Industrially sourced design projects

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Abstract
The paper describes the experiences of incorporating industrially sourced design projects into an undergraduate engineering programme. Recent experience has highlighted the importance placed on industrial relevance in engineering degree programmes.

Industrially sourced projects at the pre-University stage are referred to but the main thrust of this paper is directed at experiences with the third year design course in a four year Mechanical Engineering BEng programme. The aim of the paper is to provide an awareness of the characteristics of the project work arising from industrially sourced project work. These projects are a useful addition to the set piece projects which are focused on the formal course content. The challenges and experiences encountered in supervising industrially sourced projects presented here will be of value to course lecturers who are working in this exciting area and will also point the way to those seeking involvement in this type of project. Project realisation was reported in IDATER 94 and here project realism is presented as an additional important component in stimulating the interest and enthusiasm of the students. Pre-existing staff contact with industry, e.g. arising from consultancy , is of benefit if this type of venture is to be successful. An important role of the supervisor is to interpret the industrial problem and present it in a tractable form for student consumption.

Examples of projects are described: drilling machine design, and automatic dispensing of documents. Careful administration of the project is necessary to ensure provision of adequate technical information and to obtain the best out of group working.The experience has been found to be stimulating and motivating for staff and students and better work results than from working solely on focused academic exercises.

Introduction.

Industrial involvement in engineering degree courses is increasingly expected by degree accrediting bodies such as HEFC and the Engineering Council. The Engineering Council is the overarching body which confers accreditation on BEng degree programmes[1] and the actual process is carried out in the several disciplines by the appropriate engineering institution such as the Institution of Mechanical Engineers.

It is the design courses, particularly at senior level i.e. 3rd year of a 4 year degree programme, where industrial involvement may be most appropriate. At this level the student has accrued a measure of experience and skill which enable a credible attempt to be made at a design proposal.

While the writer's experience of industrial involvement has been at senior level it is known that considerable benefit can be obtained from industrial co-operation at first year or even at the pre-University stage. A good example of this is the work of Professor Marsh of Durham University with the "Input" courses in the North east of England[2].

These courses are admirable and ideal for what they set out to do i.e. encouraging and imbuing enthusiasm for engineering in the young potential engineer.

In engineering degree programmes the Design courses are where integration of the other main subject areas can take place. In Mechanical Engineering these subject areas are typically Thermofluids, Dynamics and Control, Solid Mechanics, Electronics and Manufacturing studies. This integrating role is paramount in developing a Mechanical Engineering BEng programme.

In an earlier paper the need for and benefit from manufacturing artefacts was reported[3]. That process was also integrative but was based on Computer Aided Engineering (CAE) applied to internally sourced projects.

This present paper concentrates on experience to date of industrial involvement and problem sourcing with the third year design course in our four year BEng programme.

This is the final year in which design is given as a structured course but most students will be involved in design in their honours year project work.

Source of industrial involvement.

It is rare that an industrial company will come knocking on the door asking for students to work on a project. The academic staff member has to make it happen.

In order that industrial co-operative type projects can be mounted it is usually the case that some activity has taken place between the staff member and the company which builds up mutual trust and respect.

Staff-industry contact is essential and industrial research and consultancy provides a rich harvest of potential projects. This is an area where University management has to realise the difference between scientists and engineers. The involvement of the academic scientist with industry appears to be optional but for the engineering academic such activity is essential if appropriate education is to be achieved. The engineer must look to industry for stimulation and awareness of realistic problems and direct involvement is essential. Consultancy must be encouraged, and evidence of such activity is sought by accrediting bodies, but with due regard to the need for staff to pursue research where possible.

Why include Industrially based design projects?

Observations indicate that the motivation, enthusiasm and quality of work of the student is much improved. Why is this so?

Relevance. There is an awareness that the task in hand is relevant and worthwhile and that someone needs an answer.

Industrial interest. A student view might be

> I am getting a bit bored by the introspective atmosphere of this place and it is refreshing to work on something for the outside (real) world.

Realisation. In industrial projects the chance that the best design will be applied as a prototype i.e. "realisation possibility" is a fillip and spur to produce a good proposal and report. This is a great motivator- the belief that the object of the project may actually be made.

Credibility. The presence of projects which relate to industry is a very strong requirement of the Engineering Council accrediting bodies. The student also feels that the course is more credible if the work has obvious direct industrial application potential.

Preparation for career employment. An insight is achieved into real design activity as it might be experienced in industry. This is especially so if there is involvement of a company based engineer at some stage of the project.

Observed Characteristics of Industrially sourced project work.

In all work to date it has been observed that the nature of the problems sourced from industry required novel or "ingenious" solutions. This puts them into an "ideas generation" category and it is a requirement of the assignment that the application of a design method has to be demonstrated. A simple method is normally applied comprising the stages of requirement, specification, ideas search, evaluation, and synthesis

All projects have been run on a small group basis. This is mainly because there is always a significant amount of ideas generation to be achieved (group operation is good for this), report writing and drawings to be created . To make a credible attempt at a report in the time available several sets of hands are required. Also despite introductory talks students can feel isolated and lost if left as individuals.

At the project introduction stage it has been found highly desirable to have the engineer who owns the problem assist the lecturer introduce the requirement.

This is one of the "critical points" of project supervision mentioned by Denton [4].
Detailed views will now be listed.

Positive aspects.

- A wide range of proposed designs result. (There is less if any copying).
- There is enthusiasm and a will to succeed.
- An enjoyment of the work is evident.
- There is usually a need for further information on some element of technology not covered in the course e.g. how is a shaft located axially? or under what circumstances do machine slides jam for kinematic reasons? This requires further reading and research or if the question indicates a class wide need it may be identified as another "critical point[4]" at which a short talk or lecture is required. The quality of attention and understanding evident at such a session underlines the advantages of "learning by doing" which project based education introduces. In this sense the industrial sourced project has more unexpected and non-standard content than the "in house" type. The latter genre is usually arranged to be focused on the programme course material and the lecturer's field of knowledge.
- With the industrial project supervising design staff are usually in a challenged position along with the student and this is usually an excellent learning environment with the lecturer as advisor rather than an "all knowing sage".
- Company experience and data are available to assist in establishing design constraints not otherwise obvious e.g. the target speed of a transport system or preference for a given manufacturing method.
- The company engineer returns at completion to assist in assessment and gives a response to the class as a whole.
- There is often a need to model proposals to estimate their viability and company resources may be available to achieve this.
- An automatic willingness on the part of the student to apply CAD/CAM/CAE methods has been observed, an example of the enjoyment of practising an acquired skill.
- It has been found that honours projects can evolve from third year design projects.

Cautionary points

- Intellectual property issues can lead to difficulties. What happens if a good idea results? Who owns the idea and the engineered design and can it be exploited by the engineering staff and students? It is clear from Starkey [5] that identification of the problem or requirement is a highly innovative step and since in the industrially sourced project such identification has already been done and the problem presented it follows that the company involved owns part of the intellectual property. A procedure which has worked is to give the company an early opportunity to patent the idea or design with the staff and students cited as the inventors.
- Does the good idea poorly presented and engineered get more marks than the ordinary idea well presented and engineered?. The answer is: probably not. The staff member is likely to be sensitive to accuracy of calculations and technological soundness of the design. It has been observed that the company engineer is more influenced by novelty aspects than by the detailed engineering treatment and performs a useful moderating influence in this respect.
- There is usually less direct exemplary support for the "formal" lecture content of the degree programme which is usually about standard engineering science based solutions e.g. hydrodynamic bearings design or stress analysis. This integrating aspect has been proposed as the most useful aspect of engineering design courses. This support may be weaker in industrially sourced projects in as much that involvement of lecture material is not guaranteed in the wider ranging industrial sourced project. But this is a reasonable price to pay for the interest and excitement that is generated in dealing with reality and in any case all projects will not be industrially sourced.
- Where does one draw the line on time especially if enthusiasm is brimming over? The design has to be frozen at some point and a firm deadline needs to be applied.
- There is a clear advantage to those students who have had some industrial experience especially where mixed experience

students are involved e.g. direct entrants with industrial training versus the rest. Sensible group mix policy by the lecturer should solve this one.

- Where a company representative assists with assessment a clear marking schedule needs to be agreed to avoid contradictions. This at least lets each assessor know what the other is giving credit for.
- There is a danger that basic principles of mechanics are overlooked in favour of achieving focused narrow objectives. This could lead to a danger of over emphasis on surface learning at the expense of understanding. The role of the lecturer here is to bring out the fundamental issues of principle when discussing progress in the groups. An example of this might be "yes it works but is it fail safe, have you considered the worst case and is that stress concentration going to cause early failure?. Of course if the design method is properly applied the evaluation stage should highlight these questions.

Examples of industrially sourced projects.

Special purpose drilling machine Design

A company had a requirement to drill an array of holes at an angle to the surface of a circular segmental cross section plate as in Figure 1. Thousands of these plates with a variety of radii and array style are used in the textile industry and, because of the unusual geometry, standard drilling machines could not be used and be economic.

There was a requirement that there should be a minimum of setting up time involved and the machine should be flexible enough to be usable for a range of hole pitch and number of lines.

This challenge was presented to the students together with an introductory lecture on how matrix stepping could be achieved. Samples of the required product from the company were presented. The application of a 5-point design method assisted greatly in getting the groups started on the attack of the problem. It was useful to time the critical point to call the class together and e.g. have a brainstorming exercise on ways of producing holes.

The overall result is likely to lead to some sort of automatic indexer or servo system operating an X-Y table in conjunction with a q axis the three axes being controlled from a micro computer. The drill guidance is a problem because of the angle of contact and attempts to control this are varied. For this reason machining by means other than a drill need to be considered.

This project exercised the students in mechanics, mechatronics, solid mechanics and tool design.

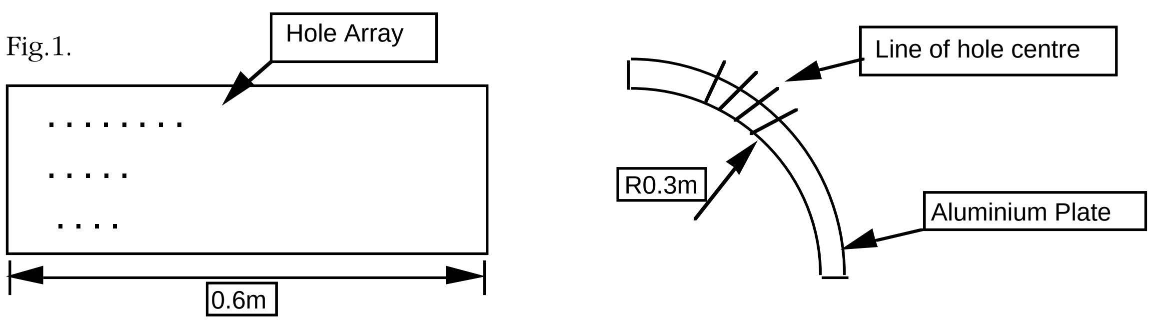
The best solutions recognised that standard "bought in technology" could be used e.g. for drilling, indexing and stiff low friction guidance systems. A frame had to be designed to hold it all together and the spaces involved suggested a fabricated structure.

After completion and assessment a debriefing session addressed common weaknesses and a known professional solution was viewed and discussed.

Envelope dispenser

The automatic dispensing of documents is currently of interest to several companies involved in the banking, personal finance and insurance business. Increasing automation using computers has led to an array of different offers of services perhaps the best known being

Fig.1.



cash auto-tellers. One company had the problem of issuing envelopes to customers at an auto teller. These envelopes are used to deposit items via the dispenser.

The lecturer and a company engineer addressed the design class to set the problem and discuss the requirement. A specification was drawn up collectively and the class worked in groups to produce their proposals. There is guidance given on document handling based on past work on this topic in the Department by Middleton and Cowpland [6].

After completion of the project the company engineer, having assisted with the assessment returned and with the course lecturer summarised their views on the solutions. This was also an opportunity to show how the company had solved similar problems.

Requirement

- The machine is to dispense one envelope from a stack within the machine to the customer via an aperture on the front of the auto-teller (fascia).
- This should be done rapidly.
- Two or more envelopes must not be dispensed.
- If the customer does not take the envelope within 15 seconds the envelope is to be retracted from the fascia.

A typical design scheme for such a device is shown in Fig 2 and would be developed in detail with material specifications, framework and transport layouts and a system design to read sensors and control drive motors and gates.

The detail drawings required were produced by CAD. The students exercised their skills in design method, dynamics, engineering materials, mechanics, mechatronics, geometric layout and visualisation.

Conclusion

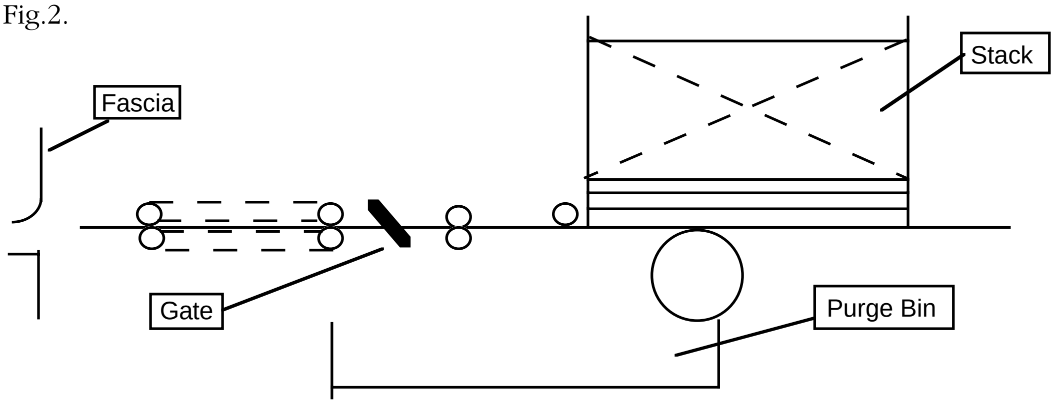
The experience of working with industrial involvement in the senior year of the design course (year three of a four year Mechanical Engineering course) has been rewarding and stimulating for the staff and students. Student motivation is high and the quality of work is better than in purely academic exercises. It helps greatly if the designs can be taken to the hardware stage but this is not always feasible given the restraints on time and technical resource. The skills and experience gained in manufacturing artefacts described by Middleton[3] did help when hardware manufacture was required.

There have been problems in getting sufficient data at short notice on components and materials but this can be solved by setting the project early in the session allowing components to be identified and suppliers approached before returning to the completion stage later.

Group work is the normal mode of operation and identifying individual contributions can be a problem. One solution is to have true group operation at the ideas generating stage with allocated tasks at the evaluation and synthesis stages. Group size of four was found to work well which agrees with the experience of Billet and Turnock[7].

Overall, inclusion of industrially sourced projects are not only motivating and rewarding but their presence is virtually mandatory in accredited courses.

Fig.2.



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