Postgraduate Industrial Placements Feeding Back into Undergraduate Provision

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***Abstract* - This paper looks at the benefits that can be achieved, by suitable integration, of a post-graduate student undertaking an industrial development project. For some years the Department of Trade and Industry for the United Kingdom has sponsored a knowledge transfer partnership between industry and higher education. In brief, a company that identifies a market opportunity for a new product or for updating an existing one may be reluctant to engage a newly qualified graduate dedicated to the research and development necessary. A partnership is agreed between the company, a local university and the government department, which provides substantial funds. In securing such a partnership the transfer of knowledge is expected to be mainly from the learning and enthusiasm of the newly qualified undergraduate and that of the university to assist the company in its innovative project. However, there can also be much gained from the investment in leading edge equipment and the outcomes of the research, to feedback into the module content of the engineering degree. The paper explains the structure of such a partnership that has had payback, both for the company and university, in terms of new technicalogical understanding and that of commercial opportunities.**

Index Terms – Academic Supervisor, Associate, Industrial Partnership, Knowledge Transfer.

INTRODUCTION

For some years the Department of Trade and Industry has sponsored a knowledge transfer partnership (KTP) between industry and higher education. The premise of this is to use a freshly graduated individual as a bridge between an academic institution and a local company. This brings together advantages for all three parties that they would find more difficult to achieve separately.

For the company these advantages centre on the research and development of new products or innovative technologies. The aim of this is to help create innovative solutions to problems and increase the competitive advantage of the business.

The graduate (known in the partnership as the Associate) gains from both the experience and training he (or she) receives working as a professional, along with higher-level qualifications from the University.

The associate's primary role however is to function as a two-way bridge from the company and academic institution. This lets businesses draw on the UK's world-leading science and technology base in its Universities, and helps put this expertise to practical use

For the Academic institution the benefits come from the feedback of knowledge developed and acquired through the Associates work. This paper looks at the nature of that feedback compared to the investment in knowledge put forward, and the different gains that can be brought through this to improve undergraduate courses.

TRAINING

The project started with an investment of knowledge into the Associate with the goal of training him to as high a level as possible within the field of Thermography. While the Associate had some general knowledge in the field from his previous academic work, the focus was so specialised that there was a substantial learning curve.

To aid his development the Associate was paired with an Academic Supervisor. He provided the initial introduction of knowledge to the Associate and established the current level of expertise. From this they identified areas of weakness and constructed a training plan to guide the Associates development.

The training included internal training within the University and external training in industry. The advantage of the internal training is that it draws on the Universities own resources and so did not require great expense. These resources included lab environments, computer equipment and software, internal staff-training programs, literary resources and of course the expertise of the Academic Supervisor himself.

In contrast to this external courses are generally commercially run and so come with significant price tags attached. The advantage of these courses is that they can offer an industrial component to the knowledge base that isn't available in the University and has yet to be developed in the Company. They can also be an excellent networking source for the Associate to help develop him professionally in the field and establish awareness of any similar projects, past or present.

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DEVELOPMENT

The training of the Associate is a continuous process that lasts through the projects length, but after his initial orientation and training is complete he was encouraged to start applying this knowledge to further the project as soon as possible. This helped shape the theory by grounding it in practical applications, and can both further the understanding of the associate and generate some initial feedback on the training methods used.

The main purpose of this however is to focus the training on developing knowledge that is applicable to the nature of the project. This ensures that there are tangible benefits generated for the company through the Associates work, and gives the work some commercial drive.

The core of developing the knowledge is to apply it in the course of the project and investigate the issues that are generated as a result. There are always problems encountered, for example from gaps or over-sights in the knowledge base or impracticalities in transferring knowledge gained in an academic environment to a business environment.

It is the Associates responsibility to resolve these problems, but as in the initial training there are vast resources available within the University and Company to help develop a solution. Identifying and filling in these gaps allows the Associate to feed back this information to the University. For them this is a key part of the partnership as it can reflect greatly on the manner they train students to work in industry.

MANAGEMENT

The associate is an employee of the University, mainly because it is the University that is the recipient of the government funds for the two years of the project, but his main place of work is with the company. The Academic Supervisor is expected to spend 8 – 10% of his / her time in running the project from the initial grant application, recruitment, supervision, financial aspects, steering group committee meetings, through to the final reporting.

For the purpose of this paper it was fortunate that the Academic Supervisor was also a course leader and subject tutor, which made the integration of the Associate's new skills and knowledge into the course provision easier.

As interesting challenges and solutions were undertaken on the company's premises along with additional development work within the University laboratories, it soon became apparent that the visual and practical nature of the project could produce some good learning material.

REINTEGRATION

As the knowledge started to produce returns for the University it was evaluated and put to use in expanding the existing knowledge base and refine existing courses. This can come from both the practical (such as modifying experiments carried out by the Associate for lab work) and the theoretical (such as gaps in the existing taught subjects).

Through his work the Associate has picked up valuable techniques from the external training bodies and his practical work that can be introduced to the courses. This has included standards developed or learnt from the industry and alternative teaching methods. There were also additional applications beyond the subject for similar courses that share a basis in method or technique, for as much as Engineering is about learning certain facts it is also important to develop a specific state of mind to approach different situations.

In addition to expanding the taught courses the Associate has also been brought in to give guest-lectures on the subject. This offers a number of advantages, one of the being the students tend to identify more easily with people closer to their own age group and experience. In turn by this point the Associate had only been out of University for a few years. As he had a good recall of his own lectures he was able to structure material in a way that would hold attention. This has included specific industrial examples he has encountered backed up with images, data and other information. It also allows the associate to pass on job-specific techniques and information that he considers valuable to anyone that might be interested in entering the industry.

This direct interaction with the students has also opened up other opportunities, for example second year students are always looking for interesting topics to base their final year projects around, and the development and application of new technologies can provide a number of ideas.

In conclusion these methods are a very successful way of developing the Universities taught courses and knowledge base. They offer a way of introducing students to new and emerging technologies that have not yet filtered into academic courses through traditional channels, and thus provide them with advantages in this field.

CASE STUDY (1)

The subject matter is not technically too difficult but it was a good introduction to the subject and allowed the Associate to feel confident in front of students. This was important as we wanted to build a rapport between him and the students so that he would start to 'open up' and talk confidently about his experience in industry and how, as an engineer, he had daily challenges with rewarding solutions.

THERMAL INSPECTION

The main two year project involves Thermography as a tool for predictive maintenance [1], with the use Digital Image Processing to automate the analysis of images.

However, in the first instance, getting used to the equipment and understanding the nature of the information contained in the images was undertaken. During this exercise on one particular site the camera identified a genuine pending mechanical failure on a conveyor system, which was repaired successfully in time but allowed for subsequent analysis of the failure.

A close inspection was made of an apparent hotspot under the conveyor belt, which produced the image shown in

FIGURE 1. This showed the hotspot was from a bearing, and upon visual inspection with it was confirmed that this bearing had seized.

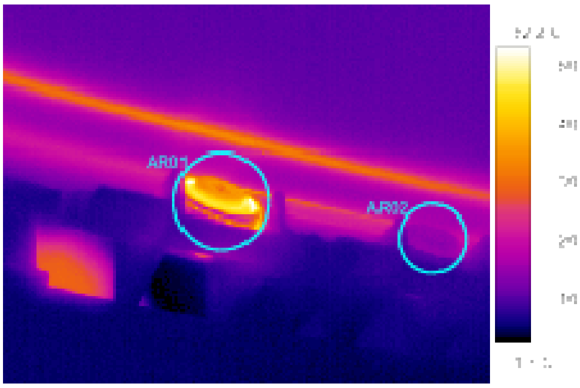

FIGURE 1
THERMAL IMAGE OF BEARING

FIGURE 2
VISUAL IMAGE OF BEARING

The two circles shown in FIGURE 1 are part of the post processing of the image and show the seized bearing and an adjacent rotating bearing with a temperature difference of over 30°C (because the bearings are made of the same material this comparison is possible). If it had been allowed to continue the bearing would have damaged and eventually broken the threaded beading that holds the belt in place, causing the conveyor to fail.

Analysis of the failed bearing revealed that it had previously been replaced, but with a cheaper equivalent and not to the specification of the conveyor manufacturer. The poor quality of the seal around the bearing had allowed the ingress of condensation, eventually causing the failure.

FINACIAL ANALYSIS

By discovering this problem further wear to the belt has been avoided, along with the possibility of the belt failing entirely. This scenario is not uncommon and can have serious implications in terms of downtime during peak operation (late deliveries) and high maintenance cost (out of hours Engineer call-out). Typical financial costs are shown in TABLE 1 that may have been incurred if the bearing had been allowed to continue until catastrophic failure.

TABLE 1
PROBABLE COST OF BELT FAILURE

Failure Consequences	**Cost**
Conveyor Downtime	?
Engineer Night Call-Out	£185
Engineer Wage (2 hours)	£110
Repair Cost	
New Belt (Transnorm TS1500 Curve)	£2300
New Bearings (80)	£400
Two Engineers to Fit (One Resident)	£315
Total Cost	£3310

This scenario assumes that the belt would break during normal peak use (during the evening or late at night) requiring a nighttime call-out from an Engineer to diagnose the problem. During the repair the conveyor would be completely overhauled and all 80 bearings replaced as a precaution.

The cost of conveyor downtime is very difficult to estimate as it depends on the client. This may be inconsequential, it may require additional staff to make up the shortfall or it may be a major problem resulting in many late deliveries.

TABLE 2 shows the estimated cost of a passive thermal inspection of the plant while in operation. The cost of the bearing for a single replacement and no additional cost is entered for the repair as its assumed the resident engineer would be able to fit it during normal working hours (while the site is idle) at no additional expense.

TABLE 2.
COST OF PREVENTATIVE MAINTENANCE

Preventative Maintenance	**Cost**
Thermal Inspection of site (Including travel)	£300
New Bearing	£5
Cost to Fit (Resident Engineer/Normal Hours)	No Extra
Total Cost	£305

SUMMARY OF CASE STUDY (1)

This is an abstract from the lecture given by the associate, whose age was slightly more than the average student and less than two or three of the mature students. The students enjoyed having a young engineer who is currently working in industry delivering their lecture and as anticipated, it led to further discussion on roles and responsibilities of young engineers and the variety of problem solving that may be required.

The technical content, although not too difficult as suggested earlier, brought out some important issues that need to be considered by production engineers and was a valuable contribution to the syllabus. More importantly the example was of a recent, actual occurrence undertaken by a newly qualified engineer, using the latest technology. This helped make their course more relevant to them.

CASE STUDY (2)

The subject matter is this one is getting more technical and involved some laboratory experiments and demonstrations. The students and associate having already met during the earlier lectures meant that there was not that apprehension that may occur whilst setting up a demonstration.

THERMAL IMAGES AND EMISSIVITY

To be able to understand a thermal image it is necessary to have a basic understanding of Emissivity. [2] This is a measure of a materials ability to absorb and emit radiation. It is defined as a ratio of the energy it radiates compared to the energy a perfect black body would radiate at the same temperature. A perfect black body is a material that absorbs and emits all radiation it comes in contact with (Kirchhoff's Law of Thermal Radiation), and would have an emissivity of one.

In simple terms this means that objects made from different materials or with different surface textures will emit different levels of radiation, and so give different readings to the camera.

In the example below shown in FIGURE 3 can be seen the thermal image of a cold beverage (taken from the fridge) alongside its digital image.

FIGURE 3. EXAMPLE OF EMISSIVITY

The thermal image shows the drink cold compared to its environment, but with an unusually high hotspot in the middle. Compare this with the digital image and there is a patch on the can where the paint has been stripped away to leave the shiny aluminium surface.

The different Emissivities of the painted surface (0.67) and bare aluminium (0.09) [2] give a different temperature value to the camera. Although they appear to have distinctly different temperatures, they are in fact identical.

This is important when looking at thermal images since it becomes difficult (and in some cases impossible) to contrast the temperatures of different materials in the same image. In all cases where data is taken from thermal images it is made clear what part of the image the thermal scale has been calibrated to.

While Emissivity is the most dominant characteristic in thermal imaging, there are others that should also be considered relative to the environment. There could be a second radiation source reflecting in the materials surface, and both of these will be attenuated in the atmosphere between the surface and the camera (depending on distance). A third source is ambient radiation in the atmosphere itself.

These must be kept in mind while taking thermal images, but will usually have a negligible effect on the results when there is a only a short distance between the camera and surface.

For some students however it can be difficult to get their heads round the concept, and so a simple experiment is used to demonstrate the effects. They are shown a mug decorated with different colors and filled with warm water, and then asked to guess which color will display a higher temperature. As can be seen below in FIGURE 4, this is in-fact a trick question as visual color has no effect on Emissivity.

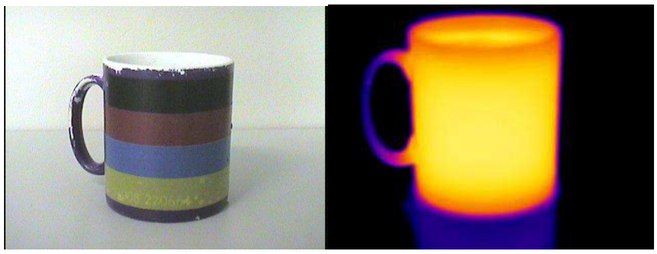

FIGURE 4. EXAMPLE OF COLOR AND EMISSIVITY

Many students will suspect the black to emit a higher temperature, and are surprised to find a uniform effect. This is used to lead in to the differences of visual and infrared light, and often then helps clarify the effects of Emissivity. The lesson concludes that while visual light is mainly made up of reflections, infrared radiation is made up of both the reflected and emitted and this ratio is controlled by a materials Emissivity.

SUMMARY OF CASE STUDY (2)

As suggested earlier the subject matter is getting more technical and although in this abstract of the lecture, it only shows the drink can and cup, there were many examples from within the partner company. These examples were again of actual working equipment in a modern conveyor system and explained eloquently by the Associate who had to try and interpret and understand the images taken in the workplace in order to develop software.

Again this wealth of fresh knowledge is being fed back into the course in an exciting a visual way.

THE WAY FORWARD

Exciting research and development has recently been undertaken on one of the company sites into the effects of oxidisation and dust deposits on the value of emissivity. This has further applications within subjects not directly connected to Thermography, such as material sciences.

The advantage of bring out new research possibilities in this way is that it can both add to the value of the service the company is producing and give the University access to data collected around industrial locations. This provides obvious advantages in the application of data as opposed to that generated in a lab as it includes the effects of ambient conditions (atmosphere, temperature, working environment) that can be difficult to reproduce.

REFERENCES

[1] http://www.flirthermography.com

[2] Bransom, M, A, "Infrared Radiation, A Handbook for Applications", *Hardback*, Plenum press, N.Y.,(1968).