A Pathway amongst Undergraduate Learning, Postgraduate Research and Industrial Involvement

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ABSTRACT: The effectiveness of an industry-based experimental learning program for engineering undergraduate and postgraduate students at Swinburne University of Technology has been discussed and evaluated. The significance of this program lies in the fact that both types of students will see the relevance of learning and how it is implemented in industry-based problems whilst industry will gain engineering expertise in a specific field. The interaction amongst undergraduate students, postgraduate students, academia and industry personnel was found to be very productive to all parties involved and to the engineering profession in general.

INTRODUCTION

The quality of engineering education is regarded as a major factor in the success or failure of industry in the present economic climate [1]. In the traditional engineering course the interaction between the research and industry has, however, been minimal. Interaction among the students, teachers and industry personnel has become an important aspect of the development of an engineering undergraduate. Student engineers, both undergraduate and postgraduate are not just part of the learning environment, but also exist within a larger sphere and so must utilise all their skills in their engineering creative process [2].

Although working engineers are often thought of as being dull, non-creative and working to a specific formula, as a student, however, the engineer-in-training is encouraged to be creative in many aspects of research, design and development. It is the problem solving process through training, that has inculcated the need for creativity and satisfaction of educational needs.

The aim of this paper is to illustrate the importance of interaction between postgraduate and undergraduate students in industrial activities with the aim of increasing the quality of the education and increase cross-fertilisation of ideas. An example of an industry-based project for learning and research has been used here to show how such a system can be very successful in initiating ideas, developing them to a research stage and implementing them in a learning environment.

PROJECT COOPERATION

Projects promote the understanding of basic concepts, enabling deep learning, broadening knowledge and encouraging creativity. They stimulate an enjoyable realistic exercise encompassing time and financial restraints, whilst learning to perform duties as part of a professional team involving a postgraduate student and undergraduate [3]. All final year undergraduate engineering students at Swinburne University of Technology are required to spend part of their final semester of studies developing and completing various aspects of a major project. The theme of the project work is defined either by postgraduate students or academic supervisors, or industrial sponsors, or by all three. The project is a combination of research, design or developmental work. Within the constraints required by these factors, students’ creativity in their approach and execution of the project work may be both enhanced and expanded to simulate conditions experienced in a research, development and work environment. The project may articulate to postgraduate students’ research programs.

Some projects involve explorations by means of repeated simulations: a hands-on personal
experience. This experience necessarily instils the development of initiative and enhances the powers of creative thought. Projects reveal what young students can create and they often do when given the opportunity [4]. Engineering students are strong on abstract conceptualisation and active experimentation, interested in practical uses for ideas and implementation of theories, likely to create and work hard and effectively if they see apparent use.

ENGINEERING STUDIES

The engineering degrees are designed to prepare students for the profession of engineering through an ordered course of study combined with cooperative work experience or industry based learning (IBL). Engineering courses extend over 5 years and include 2 semesters (12 months) of paid industry based learning and 8 semesters of academic study: an academic semester is of 13 weeks duration.

The engineering degree program operates under a student workload model based on 100 credit points for a full academic year. One credit point is deemed equivalent to one hour of student work whether in contact with staff or in private study. The typical students’ average weekly workload during semester is therefore expected to be 50 hours. Total contact hours, including lectures, classes, tutorials, laboratory and field sessions, is approximately 22 hours/week during academic semesters.

The university aims for international best practice. Issues of quality, and competency requirements by the Institution of Engineers, Australia have also been addressed. The proposed structure also allows a flexible and efficient transition to further studies which may involve double degrees, graduate diplomas, Masters by coursework or doctorate research programs.

INDUSTRY BASED LEARNING

Prior to undertaking final year studies, students undertake two semesters of supervised Industry Based Learning (IBL) pioneered by Swinburne in 1963. It involves placing students directly in vocational employment as an integral part of the engineering course structure at the completion four semesters of study and last for one calendar year (the equivalent of two academic semesters). The IBL program has the following specific goals [5] to enable students to gain practical experience, working environment by giving training in an area of engineering not easily provided in university, such as on-the-job problem solving, engineering practice and the organisation methodology of industry, to enable employers assess a student’s aptitude before offering full time employment, to motivate students improve their academic performance demonstrating the relevance of course content industrial practice, and to promote the personal development of students.

A CASE STUDY OF STUDENT AND RESEARCH INTERACTION

In this paper an industry-based project was utilised to enhance the students’ interaction with industry, the postgraduate environment and the engineering learning process [6]. The project was concerned with examining the characteristic of pressure losses in a cooling circuit of plastic injection moulding for industrial applications. Figure 1.

Figure 1. Schematic diagram a cooling circuit plastic injection moulding process

Part of the project was taken to illustrate the relationship between flow conditions, geometry and pressure drop. In this situation, an undergraduate student assisted the postgraduate student designing the experimental rig, Figure 2.
The undergraduate student then collected data and analysed them. The postgraduate student had continuous involvement in deciding the experimental parameters and the range and amount of data required. The postgraduate student then used the experimental results to obtain various operating and material correlations. This data was also used to validate the computer programs which the postgraduate student developed.

During the research program an industrial partner who had a vested interest in the project was also involved in weekly meetings which were attended by the both the undergraduate and postgraduate students and the academic supervisor. These meetings were extremely useful to the successful conduct of the research project. The undergraduate student would appreciate where the theory gained in the classroom was of significance in the research project and how details of the theory could be applied to achieve results useful for industry. The investment of capital for thermoplastic injection moulding is quite extensive for companies involved in this process and quality outcomes are a must. The involvement of a university group in researching the process is beneficial to the industry since the cost involved is very small.

The process of injection moulding is one by which plastic products are created from molten plastics at high pressure by injecting into a hardened steel die [7]. A major problem in achieving high quality project is the efficient of the dies. The process of cooling the injection dies is achieved by machining holes into the dies and running water through these conduits. In an injection mould cooling system, it is often desired to design a system with balanced flow in each lateral flow stream. Such designs can be accomplished by altering the size of the laterals, their flow system resistance, or the cross-section area of the channel [9]. Many researchers have studied various manifolds flow distribution systems although no design has been considered an optimum distribution system for injection moulding cooling line.

The parallel configured injection mould cooling line network is in the category of manifolds distribution flow. This is significant for injection moulding industries because it affects the final part quality and the productivity. It requires the cooling system to cool the cavity or core in the mould simultaneously and thus provides a uniform flow distribution, leading to a temperature uniformity of the cavity and hence improvement of the quality of the part's surface. Due to the uncertainty of coolant flow distribution and insufficient computation tools to predict the flow distribution accurately, the confidence of industry to use this technique is yet to be established. To provide sufficient understanding of the flow phenomena inside a mould cooling system an experimental and numerical investigation has been carried out. The project involved an industry partner, undergraduate and postgraduate students and lecturer.

In the experimental program, an injection mould cooling line network apparatus was designed and constructed to examine the flow field and heat transfer parameters for both serial and parallel circuits. Six different configurations of pipelines were tested. The time mean velocity distributions and static pressure values were determined for different configuration of circuits and flow rates.

The experimental rig was designed by the postgraduate student whilst fine details and construction was done by the undergraduate student. A schematic diagram of the cooling channel is shown in Figure 1, whilst the cooling baffle enhancement designed by the undergraduate is shown in Figure 2. The undergraduate student received training on using
DAS (data acquisition systems) and measurement techniques (hot-film anemometer), with the experimental results published as an internal school report [8].

For the purpose of visualisation, the undergraduate student developed a rig which was constructed from clear PVC pipes. The experimental rig was a full-scale injection mould half block cooling circuit. The rig could be used either in serial or parallel circuit by installing multiple valves.

In order to map out the local pressure and velocity distributions, 24 pressure taps were located midway between the branch points and on the opposite side of the supply and discharge lines. All the measuring ports were linked to a multi-switch controller, so each port can be measured by a pressure transducer. In the first stage of the test, water which is the most widely used coolant in injection moulding was chosen as the working fluid.

The results were gathered via personal computer linked to a Datataker DT-100. A Laser Doppler Anemometry system was used to measure local velocity distributions. A magnetic flow meter was installed at the outlet of the test rig to measure the total flow rate. The range of Reynolds numbers tested was 3,000 to 18,000.

The dimensional analysis was carried out by the undergraduate student. In the theoretical analysis, the postgraduate student used Newton-Raphson approach to solve the governing equations. A computer program was written and numerical results were compared with the experimental data for six configurations and a wide range of Reynolds numbers. The undergraduate student employed a commercially available CFD package CFX-F4D[9] to model the flow. The postgraduate student helped the undergraduate student to get familiarised with the package. The undergraduate student learned how to set up a mathematical model incorporating various input parameters. Both students were then able to see the effect of various parameters on the output as well as the importance of using realistic assumptions.

**BENEFITS AND PROJECT OUTCOMES**

The undergraduate student obtained velocity and pressure measurements for various Reynolds numbers and bubbler heights. The student was then able to correlate these data and use the CFD package CFX-F4D to make predictions. There were some disagreements between the measurements and the predictions. Measurement errors and the uncertainty in the friction factor used in the computer program may explain the disagreement. He was also able to get some understanding of using realistic assumptions in numerical modelling. The measurements are being used by the postgraduate student to validate the computer program, which was developed. The undergraduate student was able to see the outcome of his work as a computer package which was of commercial value. The results of the work were written and published at a conference, for the undergraduate student's work [10] and in a journal for the postgraduate student's research [11] and developed into an M.Eng.Sc. degree.

The effectiveness of the industry-based learning program together with cooperative postgraduate learning indicated that students who were high academic achievers always look for project work which are industry related. Between the year 1994 and 1998 the authors proposed 10 projects for the students and the industry-based projects were in high demand, particularly those with industrial involvement and postgraduate researchers attached to them.

**CONCLUSIONS**

The usefulness of an industry-based learning program for engineering undergraduate students in particular has been discussed using the example. The interaction between undergraduate students, postgraduate students, academia and industry personnel was found to be very productive. Significance of this program lies in the fact that the students will see the relevance of learning and how it is implemented in industry-based problems. The undergraduate student gained hands on experience while his/her input helped in the successful completion of the project. It is believed that the (post)graduates will find it easy to secure employment as they have had fi
hand experience in industry. The exposure also gives them a chance to select the areas in which they prefer to work. Through this academically demanding and professionally rewarding education program the graduates will develop an awareness of the working environment.

REFERENCES