ASSESSMENT OF STUDENT LEARNING IN 'SHORT CYCLE' ENGINEERING PROGRAMMES: THE EXPERIENCE OF TWO EUROPEAN INSTITUTIONS WHERE OUTCOMES BASED ASSESSMENT HAS BEEN IMPLEMENTED

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Abstract – The BSc(Hons) programmes offered by the University of Derby, like the majority of engineering degrees in the UK, and the diplomas at the Higher Technical Institute (HTI) in Nicosia, Cyprus are of three-year duration and can be regarded as 'short cycle'. The programmes offered by both institutions are geared to the application of current technology. All the Derby programmes including the BSc(Hons) degree in Electrical & Electronic Engineering and the HTI Diploma in Electrical Engineering are accredited in the UK at Incorporated Engineer level by the Institution of Incorporated Engineers (IIE). The HTI adopted an outcomes based assessment approach at programme level similar to that used in the Derby programmes and this paper examines how this influences assessment of student learning and considers the experience gained from quite different approaches used to deliver a similar learning experience.

Index terms – Assessment, Credit, Learning outcomes, Skills

INTRODUCTION

Both the Derby degree and the HTI diploma are modular in structure and use traditional forms of assessment, which include laboratory works, written assignments and time constrained examinations at module level. Naturally there are differences in the programmes of the two institutions the most noticeable being the staff contact time with students. This is 16 hours per week at Derby whereas at the HTI it ranges from 20 to 28 hours, except for the spring semester of the third year where much of the time is devoted to industrial training. Whilst there is considerable commonality in subject material offered by the programmes, the Derby one offers a greater breadth of study, which is particularly evident in the final year, as industrial training is not compulsory and only offered through a placement year. There are also important differences in the way in which credit is awarded.

Derby

The majority of UK universities deliver their programmes on a semester basis. Engineering programmes were delivered in this way but due to the gradual erosion in the length of a semester a decision was taken some years ago to change to the through semester mode because of the lengthy learning curve required in most subjects. Each semester comprises 12 weeks of tuition and in addition there are block study periods at the end of each semester and an examination period at the end of the spring semester.

Programme modules are defined by their length and status. The majority of modules are of standard length where the staff contact time is 48 hours (two hours per week for 24 weeks). The student notional learning time is 150 hours making the directed study time 102 hours, just over double the contact time.

In the first year students take nine modules but require to pass eight, so the ninth module acts as insurance provided the core requirements are met. The second year is similar but it is optional to take a ninth module. The third year comprises seven modules, as the major independent project is a double module worth 25% of the year. All modules, except the project, have formal tuition and are subject based having a theory and practice element. There are no modules dedicated solely to laboratory work, which is commonly practised in other engineering departments, including the HTI.

The 10-hour credit system in which one credit point represents 10 hours of notional student learning time has almost been universally adopted in the UK. The credit volume in each year is 120 points (60 points in the European credit transfer scheme (ECTS)). UK HE levels 4, 5 & 6 apply to years 1, 2 & 3 respectively, although University regulations allow some credit at the level below in the second and third year. Module status is core, prescribed or optional. Core modules must be passed but others need not, however there are requirements regarding credit volume and level at the end of each year. Students need to pass in six modules in the first and second year and are allowed to carry forward referrals in two modules.

HTI

The HTI use a mix of semester and through semester modules. There are four types of modules, namely theory,

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laboratory, project and industrial training. The semester length is longer than Derby's at 15 weeks but there is no corresponding block study. There are mid-semester and end of semester examination periods. Modules at the HTI are also defined by their length and status. The standard module has a staff contact time of 60 hours (two hours per week for 30 weeks) and student directed study time is double this at 120 hours making the total module time 180 hours. Other module sizes in terms of contact time are one and a half and double and triple the standard one.

The first year comprises eight modules plus English and a cultural elective and all of them are delivered through semester. The second year comprises nine modules, of which one is elective, that have formal lectures and two laboratory based modules. All modules are delivered through semester with the exception of the elective. The third year comprises five modules, one of which is elective, and three laboratory based modules in the Autumn semester. In the Spring semester two modules are delivered, one of which is elective, the independent project and industrial training, which occupies four days of the week. Industrial training is also carried out for six weeks at the end of the spring semester in the first and second year.

The credit system used, which originated in the USA, defines that a minimum of 45 hours work is required by the student for each unit of credit. An hour of work represents a minimum of 50 minutes of contact time, which is the standard length of class duration used at Derby, or 60 minutes of independent study work. For lecture/ discussion classes, this requirement equates to 15 contact hours plus 30 hours of directed study making a total of 45 hours which can be considered as the notional learning time for one credit point. The 45 hours however is a constant even though the value of components for different study modes may vary. The standard module of the theory type, which comprises lectures, therefore attracts four credit points however laboratory type modules only attract half of this at two credit points because it is considered that less directed study time is required in this type of module. This is quite different to that employed at Derby where credit is awarded solely on the achievement of learning outcomes. Modules are separated into two groups, non-transferable and transferable where both types, except when they are elective, may be considered as core. Students' can fail two of the latter type and still proceed at the end of the first and second year, but need to redeem referrals when they proceed.

ASSESSMENT STRATEGY

Whilst both institutions have adopted a similar model for expressing the generic outcomes of their programmes and have mapped these onto programme modules [1] There are however quite different approaches to assessment at module level. The HTI takes a more traditional approach, like many engineering departments in the UK with a bias towards time constrained examinations whereas the strategy used a Derby encompasses a large element of coursework assessment. Derby employs a learning outcomes model at module level whereas the HTI are moving towards this approach.

Derby

Outcomes based assessment used at module level is used to award credit for the successful achievement of module learning outcomes. All outcomes in a module need to be achieved in order to gain the module credit. Experience has shown that using a large number of outcomes can lead to student over assessment and an increase in referral and failure rates. This and other potential pitfalls in implementing such an approach, and the use of an assessment template designed to minimise such shortcomings are examined by Dodridge [2]. The template recommends that the number of assessed learning outcomes should be in the range two to four. It also states the number of learning outcomes carried by each assessment should be no more than two, but ideally one. Testing two (or more) outcomes can lead to complexity in recording failure and in the setting of referred work, since a similar assessment cannot easily be used in its entirety, where one learning outcome is passed and the other failed. It recommends that learning outcomes should be tested only once prior to referral. Testing the same outcome twice, say as a coursework assignment and by end of module examination can not only lead to student over assessment but again to complexity in recording failure. For example, the student could pass in the coursework assignment and fail the examination or vice versa and this would be recorded as a referral despite having achieved the learning outcome.

The underlying principle with regard to formulating module learning outcomes is that the curriculum designer should set down in explicit terms what is considered vital for students to achieve and the most appropriate way of assessing whether the outcomes have been achieved. A large number of second and third year modules that have an end of module examination employ three learning outcomes. Some modules that are purely assessed by coursework have four learning outcomes. With an average of 3.5 outcomes per module the student faces a total of 84 hurdles during the three-year programme and there has been and still is considerable debate as to whether this volume is appropriate since they are all formally assessed.

Assessment includes traditional end of module time-constrained examinations and in course assignments which may be written or utilise logbooks, many being laboratory based. Only two assessment models are used in modules. These are coursework only and mixed mode, the latter comprising of coursework and a time-constrained end examination. The 100% examination model is not used. There are various combinations of coursework/examination allowed by the university for mixed mode assessment and the ones used are 50C/50E, 60C/40E and 70C/30E. As all modules are operated through semester the assessment

loading is spread fairly evenly over the year. Coursework assessment is completed by the end of the Easter break thus enabling students to concentrate on the impending examinations. Well over half the modules in the programme are mixed mode. There is not one that can be described as typical but Table 1 shows one example.

TABLE 1
EXAMPLE OF A 70C/30E MODULE

Ass. No.	Semester	Wtg. (%)	Exam (hrs)
1	Autumn	30	-
2	Aut./Spr.	40	-
3	Spr.	30	2

In the first year around 77% of the assessment overall is by coursework and 23% by examination. The coursework is reduced to 60%, leaving 40% by examination, in the second year. As the third year contains the independent project, which is worth 25% of the credit, the overall coursework assessment increases but depends very much on module choice.

HTI

Theory type modules are only assessed using time-constrained examinations. The first is the mid-semester examination, which is of one-hour duration and employs short answer questions only to test basic fundamentals. The second is the end of semester examination, which is of two hours duration and comprises long answer questions covering material delivered in the semester. Modules delivered in a semester have one of each type described. Through semester modules however have two of each type but the final end of module examination, although weighted slightly higher than the one at the end of the autumn semester, tests only the material in the spring semester. The assessment patterns and corresponding weightings for theory type modules are shown in Table 2.

TABLE 2
THEORY TYPE MODULE ASSESSMENT PATTERNS

Delivery mode	Semester	Exam. type	Wtg (%)	Duration (hrs)
Through Semester	Autumn	Mid-sem	15	1
	Autumn	End sem	30	2
	Spring	Mid-sem	15	1
	Spring	End	40	2
Semester	Aut/spr	Mid-sem	30	1
	Aut/spr	End	70	2

The laboratory type modules are assessed as a logbook of laboratory reports for the whole semester or year dependent on mode of delivery. For each laboratory work the tutor examines the logbook and conducts a short oral examination during the laboratory session. The overall grade for the work is determined using a weighting for each component which is at the discretion of the tutor. The overall module grade is calculated as the average value of marks obtained for each one. Interestingly this type of module only attracts half the credit of a similar duration theory type module as explained in the previous section.

In the first year around 36% of the assessment overall is by coursework and 64% by examination using a base of contact hours but this falls to 18% in the case of coursework when a credit base is used. The second year sees an increase in coursework to 40% and a significant further increase in the third year because of the independent project and industrial training. The project is worth 14% of the final year credit, which is considered very low as the 25% employed at Derby is considered a minimum in the UK.

RELATIONSHIP BETWEEN PROGRAMME & MODULE LEARNING OUTCOMES

The Derby programme first developed programme generic outcomes in 1999 as a pilot to their inclusion in a 'programme specification', a requirement now made mandatory by the UK's Quality Assurance Agency (QAA) for Higher Education. Derby employed the model recommended by the QAA at the time [3], which was to categorise generic outcomes for a programme under the four headings: A-Knowledge & Understanding, B-Intellectual Skills, C- Practical Skills & D-Transferable Skills. The statements crafted under these headings are designed to reflect the overall learning achievements of the programme and as such will be influenced by the programme content and outcomes at module level. Mapping techniques were then employed to map these generic statements to programme modules. The HTI adopted the same approach and received some assistance from academics at Derby in order that they could comply with a condition placed on their accreditation. The accrediting body the Institution of Incorporated Engineers (IIE) are following the guidelines set out by the QAA regarding the employment of an outcomes approach and in the near future it is envisaged that such an approach will be used for benchmarking.

Derby has reflected on some of their generic statements and the experience gained has necessitated some changes [4]. It is important to ensure that such statements are meaningful since in the future they will form part of the programme specification which will be used to inform students, potential employers and other stakeholders of the expected learning achievements. Whilst mapping techniques assist traceability of outcomes at module level they do not ensure credibility of these over riding statements. This can only be achieved by examining module outcomes in detail, whether they are formally assessed or not. Module outcomes in the Derby programme can be seen to reflect generic outcomes in categories A, B & C. Transferable Skills (category D) however are not formally assessed so it is necessary to look at which modules give the best opportunity to develop these skills and add them to the map [4]. Table 3

below shows some examples of how the map of programme generic outcomes has been used to ensure that module outcomes are reflected in the generic statements for the Derby and HTI programmes respectively.

TABLE 3
EXAMPLES OF LEARNING OUTCOMES AT MODULE LEVEL RELATED TO THE PROGRAMME SKILLS MAP

Ass. No. & Sem.	Wtg %	Method	Module Learning Outcomes **See key**	A Knowledge & Understanding					B Intellectual Skills				C Practical Skills					D Transferable Skills				
				1	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4	5
Derby year 1 module: Electrical Measurements & Testing																						
1 Aut	25	Lab. report	1. Demonstrates the use of commonly used electrical/electronic measurement equipment	✓						✓			✓									
2 Aut	25	Lab report	2. Conducts tests to obtain the dynamic response of circuit		✓									✓							✓	
3 Spr.	25	Lab. report	3. Demonstrates the use of advanced measurement equipment and interpret results		✓					✓				✓								
4 Spr.	25	Lab. Exam.	4. Demonstrates the use of electrical and electronic measurement equipment for component measurement and fault diagnosis	✓											✓							✓
Derby year 2 module: Linear Electronics																						
1 Aut	30	Lab. assign.	1. Analyse the performance of an electronic circuit e.g. amplifier, filter, timer							✓			✓	✓								
2 Au/Sp	40	Lab. Assign.	2. Design an electronic circuit e.g. amplifier, filter, timer									✓			✓					✓		
3 Spr	30	Exam.	3. Calculate the parameters of an electronic circuit	✓																	✓	
HTI year 2 module: Digital Electronics & Microprocessors																						
1 Aut	15	Exam.	1. Explain the fundamentals of digital design	✓	✓																	
2 Aut	30	Exam.	1. Explain the fundamentals of digital design 2. Employ a range of techniques in the design of combinational and simple sequential logic circuits		✓				✓	✓		✓										
3 Spr	15	Exam.	3. Explain the fundamentals of microprocessor systems	✓	✓																	
4 Spr	40	Exam.	4. Write and test assembly language programs 5. Design simple microprocessor system hardware		✓				✓	✓		✓										
HTI year 2 module: Digital Electronics & Microprocessors – Laboratory																						
1 Thr. Sem	50 & 50	Lab. Log Report & Oral Exam.	1. Employ correctly the equipment used while practising with digital circuits and microprocessors										✓									
			2. Design and test the operation of simple digital circuits and microprocessors							✓				✓	✓	✓		✓		✓	✓	
			3. Use assembly language to program and test microprocessor systems											✓	✓		✓	✓	✓		✓	

Key to generic outcomes

A Knowledge and Understanding

A1 Develop an understanding of engineering and commercial principles and concepts
A2 Maintain and Manage current technology efficiently
A3 Take up a role in society with regard to economic and environment sustainability
A4 Practice codes of professional conduct, recognising obligations to society, the profession and the environment
A5 Extend specialist knowledge in the application of new technologies

B Intellectual Skills

B1 Exercise independent technical judgement at an appropriate level
B2 Design, develop and operate products. Equipment, processes and services
B3 Actively participate in financial, statutory and commercial considerations and the creation of cost effective systems and procedures
B4 Use a range of thought processes to identify problems and formulate a number of possible solutions

C Practical Skills

C1 Use laboratory scientific equipment and instrumentation competently and safely
C2 Observe, record, manipulate and evaluate data
C3 Demonstrate the process of experimentation, prototype build and manufacturing
C4 Prepare descriptive and interpretative technical reports
C5 Demonstrate the use of computer keyboard skills

D Transferable Skills

D1 Assume responsibility, as an individual or as a member of a team, for the management of resources and/or guidance of technical staff
D2 Utilise information technology in the preparation, process and presentation of information
D4 Apply numerical skills in the collection and recording of data, interpretation and presentation of data and the solving of problems
D5 Manage own roles, responsibilities and time in achieving objectives, learning. Performance, new and changing situations and contexts

The right hand part of Table 3 shows a rearrangement of the skills map to that shown in [1] so as to display more easily the link between module and generic outcomes. It is quite possible to put a tick in many more of the cells against each of the module outcomes but here only those considered to offer the strongest opportunity are ticked. Where transferable skills are not formally assessed the same consideration applies, but in this case it is useful to devise a longer list of module outcomes, which include transferable ones, and categorise them as taught, practised and assessed. An example of this approach is described in [4] and shown for the Derby module Electrical Measurements & Testing in Table 4 below. In this table the outcomes representing practical skills, shown in the bold type, are the only ones assessed and appear in Table 3 along with the transferable ones, which clearly relate to D4 and D5 and the intellectual one, which relates to B2 in this table.

TABLE 4
LEARNING OUTCOMES: DERBY MODULE ELECTRICAL; MEASUREMENTS & TESTING

Outcome No.	&Skill area	T,P,A
	A KNOWLEDGE AND UNDERSTANDING	
1	Has knowledge and a basic understanding of test equipment, measurement and testing techniques	T
	B INTELLECTUAL SKILLS	
2	Develop experimental procedures for making measurements, testing and fault diagnosis	T,P
	C PRACTICAL SKILLS	
3	**Demonstrate the use of commonly used electrical and electronic equipment**	**P,A**
4	**Conduct tests to obtain the dynamic response of circuits**	**P,A**
5	**Demonstrate the use of advanced measurement equipment and interpret results**	**P,A**
6	**Demonstrates the use of electrical and electronic measurement equipment for component measurement and fault diagnosis**	**P,A**
	D TRANSFERABLE SKILLS	
7	Apply numerical skills in analysing measurement data	P
8	Use laboratory time effectively	P

Key: T – Taught, P – Practised, A – Assessed

The Derby module Electrical Measurements & Testing is laboratory based with 15 one hour lectures and is the closest to the laboratory type module employed at the HTI. There are four equally weighted assessments, which are all conducted in the laboratory. The first three use 2/3 two-hour sessions and students complete a laboratory report for each one. Time is allowed outside of the sessions to complete any analysis and conclusions prior to submission of the report on the hand in date stipulated in the assessment schedule. The final assessment is also conducted in the laboratory and is effectively a practical three-hour time constrained examination as students are required to hand in work at the end of this session.

The Derby module Linear Electronics first assignment is laboratory based employing one two-hour session. Students subsequently have to do extensive analysis and therefore are given several weeks to complete the assignment The second assignment employs two laboratory sessions. The first is used for circuit familiarisation and the second for ECAD (Electronic Computer Aided Design) work employing the same circuit as in the previous session. The assignment then proceeds with group work involving problem solving/design. Each part, practical laboratory and group work are equally weighted. The third assessment takes place at the end of the module and is a two-hour examination. The examination paper typically has three long answer type questions on a selected part of the module content that has not already been assessed. There is no choice of questions but many tutors do offer some choice in similar examinations in other modules.

The HTI module Digital Electronics & Microprocessors is a through semester module and comprises four examinations. There are autumn and spring mid-semester ones of one-hour duration containing several short answer questions, examining the knowledge and understanding of the principles of the subjects taught. End of semester examinations have a two-hour duration and comprise long answer style questions examining in-depth knowledge and understanding. Typically the student has to answer three out of four equally weighted questions. The spring examination only tests subject material covered in that semester.

The HTI module Digital Electronics & Microprocessors – Laboratory comprises 15 experiments scheduled on a weekly basis and of two-hour duration. All laboratory experiments are equally weighted and assessment comprises of a report and short oral examination. If the report is not finished by the end of the session it can be completed outside and submitted the following week. The student may fail one laboratory and pass on the average mark obtained

DISCUSSION OF ASSESSMENT ISSUES

Clearly there are differences in the assessment of student learning between the two institutions and this manifests itself in many ways but particularly in the assessment methods employed and in the award of credit. The assessment of student learning is necessary part of quality control and in particular in maintaining and comparing standards. In designing work to be assessed tutors often give little regard to the student learning experience and the best methods to employ for the student to demonstrate the achievements of learning outcomes. Unfortunately assessment is in many instances seen as the process by which we test students learning whereas it should be thought of as part of the overall strategy for helping students to learn. To quote, “Assessment is an ongoing process aimed at understanding and improving student learning”[5] and, “We should certainly not overlook the connection between assessment and curriculum. The two should be working in parallel to each other and not independently. What I mean by this is that assessment should be curriculum-driven and not the other way round” [6].

Derby has moved significantly in a direction where learning outcomes are followed through to assessment, which is evident throughout the curriculum. Coursework assessment is regarded as being equally important as end of module examinations and rigorous internal assessment verification is applied in each case. Whist the HTI has formulated programme generic outcomes, outcomes at module level, and their assessment, have only recently been introduced in some modules. Mouskou-Peck [6] also stated, "Ideally assessment should be a continuing and ever persistent process that takes into consideration the student as a whole, and not limiting his evaluation on a specific, number of exam papers". There is therefore perhaps an over reliance on the traditional type of examination to deliver learning outcomes in the HTI programme. Assessment of student achievement in both institutions is rigorous and provides formative assessment in respect of coursework assignments at Derby and semester and mid-semester examinations at the HTI.

The question of how much credit to award is one for considerable debate. As previously stated at Derby there is no distinction between credit awarded for coursework and examination assessments unlike the HTI where they are proposing to offer only half of that awarded in theory type modules in laboratory ones. The pass mark for assessed work also highlights some differences. Derby uses an alphabetical grading system for individual pieces of assessed work and for module grades. There are 12 pass grades ranging from the lowest at D- to the highest at A+, the former being the threshold for achieving the learning outcome. In percentage terms this threshold is considered to be about 40%. Tutors are expected to mark all work using this grading scale but some still use percentages and convert to an alphabetical grade. In contrast the HTI use a percentage scale and have a higher pass mark at 50%. The Derby model is a full achievement one in which all outcomes must be achieved. There is no compensation between assessed components of coursework or between coursework and examination in mixed mode assessment.

The student perspective is also important and the following comments are by two HTI students who joined the second year of the Derby programme for the autumn semester on a Socrates exchange. Both found the assessed assignment work educationally more satisfying because it makes students work in depth for certain topics in a module, which includes research in the learning centre, learning to work alone and not being satisfied on just what is given in the formal tuition. This fulfils some of the learning outcomes but the final examination has the advantage that it makes the student work and study on all of the module subject areas and not just specific ones. However it has the disadvantage that in general reading is limited to the scope of the formal tuition. Both students suggested that a combination of the two as it is done at Derby is the best approach.

Quality systems are well established at national level in the UK by the Quality Assurance Agency (QAA) for HE. Such systems do not exist in Cyprus so the HTI Board of Governors has decided to implement the Quality Management System Standard ISO 9001:2000 to verify the quality of education offered by an independent third party. The documentation of the system has been completed in June this year and will be implemented from September. It is expected that the HTI will be ready for certification with CYS/ELOT by March 2003, the first of its kind in an educational establishment in Cyprus and Greece.

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CONCLUSIONS

Programmes from both institutions have been designed as short cycle and first cycle in the spirit of the Bologna Declaration [7] and as stated in the declaration applicable to the labour market. The declaration refers to the adoption of 'easily readable and comparable degrees'. The approach adopted by both institutions in respect of outcomes based assessment is seen as responding to this challenge despite there being more work to do regarding the adoption of a programme specification and in respect of quality assurance.

Derby will be revalidating their programmes for the 2003/2004 academic year and are considering introducing the laboratory type module employed at the HTI in the first year. Also new University regulations should be in place, which will allow examinations at the end of each semester in through semester module delivery. The HTI are to try out in the next academic year a combination of assessments similar to the Derby model where there is greater emphasis on assignment work.

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