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CREATING A LEARNER-CENTRED APPROACH IN PRODUCT INNOVATION

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ABSTRACT
The University of Hull provides modules in product innovation for a range of courses. This paper focuses upon the experience gained in the final year MEng and MSc modules which have a core 10-credit course delivered concurrently. The course's aim is to provide a simulation where students can adopt learner-centred practice (LCP) to integrate and apply their knowledge to a self-selected idea (design problem) and provide a real solution within one semester. The module facilitates learning-by-doing, in which teams must acquire resources, skills and knowledge in real time. The approach here provides a different model for adopting LCP in product innovation within a team setting (and informal peer learning) and discusses this approach within a learning outcomes framework. The experience is challenging to the students, especially those with limited design knowledge, but it does encourage self discipline, time management, and motivates the students within a chosen context to find real solutions to real problems and thus provides a sense of achievement. This paper describes and reflects on the experience gained and offers a model to other practitioners.

Keywords: masters courses, peer learning, learning outcome

1 INTRODUCTION

The University of Hull provides modules in product innovation for a range of courses. This paper focuses upon the experience gained in the final year MEng and MSc modules which have a core 10-credit course delivered concurrently for the following one-semester modules: Product Innovation and Support Technology; Product Planning, Project Management and Design Exercise; and, Eco-design.

The core 10-credit course focuses on providing a simulation wherein students can adopt leaner-centred practice (LCP) to integrate and apply their knowledge to a self-selected idea (design problem) and provide a real solution within one semester. A key aspect of the course is to facilitate learning-by-doing and provide an opportunity for the students to cover some of the subtle issues covered in the other half of their module, for example environmental impact and sustainability in the module Eco-design. From a teaching perspective, this approach has many advantages which include:

- Efficiency of teaching provision.
- Creating an eclectic mix of students (from different disciplines: electronic engineering, mechanical engineering, medical engineering and environmental technology) which helps widen the "design space" of each group and indeed promotes cross-fertilization of ideas.

- Increases student motivation through a sense of friendly rivalry as well as providing a comparator for the students' performance.

The approach here provides a different model for adopting LCP in product innovation within a team setting (and informal peer learning) and this paper discusses this approach within a learning outcomes framework. Further, this paper describes and reflects on the experience gained and offers a model to other practitioners.

2 MODULE DEVELOPMENT, AIMS AND CONTENT OF THE COURSE

The course first arose some years ago as part of the degree accreditation process with the Institution of Mechanical Engineers (IMechE) which required a greater extent of "management" within the final year of the MEng Mechanical Engineering. At that time, an existing module from MBA Engineering Innovation course was adopted and accepted by the IMechE as part of our development plan.

The aim of the course is to introduce students to the management processes involved in marketing, researching, planning and the execution if the product development process. Further, the teaching team endeavour, by facilitation, to demonstrate how the product and manufacturing process design can be structured to minimise commercial risk and time-to-market whilst maximising quality and customer value. It is worth mentioning here that the teaching team has significant industrial experience and are 'practitioners' with various research and knowledge transfer activities. The delivery of the course is broken into two main streams of activity (*i.e.*, two sessions per week): (i) a series of developmental workshops lead by the "chief executive" in which appropriate tools and techniques are introduced together with illustrative team-based exercises and thus provides formative help and support; and, (ii) a series of "group reporting interviews" with the "chairman" that provides accountability for the students. In delivering the course, a formal product development methodology is utilised as the backbone. This strategy is similar to that outlined in the 'recommended' textbook by Ulrich and Eppinger [1], but is strengthened by the addition of the Chairman's Notes provided to the students which distils the key activities of the process and thus provides a route map for the students with less design skills or experience. The road map covers the following generic stages, with each stage broken down into key aspects, tasks, tools and techniques:

- Project Launch & Planning ("see a need, fill a need")
- Concept Generation & Development
- Concept Selection, Development & Initial Market Research
- Embodiment
- Materials & Manufacture
- Detail Design
- Mock-ups, Prototyping, Testing and Refinement
- Quality, IPR, Legal, Ethical and Regulatory Issues
- Sales and Marketing
- Production
- Distribution & Related Aspects
- Finance & Profitability
- Recommendations

It needs to be understood that it is not expected that each student becomes an expert in each of these areas, but rather that each student understands and experiences the opportunity to integrate their prior knowledge in the context of the complete product development process. In terms of tangible outputs for the group simulation, these tasks relate to: (i) clarification of the product development brief based on rational investigation of a target market; (ii) awareness of financial constraints; (iii) user / customer needs; (iv) appropriate technical / feasibility calculations; (v) manufacturing strategy; (vi) product reliability; (vii) product serviceability; (viii) awareness of competitor / complementary products and technologies; (ix) appreciation of marketing and sales issues including distribution; (x) development of the product to detail design; (xi) appropriate prototyping and market testing; (xii) interpretation of complex system specifications; (xiii) selection of appropriate technologies to meet specification; and (xiv) selection and use of appropriate design and analysis tools. Thus, this module aims to provide a flexible learning opportunity for students to create their own novel product, as part of a team approach, from conception to prototype.

3 DELIVERY AND ACHIEVING THE LEARNING OUTCOMES

In delivery, students are asked to form a product development team. Once the project manager is appointed, the team select individuals to take on a specific role as they would in industry, such as a finance or marketing executive. Each team then provides new product ideas (from market-pull) and seeks approval to develop one idea. As discussed in §2, a key aspect of the course is the formal reporting activity (at the end of each week) where each team reports progress to the "Chairman" (analogous to a combination of "The Apprentice" and the "Dragon's Den"). The Chairman adopts a Socratic method whilst each group justifies their approach (within a commercial context) and thereby helps develop each team's strategy and milestones for the following week. Feedback is the key, but the skill is that it becomes much more interactive in terms of Q&A and so promotes better interpretation and robustness of each team's decisions. It also allows each team to reflect on other teams' performances and adopt alternative and successful strategies for each stage of the product development process. Each team is permitted to ask questions of the others, and indeed quite quickly there is a trade in knowledge.

As in the Engineering benchmark statement, students are encouraged to be "*rational and pragmatic, interested in the practical steps necessary for a concept to become reality*". The authors believe this statement embodies our objectives, especially in regard to the broad range of tasks undertaken which results in teams quickly becoming organised and working towards a fully developed business case (with a go/no-go recommendation) supported by market research and a finalised product design (rendered in SolidWorks CAD) using the standard design methodology discussed previously. The module is initially daunting to the students, especially those with limited design knowledge, but it does encourage self discipline, time management, it motivates the student within a chosen context to find real solutions to real problems and thus provides a sense of achievement. For example, teams must acquire resources, skills and knowledge in real time and thus are permitted to co-opt expertise within the Department (if justified). Students often report enjoying the overall experience, comment how useful the module was in employment interviews and indeed can relate to the learning outcomes which are formally:

- An understanding of the general principles of integrated design and product innovation and be competent in the use of drafting product specifications to meet customer requirements.
- Knowledge of a wide range of tools covering concept formulation, evaluation and convergence, quality planning, and design reliability.
- A conceptual understanding of a range of management tools that may be appropriately and effectively deployed in the innovative organisation based upon experience of conducting an extended team-based design process involving the selection of appropriate analysis tools and techniques.

The assessment process involves weighted, objectively-based criteria with a strong element on team performance (peer assessment), product-pitch presentation to the "board" supported by a written report which is assessed against 10 categories of generic performance. It is the process that is emphasised rather than technical expertise or the specific application of any individual management tool.

4 REFLECTION UPON OUR EXPERIENCE

Often it is possible for students to adopt a "jumping through hoops" approach, when clear assessment criteria are given as to how work will be credited, meaning that learners can work to a minimum level. However, our experience with innovation teaching is that this minimalism is not possible, and students have to adopt a strong problem-based approach which is very learner-centred. Indeed, initially students complain of spending too much time (fuelled by enthusiasm!) on the module, but this is still less than the notional learning / study hours diet of 10 hours/credit! This is because the course aims to be process-driven. The course requires deep understanding of the key concepts as opposed to just simply "knowing" them. Consequently, the learning enjoyed by the students has the following characteristics:

- Employability related.
- Elements of autonomy with a group setting.
- Manage the learning / development process.
- Reflection on one another's performance.

In previous years, students have designed and built prototypes for a wide range of product groups, including a twin-cylinder spirit optic (with the help of local publicans), an agricultural chemical dispenser which progressed to an commercial exploitation agreement, a USB file transfer device with collaboration from a Taiwanese manufacturer, an intrinsically safe syringe with input from the University's Medical School, and a modular reed bed water purification system.

An important observation can be made here: in the rational investigation of the market, the groups often form alliances and provide each other with "virtual focus groups"; therefore the products become more than just "student projects" supporting the reality of the experience. The success of the course can also be judged by favourable press releases / interest regarding new products developed. In addition, the University of Hull Department of Engineering's Industrial Advisory Panel (who were influential in setting up the BSc Product Innovation programme) have remarked that this type of course is exactly what industry wants, and some members are seeking to transfer the course to their employees as a short employee development programme.

Finally, in a post-course interview as part of a wider investigation of PBL, a student commented on this module as follows:

> *"… in my view, PBL is a good experience because I find lectures pretty boring really. PBL allows me to be active and do things. It takes me back to the real world where I can find real solutions to real world problems. It's different because it challenges me."*

This quote reflects that for learning to occur, the learner themselves must explore and reflect upon their own learning. This is traditionally difficult in subjects like Engineering, involving hard application of analytic content and high study load leading to a high degree of didactic student activity. The approach outlined here goes someway to mitigate this view.

5 THE INFLUENCE OF LEARNING OUTCOMES ON PERFORMANCE

Students begin the course with a high level of anxiety and nervousness due to the style of teaching. However, as the module progresses, the extent of competitiveness and perseverance by the students increases. Learning by its very nature can be a messy and organic affair as the student builds their capability. There is also a transition as the level of learning increases that the student progresses from undertaking knowledge-dominant processes to understanding-dominant processes (from constructing knowledge, through contesting, to contextualising knowledge). This can be reflected by the learning outcomes for this course. Moon [2] defines a learning outcome as:

> *"a statement of what a learner is expected to know, understand and be able to do at the end of a period of learning and of how that learning is to be demonstrated. Learning outcomes are linked to the relevant level and since they should generally be assessable they should be written in terms of how the learning is represented."*

Thus, reflecting upon the concept of learning outcome, there is a real tension between the old "academic excellence" and the newer "learning outcomes" systems of HE. It should be noted that there is a general assumption that a student passing a module will have achieved these learning outcomes (*e.g.* [2]). It therefore follows that those students just meeting the outcomes will receive a mark of 40 (a threshold). It is the authors' view, that as confidence / evidence of proficiency / excellence by which students meet these learning outcomes, a higher mark can be achieved (this is different to the twin systems advocated by [2]). It should be noted that if a student fails to attain one of the stated learning outcomes, then technically the student fails the module. This may be the case irrespective of the score achieved. Therefore, for practical reasons, and by default, a system of "compensation" is in operation (also this allows for some flexibility in the precision of marking). Whilst it is well understood that learning outcomes can be one of four types: Knowledge and Understanding; Cognitive / Intellectual Skills; Transferable Skills; or Professional / Practical Skills. It is far less well understood that as a learning outcome that knowledge and understanding is passive whilst the other three types are action-oriented. It is also useful to remind ourselves here that learning outcomes are conceptually interwoven with, and therefore should be explicitly linked to, both assessment mode and assessment criteria to create the entire learning process or learning experience. Therefore, care should be taken not to extract and use a learning outcome in isolation. Otherwise, an outcome is simply an objective without a measure of performance. It should also be recognised that the assessment criteria is specific *to the learning outcomes*, rather than generic aspects which are often expected in assessed work such as the quality of communication. Thus, it becomes apparent that there is an implied assumption that there is an equal balance between the three apices, but this may not be true as in practical terms often there is a bias towards a particular apex. Another view to interpret this is given by Bennett [3] as

- *Learning Outcomes - What do I want the students to know, do and understand?*
- *Learning & Teaching Strategy (focus) - What methods will best help students achieve the learning outcomes?*
- *Assessment Strategy - What mode(s) of assessment are best suited to students demonstrating the learning outcomes?*
- *Assessment Criteria - How will I know if the student has achieved the learning outcomes?*

It is, essentially, these principles that underpin the delivery of the product innovation course.

6 CONCLUSIONS

In conclusion, the following comments can be made:

- The approach described here provides a different model for adopting a LCP in product innovation within a team setting.
- The course promotes the learner's manipulation of knowledge in the context of analysis, synthesis, evaluation and application to a learner defined problem.
- The balance of learning outcomes, assessment mode and assessment criteria are interwoven to create an optimal student experience.

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