Professional Engineer Recognition

The development of professional mentoring for engineers undertaking a workbased learning Masters Degree

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Abstract— **this paper describes a method of recognising and assessing learning at Masters Level alongside the monitoring of engineering competence development in the work-place. For successful participants in the programme the outcomes lead to a Masters Degree and recognition as Chartered Engineers in the United Kingdom. It concentrates on the monitoring of professional development and competence assessment through the work of appointed Professional Supervisors.**

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I. Introduction

In 2008 Kingston University, London initiated a new MSc Professional Engineering program undertaken through work-based learning, in collaboration with the UK engineering regulatory body, the Engineering Council, London.

This paper explains how and why this initiative to develop a new learning model has come about and how it has provided an innovative approach to the mentoring of developing engineers. In particular it concentrates on the theme of competence monitoring and how professional supervisors interact with the engineers who are participating.

The process of providing learning targets is summarized. These develop the necessary knowledge and understanding at Masters Level within individual learning contracts. Also, presented in more detail, is how the competences necessary for Chartered Engineers are monitored and assessed.

The underpinning theory of mentoring we are using is explained together with details of how industrial mentors are brought into the mentoring process alongside professional supervisors appointed by the university. Also explained is the pedagogy of problem-based active learning that we have developed within this program. The current structure of the role and responsibilities of the professional supervisors is clearly spelt out and explained with details of their activities, training and reporting mechanisms.

The very positive feedback from both employers and students or participants [1] that has been forthcoming is evidenced through the participation of major UK-based and global engineering companies that are impressed by the motivation of their employees; the paper describes how an international support and mentoring strategy is being developed specifically to support participants globally.

Finally, an evaluation is made of the successes and challenges presented by this new program together with an explanation of how interested parties may become involved in it internationally.

II. Background

There is a shortage of registered Chartered Engineers in the UK, yet there are many engineers working successfully within many UK companies who are not registered. Some have the qualifications, experience and competence but have just not applied. However, an even greater number are able, have experience and are potentially very competent but do not possess the qualifications necessary to be registered. Attending a university to gain the necessary Masters degree is financially and socially quite difficult for them, involving, as it must, periods of absence from the work-place. A work-based learning Masters degree in engineering can solve this problem.

Kingston University, London has nearly 10 years experience of running Masters Programmes for professionals in many disciplines entailing the evaluation and assessment of work-based learning (WBL): the Masters by Learning Contract. In Engineering this has developed through the UK Government's Gateways to the professions Project in engineering[2], based at the Engineering Council, London into a nationwide Masters

[1] As the students are mature it is customary to refer to them as participants.
[2] http://www.engineeringgateways.co.uk

degree: the MSc Professional Engineering. Now, several universities[3] in the UK are running programmes based on the Kingston model: the model described in this paper.

The initial stage of the MSc or Entry Gateway consists of a Professional Development Audit in which there are three elements. For each of these, an in-depth analysis is required from the participant in the form of a printable electronic document:

- Evaluative Review (ER) or Reflective *Curriculum Vitae*
- Learning Contract (or Agreement) (LC)
- Competence Demonstration Action Plan (CDAP)

Once these three documents have been assessed as reaching the required standard by the university the participant's enrolment is confirmed and the documents are supplied to the participant's Professional Engineering Institution (PEI). Participants need to become members of the PEI before they can fully enrol on the MSc. The PEIs who initially signed up for the MSc are the:

- Institution of Engineering and Technology (IET)
- Institution of Mechanical Engineers (IMechE)
- Royal Aeronautical Society (RAeS)

Other PEIs are currently joining this group[4].

Each participant works towards seven learning targets (or goals) contained within the LC. The last of these is the Exit Gateway, a reflective summary, which includes a *viva voce* examination and if this is successful, the participant is awarded an MSc Professional Engineering.

The programme normally takes two to three years to complete, during which each participant is advised, monitored and assessed by an Academic Supervisor appointed by the university.

A requirement for registration by a PEI as a Chartered Engineer (CEng) is the attainment of competence as described in the Engineering Council's United Kingdom Standard for Professional Engineering Competence (UK-SPEC) [1]. In this Standard a range of competences is described in depth and these require underpinning knowledge at Masters Level. The MSc Professional Engineering provides this knowledge through WBL. However, the competences themselves require to be demonstrated in the work-place. A university appointed Professional Supervisor monitors and advises the participant and the employer on how the competences are being met and provides reports to the university. Although meeting the competences is not a requirement for the award of the MSc, the PEI is informed of progress and undertakes a Professional Review and Interview (PRI) once the participant has completed the MSc. Successful completion of the PRI results in professional registration as a CEng.

[3] Kingston University London, the University of Hertfordshire, Northumbria University and Staffordshire University have now been joined by Universities at Aston, Cardiff, Derby, Hull, London South Bank and Teesside

[4] British Computer Society (BCS), Chartered Institution of Building Services Engineers (CIBSE), Institution of Chemical Engineers (IChemE), Institute of Measurement and Control (InstMC), Institute of Physics and Engineering in Medicine (IPEM), Society of Operations Engineers (SOE)

III. LEARNING CONTRACT AND TARGETS

Learning Targets (or goals) are set during the establishment of the Learning Contract. Each is based on the work the participant is expected to undertake during the programme. These are rated in Credits [2]. 180 M-level Credits are required in the UK for the award of a Masters Degree. 15 of these are awarded for the PDA at the Entry Gateway and 40 for a successful Reflective Summary and *viva voce* examination at the Exit Gateway. The remainder are set for any acceptable Masters level prior learning for which there is evidence and each of the other 5 Targets. These targets are generally set for 10 to 30 credits each and require a deliverable outcome which can be assessed. Examples of such deliverables are:

- Report on a project undertaken
- Technical or Management report
- Presentation to be delivered to a defined audience
- Major computer programme: documented, relevant, complex and demonstrable
- Paper for publication in a learned journal
- Research results and accompanying paper for publication
- Document on Social implications, Sustainability, Ethics or Environmental issues
- Effective and engaging talks or activities provided to school, college or university students

Once these are agreed between the participant and the Academic Supervisor with the acceptance of the PS, the LC is completed.

IV. COMPETENCE MONITORING BY PROFESSIONAL SUPERVISORS

The main role of the Professional Supervisor (PS) is to ensure that the competence requirements of UK-SPEC are met in as regular a way as possible. Each PS encourages the participant to assess and note the evidence for existing competence. Once the LC has been agreed, he can help the participant to make an assessment of expected competence development over the period of the programme, together with the necessary evidence. At this stage, the CDAP is completed and provided to the university by the participant.

The PS visits the participant on a needs basis and on average makes 4 or 5 visits per year to the work-place. Each visit is about 3 hours long. Starting with the CDAP as a base, the participant's activities and progress towards meeting the competences are his principle concern and he liaises with the employer's staff whenever necessary: the participant's line manager, company mentor and human resources personnel. He also keeps in close touch with the Academic Supervisor in

order to harmonise the processes of participants meeting their learning goals and meeting the competence requirements.

Each participant keeps a Professional Development Record of skill sets required and developed in the work-place and of experience gained. This is in order that the participant's evidence of competence can be provided to the PEI on an on-going basis. The PS ensures that this happens by checking the record, asking appropriate questions and making suitable suggestions for future activity. Most PEIs have an on-line monitoring system so that such evidence is available to members of staff and PEI professional advisors on an on-going basis: for example the electronic Monitored Professional Development Scheme (eMPDS) of the IMechE, Career Manager of the IET and the on-line professional development scheme of the RAeS which is run in conjunction with the Engineering and Technology Board.

The Professional Supervisor has the majority of the face to face contact with the participant. Subsequent to each visit to the participant the PS writes a Visit Report about the progress (or lack of it) in closing any competence gaps that the participant has made since the last visit. These Reports are counter checked by a 'Lead' PS who is very familiar with the participant's PEI, and their requirements. Finally these reports are sent to the University to be lodged in the participant's electronic records. Currently Kingston University is trialling new systems with the IET and the IMechE. The reports and any other documents relevant to the participant's progress can be uploaded and stored in a document vault: in the case of IMechE, the eMPDS system. They will therefore be available for the PEI to examine prior to the PRI, to see the progress made.

PSs attend a training conference each year. The first was held in Peterborough at Perkins Engines last year and others are planned for later this year. Its purpose is to review the processes of competence monitoring, mentoring practices and to ensure that all PSs know how matters are progressing at each PEI.

V. THE PEDAGOGY OF WORK-BASED, PROBLEM-BASED AND ACTIVE LEARNING

Work-based learning is only one of a number of terms that have recently become popular to describe newer alternatives to traditional classroom based pedagogies, such as active learning, problem-based learning, action research, etc. Although there is very little agreement amongst educationists as to the meanings of these terms, there is even less agreement as to their effectiveness. Generally the outcomes of research are inconclusive with no significant evidence of these newer approaches being more effective for student learning. However, there is evidence that their use does generate enhanced student engagement; in particular, problem-based learning can improve student ability to retain information longer and develop their enhanced critical thinking and problem solving skills [2].

The work-based learning methods used in the MSc Professional Engineering programme are actually a complex mix of many different methods, and the make up of that mix can vary significantly from one participant to another. Primarily it is a combination of:

- active learning [6], where the participant is positively doing something, and
- problem-based learning where the participant is positively doing problem solving,

Significantly:

- they are doing it in their own work place.
- it is self-directed learning, and
- the participant has the major responsibility for:
    - designing their own learning activities, and
    - ensuring progression.

Another very important facet of the programme is that is a mechanism for:

- lifelong learning,
- widening participation, and
- employer engagement.

The open and flexible nature of the programme allows people to undertake learning at any stage of their life. The accessibility of the programme enables people who otherwise would feel reluctant to engage with higher education, or could not afford to engage, to gain safe and affordable access to it. The programme's learning content is directly related to the employment work place activity and the employer is a direct partner in the learning, thus ensuring the learning is far more likely to meet employers' needs.

The programme has been developed because it will allow many engineers who otherwise could not develop their capabilities to their highest potential to do so in a way that is beneficial to both employers and the wider engineering community more generally. It has not been developed because work-based learning for engineers is a naturally better form of learning than traditional engineering programmes, (although we believe it certainly can be in many situations).

As such we believe it is probably the most appropriate form for most Chartered Engineers, and engineers working at that intellectual and technical level, for the highest level of critical thinking learning and development required as part of their continuing lifelong professional development.

The basic pedagogy for all participants on the programme, whatever the actual mix of their individual learning contract, is that of experiential learning, as first identified by Dewey [3] and then later developed Kolb [4], and widely known as "Kolb's experiential learning cycle", (fig.1).

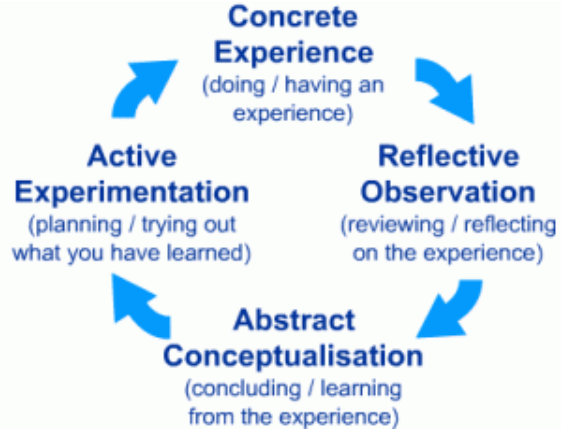

Figure 1

In this, an individual learns by going through four stages of the process:

1 Initially they have a "concrete experience", an interaction or real experience with some aspect of their environment. For our participating engineers this could be the action of implementing a new production line.

2 During or after the experience, the participant engages in "reflective observation" of:
- what they experience
- their actions within the experience, and
- the responses of others to that experience.

For instance they might try to:
- analyse why they chose a particular solution to a problem they encountered during the introduction of the new production method,
- describe what were the drivers of their decision making process,
- explain how effective the problem solution was that they chose, and
- ask, how did it impact on each other?

3 The third stage of the learning cycle is "abstract conceptualisation", which involves theory building in which critical thinking skills are developed to evaluate the reflections made about the experience. This for our participants is where the seat of in-depth learning takes place. It is the most challenging, because it requires participants to critically evaluate their existing understanding of engineering theory and practice. It may involve considerable independent study and research of technical theory, in order to be able to justify their actions, or alternatively change or amend their engineering knowledge and understanding to a new position as a result of their experience and independent study.

4 The final stage of the cycle is "active experimentation", where the theory that has been constructed is put to the test, by various means. For our participants this could be by:
- deconstruction of their new knowledge and understanding into small testable packages,
- the development of new working processes within their employing organisation for themselves and others, or
- peer review as part of the MSc programme assessment strategy.

VI. The Role of the Professional Supervisor and the Underpinning Theory of Mentoring Used

The method of mentoring being used by Professional Supervisors is essentially one of assertive empathetic involvement. The closer the PS is to the student's work involvement, aspirations and professionalism the better his understanding of the participant's needs and competence development.

It is generally recognised that this form of mentoring enables:
- knowledge sharing
- working through of professional and personal issues
- improvement and career development
- support for study or research
- provision of a sounding board or critical friend when required

Mentoring [5] is help by one person to another in making significant transitions in knowledge, work or thinking
A mentor is someone who helps another to become what he aspires to be and helps another person through an important transition such as coping with a new situation or in career development.
By providing the means to share the knowledge, experience and advice of the Professional Supervisor, participants who have a keen desire to learn and develop themselves to achieve their goals.

One of the major objectives that the PS tries to achieve as a Mentor is to try and get the participant to 'think' like a Chartered Engineer. By that we mean not being afraid to 'question' an approach to a problem, or a technology suggested as a solution. Also we encourage them to adopt a more 'Strategic' outlook rather than a 'Tactical' approach "because it's always been done that way"!

Company or Industrial mentors are brought into the mentoring process alongside the PSs whenever necessary, whether it is to ensure contact and communication or whether it is to ensure harmony of purpose. It is very important to ensure that management processes within the company are not disturbed, so if there is a need to adjust the programme, then the PS needs to be very careful to put the participant's needs first within the company context.

The learning cycle described above is believed to be very powerful in both engaging engineers in further learning and in

building continuing individual learning. However for many engineers, particularly those with many years practical experience it is not a process to which it is easy to take. Successful engineers are very capable in their area of expertise, confident in their understanding of their knowledge base whilst at the same time knowing the boundaries of their expertise, and very goal focused individuals.

It is not generally part of their make up to spend much time "navel gazing", which is how critical reflection is sometimes portrayed. The knowledge and understanding they build up is a mix explicit knowledge, that which is articulated and can we easily communicated, and implicit knowledge, that which is not (perhaps cannot be) articulated but is embedded deep within the engineer's engineering knowledge "know-how". It is often derived from experience where a key element is an ability to successfully apply knowledge gained in one field in an unrelated but similar environment. The accuracy or otherwise of this knowledge is therefore very hard to verify – and it is also hard to change.

In order to build continuous development and learning knowledge mining is required to seek out and incorporate implicit knowledge into explicit knowledge. This can be done concurrently with the "reflective observation and abstract conceptualisation stages of the learning cycle.

The role of the professional supervisor has therefore been constructed around a combination of the need to provide continuing ongoing professional direction to the participant in the progression of their learning contract, but also to engage the participant in critical debate, which challenges the participants' natural thought processes, and forces them to engage in critical reflection. It is this critical reflection which takes the participant through the reflective observation and abstract conceptualisation stages of the learning cycle. The ongoing critical conversation between the participant and professional supervisor is not one in which the learning is carried out by knowledge and understanding being passed from supervisor to participant, but it is a constant to- and fro-ing of ideas, in which engineering knowledge is the focus of the debate, and its value and voracity is subject to exposure and judgement. The professional supervisor is the initial leader of this debate, but in time the roles will be reversed and the participant, by learning from example, will be able to take the lead and start to critically reflect on their own engineering knowledge and hence continually build and develop it through a combination of experience, study and debate. The engineering conversation can then spill out beyond the restricted supervisor participant arena and into the wider employer organisation arena. The participant engineer can then move beyond the phase of individual learner and onto becoming the champion of organisational learning.

The role of the professional supervisor is thus crucial to the success of the whole work-based learning activity. They need to be professional supervisors on two levels:

- to provide the full range of advice and guidance needed by the participant on their journey to professional status,
- to have a very professional approach to their own mentoring activity.

The group of professional supervisors all have to conform to a common approach, and mentoring processes, for their activities, underpinned by a group understanding of the nature and purpose of those activities. This is not a set of processes which can be uplifted from a standard publication on mentoring. This activity and its processes can only be constructed and defined by the professional supervisors currently involved in this MSc Professional Engineering programme. It is a challenging piece of work in itself that is asking of the professional engineers doing the professional supervision to embark on considerable experimentation, reflection and theory building themselves. Progress so far has been very positive, with supervisors having produced working processes, performance and progress monitoring methods and arrangements for mapping academic working tasks against engineering competence standards. Work is ongoing toward a set of materials for the training and development of new professional supervisors, and this paper forms part of our activities to draw in the opinions and knowledge of others who can and would wish to contribute to this development.

VII. PROGRAMME EVALUATION

In order to provide reliable evidence of the effectiveness of this programme an evaluation process has been incorporated into the development project.

Initially prior to the start of the programme and during its development phase a survey was undertaken of engineering graduates who had completed an accredited engineering first degree between 2002 and 2006. The objective of the survey was to investigate the reasons why a very large proportion of engineering graduates did not progress onto professional registration.

The results of this survey [7] were surprising. In regard to furthering engineers learning to Masters Level, there was:

- no perceived deterrent in the additional costs of undertaking further studies, but:
- a lack of awareness of how to develop their knowledge to the requisite level.

In regard to Chartered Engineer registration there was:

- no perceived lack of support from employers, but:
- a lack of understanding as to how to progress.

Now that the programme has been running for two years a further investigation is being undertaken as to how well the programme has met the needs of engineers in these two areas, and to how well it is also meeting the needs of employers in helping them increase the capabilities of their engineers.

Initial feedback statements received so far from both employers and participants have all been positive and encouraging.

A number of case studies of individual participants' programmes which are relevant and illustrative of the initiative have been produced. These are available for distribution.

VIII. EMPLOYER ORGANISATIONS INVOLVED

A number of large engineering employers have sent small cohorts of engineers on to the programme to evaluate its potential for helping them meet their forthcoming engineering development needs. The majority of the engineers on the programme are employed within large companies but 25% are employed by small or medium sized enterprises or companies (SMEs). The availability of university-provided professional supervisors is particularly important for those in SMEs because they would be very unlikely to be able to get appropriate mentoring from Chartered Engineers within the company.

The majority of the participating engineers are between 25 and 35 years old. Many of these are qualified with an accredited first degree and are using the programme to speed up their progress to Chartered Engineer status as part of a career development plan.

However a significant minority, 23%, are aged 36 or over. For these engineers:

- the programme provides an opportunity to enhance their own engineering capability and develop additional job satisfaction and personal goal achievement.
- the availability of a highly qualified professional supervisor is of particular importance in enabling them to engage in critical dialogue with a peer who can independently challenge their embedded engineering assumptions.

In total 30% of participants starting the programme have non-traditional entry qualifications. Again for them the availability of a professional supervisor is important in helping them to bridge the divide between their generally practical engineering development and the academic requirements of a Masters Degree learning programme.

IX. INTERNATIONAL INVOLVEMENT.

Currently we are in serious discussions with a number of globally based multi-national companies who are very keen to adopt this approach to enable many of their senior engineers, based outside the UK, to become Chartered Engineers through UK PEI's. As these members of staff are based abroad the current ways of supporting them with both the Academic and the Professional Supervisors have to be re-thought.

Thus a new support and mentoring approach is being formulated which will involve enlisting the help of locally based senior engineers, trained by and working on our behalf, giving some Mentoring support and undertaking evaluation for us. This would be supplemented by visits by the PSs twice a year for more intensive and more in-depth reviews with each of the participants. To be cost effective for both us and the Company we would also expect that a minimum of 6-8 participants be enrolled by each overseas-based company, and that they're available in a single location for these twice annual visits. We expect the first of these 'international' participants to be underway early in 2010.

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