. Teaching institutions (indicate any collaborative links/partners):	
4. Programme accredited by:	
5. Final award:	
6. UCAS code (undergraduate programmes):	
7. Descriptors and generic criteria being used to define the programme outcomes (eg QAA qualification descriptors, level descriptors, key skills, subject benchmarks, etc). These should be attached to the document:	
8. Educational aims of the programme:	
9. Employment opportunities:	
10. The programme provides opportunities for learners to achieve the following outcomes:	11. The outcomes are achieved and demonstrated through a range of teaching, learning and assessment methods including:
A. Knowledge and understanding of:	Learning and teaching - students learn by:
	Assessment
B. Subject specific skills able to:	Learning and teaching - students develop subject specific skills by:
	Assessment
C. Intellectual skills able to:	Learning and teaching - students develop intellectual skills by:
	Assessment
D. Key skills able to:	Learning and teaching - students develop key skills by:
	Assessment
12. Structure of the programme: Show the modules which go to make up the programme of study. Indicate core, core option and elective modules or lists as appropriate.	
Level 3	
Level 2	
Level 1	

13. Module details: List the learning outcomes for each of the core modules and the common learning outcomes for the core option lists identified in field 12.				
Level 3				
Level 2				
Level 1				
14a. Assessing knowledge and understanding: Use the table below to identify which core/core option modules will assess the knowledge base identified in field 10A.				
Module code	Knowledge and understanding			
	PO1	PO2	PO3	
Mod 1				
Mod 2				
...				
14b. Assessing subject-specific skills: Use the table below to identify which core/core option modules will assess the different subject-specific skills identified in field 10B.				
Module code	Subject-specific skills			
	PO1	PO2	PO3	
Mod 1				
Mod 2				
...				
14c. Assessing intellectual skills: Use the table below to identify which core/core option modules will assess the different intellectual skills identified in field 10C.				
Module code	Intellectual Skills			
	PO1	PO2	PO3	
Mod 1				
Mod 2				
...				
14d. Assessing key skills: Use the table below to identify which core/core option modules will assess the different key skills identified in field 10D.				
Module code	Key skills			
	PO1	PO2	PO3	
Mod 1				
Mod 2				
...				

Field 14 allows mapping between module outcomes and programme outcomes. Although it takes some time to complete these maps, doing so is a very effective means of ensuring both that all programme outcomes are 'covered' and that there is not an over-emphasis on a small number of programme outcomes. Good practice here includes ensuring that students will have at least two opportunities to demonstrate each programme outcome. (It may also be considered good practice in module design to ensure that students have two opportunities to demonstrate module outcomes.

Top-down or bottom-up? Bringing the two together

Top-down design has the advantages that it ensures clarity of outcomes, and facilitates efficiency of design. However, it suffers the potential disadvantage of 'forcing' a student through a prescribed route at a defined pace without affording them the opportunity to study at their own pace or to achieve other learning outcomes important to them.

Top-down design begins by defining the programme outcomes, as above, and mapping the outline modules required to achieve these outcomes. However, before going on to design the modules in detail, it can be helpful to step back and consider levels and themes from the bottom up. Table 2 below shows how each level of study can focus on particular aspects of the student development, in addition to the curriculum being learned.

Table 2 - The changing focus of a programme as it moves through the different levels of study

Level	1	2	3	4
Subject	Consolidation	Development	Authority	Mastery
Skills	Learning	Key	Independence	Research
Intellectual capacities	Knowledge Understanding Manipulation	Application Analysis Synthesis	Evaluation Judgment Reasoning	Formulation Conceptualization Reflection

At level one

The emphasis may be on subject consolidation. This is important in an environment in which students come from varied backgrounds, and bring with them different knowledge bases. Against this consolidation background, level one modules might focus on developing effective learning skills in the students, which will help them with their further studies. These skills include an understanding of their preferred learning styles and strategies, listening and recording skills, numeracy, writing, motivation, and information handling skills (including library skills). These skills should be developed within the curriculum by designing learning experiences that address these skills specifically. At this level of study, it might be sufficient for the students only to demonstrate lower level intellectual skills, such as knowledge, understanding and manipulation of knowledge and information.

At level two

Learning skills have been developed, so it is now possible to develop the subject more rapidly. Emphasis could move from learning skills to key skills, such as IT, communication skills, teamwork and leadership. Higher level intellectual skills should be expected of the student, such as the application, analysis and synthesis of knowledge (for example, design skills).

At level three

The student should be expected to demonstrate their authority of the subject. That is to say that they will have expertise and detailed knowledge that is specific to their engineering subject. But further, they will be taking authority over new knowledge in that they will not simply accept what is given to them, but will question it as well as determine for themselves what new knowledge is important to them. This harmonises with the move to developing independence (skills), where the student will accept responsibility for their own learning, and will demonstrate their ability to determine what they need to learn, how they will learn it and how they will know that they have learned it as well as how they will apply it and incorporate it into their wider schema of the subject. Key in achieving this is the intellectual capacity of the student to be able to evaluate information and make reasoned, objective judgments on information and their own learning.

At level four

The focus of postgraduate study here moves to mastery of the subject, the development of research skills and the intellectual capacities of formulation, conceptualization and reflection.

Module design

Modules are the essential building blocks of programmes. They make essential contributions to the attainment and assessment of the programme outcomes. The section on programme design above has already referred to the essential design parameter that the learning outcomes of modules must together assure that the programme outcomes have been met. In other words,

if all of the learning outcomes of all of the compulsory modules of a programme have been attained and demonstrated by a student, then it is judged that all of the programme outcomes have been demonstrated

and the student will be able to graduate. An important feature here is that the learning outcomes of modules are established at a certain level of study (1 to 3). This means that the module designers must follow the themes established by the programme designer for each level of study and that they must be set at the appropriate level of study as prescribed by the qualifications framework² or the SEEC level descriptors (see Appendix 3 Section 8).

Module specification template

The main fields of a typical Module Specification Template are shown in table 3 below. For the purposes of this guide, the important fields are 5, 6, 7, 16 and 17.

² The Framework for Higher Education Qualifications (FHEQ) has five levels, three of which are at undergraduate level. These are: Certificate (C level); Intermediate (I level), foundation degrees, ordinary degrees and diplomas; Honours (H level), honours degrees, graduate certificates and graduate diplomas.

Table 3 – The major fields in a Module Specification Template

1. Parent programme (the programme for which the module is designed):	
2. Module title:	
3. Level:	
4. Credit rating:	
Description of the module	
5. Educational aims:	The module aims to...
6. Learning Outcomes: On completion of the module, the student is expected to be able to...	
LO1	
LO2	
LO3	
...	
(If this is a core or core option, transfer these outcomes to section 13 of the <i>Programme specification template</i>)	
7. Range statement: Give a description of the content to be included in the module or the content of the topics to be studied:	
Contribution to programmes of study	
8. Explain why and how this module makes a necessary contribution to the learning opportunities provided by the parent programme:	
9. In what ways might this module contribute to programmes other than the parent programme?	
Design parameters and tools	
10. Descriptors and generic criteria being used to define the programme outcomes (eg QAA qualification descriptors, level descriptors, key skills, subject benchmarks, etc). These should be provided for validation and available to students.	
11. Describe the source of evidence for the effectiveness of the assessment and student learning activities (eg books or other publications – give references, student evaluations, previous experience, research).	
Learning activities	
<i>(Note the learning outcomes for a core option module should be the same as those for all the modules in the core option list.)</i>	
12. In order to achieve the learning outcomes, the students will be engaged in the following learning activities. (Identify both in-class and out-of-class activities. For in-class, identify the range of classes [lecture, tutorial, seminar, practical, workshop, etc].)	
13. What evidence do you have that the learning activities described above will be effective in helping students to achieve the learning outcomes?	

Assessment						
14. The learning outcomes will be assessed using the following methods (show weightings):						
15. Explain why you consider these assessment methods to be both valid and reliable and how they will support the students in their learning.						
Assessment						
16. For each of the learning outcomes listed in 6, describe the criteria which will be used to make judgments and the standards to be set for each criterion to achieve the relevant grade. (Use one table for each learning outcome defined in the module.)						
Learning Outcome:						
Criteria	F	E	D (Threshold grade)	C	B	A
C1						
C2						
...						
17. Indicate which learning outcomes in section 6 are to be assessed by each assessment method in section 14.						
Learning Outcome	Assessments					
	1	2	3	4		
LO1						
LO2						
...						
Resources						
18. List the recommended texts, initial sources of electronic reference material, and other information sources to be used. If these resources do not currently exist, then indicate how and when they be made available.						
19. Explain how you will be using technology to support the students in this module. If you do not intend to use technology, then justify this decision.						
20. Describe other learning resources which are necessary for the students (eg WOLF, study skills support, laboratory or other equipment, external expertise, etc). Indicate whether these are needed for learning or for assessment. Indicate the teaching accommodation which will be required and the nature of its use. If any resources do not currently exist, then indicate how and when they will be made available.						

Field 5 allows the designer to describe their broad purposes in offering this module of study. These aims should be general and usually only one or two are required.

Field 6 allows the designer to list the learning outcomes of the module. The next chapter will deal with learning outcomes in more detail, but suffice it to say at this stage that recommended practice suggests that there should be between three and six learning outcomes for a module (although it is possible to design an effective module with only one learning outcome). Fewer learning outcomes generally result in statements that resemble broad aims and modules with more than six learning outcomes tend to over-specify outcomes and the outcomes tend to resemble assessment criteria (see next chapter). Since learning outcomes specify broad areas of learning, it is necessary to identify the criteria that will be used to assess each learning outcome. There may be several criteria which must be satisfied together in order to demonstrate a learning outcome.

Field 7 is included to allow the designer to specify the area of curriculum. This may include content or topics to be 'covered'. Specifying the curriculum here allows the module to be described in terms of learning outcomes which are free of content.

Assessment of Learning Outcomes

Fields 16 and 17 together allow the designer to determine assessment criteria and an assessment strategy. There are three essential concepts embodied within the table in field 16:

Concept 1:

A number of criteria are necessary to allow assessors to make a judgment as to whether a student has demonstrated achievement of the learning outcome. An assessment task must allow the student to demonstrate how they have met these criteria and it must be judged against these criteria. All criteria must be demonstrated for the student to be deemed to have demonstrated the learning outcome.

Concept 2:

The judgment of attainment of a criterion is set at a **threshold level**. This means that the minimum standard of achievement must be described, not the mean or an aspirational level. That is to say that the threshold establishes a satisfactory level of attainment (no more).

Concept 3:

Grading standards may be set above (and below) this threshold in order to specify what the student will need to demonstrate to achieve a grade above the threshold. The student will usually achieve a profile of grades against the criteria and it will be a matter of professional judgment (or an appropriate algorithm) for the assessor to determine a grade against the learning outcome. This allows the assessors to reward higher levels of attainment by students.

Field 17 leads the designer towards an assessment strategy. Usually, a module has a number of assessment tasks (unseen written exam, written assignment, lab work, oral or poster presentation etc.). The table in this field allows the designer to ensure that the assessment tasks will cover all of the learning outcomes. Mapping the tasks to outcomes also identifies any learning outcome which is being over-assessed. This allows the assessor either to simplify some assessment tasks or even to eliminate any redundant tasks.

Actually, there is a fourth concept, which is implicit within the design. The act of determining criteria and thresholds (and the other grade descriptors) establishes explicit, fixed performance descriptors. This reduces the tendency for drift during a marking exercise³. This makes the process of assessment more reliable by ensuring that judgments are less dependent on who marks the assignment (inter-marker reliability) and the order in which scripts are marked (intra-marker reliability).

Orthogonal assessment

This is probably the most radical change in the philosophy of assessment practice that has come as a result of the move to an outcomes model of programme design and assessment (such as described in the UK-SPEC).

Traditional assessment practice involves a number of assignments which together produce an average mark or grade for the module. Consider the assessment strategy as described in the table below. For the purposes of this analysis, let us assume that there are two assessments, each having four criteria of equal weight (25%). C_{nm} represents the nth criterion of assignment m. We will assume also that the assessors are using a percentage marking scheme and averaging numerically. The pass mark is 40%. The same argument would apply using grades, in which case an algorithm would be used for averaging.

	Assessment 1	Assessment 2
Criteria used for judgments	C11	C21
	C12	C22
	C13	C23
	C14	C24

A student receives marks as shown in the next table:

	Assessment 1	Assessment 2	Average mark (%)
Criteria used for judgments	12	9	
	12	11	
	15	10	
	8	7	
Mark for assignment (%)	47	37	42

The student’s average mark for the module is 42%. They have failed the second component (37%), but the rules will allow compensation for marks of 35% or above in one component. Therefore compensation will be applied to the second assignment, and the student passes the module.

However, with an outcomes model, the process is different. Consider the model below. In this outcomes based model, the learning outcomes for the module have been established in the module specification template (assume there are four). These are used consistently across the assignments. That is, the judgments for each assignment are made against the

³ Grade drift is a term used to describe the tendency for a marker to unconsciously revise their judgment of performance. If the first assignment marked is of a high standard, then those that follow will suffer by comparison. Alternatively, if the first few scripts are of a lower quality and receive marks or grades, and then a high quality script is encountered, those that follow will receive lower grades or marks even if they are of the same quality as the first few. Explicit criteria tend to ‘tie down’ judgments and make them more consistent

(relevant) learning outcomes, using the criteria for each learning outcome. This analysis uses the same marks matrix as in the analysis above, but this need not be the case.

The marks are now averaged across the learning outcomes (not the assignments) to give an average mark (or grade) for each learning outcome.

	<i>Assessment 1</i>	<i>Assessment 2</i>	<i>Average mark for each outcome (%)</i>
<i>LO1</i>	<i>12</i>	<i>9</i>	<i>42</i>
<i>LO2</i>	<i>12</i>	<i>11</i>	<i>46</i>
<i>LO3</i>	<i>15</i>	<i>10</i>	<i>50</i>
<i>LO4</i>	<i>8</i>	<i>7</i>	<i>30</i>
<i>Average mark (%)</i>			<i>42</i>

The implications for the student are very different in this case. The average mark for the module is still 42%. However, the student has 'failed' on learning outcome 4. That is, they have not demonstrated that they have attained this outcome. There is no compensation for this; students must demonstrate each and every outcome, so this student will have failed the module. Any attempt at recovery through a retaken assignment needs only to focus on learning outcome 4.

Note:

1. In effect, the student has been given two attempts to demonstrate LO4 and has failed on both occasions.
2. Even if the average mark is a fail mark for a learning outcome (30% as in LO4), if any attempt, in any assignment, results in a pass mark (10 or greater in this example), then the student has, at some time during the module, demonstrated this learning outcome, and should pass. For example, marks of 10 and 5 would still result in an average mark of 30% for this learning outcome. This would traditionally be seen as a fail mark, however, the student has demonstrated the outcome in the first assignment, so the module is 'passed'.

Implications for recording and decision –making

For the assessor

1. For each assessment, judgments are made (and marks are awarded or grades are assigned) against the learning outcomes being assessed (using the relevant criteria for the LOs).
2. Orthogonal assessment removes any decision-making in regard to compensation, as it is not necessary to compensate for individual components of assessment.
3. There can be no compensation for a 'failed' learning outcome.
4. It is possible to 'pass' each assignment, but to fail the module. For example, using the grid above, the student has achieved 47% for assignment 1 (pass). If they achieved 15 for LO1 in assignment 2, then they would achieve 43% for this assignment (pass) and an average of 45% for the module (pass). However, they still have not achieved a pass for LO4 on either occasion. This is what matters, so they will fail the module.
5. Feedback to the student on each assignment will need to focus on their attainment against the Los as well as the assignment itself. The student will need to be advised that, even though they may have achieved a 'pass' mark for the assignment, they have failed to demonstrate a learning outcome, and they must demonstrate this LO in the remaining assignment.

For the examination board

1. The information presented to the exam or assessment board will be different. Traditionally, they will have been given the marks for the individual components of assessment (47% and 37%) as well as the overall mark (42%). In the outcomes model, they only require the overall mark and a pass/fail notation for each learning outcome.
2. The board will simply make a ratifying decision based on the learning outcomes. If all are demonstrated (passed), then the student has passed the module and can progress or graduate. If any one or more of the Los are failed then the student needs to re-sit.
3. The exam board may wish to bring any further regulations into the decision-making process, but that is a matter for the institution to decide.

Examples:

1. They may determine that students also need to pass every component.
2. They may determine that students also need to pass every component after compensation has been applied.
3. They may use the overall mark to assign a classification to the module or degree.

However, these are not requirements of a learning outcomes assessment regime.

Reducing the assessment load on staff and students

Given the competing and increasing demands on academic staff time, there is pressure on them to reduce their assessment load. Further, there is a recognition that students in Engineering are over-assessed. Orthogonal assessment in a learning outcomes model can simplify the decision-making process by removing the need to consider compensation and by making it easier to determine assessment criteria (which are consistently applied to the learning outcomes, rather than changing according to the assignment). There are two further approaches, which can be used to reduce existing assessment loads.

Reducing assessment load by simplifying the assessments

In the example, each assignment assesses all four learning outcomes. This results in a degree of redundancy. Although it might be argued that good practice would allow two opportunities for the student to demonstrate each outcome, each learning outcome really only needs to be assessed once. So in this strategy, it may be argued that there is over-assessment. To reduce this, it would be possible to simplify either, or both, of the assignments such that they assess fewer learning outcomes. For example, assignment 1 might focus on LO1 and LO2 and assignment 2 might focus on LO3 and LO4.

Reducing assessment load by reducing the number of assignments required

Some courses in Engineering still have a relatively large number of assignments. It is not uncommon to see four or more assignments in a module. A mapping exercise can help to streamline assessments while still ensuring that they assess all of the learning outcomes. Consider the table below. This depicts a module with four assessments. Each assessment will have its own set of criteria, which may not be linked to the learning outcomes. By mapping the assessment tasks to the LOs, it is possible to see which assessments are more efficient in assessing LOs and which LOs are over-assessed.

Learning outcome	Assessments			
	1	2	3	4
LO 1	X	X		X
LO 2		X	X	X
LO3	X	X	X	X

X indicates that the assignment is very effective in assessing this learning outcome
x indicates that the assignment addresses the learning outcome, but that it could do so more effectively.

It is clear that Assessments 2 and 4 are most effective in Assessing the Learning Outcomes. With a minor adjustment to Assessment 4 to address LO2 more carefully, it would be possible to eliminate assessments 1 and 3 from the schedule.

The mapping achieves two outcomes:

It identifies which assessments are not necessary

It identifies ways in which some assessments could be modified in order to make them more effective in assessing learning outcomes.

Note:

This discussion refers to the need to address learning outcomes in assessment. It shows how assessment design (and regulations) needs to adapt to this methodology. The key points are:

Assessments should be designed to assess learning outcomes. The criteria used should be the criteria necessary to make judgments on the learning outcomes.

All learning outcomes must be demonstrated for a student to pass the module.

There is no compensation at the level of learning outcome.

Section 3 - Draft Guidelines on Learning Outcomes, Assessment Criteria and Standards

Aims and Learning Outcomes

The educational aims of a module are statements of the broad intentions of the teaching team. They indicate what it is the teaching team intends to cover and the learning opportunities they intend to make available to the student. A learning outcome is a statement of what a learner (student) is expected to know, understand and/or be able to do at the end of a period of learning⁴. It is advisable to express learning outcomes with the common prefix:

‘On completion of (the period of learning e.g. module), the student **is expected to** be able to...’

Generally, learning outcomes do not specify curriculum, but more general areas of learning. It is not possible to prescribe precisely how specific a learning outcome statement should be. There is a balance to be struck between the degree of specificity in a learning outcome statement and that achieved by the assessment criteria (below). If there are too many learning outcomes for a module, then either they are becoming assessment criteria or they are specifying too much curricular detail. The curriculum should be described in the range statement. Too few learning outcomes are unlikely to provide sufficient information on the module. As a guide, there should be between 3 and 6 learning outcomes for a module.

Examples of Learning Outcome Statements

1. Level 2 BEd programme
On completion of the module the student is expected to be able to-
Explain the more common reasons for difficult behaviour in primary school children in class situations, indicating standard techniques for ameliorating that behaviour.
2. Level 3 English Literature
On completion of the module the student is expected to be able to-
Demonstrate detailed understanding of the influences of the historical and social context within which the chosen text is set, both from the study of the text itself and from the study of other contemporary literature.
3. Level 2 Physics
On completion of the module the student is expected to be able to-
Perform calculations on wavefunctions and in the solution of the Schrodinger equation for a range of one-dimensional problems.
4. Level 3 Optoelectronics
On completion of the module the student is expected to be able to-
Describe and explain the function of the basic devices of optoelectronics; optical fibres, liquid crystal displays, bi-polar and surface field effect transistors and MOS light emitting diodes.

⁴ The terms ‘unit’ or ‘module’ are often used to describe a period of learning. This guide uses the term module. The essential element of the description is that the period of learning leads to the attainment (and assessment) of defined Learning Outcomes. That is, the outcomes of this period of learning are assessed in some way.

A well-written learning outcome will contain the following components:

- A verb that indicates what the learner is expected to be able to do at the end of the period of learning
Appendix 2 gives a table of verbs set against Bloom's hierarchy of the cognitive domain.
- Words that indicate on what or with what the learner is acting
- Words which indicate the nature of the performance

In example 2 above:

- The verb is 'demonstrate'
- The learner is acting on 'the influences of the historical and social context'
- The nature of performance is described by 'a detailed understanding'

Levels of Learning Outcomes

Learning outcomes should be developed and described with reference to a particular level of study. A number of generic level definitions exist across the Higher Education sector. Appendix 3 shows the generic level descriptors produced by QCA based on the Northern Ireland Credit Accumulation and Transfer project team (NICATS) These are probably the most widely known and accepted generic descriptors. The generic levels 4, 5 and 6 map to undergraduate levels 1, 2 and 3. Levels 7 and 8 map to postgraduate levels of study. They have been developed with the intention that the curriculum specialists will use their professional expertise to translate them into their own subject area. They should be used as a guide to writing learning outcomes and assessment criteria. However it is the assessment criteria rather than the learning outcomes which define a particular level of study and assessment. It may be possible for learning outcomes in adjacent levels to be similar as long as the assessment criteria are distinct and relate appropriately to the level descriptors. In some subjects, such as engineering, the level of study may be implied in the nature, and generally understood complexity, of the learning required (e.g. Schrodinger equations, in example 3 above). It may also be implied from the underpinning learning necessary.

Assessment criteria and standards of attainment

Standards of attainment should be distinguished from levels (above). The **Learning Outcome** defines what the student is expected to be able to demonstrate on completion of the module. This is set against a particular **level** of study. To gain credit (pass the module), the student must demonstrate achievement of all the learning outcomes associated with that module. Since learning outcomes specify general areas of learning, it is necessary to identify the criteria that will be used to assess each learning outcome. For each criterion, it will be necessary to identify standards of achievement.

For each learning outcome, the student will be judged to have demonstrated a certain standard of achievement against each criterion and this will lead to an attainment profile. It is then a matter of professional judgement to establish whether or not that profile provides evidence that the student has demonstrated their ability against that learning outcome.

Section 4 - Levels, thresholds and attaining a Learning Outcome

Levels, criteria and grades

Sections two and three of this guide discussed the concepts of:

1. Programme Outcomes
2. Module learning outcomes and their link to Programme Outcomes
Programme Outcomes are only assured if all of the core modules are passed, and these modules are only passed if all of the learning outcomes are demonstrated.
3. Level descriptors and qualification frameworks
4. The need for explicit criteria by which judgments are made
5. Threshold standards against each criterion
6. The possibilities for other grade descriptors
7. Orthogonal assessment

Before moving on, it is important to establish a number of distinctions:

Level descriptors are used to describe the level at which a module is operating and a student is working. These descriptors establish the notion of development of intellectual, personal and other skills as a student moves through the different years (levels) of a degree programme. For example, the table below shows the different learning environment within which a student is expected to demonstrate learning at the different levels of undergraduate study. The statements are derived from the QCA / NICATS level descriptors (levels 4 to 6, which map to undergraduate levels 1 to 3). These levels must be distinguished from a 'level of performance' which a student may demonstrate in undertaking an assignment. This might more appropriately be referred to as a 'standard of performance'.

Undergraduate level	Level 1	Level 2	Level 3
Context or level of skill appropriate to the level of study	Develop a rigorous approach to the acquisition of a broad knowledge base.	Generate ideas through the analysis of information and concepts at an abstract level.	Critically review, consolidate, and extend a systematic and coherent body of knowledge.
	Employ a range of specialised skills.	Command wide ranging, specialised technical, creative and/or conceptual skills.	Utilise highly specialised technical or scholastic skills across an area of study.
	Determine solutions to a variety of unpredictable problems.	Formulate appropriate responses to resolve well defined and abstract problems.	Utilise research skills.

Learning outcomes are statements of what a student is expected to know, understand and/or be able to do at the end of a period of learning (module).

Criteria are used to provide more detail for the benefit of both the student and the assessor about what is required as evidence that a learning outcome has been demonstrated. Several criteria will normally be used to define a learning outcome.

Threshold statements are used to show the standard of performance which must be demonstrated for each criterion in order to achieve the learning outcome. The threshold is literally the lowest achievement demonstrated that will be deemed to justify that the criterion has been met.

Grade descriptors are used to indicate what must be achieved in order to attain a grade above (or below) the threshold.

Perhaps the best way of explaining the distinctions is to give an example. What follows is an attempt to interpret the UK-SPEC specific outcomes as learning outcomes. The table below uses the second detailed specific outcome given under the specific outcome 'Engineering Analysis' in the UK-SPEC. The left hand column identifies three criteria which may be used to make the judgments on a student's performance. The matrix gives a range of standards of performance which the assessor might use to determine if the outcome has been demonstrated and to determine a grade for the student against this learning outcome. The first column in the matrix identifies the threshold, which is the minimum acceptable performance which the student must demonstrate in order to demonstrate achievement of the learning outcome.

Learning Outcome	Identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques			
Criteria	D Threshold	C	B	A
Identify and use a range of analytical methods	Use one of two given standard analytical methods to perform a standard analysis.	Justify and use a chosen analytical method to describe the performance of a given system or component.	Use more than one analytical method to compare the performance of two or more systems or components.	Identify the most appropriate analytical method and use it to specify system performance requirements, with full justification of choices.
Use a range of modelling techniques	Use one of two given standard modelling techniques to model a standard system response.	Justify and use a chosen modelling technique to describe a system response.	Use more than one modelling technique to compare the performance of two or more systems. May use a technique beyond those given in class.	Identify the most appropriate modelling technique and use it to specify system performance requirements, with full justification of choices. May use alternative and innovative techniques
explain the performance of systems	List and specify the parameters which determine performance for two given systems or components.	Classify a range of systems or components, using standard performance parameters.	Evaluate the suitability of a range of alternative system or component options for a given application or requirement.	Draw up and use an appropriate list of performance requirements to determine the most appropriate system or component for a range of different applications.

Note:

1. The matrix shows an increase in the complexity of the analyses and explanations required as the grading moves from threshold (D) to the highest standard (A).
2. Depending on the subject of study, particular examples might be given in place of the words 'standard, given system or component'. For example, they might be a suspension bridge, a data interface or a cooling system. Further, the modelling techniques and analytical methods may be specified, e.g. use Thevenin's theorem to determine the outputs of a given electrical circuit.
3. The statements are all positive. That is, they describe what the student must do to gain the grade. They do not contain any negative language (such as, may make one or two small errors in analysis, but not so as to skew the analysis beyond acceptable limits). This is the kind of judgment the assessor must make, i.e if this is the case, then has the student still achieved the required standard? For example grade B standard for the first criterion states 'Use more than one analytical method to compare the performance of two or more systems or components'. If a student does this, but makes one or two minor errors in an analysis, then it might be judged that they have still met this standard. They would be awarded a B grade.
4. The increasing standards operate in one dimension. That is, they increase the complexity of the requirement in terms of moving from given systems or techniques to comparing, evaluating and ultimately choosing systems or components. It is possible to describe other ways in which increasing student performance could be demonstrated. The table below makes further suggestions.

Learning Outcome	Identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques			
Criteria	D Threshold	C	B	A
Use of information	Sources come from text books and material provided through the module	Uses a range of sources of information (module material, text books, reference sheets, library and internet)	Evidence of information from sources not provided directly through the module. Use of both primary and secondary texts.	Identifies the most appropriate information sources, with evaluation of the source.
Communication skills	Grammar and structure of communication aid clarity. Logical development of arguments or analyses. Sources of information are recognized.	Well structured, no irrelevant material and no significant omissions. Sources of information are clearly identified.	Compelling argument, well supported with data, diagrams and information. Well referenced.	Comprehensive communication, with full Harvard referencing. Standard equal to that of published work.

Note:

1. The table above demonstrates 'build-up' standards. That is to say that each grade incorporates the achievement of the grades below.

Making the judgment

The assessor is making a judgment about whether the student has demonstrated the learning outcome at threshold standard (D). To do this, they will make professional, academic judgments.

Example one. Communication skills, threshold grade.

Some sentences or paragraphs of a report may not be written in a clear manner, or perhaps a section of the report may be in 'the wrong place', but, overall, the piece is understandable. If this is the case, as determined by the assessor, then the threshold has been met.

Example two. Identify and use a range of analytical methods, grade B.

The student may use several analytical methods to compare the performance of several systems, but may make some small errors or omit one or two system parameters. Again, it is a matter of judgment by the assessor as to whether this standard has been demonstrated (notwithstanding the minor errors).

Compensation

Having established a grade against each criterion, an appropriate algorithm would be used to determine an overall grade. This grade needs to be a D or above for the learning outcome to be demonstrated. The student may fall short of a D grade for one particular criterion, but the assessor may make the judgment that, overall, the grade should be D or higher. If this is the case, then the learning outcome has been demonstrated. (i.e. the notion of compensation occurs at the level of the criteria, but not the learning outcomes. As before, if any learning outcome has not been demonstrated, then compensation cannot be applied and the student may not pass the module.

Marks or grades?

Percentage marking schemes have been used widely in Engineering for many years. The main reasons are that it makes it easy to average a set of results (even though we know this to be statistically flawed), and that it aids the practice of 'dividing the marks' across a number of headings (e.g. in a technical report: introduction 10%, method 20%, results 25%, conclusions 20%, errors and discussion 15%, references 10%). There are, however, several disadvantages. Aggregating marks loses the distinction between different standards of performance across the criteria. Even the simple statement of a mark (say, 15 out of 20 for the method section) does not explain what the student has achieved, nor does it justify the mark. Finally (although there are more arguments against marking to percentages), it is argued that, if it is not possible to distinguish between two marks or grades, then there is no distinction, and they should not be used (e.g. if it is not possible to distinguish – and specify – the difference between a 56 and a 57, then the scale is too small).

Grades

The key information required by the assessor and the awarding board, and the key feedback desired by the student is whether or not they have 'passed'. This indicates at least two grades – pass and fail. Beyond this, it is useful to distinguish between a pass that is in danger of becoming a fail (so the student will know of this danger) and a higher standard of performance (and similarly, it is good practice to be able to distinguish between a very poor fail and a 'borderline' fail). This leads to a number of grades. A workable scheme would provide six grades:

- A:** an excellent performance. The highest standard defined in the criteria. Leading to a first class degree.
- B:** a very high standard of performance, but with some room for improvement. Leading to a second class degree.
- C:** a good standard of performance. This is a clear pass. Leading to a 2.2.
- D:** the threshold standard. This is the minimum performance required. Any decline in performance may lead to future failure. Leading to a third class degree.
- E:** an unsatisfactory level of performance. Very close to satisfactory and may be redeemable. A little improvement will ensure a future pass.
- F:** very unsatisfactory level of performance (or none). It is unlikely that this can be redeemed easily. Considerable improvement is necessary.

Grades have the advantages of being able to show a profile of attainment for a student and of being matched to explicit standards of performance.

An averaging algorithm for grades

The difficulty is that it is not easy to aggregate grades. One simple method is to convert grades to numbers (grade point averages). A= 75, B=65, C=55, D=45, E=35, F=25. The problems here are that the scale is not linear, the conversion has to be reversed after aggregation and it is really not dealing with the issues of an outcomes based model.

An alternative approach may state that:

If most of the criteria receive a given grade or higher, then that is the grade awarded, unless one or more criteria receive two grades lower than this level.

Examples:

Grades awarded for four criteria which make up a Learning Outcome	Final grade for the outcome	Explanation
A B B C	B	Most of the grades are at B or higher.
A B B E	C	The last grade is more than two grades lower than B.
D D E C	D	Most of the grades are D or higher.
D C E E	E	Most of the grades are E or higher.
D C C F	E	The last grade is two grades lower than D.

These examples apply to the criteria used to judge a single learning outcome, and lead to the overall grade for the outcome. The same process can be applied when aggregating the grades of several learning outcomes in order to provide a grade for the module. Of course, if any learning outcome results in a fail grade, then the module is failed, regardless of the final module grade. In this case, the algorithm could be modified appropriately to ensure the final grade is a fail. That is, if any learning outcome results in a fail grade, the module grade will be E or F. In this case, the student may be required to undertake a further assessment in order to pass the failed outcome.

Institutional regulations

The discussion above is independent of individual institutional regulations. There may be cases where the institutional regulations appear to be in conflict with the principles established in this guide. Clearly, assessment boards must adhere to institutional regulations, but they must also ensure that all learning outcomes have been achieved before a student can achieve an engineering degree. For this to happen the student must satisfy both the requirements as described here as well as satisfy the institutional requirements of graduation.

Section 5 - Assessment practices in engineering

In 1998 Dr. Norman Jackson, then of the Quality Assurance Agency, published an account of a detailed study, done with the EPC's⁵ support, of the development of a specification for a departmental quality management framework for engineering departments (Jackson, 1998). Drawing on data from seven departments, he reported that:

- Amongst a wide range of views about the purposes of assessment, there was a convergence of views amongst the participants that assessment is primarily to assess learning and secondarily to assist learning.
- Most departments use problem-solving exercises.
- Final projects were set in all participating departments and accounted for between 17% and 23% of the final year marks. However, project aims do not explicitly identify the full range of qualities, skills and attributes that the project is intended to develop. Similarly, marking schemes do not always acknowledge the full range of qualities, skills and attributes that academics take into account when they are evaluating performance.
- Essay assignments feature in the assessment regimes of three departments but are only used in the early stages of the course in two.
- Design tasks, computer-based exercises, oral presentations, laboratory/workshop reports and group projects feature in the assessment regimes in all departments but the frequency of use and overall contribution of marks varies considerably.
- Work-based learning and assessment is featured in three [out of seven] departments.
- Less used methods of assessment include: multiple choice tests, short answer questions, oral tests, fieldwork reports, learning portfolios, student led seminars.
- Coursework contributed between 14% and 60% of final module marks. There is no consistent trend in the pattern of examination and coursework through the BEng. programmes.

Three points of significance for the EPC's Output Standard project were drawn out of Dr. Jackson's points:

1. Engineering departments are using assessment methods that are fit for the purpose of assessing student performance in relation to the output standard.
2. There is no evidence of a systematic, programme-wide approach to assessment, although best assessment (and learning) practice contains comprehensive assessment plans that are demonstrably fit for purpose.
3. There is considerable variety of practice between departments (as well as within departments), which raises further questions about fitness for purpose.

It was argued in a paper for the EPCs Assessment Working Group (Knight, 2001) that the output standard implies an approach to assessment with the following characteristics:

- A systemic, programme-wide approach to assessment;
- Summative, grade-bearing assessment of those outcomes that can be reliably and affordably assessed ;
- Greater use of formative assessment, especially for output standards that resist summative assessment;
- The orchestrated use of a range of assessment methods.

⁵ The EPC is the Engineering Professors' Council. The EPC undertook a project to establish standards for engineering graduates at the output of their engineering degree course. This led to the publication of the EPC Output Standard in 2002. This framework has now been replaced by the UK-SPEC. However, much of the work of the EPC's Assessment Working Group (AWG) is relevant to this guide.

Dr. Jackson's findings suggest that good practices are in place and, taking heed of the four points above, that there is much to be done to establish coherent assessment practices that are fit for the purpose of assessing outcome Statements.

The AWG survey of May 2001

With such points in mind the EPC's Assessment Working Group (AWG) undertook a further survey around Easter 2001 in order to check whether Jackson's picture held true for engineering departments in general and to get a better idea of points of tension in current assessment practice. The belief was that good information on these points would help the AWG to formulate realistic assessment advice that capitalised on best practices already in currency amongst engineering teachers.

Forty-eight responses were received. The most common assessment techniques were identified, and the main findings were:

- All informants used examinations, emphasising their importance in providing secure judgements of individual attainments. (There are lively concerns about plagiarism in coursework.)
- Time-constrained tests, often done in lectures, were reported by almost half the informants.
- Virtually all informants used project work and reports of project work to assess students.
- Three quarters referred to presentations.
- Just over half of the informants mentioned using laboratory reports for assessment purposes.
- Design studies were specifically identified as powerful assessment methods by about a quarter of respondents.
- About a quarter praised viva voce examinations or other oral investigations as searching appraisals of understanding and good safeguards against plagiarism.
- A similar number valued assessment by poster presentation.

This is reassuring because these are assessment methods that need to be used if the range of achievements subsumed UK-SPEC is to be appropriately assessed. As one informant said:

"The methods employed currently are perfectly adequate. They provide for a variety of assessments and allow both formative and summative feedback. The methods have evolved over a number of years and are still being enhanced and improved. I would expect to be looking continually at what we do and how we do it and developing new strategies as we move along."

There is expertise in the community of engineering teachers. The task is to ensure that it gets sufficiently distributed, although the report also noted that:

- There are other good assessment methods that informants did not mention. (See Hounsell et al (1996), for example.)
- There are no data on the quality of assessment practices. It is possible to use a method badly, perhaps by trying to use it for a purpose to which it is not well-suited.
- The survey provides no information about scaffolding – the amount of help and guidance students have. The UK-SPEC implies that graduates will be able to demonstrate the achievement of learning outcomes in situations where there is not much scaffolding. It is not clear how far current assessment practices prepare students for this.

More seriously, the UK-SPEC is a *programme* standard, which implies that assessment needs to be understood as a coherent, programme-wide process. Furthermore, the 'Ability to' statements are derived from an analysis of what engineers do and, as such, they are authentic. With authenticity goes complexity. And complex learning goals imply assessment practices that are true to complexity, rather than ones that reduce complexity in the interests of ease or cost. However, a significant point emerging from the survey was that informants attached a lot of importance to examinations because they are reckoned to provide uncompromised information about individual achievement. Some added to this the claim that

these methods provide objective and reliable information about individual attainments. Unfortunately, the UK-SPEC relates to complex achievements that tend to resist reliable (or reliable and affordable) judgement. Informants' emphasis on reliable and secure assessment is in some tension with the need for valid assessments of complex learning. The essential questions are:

1. How is it possible to have reliable assessments of achievements as complex as those described by the Detailed Specific Outcomes?
2. Are the costs of increasing the reliability of tolerably-valid assessments of complex achievements sustainable?

The survey established that extra demands on engineering teachers such as the demands of revising programme assessment practices so as to align them with the UK-SPEC would test a system already in tension. Informants identified a number of contributors to this state:

- The prime contributor was the semester system. No-one had anything good to say about it. Complaints were that it led to a bunching of assignments, that scripts had to be marked to tight deadlines, leading to what one person called severe time compression. Reference was also made to fragmentation and to the difficulties of scheduling complex and authentic assessments in semester-long courses (by the time students have learned enough to be able to tackle complex assignments there is not enough time left for them to undertake them). Opportunities for formative assessment could be similarly restricted.
- Time was widely felt to be in short supply. Improved quality assurance procedures, tightening up double marking practices, for example, added to pressures on time.
- New assessment methods were valued but seen as costly, particularly in the sense of demanding a lot of time (for students to do them and for teachers to mark them).
- Large classes and rising student numbers have exacerbated tensions.
- More valid assessment methods often made it harder to detect plagiarism.

It was also felt that the output standard is a threshold standard, which means that teachers need to derive from it grade indicators for above-threshold performances (3rd, 2:2, 2:1, 1st) and that this is inherently hard, doubly so given widespread unfamiliarity with this necessarily-technical language of learning outcomes. The survey report therefore concluded that while elements of appropriate assessment practice are in place in the engineering community, considerable help should be offered to those trying to devise coherent and valid programme-level assessment practices appropriate to the Outcome Statements. Informants offered suggestions for improving practice, such as:

- Greater specificity and clarity about assessment practices, expectations and criteria.
- Fewer conventional examinations. "I do feel that our main problems within the HE sector is the invalidity of assessments, and the wild belief in the reliability of unseen examinations (even when there is research to show their ineffectiveness in predicting professional success)."
- More formative and less summative "it's the formative assessment that really helps students to learn".
- More collaborative and group assessments.
- Enhanced, substantial design assignments.
- 'I would like to see more emphasis on integrative project work and less on syllabus content. This would generate the diversity which the engineering sector needs. The change in emphasis in assessment would be to enhance standards in the higher levels of taxonomies such as that of Bloom etc. It would also be more motivational, if initially more challenging, to the student cohort.'
- Doing more to emphasise and assess non-engineering skills, especially communication, planning and management skills.
- More oral assessment.

- The introduction of personal development records, which are also known as portfolios or records of achievement.
- Assessment need not be so radically different from that currently deployed. It could require both students and staff to work collaboratively. 'One example in my department is an examination in which students are posed a brief and incomplete outline of a problem. Working initially in groups, but then individually, they use the invigilator as a consultant to obtain further student specified data to define the problem before moving to propose and justify solutions.'

The introduction of UK-SPEC and accreditation based on output standards has produced several issues, in particular how to identify evidence that learning outcomes are being met and at what level. The Engineering Subject Centre has held discussions with both the ECUK and the EPC on how the engineering community could be further supported in aligning the assessment of learning outcomes with the UK-SPEC.

The three organisations have formed an Assessment of Learning Outcomes Working Group which aims to provide support to the engineering community to enhance the process of assessing learning outcomes. The Working Group meets regularly and aims to facilitate the sharing of experiences between programme leaders and accreditation teams and capture and disseminate examples of good assessment practice and how UK-SPEC is informing curriculum design. Further information and resources are available from the groups website www.aloe.ac.uk

Section 6 - Practical assessment methodologies appropriate to the UK-SPEC

Section 5 listed eight assessment techniques that may be well-suited to the Output Standard, while noting that:

- They are not universally used.
- There are tensions that inhibit many engineering teachers from doing a great deal to align their assessment practices with those implied by the output standard.
- Module-level assessment reform is not sufficient for the purpose of warranting achievements of students across a programme, nor for helping their learning across the undergraduate years, nor for helping them to make strong claims to achievement.

Approaches to developing appropriate, practical assessment methodologies

The first thing to accept is that changing practice requires time and effort. It will involve some costly re-shaping of the way academics think about assessment and how they *design* assessment methods. However, it will not necessarily lead to more complex, time consuming or expensive assessment *practices*. With good leadership and understanding, it can lead to *better*, rather than *more* assessment methods. Some methods may well be new, others will result simply from modifying existing methods to ensure greater alignment with the output standards.

Five approaches are discussed in this section. It is for the community, either within a particular engineering department, or nationally, to determine which particular approach or approaches will work best for them.

Analysis of existing practices

The eight most common assessment practices in engineering were identified in chapter 5. These can be summarised as examinations, time-constrained (class) tests, project reports, presentations, lab reports, design studies, vivas or orals, and poster presentations. The interesting thing here is to note that this list identifies *how* the students are being tested, rather than *on what* they are being tested. An effective analysis might consider each of the common assessment methods in turn and determine their effectiveness in measuring a student's achievement against each of the four areas of General Learning Outcome. This might lead to a 4 x 8 matrix as below:

	1 Knowledge and Understanding	2 Intellectual abilities	3 Practical skills	4 General transferable skills
exams				
class tests				
project reports				
presentations				
lab reports				
design studies				
vivas/orals				
posters				

For example, exams might be effective in assessing knowledge and understanding, lab reports might be effective in assessing certain aspects of practical skills (such as mathematical modelling, use of standard software platforms, conducting a sensitivity

analysis, critically assessing results.), and design studies might be effective in assessing a student's ability across all of the General Learning Outcomes.

The same analysis could also be applied to the Specific Learning Outcomes, leading to a 5x8 grid as follows:

	1 Underpinning science and mathematics	2 Engineering analysis	3 Design	4 Economic, social and environmental context	5 Engineering practice
exams					
class tests					
project reports					
presentations					
lab reports					
design studies					
vivas/orals					
posters					

It would even be possible to sub-divide each of the five fields into their Detailed Specific Outcome statements (giving 26 outcome statements across the grid), but this might be considered to be rather unwieldy. However, it should be noted that it has the advantage of recognising that different specific outcome statements in any field may require, or benefit from, different assessment methods. As an example of this, consider that, under 'Engineering Practice', the ability of a student to demonstrate 'workshop and laboratory skills' and 'understanding [of] codes of practice and industry standards' might be assessed using different methods.

Analysis of Generic Learning Outcomes

This approach simply turns the grids the other way round. The analysis begins with the Generic Learning Outcomes (or the specific outcomes in the second case) and, for each field, identifies effective assessment methodologies for the outcomes to be appraised. This analysis provides an opportunity to go beyond traditional assessment practices in university engineering departments and consider methods by which engineers are evaluated in employment or methods used in other academic disciplines.

In considering the two orthogonal forms of analysis above, it is possible to identify assessment methods which are effective across a large range of the learning outcomes and to distinguish these from methods which are only effective for a small range of statements. In this way, the analysis may well identify redundant assessment methods. The analysis could also be extended to consider other criteria for determining effective assessment methods e.g. cost and time demands.

Analysis of existing assessment criteria

This analysis shifts the focus from *how* students are assessed to *what* they are assessed on. The output standards may relate most closely to the final year of a student's programme, so this analysis would identify all of the assessment tasks students undertake in their final year and, for each one, list the assessment criteria being used. These criteria can then be easily mapped to the 26 detailed statements in the output standards that will show where there is over-assessment and where there are gaps in the assessment.

This form of analysis is, perhaps, better than the first two, as it focuses on what is being assessed, rather than on how. It also shows the degree of 'coverage' of the learning outcomes. Again, it is possible to turn the analysis through 90 degrees and to begin with the output standards and map them to the assessment criteria.

Assessment strategy for a programme – leading to a map

The first three approaches provide useful information on existing practice. However, they analyse what *is*, rather than begin by thinking about what *ought to be*. An alternative approach would begin with the output standard for a programme of study and go on to consider how the student might be given the opportunities necessary to:

- develop these abilities;
- provide evidence of having achieved these abilities.

This leads to a top-down, systematic and systemic approach to both programme design and to an assessment strategy. The first bullet point (development of abilities) gets a programme team thinking about the modules that need to be in a programme and how programme learning outcomes will be distributed so as to support the output standard. The second bullet point (provision of evidence) leads the team to the identification of an assessment strategy which operates across the full set of modules. This improves the chances of ensuring (a) that all of the Detailed Specific Outcome statements are assessed and (b) that none of them is over-assessed. It is also likely to lead to a more uniform learning and assessment environment for the student – but it *may* require large changes in practice from the status quo and therefore meet resistance from hard-pressed academic staff.

Assessment practices beyond engineering

Section 5 identified the eight most common assessment methods. It also identified further findings by Jackson in regard to ways of improving current methods or introducing new methods. Key suggestions included collaborative or group work, enhanced design exercises, integrative project work, Personal Development Records or Records of Achievement and staff collaboration. Jackson's (1998) work also reported pleas for clearer criteria and formative uses of assessment (to improve learning).

The development of an assessment strategy, as discussed above, should lead to staff collaboration in assessment and to a reduction in assessment overload. Introducing clear criteria and standards indicators should improve the reliability and even the validity of assessment and an analysis of existing assessment methods, as also discussed above, should lead to better validity. Indeed, an assessment strategy should be able to bring together assessment methods that were previously used independently of each other.

It could be argued that assessing something as complex as the output standard *requires* a harmonised approach, which might bring together such methods as project or design reports, an oral presentation and a poster presentation. Some universities use this bundling of assessment methods (with the further inclusion of a question and answer session) to assess the final year project. What is being suggested here is not the discrete use of a range of methods, but a harmonised, strategic approach to assessment. Matters would be further helped by the application of the detailed Specific Learning Outcome statements as criteria for assessment.

If we go beyond engineering education, we discover other assessment methods used in other subjects that might well translate to engineering and may even be more effective in assessing the output standard. These methods include crits in Architecture or Art and Design, public enquiries in Legal Studies, problem based learning and assessment in Health and Nursing, portfolios and records of achievement in a range of other disciplines, and negotiated assessment in work-based learning programmes. The ASSHE Inventory (Hounsell et al., 1996) reviews these and many other assessment techniques engineering academics may find useful in the context of assessing graduate output standards.

However, effective, reliable assessment begins, not with the assessment method, but with a careful description of what it is that the assessment is attempting to assess (the criteria and standards).

Good programme design

The programme specification guide summarised in table 1, section 2 is devised to encourage good programme design. Notable in the guide is the requirement to identify the programme design tools in field 7. These should include an appropriate output standard or range of output standards in engineering programmes. Field 10 identifies the programme outcomes, which arise from the design tools, and the student learning activities and assessment methods to be used. Field 11 provides the opportunity for the programme design team to determine an assessment strategy at each level of study. It is at level three (final year) that the strategy should be mapped to the output standard. This is where the programme team can optimise assessment, harmonise assessment methods across the modules and encourage collaboration between module tutors and academic teams in devising an appropriate range of assessment methods. The generic criteria identified here also ensure better validity and reliability. Field 14, although still very general, affords the opportunity to map the output standard to the assessments in each module.

Good module design

The module specification guide summarised in table 3, section 2 is intended to encourage good module design. The programme design team identifies the learning outcomes necessary for the student to achieve all of the programme outcomes, which in turn arise from the output standard. This ensures that the modules are contributing directly to attainment of the standard. Having articulated these learning outcomes at module level, the guide provides a methodology for identifying the learning activities and assessment strategy for the module. There is a clear focus on identifying the criteria by which judgements can be made about a student's attainment of the learning outcomes and on describing the threshold standard for each criterion. This reductionist approach may belie the complexity and fuzziness of assessment, but it provides a much clearer starting point for assessment, and it provides a language for those who judge student achievement in which they can discuss their judgements.

Calibration: the need for grade indicators

Although this guide attempts to provide examples of the meanings that the outcomes statements can take, there may still be a need for more detailed guidance on what would count as evidence of threshold performance on each of the 26 statements. Whether the EPC takes up the job or not, departments adopting the output standard would also need indicators to help them tell students about the characteristics of performance beyond the threshold, indicators that they would also use to make good, differentiated judgements of achievement.

The word indicators is used here rather than descriptors as it is not possible to pre-specify all forms of achievement in a determinate way. Fuzzy indicators are the right sort of indicators for some achievements, although when it comes to the assessment of information retention, tight performance descriptors can be specified. Carter and Neal (1995) have provided an example of a semantic scale that they use to help them make good judgements of postgraduate projects.

Similarly, the words 'beyond the threshold' are used to indicate that higher achievement can be evidenced in at least two ways. Threshold descriptors establish the range and standard of performance required to meet the learning outcome. Higher performance can be characterised either by evidence of additional abilities (beyond those identified by the criteria) or by higher standards of performance (above the threshold) which lie within the learning outcome.

Section 7 - The principles of effective assessment

The role of assessment

Assessment of student learning has a central role in both programme design and in the learning environment of the student. It is a key mechanism in determining and maintaining standards and in achieving validation and accreditation. Finally, it is an important method of communicating to all stake holders in the programme what a student will know, understand and be able to do as a result of completing the programme. What follows is a brief outline of principles, policies and practices that will help to ensure that assessment is effective. An important responsibility for a course leader or programme designer is to ensure that all assessment practices in the programme follow these principles.

1. The Context of Assessment

- 1.1. Assessment is the exercise of judgement on the quality of students' work, as a way of supporting student learning and appraising its outcomes.
- 1.2. Rigorous assessment procedures are a principal resource for the maintenance of standards. At the same time, the design and conduct of assessment both need to be sensitive to the central role assessment plays in the facilitation of student learning.

2. Principles of Assessment

Assessment has a number of purposes, including

- 2.1. enabling examiners to certify that the students have **met a certain standard of performance** (e.g. the UK-SPEC).
- 2.2. **certifying levels of achievement**, by enabling students to demonstrate to examiners the extent to which they have achieved the learning outcomes of their programme of study;
- 2.3. motivating students, by providing them **with an opportunity to review and consolidate what they have learnt**, and by requiring them to demonstrate the knowledge, understanding and skills they have developed in their programme of study;
- 2.4. informing the students, by giving them accurate information on their strengths and weaknesses, *with the aim of improving* the quality of their knowledge, understanding and skills;

In order to meet these principles, those involved in assessment need to ensure that there is an appropriate match between assessment strategies and intended learning outcomes, and that their assessment practices are:

- 2.5. fair i.e. reasonable and conducted in an equitable manner;
- 2.6. valid i.e. that they employ instruments designed to **make judgements which match the Learning Outcomes**;
- 2.7. reliable i.e. that they **deliver accurate judgements** that have been subject to appropriate forms of confirmation;
- 2.8. feasible i.e. that assessment is carried out in a manner which does not impose too much of a burden upon either the students or the staff.

3. Policies and Practice on Assessment

Good practice in assessment involves policies and procedures to ensure

- 3.1. the identification and communication of threshold standards and higher standards of performance;
- 3.2. the fairness, validity and reliability of assessment processes and judgements;
- 3.3. the provision of regular, frequent and prompt feedback on student progress which identify strengths, weakness and *advice on how to improve*;
- 3.4. that opportunities are offered for students to discuss progress with the relevant tutors or assessors.

4. Information about Assessment

Should include

- 4.1. the learning outcomes that will be assessed;
- 4.2. the purpose, methods and schedule of assessment tasks;
- 4.3. advice on the format, structure etc. of written and other assignments;
- 4.4. the **criteria** for assessment, including descriptors of **threshold standards** and higher **standards of performance**, indicating what is expected in order to pass or to achieve a particular grade or classification;
- 4.5. which elements will count towards final grading and with what **weighting**⁶;
- 4.6. the marking and assessment mechanisms that will be used.

5. The Assessment Process

A number of types of assessment may be distinguished, although a single assessment task may involve more than one type

- 5.1. **diagnostic assessment**, which predicts a student's aptitude and preparedness for a module or which determines these at an early stage in the module;
- 5.2. **formative assessment**, which gives students **feedback** on the progress they are making during the course of their learning;
- 5.3. **summative assessment**, which makes a final judgement on the student's achievement.

6. The place of Assessment in Programme Design

- 6.1. Assessment should be addressed as an integral part of programme design, with a clear relation between assessment tasks and the programme outcomes.
- 6.2. Assessment design should be undertaken only by staff with a thorough understanding of the **standards** appropriate to the module or programme they are assessing, **and who have been adequately trained and briefed as assessors**.
- 6.3. The scheduling of assignments should avoid any excessive or unbalanced workload for students and for staff.
- 6.4. Assessment judgements would be made in accordance with clear and consistent assessment *criteria*, grade or classification descriptors (*standards*) and *marking schemes*.

7. Feedback on Assessment

- 7.1. Students should receive **regular, frequent and prompt** feedback on their performance and their progress.
- 7.2. Feedback is likely to be most useful where it is specifically related to learning objectives and assessment criteria.
- 7.3. **Open feedback** should be encouraged, where the feedback is provided in a manner that encourages the student to consider further the aspect of their assignment on which the feedback is being provided.
- 7.4. Feedback should be provided in a manner which encourages further **discussion**, whether between the student and tutor, or among groups of students.

Students will achieve heightened performance if

- 7.5. they are made aware of the criteria, standards and weightings;
- 7.6. the criteria and standards are **explained** to them;

⁶ All Learning Outcomes must be demonstrated for a student to pass a module and thus to achieve all of the programme outcomes. However, it is possible for a programme design team to determine that only certain Learning Outcomes, or modules, will be used to determine the overall classification. Indeed, it is even possible for a module team to determine those Learning Outcomes that will be used to determine the grade for the module (provided all LOs have been achieved).

- 7.7. they are **fully prepared** for an assignment i.e. given a full and clear explanation of what is required, how to produce a good assignment and what it is that the assessor is looking for;
- 7.8. they are given **examples** (perhaps from previous, anonymised student work) which they can analyse for themselves in order to see how judgements are made;
- 7.9. they are given **prompt feedback** in a manner which encourages thought and discussion by the student;
- 7.10. they are given classroom opportunities to **discuss** assessment outcomes with the tutor and student groups.

These systems are not designed to spoon-feed the students. Rather, they give the students focus on the key elements of their learning and identify exactly what it is that they are required to do and what standard they are required to achieve.

A number of national and international developments in assessment have been reported widely and have demonstrated their effectiveness in encouraging student learning (and hence developing enhanced performance). These include:

Negotiating assessment criteria with the students.

This often results in a set of criteria very similar to those which the tutor would have identified anyway, but with the benefits of achieving a greater **understanding** by the students of what they mean and greater **commitment** by the students to achieving them.

Self-assessment. Where the student is required to **judge** their own work against the **criteria** and **standards**.

Peer assessment. Often for formative use only, this develops a greater awareness of what a good assignment might look like.

No system is perfect and not every student will see the benefits of an effective system, but like good teaching, **effective assessment should be designed to encourage enhanced learning by the student.**

Section 8 - References and resources

Most of the resources to help colleagues in the assessment of the output standard are ones that the engineering community needs to develop for itself and these are being captured wherever possible by the ALOE WG at www.aloe.ac.uk. The nearest to an off-the-shelf resource is Heywood (2000). Although this is very definitely about assessment in general, Heywood's first profession was engineering and his examples are often drawn from engineering education. The same is true of Cowan (1998), although this is a book about teaching first, assessment second. The ASSHE inventory (Hounsell *et al.* 1996) has already been recommended. Other standard works on assessment include Black (2000), Boud (1995), Brown, Bull & Pendlebury (1997) and , Walvoord & Anderson (1998).

A gateway to hundreds of resources on engineering education can be found in the Resource Database on the Higher Education Academy – Engineering Subject Centre website at:

www.engsc.ac.uk/er/resources

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Appendix 1 – the UK-SPEC Output Standards for Accredited Engineering Programmes

General Learning Outcomes

1 Knowledge and Understanding

Graduates must be able to demonstrate their knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics. They must have an appreciation of the wider multidisciplinary engineering context and its underlying principles. They must appreciate the social, environmental, ethical, economic and commercial considerations affecting the exercise of their engineering judgment.

2 Intellectual Abilities

Graduates must be able to apply appropriate quantitative science and engineering tools to the analysis of problems. They must be able to demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs. They must be able to comprehend the broad picture and thus work with an appropriate level of detail.

3 Practical Skills

Graduates must possess practical engineering skills acquired through, for example, work carried out in laboratories and workshops; in industry through supervised work experience; in individual and group project work; in design work; and in the development and use of computer software in design, analysis and control. Evidence of group working and of participation in a major project is expected. However, individual professional bodies may require particular approaches to this requirement.

4 General Transferable Skills

Graduates must have developed transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

Specific Learning Outcomes in Engineering

Graduates from accredited programmes must achieve the following five learning outcomes, defined by broad areas of learning⁷.

1 Underpinning science and mathematics, and associated engineering disciplines, as defined by the relevant engineering institution

Knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, to enable appreciation of its scientific and engineering context, and to support their understanding of historical, current, and future developments and technologies;

Knowledge and understanding of mathematical principles necessary to underpin their education in their engineering discipline and to enable them to apply mathematical

⁷ The weighting given to these different broad areas of learning will vary according to the nature of each programme.

methods, tools and notations proficiently in the analysis and solution of engineering problems;
Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline.

2 Engineering Analysis

Understanding of engineering principles and the ability to apply them to analyse key engineering processes;
Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques;
Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems;
Understanding of and ability to apply a systems approach to engineering problems.

3 Design

Design is the creation and development of an economically viable product, process or system to meet a defined need. It involves significant technical and intellectual challenges and can be used to integrate all engineering understanding, knowledge and skills to the solution of real problems. Graduates will therefore need the knowledge, understanding and skills to:
Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues;
Understand customer and user needs and the importance of considerations such as aesthetics;
Identify and manage cost drivers;
Use creativity to establish innovative solutions;
Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal;
Manage the design process and evaluate outcomes.

4 Economic, social and environmental context

Knowledge and understanding of commercial and economic context of engineering processes;
Knowledge of management techniques which may be used to achieve engineering objectives within that context;
Understanding of the requirement for engineering activities to promote sustainable development;
Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues;
Understanding of the need for a high level of professional and ethical conduct in engineering.

5 Engineering Practice

Practical application of engineering skills, combining theory and experience, and use of other relevant knowledge and skills. This can include:
Knowledge of characteristics of particular materials, equipment, processes, or products;
Workshop and laboratory skills;
Understanding of contexts in which engineering knowledge can be applied (eg operations and management, technology development, etc.);
Understanding use of technical literature and other information sources;

Awareness of nature of intellectual property and contractual issues;
Understanding of appropriate codes of practice and industry standards;
Awareness of quality issues;
Ability to work with technical uncertainty.

Appendix 2 Action verbs for Learning Outcomes and assessment criteria
(from the HECIW handbook, 1996)

ACTIVITIES GIVING:	ACTION VERBS
EVIDENCE OF KNOWING	define, describe, identify, label, name, outline, reproduce, recall, select, state, present, be aware of, extract, organise, recount, write, recognise, measure, underline, repeat, relate, know, match.
EVIDENCE OF COMPREHENSION	interpret, translate, estimate, justify, comprehend, convert, clarify, defend, distinguish, estimate, explain, extend, generalise, exemplify, give examples of, infer, paraphrase, predict, rewrite, summarise, discuss, perform, report, present, restate, identify, illustrate, indicate, find, select, understand, represent, name, formulate, judge, contrast, translate, classify, express, compare.
EVIDENCE OF APPLICATION OF KNOWLEDGE/ UNDERSTANDING:	apply, solve, construct, demonstrate, change, compute, discover, manipulate, modify, operate, predict, prepare, produce, relate, show, use, give examples, exemplify, draw (up), select, explain how, find, choose, assess, practice, operate, illustrate, verify.
EVIDENCE OF ANALYSIS	recognise, distinguish between, evaluate, analyse, break down, differentiate, identify, illustrate how, infer, outline, point out, relate, select, separate, divide/subdivide, compare, contrast, justify, resolve, devote, examine, conclude, criticise, question, diagnose, identify, categorise, point out, elucidate.
EVIDENCE OF SYNTHESIS:	propose, present, structure, integrate, formulate, teach, develop, combine, compile, compose, create, devise, design, explain, generate, modify, organise, plan, re-arrange, reconstruct, relate, re-organise, revise, write, summarise, tell, account for, restate, report, alter, argue, order, select, manage, generalise, precise, derive, conclude, build up, engender, synthesise, put together, suggest, enlarge.
EVIDENCE OF EVALUATION	Judge, appraise, assess, conclude, compare, contrast, describe how, criticise, discriminate, justify, defend, evaluate, rate, determine, criticise, choose, value, question.

Appendix 3 National Qualifications Framework - Level descriptors

http://www.qca.org.uk/libraryAssets/media/qca_05_2242_level_descriptors.pdf (accessed 15/05/08).

Note: The categories used within the QCA, NCF are NICATS categories, and thus these definitions are those used by NICATS. These are also used in Wales. The full

Generic levels 4-6 in this table relate to university levels 1-3. The level descriptors should be seen as a developmental continuum in which preceding levels are necessarily subsumed within those which follow.

Learning accredited at each level is reflected by the indicators in the table below:

Level	Intellectual skills & attributes	Processes	Accountability
Entry	Employ recall and demonstrate elementary comprehension in a narrow range of areas with dependency on ideas of others. Exercise basic skills Receive and pass on information.	Operate mainly in closely defined and highly structured contexts. Carry out processes that are repetitive and predictable. Undertake the performance of clearly defined tasks. Assume a limited range of roles.	Carry out directed activity under close supervision. Rely entirely on external monitoring of output and quality.
1	Employ a narrow range of applied knowledge and basic comprehension. Demonstrate a narrow range of skills Apply known solutions to familiar problems. Present and record information from readily available sources.	Show basic competence in a limited range of predictable and structured contexts. Utilise a clear choice of routine responses. Co-operate with others.	Exercise a very limited degree of discretion and judgement about possible actions. Carry restricted responsibility for quantity and quality of output. Operate under direct supervision and quality control.
2	Apply knowledge with underpinning comprehension in a number of areas. Make comparisons. Interpret available information. Demonstrate a range of skills.	Choose from a range of procedures performed in a number of contexts, some of which may be non-routine. Co-ordinate with others.	Undertake directed activity with a degree of autonomy. Achieve outcomes within time constraints. Accept increased responsibility for quantity and quality of output subject to external quality checking.
3	Apply knowledge and skills in a range of complex activities, demonstrating comprehension of relevant theories. Access and evaluate information independently. Analyse information and make reasoned judgements. Employ a range of responses to well defined but often unfamiliar or unpredictable problems.	Operate in a variety of familiar and unfamiliar contexts using a range of technical or learning skills. Select from a considerable choice of procedures. Give presentations to an audience.	Engage in self-directed activity with guidance/evaluation. Accept responsibility for quantity and quality of output. Accept limited responsibility for the quantity and quality of the output of others.

Level	Intellectual skills & attributes	Processes	Accountability
4	<p>Develop a rigorous approach to the acquisition of a broad knowledge base</p> <p>Employ a range of specialised skills.</p> <p>Determine solutions to a variety of unpredictable problems.</p> <p>Generate a range of responses, a limited number of which are innovative, to well defined but often unfamiliar problems.</p> <p>Evaluate information, using it to plan and develop investigative strategies.</p>	<p>Operate in a range of varied and specific contexts involving creative and non-routine activities.</p> <p>Exercise appropriate judgement in planning, selecting or presenting information, methods or resources.</p>	<p>Undertake self-directed and a limited amount of directive activity.</p> <p>Operate within broad general guidelines or functions.</p> <p>Take responsibility for the nature and quantity of outputs.</p> <p>Meet specified quality standards.</p>
5	<p>Generate ideas through the analysis of information and concepts at an abstract level.</p> <p>Command wide ranging, specialised technical, creative and/or conceptual skills.</p> <p>Formulate appropriate responses to resolve well defined and abstract problems.</p> <p>Analyse, reformat and evaluate a wide range of information.</p>	<p>Utilise diagnostic and creative skills in a range of technical, professional or management functions.</p> <p>Exercise appropriate judgement in planning, design, technical and/or supervisory functions related to products, services, operations or processes.</p>	<p>Accept responsibility and accountability within broad parameters for determining and achieving personal and/or group outcomes.</p>
6	<p>Critically review, consolidate, and extend a systematic and coherent body of knowledge.</p> <p>Utilise highly specialised technical or scholastic skills across an area of study.</p> <p>Utilise research skills.</p> <p>Critically evaluate new information, concepts and evidence from a range of sources.</p>	<p>Transfer and apply diagnostic and creative skills in a range of situations.</p> <p>Exercise appropriate judgement in a number of complex planning, design, technical and/or management functions related to products, services, operations or processes, including resourcing.</p>	<p>Accept accountability for determining and achieving personal and/or group outcomes.</p>
7	<p>Display mastery of a complex and specialised area of knowledge and skills.</p> <p>Demonstrate expertise in highly specialised and advanced technical, professional and/or research skill.</p>	<p>Conduct research, or advanced technical or professional activity.</p> <p>Design and apply appropriate research methodologies.</p> <p>Communicate results of research to peers.</p>	<p>Accept accountability in related decision making including use of supervision.</p>
8	<p>Make a significant and original contribution to a specialised field of inquiry</p>	<p>Demonstrate command of methodological issues.</p> <p>Communicate results of research to peers and engage in critical dialogue.</p>	<p>Accept accountability in related decision making including use of supervision.</p>

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