

## **INTEGRATING THE ENGINEERING MANAGER**

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### **ABSTRACT**

Engineering managers are pulled in many directions. Small doses of Continuing Professional Development, CPD, can follow those directions, but when the managers want to build up to a higher degree the choice available often forces them to specialise. The industry based Automotive integrated graduate development scheme, IGDS MSc at Hertfordshire – one of the largest of its kind in the country - manages to focus on Design, Manufacture and Management.

Adding the varied content of modules within this part-time programme to the managers' already busy schedules creates a risk that the learners themselves may compartmentalise their development, treating each module as a self-contained unit and not consolidating the total experience.

Positioning an MSc in between the specialist engineering degree and the MBA, requires a balance of depth, breadth and integration. This paper discusses how this balance can be achieved. There is the blend of taught modules across a number of disciplines. The choice of external contributors keeps the programme fresh. The unique integrating examination and the industry based but academically stretching project bring the learning together.

Industry and Government provide expert speakers who input directly into the modules. This year the module on Product Engineering mushroomed to the status of a national conference. An external audience increased the depth of discussion in the sessions.

The inclusion of the industrial mentors at the final project presentation seminar also encourages another conference atmosphere and demonstrates the vitality of the project part of the course. The effectiveness of the whole programme can be seen in the career moves of its graduates and the associated impact on the sponsoring companies.

### **THE MSc WITHIN CONTINUING PROFESSIONAL DEVELOPMENT**

Continuous professional development is a well-recognised feature of the modern engineer's life. It is not just a "must have" or a regulatory requirement. It is vital to maintaining the levels of skilled engineers. This paper will look at the particular lessons that have been learnt by matching the experience of industry with the academic process, when working with engineers and managers in the Automotive Sector.

In the Government's own Automotive Innovation and Growth Team Report, Sir Ian Gibson (1) recognises that the shortage of Engineering Staff involved in product engineering, manufacturing, computer-based engineering and specialist automotive engineering applications is a significant problem. The report cites amongst its proposed countermeasures to be employed by the vehicle manufacturers, "enhanced personal development packages" and talks about the need for education institutions to be involved with industry.

Back in the 1990s, well before the Dearing (2) recommendations for employers to become more involved with universities in both the nature and the finance of training, the Engineering and Physical Science Research Council encouraged and initially funded a number of collaborative programmes for Masters level education. The objective was to help develop the competitiveness of the UK engineering community. Each IGDS had at its core a partnership of universities and industry. The variety of modules within each programme has been designed to cater for the CPD needs of the engineers. A strong distinguishing feature of all the programmes has been the high level of industrial input. In some cases practitioners deliver 30% of the teaching. The final project combines the rigour of academic research with the work-based challenge.

If new programmes are to be developed and Gibson is pointing in that direction, the experience and lessons learnt within the IGDS programmes are a valuable resource. The particular programme run at Hertfordshire delivers an MSc

in Automotive Engineering: Design, Manufacturing and Management. Together with its four partner universities, Birmingham, Loughborough, Luton and the Open and a number of major companies in the sector, it has developed and run a broad MSc that still allows the individual to focus in the particular area that will suit their career path. In the particular context of business engineers Bullen et al.(3) state that these "*business engineers' require continuing professional development to enable them to take a systems view of the industry and its processes, whilst developing their technical and managerial capabilities*". The integration of all the learning within the MSc programme is essential if delegates are to maintain that systems view.

Engineering managers are pulled in many directions. Small doses of CPD can be planned to follow those directions. Many IGDS modules may be taken as incremental contributions to a CPD plan. When the manager or engineer wants to make a career step, one route is to build up on the CPD achievements to a higher degree, but the choice of MSc. often forces them to specialise. For those whose career route is within their specialty an appropriate specialist MSc does provide the correct support. The broader based engineering manager often requires an MSc that works in the area between the specialist engineering degree and the business focused MBA. The industry based Automotive IGDS MSc at Hertfordshire manages to focus on Design, Manufacture and Management.

## THE AUTOMOTIVE IGDS

This programme represents one of the largest modular automotive MSc's in the country with 150 delegates registered at any one time. The average age of the delegate is between 30 and 35. You will notice the lack of the word student. The word delegate better describes the working engineer or manager who interrupts their work flow to engage in a learning programme, without losing the responsibility for that work flow. These experienced engineers are drawn from over 30 different major automotive companies. They are seeking a masters degree as part of their career progression and are looking for a flexible programme that will both broaden and deepen their awareness of the international motor industry.

Malcolm Thomas, the Engineering Director Product Development Europe - Ford Motor Company, has said, "We are an enthusiastic supporter of the Automotive Masters Program due to its combination of both technical and commercial modules. We also see the

participation of a range of the Automobile Industry being a benefit to our delegates." (4)

Through the consortium of five Universities twenty-two modules are on offer. These enable delegates to select the taught element of their MSc according to their needs. This flexibility allows tailoring of a programme to meet a delegate's and sponsoring company's needs. The programme is characterised by its blend of automotive management elements alongside engineering design and manufacture.

How, then, has that need for the well integrated, well developed engineer been fostered by the Automotive IGDS at Hertfordshire? To make the MSc experience effective in the area between the specialist engineering degree and the MBA requires a balance of depth, breadth and integration.

This balance can be achieved by the blend of taught modules, customised to the delegate's needs, the choice of contributors that allows the combination of practitioner and academic in the taught modules, a unique integrating examination, developed for this programme, that stands as a gateway between the taught elements and the project part of the programme and an industry based but academically stretching project that enables the delegate to deliver benefits directly to his or her sponsoring employer.

### Blend of taught modules

All delegates take four core modules. At the beginning of the programme, two of these provide an overview of the industry, first by looking at the automotive industry in its international context and then at the role of product engineering in facing up to the challenges of that context. At the end of the taught part of the programme, the other two modules look at the lean enterprise and the wider constraints of the environment. These core modules make up half the taught part of the programme.

The optional part of the programme is divided into three themes. The range of modules in the Design theme includes powertrain, materials, vehicle dynamics and ergonomics, electronics and the uses of computer aided engineering. The second theme on Manufacture covers the processes and materials used in automotive manufacture, the structure and design of manufacturing systems, and the application of both quality methods and ergonomics to manufacturing. The modules within the Management theme relate to finance and risk, project management, management skills and currently the most popular module on Innovation.

Maintenance, quality and new product development feature as well.

It is within these optional modules that the delegates can focus on their specialist interests. The delegates choose six optional modules to complete the taught part of the programme. With the restriction that delegates cannot concentrate totally within one section of the programme, very few delegates take the same path through the programme.

The method of delivery of the modules ranges from the one week residential to distance learning with some modules featuring a combination. In the residential context, the experience of the delegates is valued as a rich resource, e.g. in group discussions. In terms of the choice of option modules and final project the delegate decides much of how, when and what will be learned. The required personal planning is a strong indicator of self-direction. Common to all modules is the referencing of assignments to the working situation, where the delegate must solve a problem in the real world to their own satisfaction as well as the tutor's.

The relevancy of the modules is reinforced by the industrial contributions. Over the life of the programme contributors have included senior managers from original equipment manufacturers, OEMs, Tier 1 suppliers, design consultants and government advisers. There is the small danger that an external speaker might see the opportunity for sales promotion, when talking to a group of middle managers in the automotive industry. The maturity and background of the delegates has kept tight control on these external contributions.

The structure, design and content of the modular part of the programme provide elements of Knowles' andragagogical approach (5) that is required when working with mature middle managers,

### **Need to integrate the learning**

There is a strong risk with this modular system of learning that the delegates may compartmentalise their development. To engage in the modules and their associated learning, the delegates have had to interrupt their workflow, without losing the responsibility that goes with it. This leads to a tendency to package the learning. It was felt therefore by the programme designers that there needed to be a gateway before the project that would enable the delegates to bring all their learning together.

The delegates are predominately engineering managers with about ten years experience in the industry. They have to complete ten modules in

approximately two years. Five subject based examinations each year would be daunting for the delegates and a further encouragement to compartmentalise. This complex administrative task involving five universities would do little to support the self-directed nature of the programme.

Although the individual modules are examined by group projects and individual written assignments, the programme designers were reluctant to have no situation where the delegate would be asked to demonstrate their own ability in an examination setting. To provide a mechanism that fosters integration of the modular learning and that does so in a way that both supports and challenges the delegate, a single integrating examination was chosen to be the "Go-No Go" gateway between the taught modules and the 50% major project component of the programme.

### **THE INTEGRATING EXAMINATION**

Not only did the design of this Integrating Examination have to meet the objectives set out above, there was the issue of fairness to all delegates. Whilst they will all have studied ten modules during the programme, their selection would have been from up to twenty-two different taught modules, with little commonality between the delegates' choices. To have set one or more questions in the examination for every available module would have made the question of fairness intolerable. The solution was to use a case-study scenario as the basis for the examination, to design open questions with multiple pathways through them and to run a preparation workshop one month prior to each year's examination. The nature of the questions had to be such that each delegate could generate appropriate answers based on their own set of learning in the programme and their understanding of the industry as a whole.

#### **The Scenario.**

The majority of delegates come from well-established posts in the industry. A real case study would advantage some delegates and disadvantage others depending on the relationship of their employer's organisation to the subject of the case study. It has been necessary to invent a new entrant into the UK automotive sector. This fictitious European automotive manufacturer has had to share in the ups and downs of the industry for some fifteen years. Whilst the directors have kept their seats on the board, they have managed to make a series of ambiguous strategic decisions. These have included refocusing the military supply division to launch a civilian 4x4 people carrier, setting up a manufacturing plant in South Africa, designing a

new vehicle based on just the flimsiest idea released from a Royal Society of Arts design competition and most recently launching a niche sports car on an overstretched production line. This fictitious company has had to work in the known context of the real world with the competition pressures, the new technologies and customer preferences that are affecting the real OEMs. In South Africa, just like the real world the issue of Aids amongst the workforce had to be faced.

Each examination cohort is presented with a case study that includes the basic history of the Sunrise Motor Company and the latest episode of its fortunes. The amount of information is sufficient to set the delegates thinking, but certainly not the entire story – enough figures in the published accounts to determine something of the size of operation, but not enough to allow clear predictions or obvious conclusions. The outline of the fortunes of Sunrise with a number of divisions and a variety of products forms the basis for a particular case study. Finally the study gives a detailed look at one particular part of the organisation, the problems it may be facing and the opinions of the key personnel associated with it.

The delegates receive their case study one month before the examination. They are invited to annotate it with ideas from the various modules. Thus it becomes part of their revision programme. They are then allowed to take their annotated copy of the case study into the examination. These annotations tend to include real world background information together with the delegates own assumptions and proposals about the Sunrise Motor Company.

### **Questions Design.**

The compulsory first question of the examination follows the line of the specific story line of the case study and asks the delegate to relate the issue to current situation in the world's automotive environment. This is an over arching question that allows the delegate to draw on the core modules of the programme, but also to set out any assumptions that will support the later answers.

The three themes of the programme have already been mentioned. It is these themes that provide the focus for the remaining questions in the examination. Each of three questions provides the delegates with the opportunity to demonstrate a broad understanding of the theme and an in depth knowledge of at least one module. An example would be a question under the design theme that asks about the consequences of introducing a new vehicle design based on an existing vehicle

platform. There would be the need for some general points relating to compatibility between different vehicles being constructed on the same platform, but there is then ample scope for a delegate to concentrate on a particular area. It might be the selection of powertrain or the ride requirements. It might be the flexibility derived from using computer-aided engineering.

The management question has often been looking forward to some new initiative that the Board of Sunshine Motor Company have endorsed. The answer to such a question may start with long-term objectives or the make up of a management team. The design of questions allows the delegate to focus on a particular element of that initiative. It could be the selection of the team and the detailed roles. In looking at the plan it could be about outlining the workload or managing the risks. The delegate becomes part of the team, in each case constructing his or her own next phase of the case study to justify the choice of approach.

An alternative description of all these questions is that they operate as single person simulation exercises. The delegate has often to decide the future action of Sunrise and provide a justification or act as a consultant with specialist expertise to assist Sunrise with its chosen strategy.

The question is not, "use the specified tools to solve the specified problem," but, "explore the question, as you see it, using all the tools at your disposal and tell us where you would direct your efforts and why." The delegates are being entrusted to solve a simulated real world problem in their own way. (5)

It has become clear from the experience of running the examination that the majority of delegates are capable of learning and retaining the knowledge from the various modules. What has also become clear is that some delegates can apply that knowledge in creative and innovative ways. These delegates use their own understanding of the industry to delve deeper into the case study. They are able to see and respond to the unarticulated problems as well as the clearly stated ones.

### **Preparation Workshop.**

Although the programme has only one examination, there is often a feeling of apprehension amongst the delegates to be overcome. They are full time managers. Examinations are not part of their work experience, but group discussions and the presentation of short reports are. The style and environment of this examination needs to be introduced. A short workshop has been

incorporated within the last core module of the programme. This uses an earlier case study and a sample set of questions as a group exercise.

As a group the delegates have time to build up their understanding of this imaginary company, Sunrise, and brainstorm suggestions for its future. By discussing and then presenting outline plans for the answer to each question, the delegates can receive valuable feedback about interpretation. This together with their own research with which to annotate the case study ensures that they are indeed in control of the learning process. Whilst the workshop has no assessed outcome, it is a substantial part of the process, with its driver being the integrating examination itself.

This then is the hidden strength of the exam. Its presence within the programme drives the delegate to view the last two years of learning and development in an integrated manner.

## CONFERENCES

The input that Industry and Government provide into the taught modules has already been mentioned. This year, by concentrating those external inputs into two days and relocating to the new Ford Centre for Engineering and Manufacturing Excellence, CEME, at Dagenham a section of the core module, Automotive Product Engineering, mushroomed to the status of a national conference. "Surviving the Shakeout" focussed on how the UK Automotive Industry can meet its future challenges through product engineering. With this higher profile the conference element attracted more speakers, including Roger Putnam, Chairman of Ford Europe, and Nick Brayshaw of Wagon Plc. The presence of other senior engineers in the audience ensured an active and informed level of debate.

## PROJECTS

A senior engineering role in industry requires the ability to engage in and present at conferences. The project element of the programme is extended to include seminar presentations to an invited audience. Industrial mentors and other contributors to the programme provide a challenging seminar environment. The conference atmosphere of these final seminars demonstrates the vitality of the project part of the course. The delegate's performance in the seminar including his or her handling of questions from an informed professional audience contributes to 20% of the project assessment.

The subjects chosen for these projects attest to the wide range of interests of the delegates. Alan

Payne's project in 2002 looked at the skills issues amongst his company's production engineers. (6) His proposals were initiatives to improve the development and retention of skills within engineering departments.

A project on Child Safety went beyond just the legal obligations for vehicle designers. The relevant vehicle design attributes were reviewed against a survey of over four hundred primary school children.(7) One particular issue was the quality of support provided for the head and upper body, especially when the child sleeps.

Pollution is a major concern in the automotive industry. A recent project applied the theory of experimental design to determine vehicle/engine-operating parameters influencing the Onboard Diagnostic Catalyst Monitor Index Ratio. (8) This was a step towards developing a desktop development tool.

Many of the projects within this programme have to remain confidential for a period of time. The delegates have access to commercially sensitive information and they are working on innovations that would give their sponsor a competitive advantage. For example, four years before the previous project and well before the publication of the Stage III Vehicle Emission Standards, David Green was developing a pilot on-board emissions performance diagnostic system.(9) This allowed other engineers within his company the opportunity to gain experience before the actual system was launched across the whole range of gasoline engines.

## THE EFFECTIVENESS OF THE IGDS MODEL

The effectiveness of the Automotive IGDS programme can be seen in the career moves of its graduates and the associated impact on the sponsoring companies. Just two examples are included here.

Steven Thompson, who graduated in 2000 and is currently a Six Sigma Project Co-ordinator with Ford Motor Company was quoted in Bullen (4), "I no longer believe that the course is simply a qualification, but instead a new way of thinking and presenting one's self."

Dennis Coltman who graduated in 1999 whilst at Lotus Engineering Ltd was also quoted in Bullen (4), "My career ambition three years ago, at the start of the course, was to achieve the position of Chief Engineer within a period of two to four years. Earlier this year [1999], I was given the job of General Manager of the Powertrain Controls Group (a Chief Engineer position, but named differently for other reasons). This is an important position within the company; it is outward facing

and deals with more strategic issues rather than tactical, day-to-day issues. I feel much better equipped to undertake this task having completed the MSc course." Dennis was one of the speakers at "Surviving the Shakeout".

Both examples support Knowles' (5) view of learners being motivated by a need to improve an area of their life including career planning and the role of external motivators such as salary, promotion and internal needs like increasing self-esteem.

This is not to say that all the other IGDS programmes that are still running do not provide excellent examples of continuing professional development in a mould favoured by Dearing. Like them the Automotive IGDS stresses the contribution made by industrial practitioners.

The designing steering committee of the Automotive IGDS has always emphasised the value of integration. The integrating examination is a particular element of that emphasis. It addresses the type of delegate that studies on the programme. It encourages the creative and innovative thinking that is needed to gain the full benefit from the learning that is distributed throughout the programme. Eight presentations have demonstrated that this innovative examination provides an effective and efficient assessment method for the mature postgraduate. Its very presence provides the stimulus for engaging the delegates in enthusiastic group activity.

Continued use of external contributors is not just good practice. It can develop the role of a programme to support the wider professional community. The support from industry is demonstrated by the participation of some of its key engineers. The Hertfordshire MSc course has also been recognised by the Society of Motor Manufacturers and Traders, the SMMT.

## REFERENCES

- 1 Gibson, I. 2002, The Automotive Innovation and Growth Team (AIGT) Report, DTI
- 2 Dearing, L. 1997, National Committee of Inquiry into Higher Education Higher education in the Learning Society - Summary Report (The Dearing Report), NCIHE
- 3 Bullen, P. R., Taylor and Mughal , H., Developing Engineering in the Automotive Industry, Paper number C574/019/99, 1999, International Conference on Education in Automotive Engineering.
- 4 Bullen, P. R. 2002, The Automotive Engineering Centre of Excellence, University of Hertfordshire

5 Knowles, M. H., E; Swanson, RA, 1998, "The adult learner: the definitive classic in adult education and human resource development", Gulf Pub. Co., Houston, Texas.

6 Payne, A. P., 2002, Production Engineering Skills Development And Retention, MSc Thesis, University of Hertfordshire

7 Ranger, J., 2001, Child Occupants in Passenger Vehicles, MSc Thesis, University of Hertfordshire

8 Malby, A., 2002, Research, Understanding and Application of Design of Experiments to the Development of Index Ratio Catalyst Monitor, MSc Thesis, University of Hertfordshire

9 Green, D., 1998, The Pilot of a Powertrain On-Board Diagnostic System on Puma, MSc Thesis, University of Hertfordshire