A model of critical reflection within a work based learning programme

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Introduction

The Engineering Council's Gateways Project arose as a result of Sir Alan Langland's "The Gateways to the Professions Report", (Langlands, 2005), which looked at how employers and the professionals could sustain and improve access to the professional particularly in light of the planned changes to university funding mechanism. Amongst its recommendations were ones that addressed issues of promoting wider and fairer access.

In response the (then) UK Government established a development fund for projects that tackled issues and barriers faced by people seeking to enter the professions through higher education. In 2006, funding was awarded to the Engineering Council for work that aimed to address the issue that working engineers who were eligible did not, for whatever reason, progress to become professionally qualified.

This funding was used to set up what has now become known as the Engineering Council's Gateways Project. (Engineering Council, 2010). This originally consisted of four UK universities, or Higher Education Institutes (HEIs) and three of the Professional Engineering Institutes (PEIs), working together with the Engineering Council (EC) to develop a common approach to running work based learning programmes which enabled the concurrent development and demonstration of professional engineering competences alongside academic achievement. The early work concentrated on: establishing a common framework of principles for programme delivery but which still allowed flexibility for individual universities to suit their own needs; producing an escalator of programmes which allowed individual engineers to get on and off at levels appropriate to their needs; and establishing a process map and a set of working practices to engage with the various PEIs (subsequently to become the PEI Registration Protocol and the Participating HEI Protocol).

1. Current Gateways Project Status

The first MSc Professional Engineering programme started recruiting in late 2007; the first BEng version in 2011. Currently (May 2014) there are 150 students on both MSc and BEng versions of the programmes at the 8 universities who running programmes, from nearly 100 different employers. So far the project has resulted in 29 MSc graduates and 12 BEng graduates, with 15 achieving Chartered Engineer, and 2 Incorporated Engineer, status. So far 17 PEIs have signed up to support the project.

A detailed analysis of the project start was presented at EE2010, (Seddon and Lock, 2010). The Engineering Council produced a final Project Review (Engineering Council, 2011), which concluded that most of the original projects aims had been achieved. Further wider analysis of the project (Seddon, 2012) identified additional challenges and opportunities.

The original plan was for the project to last for 5 years, from 2006 to 2011, with the first two years funded by the UK Government. However with the success of the project it was subsequently agreed that it would be extended via the Engineering Council chairing a Steering Group to continue the outreach activities to other universities, PEI's and the wider stakeholder community, and maintain a web presence giving advice and guidance to interested parties and potential participants. (http://www.engc.org.uk/engineering-gateways.aspx)

2. An Integrated Active Learning Delivery System

Aston University has a strong reputation for providing high quality engineering programmes which produce graduates with excellent employability skills. Active learning and employer engagement activities have always been a key component of many of Aston's programmes and so becoming part of the Gateways Project in 2010 was a sensible step.

In addition to staring up programmes in the UK, Aston also started delivering the programme overseas. This had not been envisaged within the original project scope but recognition of this potential demand, the Project Steering Group confirmed that the pathway should be open to those outside the UK and a statement outlining this position was agreed.

In 2011 Aston also started the first BEng programme within the Project, called the BEng Professional Engineering (Power Systems). Targeted specifically at engineers working in the power generation and transmission industries, this was, and still is, primarily but not solely, an articulation pathway for engineers graduating from Aston's Power Systems Foundation Degree programme.

In 2013 it was decided to amalgamate the delivery of Aston's various work based learning engineering programmes at masters, bachelors and foundation degree level under the auspices of a single delivery group to be known as Aston Professional Engineering Centre or APEC. The purpose of this was twofold:

a) To provide for the integrated delivery of a portfolio of programmes to better meet the needs of employers and their engineers thereby reinforcing the original escalator idea of the Gateways Project

b) To enable a more considered and thoroughly supported "learning model" to be developed so as to enhance the learning experience for engineers on these programmes.

3. Learning Model Development

A key component of all of Aston's work based learning programmes is the integration of theory with practice. From the start of the MSc programme in 2010 it was therefore thought to be essential that the educational practice being employed in the programmes should be adequately supported by a

theoretical understanding of the learning experiences being created. However it was found not possible to do this even from within the very wide range of identified existing models (Mosley, 2005). So an ongoing process of experience with the programme delivery, both the good and the bad, research into establishes theories of practice, discussions between programme team members, and long periods of reflective thinking, has produced the learning model we are now using.

From the early work nearly 100 years ago, (Dewey, 1916), through that of Lewin and onto more recent work, (Kolb, 1984), there exists an extensive literature about the nature and value of experiential learning. Most of these have proved valuable in the process of creating our learning model with many useful perspectives being identified. By adapting and connecting a number of these perspectives it was found to be possible to construct a relatively simple and communicable model. This triple mode learning model starts by linking an adapted traditional learning cycle with an adaption of Kolb's experiential learning cycle, and then linking them with an adaption of a "double loop learning model" (Argyris and Schon, 1974). The resulting model, although fairly coarse does effectively capture all the elements of the different teaching and learning methods employed by the various programmes. It has also proved to be a good tool for communicating the differing methods being taken by the programmes to participants and their employers. Whether it has any further value in more generally articulating understanding about teaching and learning is still to be determined.

Before giving a brief description of the model it important to explicitly state that although the model describes a progression of differing learning modes there is no implication of any hierarchy of value. All modes are equally valuable, and comprehensive continuous learning and development for professional engineers requires all three modes to be utilised concurrently.

The APEC Triple Mode Learning Model

In the first mode of learning, learning by imitation, learning is based on the unidirectional transmission of accepted knowledge and understanding to the learner from either individuals or knowledge artefacts, and is usually pre-determined in the form of either learning outcomes or competence statements.

Once a learner starts to undertake some form of practice then the second mode of learning, learning by experience, is enabled. Whilst it is not an absolute though that this will always happen, if the barriers to learning are low, and what Jarvis calls "disjuncture" occurs, (Jarvis, 2004), then

subsequent non-critical reflection will leads to adaption of what Schon calls “theories in use”, (Schon, 1991), and hence behaviour modification which minimise that disjuncture. This mode of learning is crucially important to engineering and underpins most of continuous technological improvement. But it is unlikely to be sufficient to create breakthrough understanding needed for successful innovation of new technologies.

This happens when the non-critical reflection is modified to become critical reflection. In our model this starts with critical thinking, wherein the assumptions, taken-for-granted, and the underpinning knowledge and understanding supporting practice start to be questioned. When such questions identify weaknesses or flaws, then subsequent creative thinking may be able to find possible new approaches and theories, which with reasoning and rational thinking follow through to breakthrough understanding, which in turn can be challenged and tested by discourse and further reflection.

The difference between non-critical, or incremental reflection, and critical reflection is not clear cut, but it is important. A whole range of advanced thinking skills can be employed in various ways to move student’s reflection skills along a spectrum towards becoming more critical. It is this activity which is of real significance to the way the model is utilised by APEC in the MSc Professional Engineering programme.

A fuller explanation of the model and its workings is available on the APEC website, but the difference between incremental, (or non-critical), and critical reflection is captured by the words *“There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.”* **(Donald Rumsfeld)**

Incremental reflection is interested in the known knowns and unknowns; critical reflection is more interested in the unknown knowns and unknowns.

4. Model Usage

By using real work projects as the basis for much of the work based learning programmes run by APEC we are able to apply the various modes of learning identified by the models to create clarity and a direction of purpose in the learning tasks and activities associated with those projects. The learning tasks do not become obscured by the real work needs of the project.

At the Foundation level we produce learning materials which are designed and structured to provide all the underpinning knowledge and understanding to support the professional engineering activities of the engineers undertaking the programme in accordance with the requirements of the first mode of learning. These materials are developed in partnership with the employers who engage with the programmes, and delivered by staff who have the combination of academic and professional experience to make the connections between theory and practice.

At Bachelors level the programmes have a blended learning format which gives roughly a 50:50 split between remotely accessible programme content and work based learning projects. The remotely accessible content aligns to first mode learning mode, and the work based learning project aligns to the second mode of learning. The work based projects are chosen in conjunction with the engineers and their employers such that they can practice the use of their incremental reflection skills and their underpinning knowledge and understanding to modify and improve their active theories of action. In doing this they are supported by both academic supervisors and professional supervisors.

At Masters Level the virtually all of the programme is structured around a series of real work projects. These projects provide the basis for both incremental reflection leading to second mode learning, and the opportunity for engagement in critical dialogue with both academic and professional supervisors,

which enables the students to practice critical reflection which is key to third mode learning. Within the relatively short duration of these programmes we do not think it possible for the engineers to fully develop expertise in critical reflection sufficient for it to become embedded into all their professional activity, but the programme gives them the trajectory they need for their own future self-development. The objective is for them to have learnt how to learn from their own professional practice and their critical as well as incremental reflection of that practice.

Fundamental to achieving this objective is the need for participants to acquire the thinking skills that are required for critical reflection, and to understand how to apply them properly. Early on the programme team at Aston realised the importance of this and set up a distinctly separate approach to the delivery of the first module in the MSc Professional Engineering programme, which is called the Professional Development Audit module.

It is an Engineering Council requirement that all programmes which are part of the Project start with a PDA module. The objectives for the PDA are that:

"*This PDA is a reflective examination and assessment of the individual's education, qualifications, experience and competences upon enrolment. This is then used to:*

- *determine the difference between current competences and those of UK-SPEC*
- *define the scope of their learning contract or other equivalent document*
- *determine how the individual intends to meet the required competences*"

(**Engineering Council**)

Whilst there is no mention of the need for the PDA to develop the critical thinking and critical reflection skills of programme participants it does provide the ideal opportunity for doing so. In a multi-disciplinary programme, which the MSc Professional Engineering programme is, then it is these critical reflection skills that can be used as the consistent common linkage across all the disciplines. Hence they will contribute to both the definition of the learning contracts and how the individuals on the programme intend to demonstrate the competences required by UK-SPEC.

The Aston PDA team set about developing a range of learning packages that would introduce all programme participants to the concepts of critical thinking at the very start. Part of the assessment package for the PDA is an evaluative review where one of the learning outcomes is evidence of critical thinking skills. Having demonstrated them at the start of the programme they can then be applied in the work based projects that follow. An analysis of this particular aspect of the programme suggested that in order to promote professionalism amongst Professional Engineering students, the concepts of reflection and reflexivity need to be embedded into the curriculum, (Andrews, Clark & Glew, 2011).

5. Participant Experiences

The Aston MSc Professional Engineering programme currently has 45 participants enrolled onto it. 24 of these are UK home students and 21 are international students based in Angola, Indonesia and Azerbaijan. Only one student has so far completed the programme having been the first to start in April 2010. The challenging intrinsic nature of work based learning coupled with the high expectations for demonstration of both critical thinking and professional competence results in a dropout rate of just over 25%. Typically the expected programme is 3 years but a number of the overseas participants who are enrolled as part of a company cohort will be taking a full five years to complete because of the work pressures of their normal employment role.

However on the positive side the programme has such flexibility that it can adapted to participant's varying work roles to help prevent them dropping out. We have had one participant who started the programme when they were working in Angola, they then moved onto to working in the UK for a short while before transferring on an assignment to Singapore. Subsequently they took and employment sabbatical in Japan, and finally they are now back at work in Indonesia. During all this the programme team, with the help of the employer have been able to continuously support the programme of study and, although now extending to 5 years, it has yielded significant benefits to both participant and employer.

Although it is too early to demonstrate conclusively the long term impact of the programme on the participants professional performance, because of the individual nature of the programme participants have frequent one-to-one face-to face meeting with their supervisors and so it is possible to reasonably accurately gauge what the short term of the programme has been from the feedback of those supervisors.

So far participants have found the programme stretching and in some case uncomfortable because it does not match their expectations of what a Master's programme should be. This is in spite of the fact that all applicants are interviewed by either the Programme Director or one of the Lead Supervisors before they are accepted onto the programme, and very clear guidance is given to them at that interview. This would appear to be an example of the impact of embedded mental models and how difficult they can be to change.

Most of the dropout rate occurs during the first year of enrolment; those participants who getting thought their first year are looking likely to complete. An analysis of the reasons for dropping out, as given by those who had dropped out, undertaken in early 2013, indicated that the primary reason was related to change in their employment status or role. Only one of the seven ex-participants who had dropped out at that stage admitted to the programme being harder than they could cope with. From discussion with the supervisors of those who dropped out however it is though that this was a significant factor for at least three others. Because the programme fees are normally paid by the participant's employers there is a clear incentive for students not admit to reasons for dropping out other than work related ones.

Feedback from the programme's first graduate, and their employer, was very positive with evidence being provided of both significant benefits being gained by the graduate and by the employer in terms of the output of the work based projects completed by them whilst on the programme. This aspect of work based learning has also been demonstrated on the BEng Professional Engineering (Power Systems) programme where so far 20 participants have graduated.

The programme's emphasis on critical thinking and critical reflection has been noted by a number of participants as being both very difficult and very valuable to them, and resulting in a marked change in the way they view not just the work base projects they are undertaking but also other aspects of their employment.

6. Programme Challenges

The MSc Professional Engineering programme is very much a niche programme which has a very valuable contribution to make to the achieving the objective identified in the Langland's Report, but only for a small percentage of potential professional engineers.

On the other hand the BEng Professional Engineering has the potential to make a much bigger impact if the arising understanding of the success factors for work based learning that have been learned as a result of its development in concert with the MSc Professional Engineering, are reflected

upon (both incrementally and critically) and then used to both improve it and other experiential learning activities associated with the much larger traditional taught engineering programmes

Some of the key challenges and outcomes now being considered by the Programme Team are:

1) The consistent assessment of learning achievement across a multi-disciplinary work based learning programme is very difficult to achieve. An ongoing programme of refining and improving the assessment strategy and associated assessment criteria is underway.
2) There needs to be a clear and common understanding of objectives, processes and terminology employed. The lexicon of teaching and learning is full of terms which have multiple and sometimes ill-defined meanings.
3) The success factors for individuals undertaking work based learning programmes are not consistent across individuals. We have started to recognize the extend of some of the variables that influence the success factors but a body of work need to be done to gain a better understanding of the relationship between them and how programmes can be adapted to make bets use of such understanding.
4) The sustainability of high quality work based learning will only be achieved if programme fees are sufficiently high enough to support the frequent and regular input to participants from supervisors and mentors. Fortunately the benefits that are possible from high quality work base learning mean that this is possible to achieve. At the same time though the Programme Team are exploring the use of advanced communication technologies to support and enhance the learning experience whilst also reducing the costs.
5) The significant cultural differences that exists across the world mean that programme expectations (the mental models) are not simply transferable. Programmes can be developed which have the objectives of achieving a consistency of expectations of output.

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