SYSTEMATIC DEVELOPMENT OF MODULAR LEARNING OUTCOMES

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Abstract — *As part of the drive towards a more systematic approach towards quality assurance in Higher Education in the UK, the Quality Assurance Agency (QAA) for Higher Education has stated that all modules should state their learning intentions in the form of learning outcomes. Having undergone a recent QAA audit, it seemed logical to use the Engineering Benchmark Statements for the development of a new degree scheme with the Division of Design and Engineering. The intentions of this paper are to: propose a model for developing outcomes from QAA Engineering Benchmark Statements and Programme Specifications; identify some basic tools/techniques that can be used within this model; illustrate the application of this model for developing module learning outcomes; identify the problems encountered using the model.*

Index Terms ¾ Curriculum development, learning outcomes, topic analysis, teaching and learning experience.

INTRODUCTION

Like many other Engineering Departments across the UK, the Division of Design and Engineering at the University of Paisley has come under pressure to try to reverse the downturn in student numbers on our degree programmes. As part of a University & Faculty strategic change plan, the decision was taken to change our focus from Chartered Engineer (CEng) accredited courses to that of Incorporated Engineer (IEng) accredited courses. This would entail developing a combined degree scheme that would be designed to enable students to take a number of 'with' options. As design in its broadest sense covers many aspects of mechanical and manufacturing engineering, it seemed logical to adopt a design-based title for the proposed degree scheme. In addition, initial market studies indicated the popularity of Product Design [1] as a title and industry indicated the need for engineering designers familiar with modern design processes and methods.

Having recently undergone a QAA audit most of the Programme Development Team was familiar with the Engineering Benchmark Statements [2]. However, the majority of the team had very little experience of developing outcome- or competence-based courses and modules. In fact, like many other Higher Education Institutions, the majority of staff, although well qualified in their own particular discipline, have no or very little formal training or background in the theories of learning and teaching. Furthermore, there was the added 'constraint' of ensuring that the course developed would also be satisfactory in terms of IEng accreditation through the Institute of Incorporated Engineers (IIE). Therefore, as part of this development process a model for curriculum development was proposed. The description of this model is the main focus of this paper.

DEFINITIONS OF BASIC TERMINOLOGY

There are a number of basic definitions that must be provided before documenting the curriculum development model. This is to ensure consistency in the use of educational terminology across the Programme Development Team, taking into consideration the comment made above about the lack of formal background in educational theory. First and foremost, it must be made clear what is meant by 'curriculum' and 'curriculum development'. In terms of Higher Education, a suitable definition of curriculum is [3]:

"the total planned learning program for any student."

Therefore, it logically follows that curriculum development is the act of planning the learning program. This can be achieved by considering four classic curriculum questions [4]:

- What learning objectives/outcomes are we seeking to achieve?
- What learning experiences are required to achieve these objectives/outcomes?
- How can the learning experiences be effectively organised?
- How can we determine if these objectives/outcomes have been achieved?

This logically leads to the definition of a 'learning outcome'. In it's simplest form, a learning outcome can be defined as the product of learning [5]. In this case it is the product of the planned learning programme. The use of learning outcomes therefore requires [6]:

- an explicit statement of the learning intent i.e. the learning outcome;
- consideration of how this learning outcome can be achieved i.e. the learning experience;
- consideration of the level of performance required in achieving the learning outcome i.e. the assessment criteria.

This definition allows curriculum to be redefined as 'a structured series of intended learning outcomes'.

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BASIC CURRICULUM DEVELOPMENT MODEL

To be of use to academics in Higher Education, most of whom are already overburdened with administration and trying to cope with the ever-increasing rate of change being forced upon them, the proposed model and associated tools/techniques must be simple and easily applied. Therefore, the model has been developed with this in mind. The model proposed is a simple five-step, iterative process as illustrated in Figure 1 and it can be employed for developing outcomes for both programmes and modules [7]. The five steps are described below.

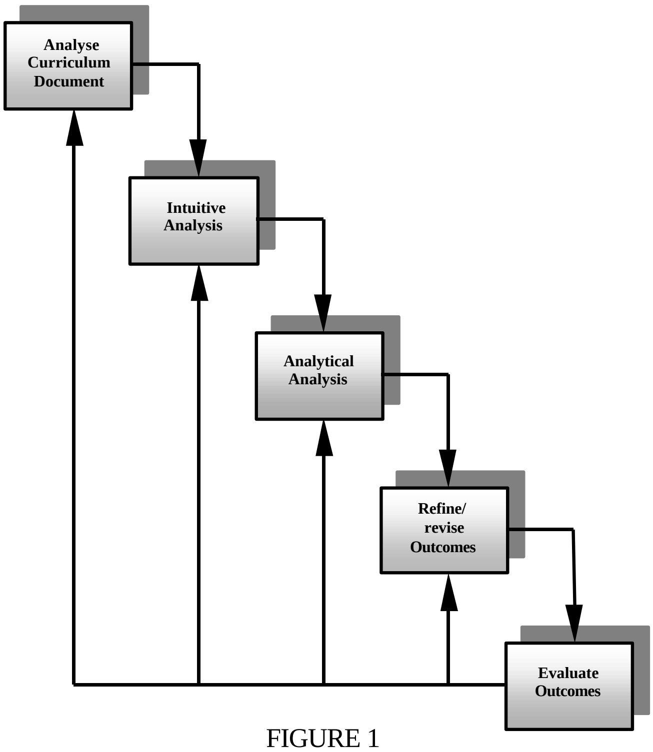

FIGURE 1
BASIC MODEL FOR CURRICULUM DEVELOPMENT

Analyse Curriculum Document

Regardless of the time spent developing a curriculum document, those who have to put it into practice will invariably identify weaknesses in it. Therefore, one of the main roles of the curriculum development team is to compensate for any perceived weaknesses. This is achieved through interpretation of the programme learning outcomes and determining appropriate content and context for achievement of these.

Intuitive Analysis

Also known as topic analysis, intuitive analysis is used to identify the intended learning outcomes. Much of what is developed in Higher Education within curriculum development is based on intuition. This is based on an individual's experience and knowledge of the subject area under development. Therefore, within a development team there may be different perspectives of what is considered essential for a particular subject/discipline. In order to get the broadest possible topic coverage, at the outset of the intuitive analysis one possible technique to employ is brainstorming. This will allow every member of the development team to express their views on the possible direction and intentions of the programme/module. The next step is to structure the output of the brainstorming into learning outcomes. This can be achieved by using a topic analysis technique. There are various models of topic analysis but the one employed within the context of this paper is the Stenhouse model [8]. This model suggests that some of the aims can be used to directly formulate the sub-topics and it can be used to achieve these. This model of analysis also helps structure learning to ensure the achievement of such aims is more likely, which is the main reason for it's use.

It is useful to consider, at this point, the outcomes involved and where they lie within the three domains of learning, particularly for module outcomes. This will be achieved by considering the three domains of learning in turn and brainstorming to ensure comprehensive coverage of each of the elements of the sub-topics. The three domains are [9]:

- psychomotor;
- cognitive;
- affective.

These are defined as follows:

- ***Psychomotor*** **-** relates to the measurement of the performance of some sort of manual skill. This usually involves the manipulation of equipment, materials, tools and/or objects e.g. producing a design drawing, machining a part, etc. Therefore the psychomotor domain is primarily about ***doing*** something.
- ***Cognitive*** **-** involves at its most basic the memorising or reproduction of material that has been learnt and hopefully understood. Therefore, this involves thought processes e.g. select a suitable material, define a term, etc. and means that the cognitive domain is about ***thinking***.
- ***Affective*** **-** this domain includes the demonstration of feelings and emotions towards people or ideas. Therefore it is primarily concerned with ***attitudes***.

Within each of these domains, there are a number of levels of 'performance' that can be defined [9]. These are listed in Table 1 in order of increasing difficulty for each of the domains. To achieve performance at the most difficult levels requires the less difficult levels to have already been mastered. These are particularly useful for determining the entry behaviour. The easiest way to illustrate the domains and levels into which the sub-topics fall is in the form of a table. This will be illustrated when considering the application of the model.

TABLE 1
PERFORMANCE LEVELS WITHIN THE THREE DOMAINS

Increasing Difficulty	DOMAIN: Cognitive	DOMAIN: Affective	DOMAIN: Psychomotor
↓	***Knowledge*** – recognition and recall of information	***Receiving*** – aware of passively attending certain stimuli	***Imitation*** - observes skills and tries to repeat it
	Comprehension - interpret, translate or summarise given information	***Responding*** – complies to given expectations by reacting to stimuli	***Manipulation*** – performs skills according to instruction rather than observation
	Application – uses information in a situation different from original learning context	***Valuing*** – displaying behaviour consistent with single belief or attitude in situations where not forced to obey	***Precision*** – reproduces a skill with accuracy, proportion and exactness and usually performed independently of original source
	Analysis – separates whole into parts until relationships are clear	***Organising*** – committed to a set of values as displayed by behaviour	***Articulation*** – combines one or more skills in sequence with harmony and consistency
	Synthesis – combines elements to form new entity from original one ***Evaluation*** – makes decisions or judgements based on criteria or rationale	***Characterising*** – total behaviour consistent with internalised values.	***Naturalisation*** – completes one or more skills with ease and becomes automatic

Analytical Analysis

The focus of the analytical analysis is how the outcomes are to be achieved within the learning and teaching experience. In any learning and teaching experience there are four elements as illustrated in the basic model of teaching in Figure 2 [9]. This includes:

- ***Learning outcomes* -** what the students should be able to do after instruction.
- ***Entry behaviour* -** what the students should be able to do before instruction.
- ***Instructional techniques* -** the teaching process used to enable students to achieve the outcomes.
- ***Assessment* -** the process used to determine how well the student can achieve the outcomes.

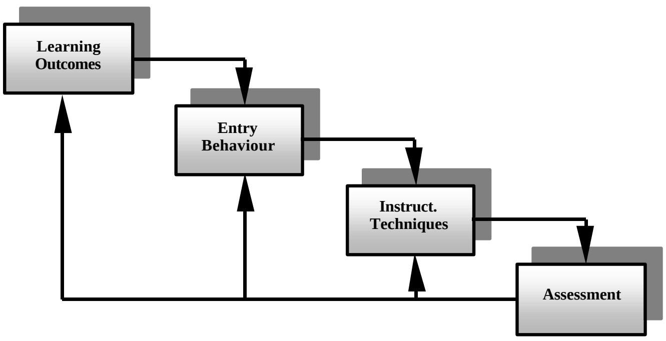

FIGURE 2
BASIC LEARNING AND TEACHING MODEL

The determination of the outcomes has already been covered in the intuitive analysis. The instructional technique and the assessment are more relevant in curriculum development at a modular level. However one of the main considerations within the analytical analysis is the entry behaviour. Another consideration of the analytical analysis is to do with resources and in particular the influences and constraints on the learning experience and achieving the outcomes.

In terms of the outcomes already developed, the focus of the analytical analysis is on determining what is considered as suitable entry behaviour for prospective candidates. Typically, this is considered in general terms of qualifications required for entry to the module. However, in this case the focus will be on the skills required to achieve the outcomes based on the required preformance for each domain. This will help identify topic areas required for achievement of the outcomes and be used to develop the modular content. It will also help identify what are considered suitable entry qualifications. The other focus of this analysis for the module outcomes is on resources. These will mainly be the physical resources available and the best way to formulate these is in a tabular format.

At this level there should be enough detail to specify both instructional techniques and assessment methods for the module. The outcome and content statements can be used to help identify appropriate instructional or assessment methods for the module. Using the results of the analytical analysis in conjunction with the matrix illustrated in Table 2, possible combinations of instructional technique and assessment method can be outlined for module outcomes. Many of these instructional techniques can also be employed as assessment methods and this allows the matrix to be used to identify suitable assessment methods.

TABLE 2
INSTRUCTIONAL TECHNIQUES/DOMAIN MATRIX

Instructional Technique	*Psychomotor* Low	*Psychomotor* High	*Affective* Low	*Affective* High	*Cognitive* Low	*Cognitive* High
Lecture	XXX					
Demonstration	XX					XX
Team teaching	X					XX
Discussion			XX			XX
Debate			XX			XX
Question & Answer						XXX
Video	XX		XX			XX
Seminar			XX			XX
Laboratory/workshop	XXX		X			XX
Gaming/quiz			XXX			XX
Brainstorming						XX
Field trip	X					XX
Ice breaker			XX			
Simulation	XX		X			X
Case study						XX
Project/assignment	XX		XX			XX
Tutorial			XX			XX

Refine/revise Outcomes

The product of the intuitive analysis is the definition of the desired learning outcomes. However, in the light of the analytical analysis, these may require to be refined or even completely revised due to resource implications. Once refined or revised appropriately, the outcomes should be ready for implementation.

Evaluation

After having been implemented, the outcomes should be evaluated using an action research strategy. Action research is basically about trying to continually improve the learning and teaching experience. In this case it has been used as an appraisal technique in order to help in the understanding and improvement of the development and subsequent delivery of the learning outcomes developed. Action research involves a simple cyclical process of observing the effects of teaching techniques, reflecting on these observations and analysing them and taking action to improve the techniques. This is illustrated in Figure 3 [10]. The various stages are:

1. ***Reflecting* -** on the last piece of learning and teaching and write a short account of it.

2. ***Explaining* -** write up any ideas, theories or models that might explain what occurred.

3. ***Action Plans* -** look at the areas requiring improvement and develop an action plan to improve these.

4. ***Action* -** implement the action plan on the next piece of learning and teaching.

5. ***Reflecting (again)* -** write up what happened and appraise the teaching in terms of the action plans i.e. what you set out to achieve.

6. ***Continuing* -** continue round the learning cycle revising the improvements and the action plans.

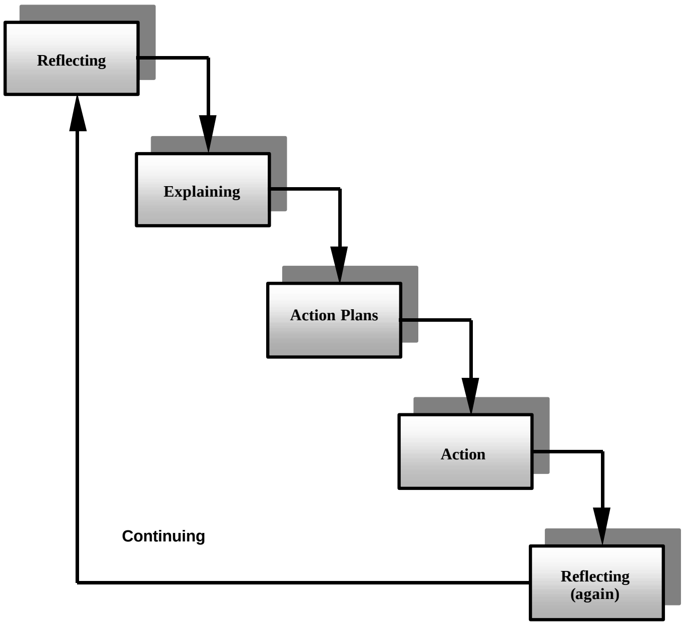

FIGURE 3
RESEARCH ACTION MODEL

APPLYING THE MODEL

Although the model can be used for the development of either programme or module outcomes, for the purposes of this paper the focus will be on the development of module leanring outcomes. The application of the model is described in the follwing five sub-sections.

Analysing the Curriculum Document

The main document to be analysed is the Programme Specification. However, occasional reference is made to the QAA Engineering Benchmark Statements [2] as these were used to develop the programme outcomes as stated in the Programme Specification.

The Programme Development Team produced a list of module titles to reflect the programme aims and outcomes. One module that was developed with and will be used to demonstrate the curriculum development model was entitled Product Design and Development. After an initial brainstorming session it was agreed that the aim of the module was to introduce the design process and the various phases of the design and manufacture of a product from identifying the customer need to satisfying that need. It was also agreed that as analytical approaches to design were being covered in other modules that the focus should be limited to the embodiment phase of the design process.

Intuitive Analysis

Having defined the aim of the module, the brainstorming session continued and identified four topics considered 'core' to the design process and these are illustrated in Figure 4. These were then developed further in to four learning outcome statements as follows:

- **Learning Outcome 1**: Identify and describe the generic phases of the design process.
- **Learning Outcome 2**: Generate a Product Design Specification (PDS) in accordance with current standards.
- **Learning Outcome 3**: Apply simple design methods for various phases of the design process.
- **Learning Outcome 4**: Generate and present a solution for a simple design problem in accordance with current standards.

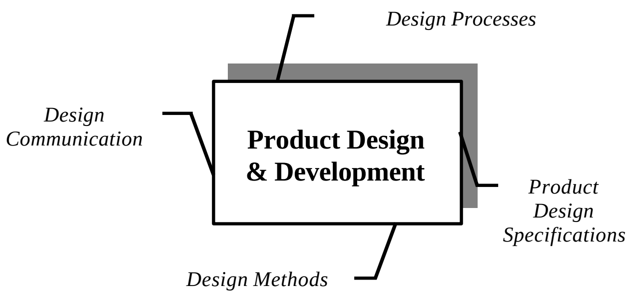

FIGURE 4
STENHOUSE TOPIC ANALYSIS FOR MODULE

Analytical Analysis

The same approach to developing the outcomes was taken to develop the content for each of the outcomes. However, the development of these is outwith the remit of this paper. Therefore, the primary focus of the analytical analysis is determining what is considered suitable entry behaviour and the main influences/constraints in achieving the outcomes once the content has been developed. This is best documented in a tabular format. The analysis for this module is illustrated in Table 3 below.

TABLE 3
ANALYTICAL ANALYSIS FOR MODULE LEARNING OUTCOMES

Entry Behaviour	Outcome	Influences/Constraints
Listening, reading, writing, comprehension, application, analysis, synthesis, evaluation, manipulation, oral communication	**1.** ***Identify and describe the generic phases of the design process.***	Previous experience, vocabulary, level of thought processes, gaps in entry behaviour, laboratory access, time
Listening, reading, writing, numeracy, comprehension, application, analysis, synthesis, evaluation, manipulation, precision, oral communication, presentation	**2.** ***Generate a Product Design Specification (PDS) in accordance with current standards..***	Prejudices, vocabulary, manual dexterity, level of thought processes, concentration, gaps in entry behaviour, laboratory access, time
Listening, reading, writing, numeracy, comprehension, application, analysis, synthesis, evaluation, valuing, manipulation, precision, articulation, oral communication	**3. A*pply simple design methods for various phases of the design process..***	Prejudices, vocabulary, manual dexterity, level of thought processes, concentration, gaps in entry behaviour, laboratory access, time
Listening, reading, writing, numeracy, comprehension, application, analysis, synthesis, evaluation, organising, articulation, oral and graphical communication, presentation	**4.** ***Generate and present a solution for a simple design problem in accordance with current standards.***	Previous experience, vocabulary, manual dexterity, level of thought processes, concentration, gaps in entry behaviour, laboratory access, time

At this stage there should be enough information to identify and tabulate appropriate instructional techniques and assessment methods for the learning outcomes using Table 2. This is best documented in a tabular format as illustared in Table 4 below.

TABLE 4
INSTRUCTIONAL TECHNIQUES AND ASSESSMENT METHODS

LO	Instructional Technique	Assessment Method	Rationale
1	Lecture, Discussion, Video, Assignment	Group Assignment	Lecture and discussion to introduce generic model of design process and video to reinforce industrial practice. Formative assignment to discover other models of design process.
2	Mini-lecture, Case Study, Discussion, Demonstration, Assignment	Group Assignment & Oral Presentation	Short lecture on PDS followed by interactive case study and discussion. Demonstration on how to compile PDS and then group assignment to compile PDS for given design problem.
3	Lecture, Demonstration	Group Assignment	Lecture outlining tools and techniques for various phases of design process. Demonstration of one tool/technique for each design phase.
4	Mini-lecture, Gaming, Simulation	Group Assignment & Oral Presentation	Short lecture on the importance of presentation for design solutions. Series of games for graphical communication, interpretation and questioning. Simulation for design problem brief.

Refine/revise Outcomes

From the above analysis there appear to be no grounds for refinement nor revision of the module outcomes. With suitable entry behaviour and resources, the outcomes should be achievable. The above information will form the basis for the module descriptor.

Evaluation

This module is due for its first presentation during Semester One of the session 2002/2003 after which it will be evaluated using the research action model detailed in Figure 3. At that point, any problems encountered with any aspect of the delivery of the module will be considered and appropriate ammendments made.

CONCLUSIONS

The model developed in this paper was originally developed to provide a framework for the development of programme and module outcomes with the Division of Design and Engineering at the University of Paisley. The intention was not to impose a prescriptive model to outcome development. For example, any appropriate topic analysis techniques could be used and not just the Stenhouse model. Some project management tools used for work breakdown also scertain quality management techniques are equally applicable. This is illustrated in the summary table in Table 5 below.

TABLE 5
SUMMARY TABLE OF CURRICULUM DEVELOPMENT MODEL

Step	Input	Output	Tools/techniques
Analysis of curriculum documents	QAA Benchmark Statements, Accreditation guidelines	Perceived weaknesses, content/context, framework for programme/module development	Not applicable
Intuitive analysis	Framework for programme/module development	Programme or module outcomes	Brainstorming, topic analysis techniques project & quality management tools, Domain/Level of Performance matrix
Analytical analysis	Programme or module outcomes	Entry behaviour & resources required	Topic analysis techniques i.e. Stenhouse, Davies, Rowntree or Gagne methods, Instructional Technique/Domain matrix
Refine/revise outcomes	Programme or module outcomes Entry behaviour & resources required	Revised/refined programme/module outcomes	Topic analysis techniques, project and quality management tools
Evaluation	Programme or module outcomes Achievement statistics	Revised/refined programme/module outcomes	Action Research Planner

Although the application of the model is relatively simple, there may be problems using the attainment statements in the QAA Engineering Benchmark Statements. These qualify the level of achievement for the outcomes as ‘threshold’, ‘good’ and ‘excellent’ and are progressive. This means that 'good' includes 'threshold' and 'excellent' includes both 'good' and 'threshold'. Problems may be encountered where the statements for the levels of attainment indicate radically different performance requirements. For example, in mathematics, quite different instruments of assessment would be required to demonstrate the selection of appropriate mathematical models from a standard range as opposed to identify appropriate methods. The selection of appropriate methods from standard methods is setting the range for performance while the identification of appropriate methods is more open-ended. As assessments will have to be designed in such a manner as to allow students to attain an 'excellent', this may present problems for those weaker students in attaining a 'threshold' performance. Therefore, this issue would have to be explored further in the context of the module outcomes and associated assessment.

Despite this, there is a need for a more systematic approach to programme and module development, particularly with the emphasis now on the use of learning outcomes. Such an approach will facilitate the develoment of well-defined outcomes that will [11]:

- define appropriate module identity and content;
- help identify appropriate instructional techniques and assessment methods;
- provide a framework for evaluation and continuous improvement.

The model presented in this paper helps achieve these criteria and will evolve as the use of learning outcomes in Higher Education evolves.

ACKNOWLEDGEMENT

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