Assessing design and technology competency in initial teacher training (Assessing technology learnt rather than technology taught)

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Abstract

This report documents the some of the progress made by the University of Wolverhampton's Centre for Design and Technology Education in adjusting and developing its programmes so students are prepared and assessed in terms of learning outcomes rather than solely by taught assignment tasks. University policy objectives dictate a four-year development programme ending in 1999. At an early stage it was recognised that the success of the programme depended on the installation of appropriate computer software and access to terminals; consequently, an investment programme was put in place to overhaul the existing administrative support systems and records and leaving room for these proposals.

Traditionally, assessment of student progress and achievement in the knowledge part of technology education has been dominated by subjective and often secretive judgements by teachers. Generally, there has been an uncoordinated set of objectives (by the end of this experience students should be able to...) attached to each module of work; students have constructed their programmes by module content rather than the intended outcome of a module. These procedures and choices have not been positively related to what is required by employers and referencing strategies. "Recently, pressures from employers backed by research data caused a major shift towards what the learner knows, or can do as a result of learning" (Otter 1992, pg. 1). Linking tutor-led learning experiences with assessment tasks; the integration of learning outcomes with records of achievement and the matching of student module choices to employer requirements is a developmental process. The current focal point is the link between student career preparation and what employers have identified as required skills.

This report explores the issues linked to the development of technology specific outcomes, personal transferable skills, generic academic outcomes, professional outcomes, student module choices based on the learning outcomes of subject modules and, briefly, the development of records of achievement and employment profiles.

Preamble

There has been intense debate recently about the nature of teacher training and preparation on the back of Government announcements on standards and quality in teacher education. Much has changed over the last ten years in universities and other institutions of higher education responsible for initial teacher training. Design and technology students have never been more rigorously and appropriately trained in terms of subject work and pedagogy; programmes and awards have been designed to contribute significantly to subject development in design and technology. Developments have been supported by changes in capital equipment and resources available to students.

Complete two and three year training programmes are validated every five years. As greater numbers of students taking the subject at A-level have worked their way through to the university applications stage so institutions have responded by offering dedicated design and technology programmes. These programmes are structured to accommodate students wanting to enter industry by taking a specialist three year Bachelors *Design and Technology* Degree as well as those who want to pursue a two/three year Bachelors degree course leading to Qualified Teacher Status. The traditional PGCE route remains open to those taking the 'industry' route as a fourth year and there are also design and technology post-graduate and Masters level modules available to suitably qualified teachers and students.

These and other developments have been secured modestly and quietly in the face of some radical changes in higher education such as a 50% reduction in the unit cost of training teachers and a repositioning of 80% of 'professional' training into schools. Recent research has highlighted the necessity to separate out 'teaching' from 'learning' and this is a report about one of the initiatives in higher education which is changing the way students of design and technology are prepared for assessment of what has been learnt and how achievement is recorded. Learning outcomes, student profiles and records of achievement are becoming an increasingly more important

part of graduation in competitive employment markets.

1 Introduction

This is a report about developments in higher education which are changing the way students are prepared for assessment and how achievement is recorded. '*Learning outcomes*', '*student profiles*' and '*records of achievement*' are becoming an increasingly more important part of graduation into competitive employment markets. Universities in the UK have seen national vocational qualifications being developed at higher levels and an increasingly important need to have a delivery and assessment structure which will integrate teaching programmes with the professional qualifications. Specifying higher education programmes in terms of learning outcomes, rather than as objectives and content-focused descriptions appears to be a way of doing this.

The rate of structural change in higher education has increased and requires those concerned in teaching and learning to be clear about what it is that students are expected to achieve and the ways of developing the outcomes most desirable for them to achieve. There is an expansion of graduate training in the UK through the development of several different modes of study; this fact, coupled with changing teaching and learning modes and the influence of information technology, means that the graduates may not necessarily have followed a traditional three-year course. Increased staff/student ratios and a drive to make students take greater responsibility for their own learning have resulted in staff concentrating on facilitating learning and on assessment. The recruitment of graduates into industry for their intellectual, practical and personal skills generally takes precedence over subject expertise suggesting that the employers' notion of an *appropriate* graduate differs from the academic view.

A Learning Outcomes project (1992-1994) evolved at the University of Wolverhampton as a result of the Enterprise in Higher Education initiative launched nationally in 1989 and sponsored by the Department of Employment in the UK. Although the university's five year contract with the Employment Department has been completed, internal work on records of achievement, profiling and learning outcomes continues.

In 1994 the Secretary of State for Education referred to a need to achieve '*comparability of standards*' (Patten, J. in a speech to the Higher Education Funding Council 1994) and to separate the notion of standards traditionally demonstrated through aims and objectives (i.e. intentions) from what must be achieved (i.e. outcomes) by a student to gain credit for successful study. The *learning outcomes based curriculum* has been developed as an answer to the comparability issue.

2 Background

In 1991 the University of Wolverhampton (referred to as the University) made a decision to move to a curriculum design based on learning outcomes (parallel to its bid for ISO 9000 'quality mark' recognition) and set an agenda which clearly identified areas to be brought more sharply into focus in a modular delivery system. (*See figure 1*) The following objectives for the scheme were agreed:

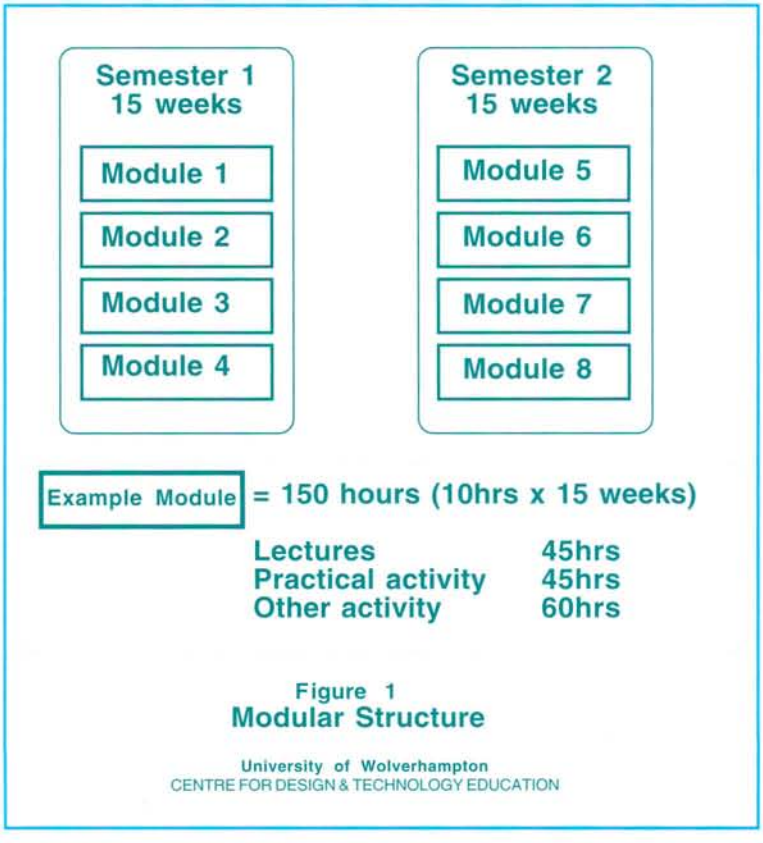

Figure 1
Modular Structure

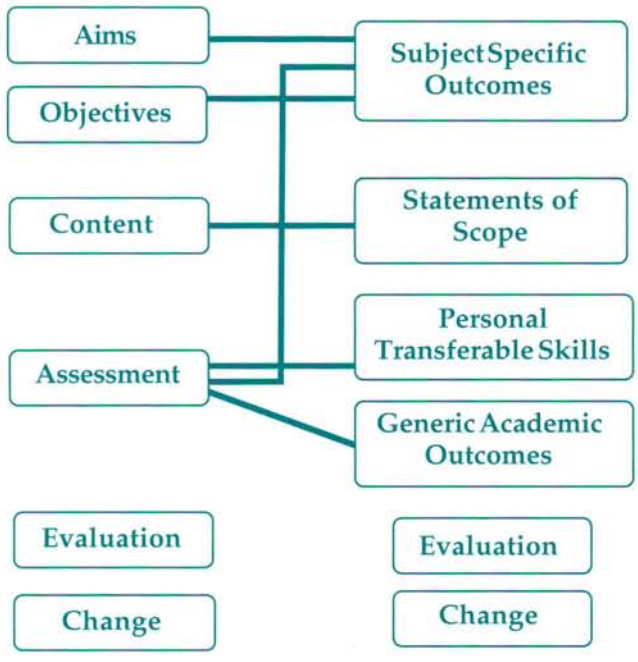

Figure 2
Learning Outcome Equivalents

- achieve clarity of knowledge, theory and skills to be developed in a given module
- facilitate better planning and awareness of what can be achieved in a module
- demystify the processes of assessment for students by articulating clear goals
- facilitate claims for credit from learning
- develop a basis to link to higher level National Vocational Qualifications (NVQs) (but not create a set of 'national standards' for higher education)
- facilitate monitoring of quality of learning.

It seemed sensible to expect that learning outcomes would, therefore, need to:

- describe a balance between breadth of knowledge and ability to 'do'
- include subject knowledge and principles
- acknowledge qualities sought by employers
- be understood by students, staff and employers.

It was also recognised that "...there were some outcomes of higher education which could not be described in these terms..." (Otter 1992) such as integrity, personal development and professional ethics.

3 Introducing learning outcomes

How are first degree graduates different from non-graduates and why is graduation at first degree level more important than the subject of the degree? "The notion of what a degree represents has never been very clear" (Otter 1992) but it has been argued that graduates share a range of common skills and qualities such as analytical and conceptual traits; that they are able to assemble resources and communicate and that they hold a level of expertise in a specialist subject. However, is not clear how parity (comparability) of skills across institutions is measured or how the processes of learning and assessment develop and measure skills. Further, it is not clear how institutions set a criteria for goals or even, whether more concrete 'technological' objectives are structured at all. Cohen and Manion (1989, pg. 28) suggest that there is "...terminological confusion..." and that "...words like aims, goals, tasks, objectives and learning outcomes are used freely and indiscriminately..." Discussion is currently focused on the term 'learning outcomes' and, according to Gilbert (1996 pg. 93) "...has re-opened the debate regarding the concepts of intention and the terminology used to describe them." Outcomes do not lie parallel with objectives, they completely subsume them. (*See figure 2*)

The learning outcomes movement seeks to recognise and celebrate student achievement. Learning outcomes are about 'what a learner knows and can do as a result of learning' (Otter 1992) rather than about the more traditional description of learning input such as *syllabus* or *module* content. Writing programmes, teaching material and resource development in terms of learning outcomes is more far-reaching then a mere technical exercise; "...it raises

issues about the purposes of higher education, the nature of learning and the role of the lecturer." (Cowie 1994 p.3).

4 Objectives and outcomes

An *objective* would appear to be lacking in a single definition but consensus leads to a *specification of changes of behaviour in students and the criteria by which activities are developed, knowledge organised and assessment tasks prepared.* e.g. a typical objective might read: '*to develop skills for design decision-making*'. Ambiguity creeps in when the instructional and behavioural objectives are open to interpretations or misinterpretation when what is needed by students and assessors are words not open to interpretation.

Conversely, typically behavioural objectives can be achieved through routine and practice resulting in a reliable performance of a given task rather than occurring as an indirect consequence of technology education activities. Here, learning can take place without the teacher/student interaction. Non-behavioural objectives such as '*develop critical thinking and understand concepts*' cannot be expressed in terms which are assessable and do not link to the content to which they relate.

Objectives are what one ends up with after some form of engagement and invariably reflect the content of the curriculum by approaching it from the beginning. Observation of previous PATT papers reveals example objectives such as '*Demonstrate an understanding of...*', '*Work safely and sensibly...*', '*Comprehend applications of technology...*', '*Appreciate the concept of...*', '*Develop personal skills in...*'. Clearly, they are not saying *how well* a student must perform acquired skills to gain credit or reflect on a context in which the technology education is set. They expose what students should develop during a module but do not make it clear whether a student is expected to *know in detail or know in general or know and be able to apply.*

Outcomes are concerned with what emerges from the curriculum by approaching planning from the end of a module (its outcome) and working back towards the beginning. They are unambiguous, specific statements of expected behaviour including the conditions under which the behaviour will occur and acceptable standards of performance. They are about what the learner knows or can do as a result of learning; e.g. knowledge, being innovative, comprehension, the ability to apply knowledge in different situations and the processing skills acquired to do this. For personal outcomes one can expect to demonstrate interpersonal skills like team-work, negotiation, reflection, self-assessment and acting independently. Above all, outcomes are capable of being assessed and the assessment procedure understood by those being assessed. Figure 3 shows how the learning outcomes strategy has evolved.

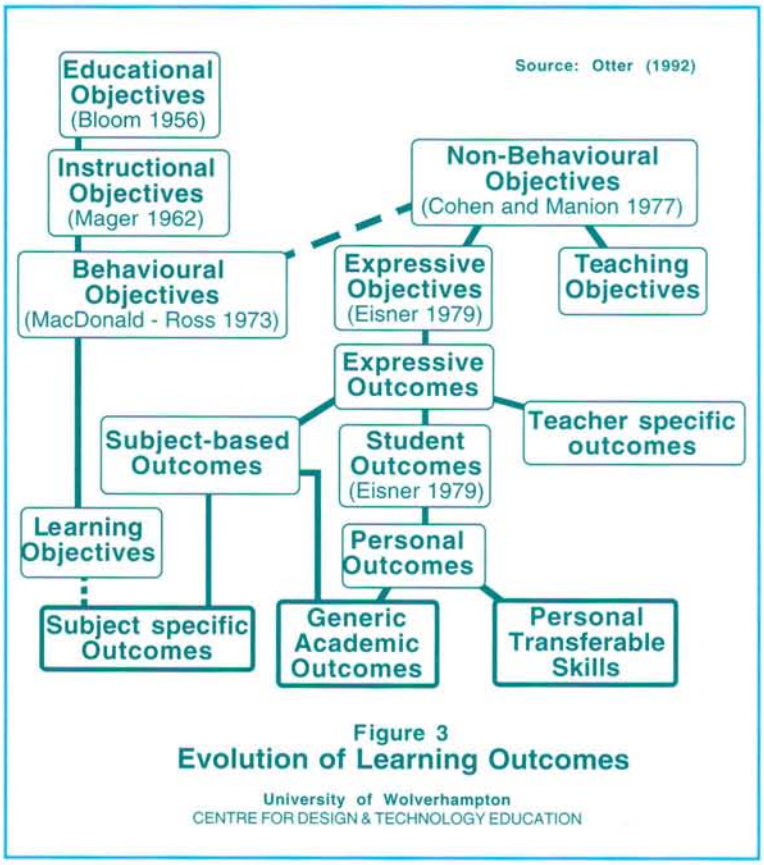

Figure 3
Evolution of Learning Outcomes

5 Working towards learning outcomes

Assembling teaching and learning experiences and support resources for technology education in higher education is becoming increasingly outcome-led. Current discussion concerning what might be understood by the term 'learning outcomes'

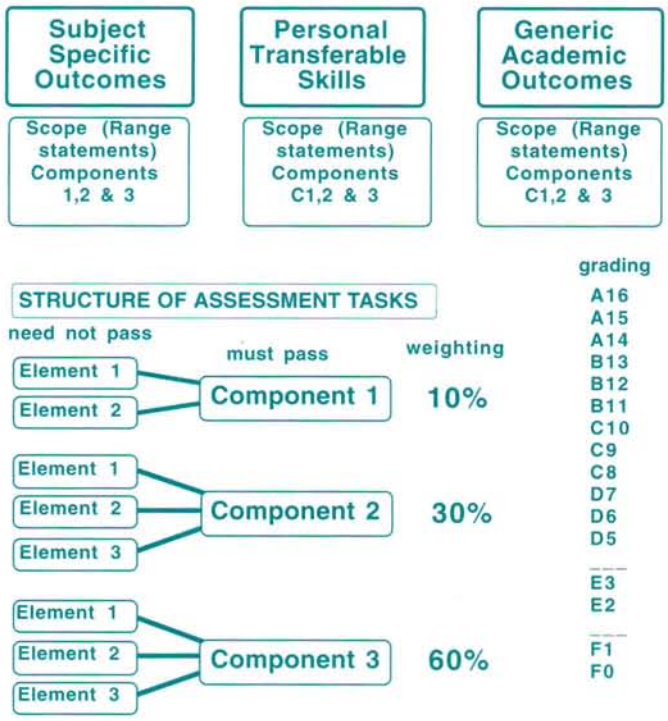

Figure 4
Learning Outcomes and Assessment
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has reopened the debate regarding the concepts of intention and the terminology used to describe them.

With existing university modules of study in *learning outcomes format* and all new modules in the same format the Records of Achievement (RoAs) can be in place for all students. Discussions being held with the National Council for Vocational Qualifications, which is responsible for promoting National RoAs, suggest that as subject portfolios are developed in future the learning outcomes of subject modules can be added to the Internet catalogue. Students can access the catalogue to facilitate their module (and course) choice – a module choice based on various outcome combinations influenced by employment aspirations.

Writing course and assignment material in 'learning outcome' format will evidence the assessment of students' transferable skills. This information is fed into students' Records of Achievement through the university 'on-line' system for the production of RoAs. Students are able to undertake the process of recording achievement and completing a personal development plan. The move towards a learning outcomes based curriculum is not simply a technical exercise in restating objectives, it is far more radical; reporting about the University of Wolverhampton project Cowie explains that academic staff who became directly involved in the process of changing their teaching to learning outcomes based reported the greatest fundamental change and improvement in their feelings about the planning, teaching and learning process.

6 Categories of learning outcome

Designing programmes in learning outcome form does involve expressing the outcomes of a module in terms of (i) subject-specific outcomes (SSOs) , (ii) personal transferable skills (PTSs) and (iii) generic academic outcomes GAOs). Provision for information on the scope or range an outcome covers (a syllabus) and the linking of learning outcomes to assignment components for the purpose of assessment is necessary in order to provide a criteria for the assessment of each task. (*See figure 4*) These steps are essential if there is to be congruence between outcomes, assessment tasks and the learning experience which reflects the level of the work.

Subject-specific outcomes

Subject-specific outcomes are those related to the academic subject content of a specific module. They will be based on the learning objectives traditionally used in module design and will be statements about what the student (rather than the staff) is expected to achieve on completion of the module. Moving the 'syllabus' (see 'Statement of scope' below) alongside the subject-specific outcomes provides a clear indication of the content which is required to meet the outcome (Allen 1996 p.5). Outcomes go some way to address the concern in technology education that learning undertaken while developing and manufacturing a product is greater than the learning which can be observed in the product (assessment by product). There is such a profusion of accessible literature and well-rehearsed statements about minimum technology entitlement and technology (subject) breadth it is inappropriate to

explore the detail here. However, there is a question in technology education as to whether there are core subject outcomes to be developed throughout a programme in order to give subject coherence, i.e. a hierarchy of outcomes, or whether there are several parallel strands of outcomes because the subject has such a wide horizon.

Personal transferable skills

Desirable graduate employment characteristics published by the Confederation of British Industry and employers has resulted in a list of personal transferable skills which undergraduates are expected to achieve (often found by using sophisticated selection techniques to identify particular competencies). Employers indicate they want graduates to:

- have effective individual and group communication skills (higher level proficiencies in reading and writing)
- have ability to solve problems
- be able to take initiative
- apply personal skills in different contexts
- have an ability to work effectively in groups (Source: Pretzer 1996)

More specifically graduates should have:

- values and integrity
- effective communication
- applications for technology
- an understanding of the world
- personal and interpersonal skills
- problem-solving ability
- positive attitudes to change

(Source: Confederation of British Industry, Otter 1992)

A survey of current employer information has resulted in a consensus of personal transferable skills which undergraduates are expected to achieve. Additional professional skills (e.g. those required for teaching such as time management, self assessment and leadership) should be added to this list. See Appendix 2 for more detail.

1 Communicate effectively
2 Organise
3 Gather information
4 Use information technology
5 Act independently
6 Work in teams
7 Be numerate

Generic academic outcomes

These statements give information to students which allows them access to what is expected of them in their subject in terms of academic complexity and to what is meant by the level of the module; level descriptors prove to be useful in making 'level-ness' more explicit. It is here we should isolate what is unique about technology education in order to strengthen our perceptions of what a technology education graduate is and what benefits there are in studying in this area. The Generic Academic Outcomes proposed for technology education are as follows:

A Knowledge and understanding – linking investigative activity to innovation
B Graphic Communication and presentation – making use of information
C Application and creativity through designing – selecting a design procedure
D Solving three dimensional problems – matching resources to design opportunities

What remains is to add assessment level descriptors which can be measured (1, 2 and 3) to each outcome.

Statements of scope or range

The outcome statements need to be accompanied by a clear indication of the scope or range and the contexts in which the outcomes are to be achieved. The statements of scope replace the traditional syllabus which is usually detached from objectives; here, the *syllabus* is described as *statements of scope* alongside the outcomes to provide a clear indication of the content which is required to meet the outcome. Each taught session would be

accompanied by a statement of the outcomes which the session addresses.

7 Using learning outcomes

The structure of student study at the University is based on a selection of modules; four are taken in one semester, eight in each year of study at undergraduate levels 1, 2 and 3. Each module is worth 15 credits (150 hours of study); current assessment of what is learnt is by assignment and a selection of tradition methods of scrutiny are employed such as examination, continuous assessment, verbal presentation, group work, three-dimensional exhibition and reports. Assignments have weighted components which are compulsory and elements which students can afford to fail. Grading is by a sixteen grade point scale, A16 to F0. (*See figures 1 and 4*)

An example of subject specific outcomes, personal transferable skills and generic academic outcomes in use is given in Appendix 2. Here, the expectations for the module 'DT3009 Invention and Innovation' are shown together with the statements of scope and assignment components to which outcomes are related. Figure 3 shows a matrix across a complete, three year design and technology module portfolio.

8 Issues for technology education

For staff in technology education the main issues to emerge from planning discussion are:

- differentiating between 'objectives' and 'outcomes'
- agreeing on the generic academic outcomes
- determining the number of outcomes needed
- using the term 'statement of scope'
- making changes strengthen the coherence of the learning programme
- the role of personal transferable skills in technology education
- focusing on the process students go through rather than the product and avoiding a fragmented, competency-based approach
- making outcomes a liberating experience and academically viable.

Feedback from university groups working to the 'outcomes' framework moved from an initial resentment at the time spent on re-considering and re-writing to an attitude of interest and optimism resulting in:

- greater clarity of what students will be able to do at the end of the module rather than what staff deliver at the beginning of the module
- greater clarity of what is possible in given practical resources available to students.
- more effective planning and delivery of the module material
- a far better positioning of assessments because of the focus on when to assess outcomes
- an increase in the likelihood of students covering all the material rather than concentrating on a few aspects to gain a bare pass
- greater consistency of documents, delivery approaches and assessment
- better descriptions of modules on which students can base choices
- more effective communication and sharing of information with students.

9 Conclusions

It appears that learning outcomes need to fall somewhere between lists of factual information and lists of cognitive skills removed from subject context. Technology subject knowledge cannot be separated from practical and personal skills. Practical skills and competencies are not separable from the content and context of the subject and may be better used as criteria for the assessment of factual knowledge. In Appendix 2 the outcomes and skills for the module 'Invention and Innovation' show the links between practical skills and competencies used as assessment criteria and subject content. For instance, at Generic Academic Outcome 'A' the area of knowledge (scope) a student is expected to know and understand is addressed through practical assignments (components).

Knowing whether the student has achieved this invariably means the student is required to communicate this information orally, in writing or, more frequently in technology education through the application of information to propose the practical solution to a problem. Knowledge acts as a vehicle through which competent practical application is demonstrated and assessed. The most important factor in achieving clarity and precision for students, staff, examiners and employers is the requirement to assess outcomes. A measurement of learning might best be achieved through the description of outcomes or what a learner knows and can do as a result of learning rather than through the more traditional description of objectives and course content.

Appendix 1

Personal Transferable Skills are described as the ability to:

1. Communicate effectively

i) Writing skills – write accurately and effectively in a variety of structured formats (e.g. essay, reports, instructions), and demonstrate the appropriate conventions in each. Recognise different audiences and demonstrate use of appropriate writing styles and relate these to appropriate audiences.

ii Oral presentation skills – give presented material in a variety of structured formats (e.g., formal presentations, formal and informal explanations, instructions). Recognise different audiences and make use of appropriate styles including interactive responses.

2. Organise

Identify and use existing resources effectively; develop flexibility in approaches to the management of work in hand. Recognise task demands and manage time effectively. Monitor, review and reflect upon self-management.

3. Gather information

Gather information (archival and library material, data, statistics) and develop effective storage and retrieval systems. Interpret, analyse and synthesise material in a variety of forms (statistical or textual data, in an appropriate context).

4. Use Information Technology

Create, store, send and retrieve data in a variety of forms (word-processing, electronic mail, databases, spreadsheets, graphics.) Make effective use of information from a variety of sources e.g. CD-ROM, JANET, Internet.

5. Act independently

Develop autonomy, initiative, self-motivation and resourcefulness; demonstrate decision-making and problem-solving skills. Assess progress, and monitor, review and reflect upon own performance and achievements.

6. Work in teams

Work co-operatively in groups, share decision-making and negotiate with others. Awareness and ability to adopt a variety of roles. Listen to relevant opinions before reaching decisions and relate the ideas of others to the task in hand. Evaluate the strengths and weaknesses of group effectiveness and of own performance.

7. Be numerate

Process numerical information related to real-life problems and interpret the outcomes. Develop sufficient symbolic and vocabulary skills to express and interpret a variety of coded statements

It is important to remember that self-assessment should be incorporated into all of the above so students can:

i) identify learning processes and gain made

ii) develop self-knowledge and the ability to reflect upon effectiveness

iii) record, monitor and review progress

iv) make decisions about further development of skills.

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Appendix 2

Example of bundled outcomes taken from the module Invention and Innovation DT3009

5.1 LEARNING OUTCOMES: SUBJECT SPECIFIC
By successful completion of the module students will be able to:

Outcome (I)	**Demonstrate the importance of protecting potentially commercial ideas**
Scope	Case study material and personal invention/s emerging from module assignments
Assessment	Components 2 and 3
Outcome (II)	**Recognise the significance of procedures underlying the legal aspects linked to the protection of commercial ideas**
Scope	Copyright, Design Registration and Patents
Assessment	Components 2 and 3
Outcome (III)	**Structure idea generation strategies and select and develop ideas with registration and patent potential.**
Scope:	Two personal 3D projects demonstrating personal innovation strategies and inventiveness
Assessment	Components 1 and 2
Outcome (IV)	**Prepare Design Registration and Patent protection applications**
Scope	Documentation and certificate of registration of design, facsimile patent data, full size working models with fine detailed features/characteristics
Assessment	Components 2 and 3

5.2 LEARNING OUTCOMES: PERSONAL TRANSFERABLE SKILLS
By successful completion of the module students will be able to:

Outcome 1	**Communicate effectively**
Scope	Written: record accurately in structured formats and write imaginatively to support 3D work Oral: Presentations of personally prepared material convincingly delivered to peer group
Assessment	Component 3
Outcome 2	**Gather and organise information**
Scope	Use resource bases in patent library and Internet; isolate Design Registrations and patents applicable to their chosen area of product development
Assessment	Components 2 and 3

Appendix 2 (continued)

Example of bundled outcomes taken from the module Invention and Innovation DT3009

Outcome 3	**Use Information Technology**
Scope	Use laser disk packages to retrieve information and develop expertise. Use the Internet effectively
Assessment	Components 2 and 3
Outcome 4	**Act independently**
Scope	Demonstrate self-motivation, initiative and resourcefulness, decision-making and problem solving skills
Assessment	Components 1, 2 and 3

5.3 LEARNING OUTCOMES: GENERIC ACADEMIC OUTCOMES

Outcome A	**Knowledge & Understanding**
Scope	Perform Design Registration and patent procedures according to the official system; develop original thinking and ideas and how to locate external support.
Assessment	Components 2 and 3
Outcome B	**Graphic Communication and Presentation**
Scope	Produce patent specific language and documents, technical and product specifications and product display
Assessment	Components 1, 2 and 3
Outcome C	**Application and Creativity**
Scope	Develop ideas into 3-dimensional products and systems and modify products and systems based on experimental, recorded evidence
Assessment	Components 1, 2 and 3

Appendix 3
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Outcomes and Skills Across Design and Technology Modules
Specialist Route

Module		Subject Specific Skills									Personal Transferable Skills							Gen. Acad. Otc.			
Part 1		I	II	III	IV	V	VI	VII	VIII	IX	1	2	3	4	5	6	7	A	B	C	D
Communication 1 L1	**DT1001**																				
Ex mats & processes 1 L1	**DT1000**																				
Foundation technology L1	DT1002																				
Pers. development 1 L1	DT1003																				
Electronic tech systems L1	**DT1005**																				
Control 1	DT1014																				
History of design processes	DT1007																				
Information Tech. for D&T	DT1004																				

Part 2

Communication 2	DT2007																				
CAM for D&T	DT2013																				
Design for production	DT2014																				
Critical review	DT2009																				
Designing for clients Part 1	DT2021																				
Designing for clients Part 2	DT2022																				
Ex mats and processes 2	DT2011																				
Product develop and model.	DT2012																				
Communication 3	DT3007																				
Control 3	DT3030																				
Personal dev 2 Part 1	DT3011																				
Personal dev 2 Part 2	DT3012																				
Entrepreneurial techology	DT3003																				
Invent. and innovation	DT3006																				
Product design Part 1	DT3010																				
Product design Part 2	DT3009																				