# Work Based Learning for the Development of the Chemistry Professional.

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ABSTRACT:

Changing employment patterns together with changing competencies and skills requirements and the rise of the so-called 'knowledge economy'' has driven innovation and development in training and education addressing the need of modern societies to implement continuing life long education.

The Life long learning agenda is clearly articulated in the UNESCO declaration which has a specific reference to Environmental Education for sustainable development. It reflects the need to access learners at 'non traditional/conventional' situations taking advantage of learning potential located outside higher education institutions.

Barnett (1999) sets out the context of the modern work place and the worker within it. He describes working life as "supercomplex" with the need to accommodate technological, social, managerial, patterns of consumption at increasingly rapid rates.

Chemical scientists and technologists are at the forefront of these changes and need to embrace a culture of life long professional development. This ethos has long been recognised by the learned societies and chartered institutes in the UK. For example this is recognised by the RSC for chartered scientist status that states twelve professional attributes against which a Candidate's performance is continually judged. As well as understanding of the pure knowledge base the attributes include being part of a community of practice or team, in which people share learning and development in their professional field (see http://www.rsc.org/Education/Qualifications/AttributesCChem.asp).

The Work based learning framework (as developed at Middlesex University) provides the opportunity to integrate and utilise these principles to accommodate work place projects in real world scenarios. A project based framework, incorporated into a rigorous academic framework, can enable learners to achieve professional qualification at different levels ranging from first degrees to doctorate level.

This paper describes and critically analyses the experience at Middlesex University in developing a viable work-based framework for professions. The paper will also consider the relationship between the needs of the profession and the educational pathways that can be utilise to achieve a culture of continuous professional development. Key themes will also include the role of mentoring by a co-professional to support ongoing professional practice and consideration of the practicalities of building mutual support through learning projects.

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INTRODUCTION

Staff operating within the field of chemistry are highly qualified and highly skilled. Chemists will have generally studied 3 to 5 years and frequently longer in order to obtain professional body recognition. Training and learning seldom stops there with many practitioners proceeding to masters and higher degree level. In addition, many at the work place maintain their competency and keep with new development through ongoing training via specialist courses and through the gaining of experience in practice.

The working lives of Chemists and Chemical Engineers are increasingly complex. Many chemists are no longer working in isolation on individual projects. More and more they are members of larger teams, working on large projects, having to interact with other professions. This is now recognised by a number of professional associations most notably the RSC in the UK which identifies 12 professional attributes for the Chartered Chemist. These are presented in Figure 1:

1. Make significant personal contributions to key tasks in your employment area and understand fully the chemistry objectives of the work done and its relevance to the employer or others.
2. Demonstrate a high level of appropriate professional skills in the practice of chemistry.
3. Develop your chemistry and other professional skills as required for the work undertaken and career development.
4. Demonstrate an understanding and appreciation of Health, Safety and Environmental issues and adhere to the relevant requirements relating to your role.
5. Evaluate critically and draw conclusions from scientific and other data.
6. Demonstrate integrity and respect for confidentiality on work and personal issues. Demonstrate other professional attributes such as thoroughness and reliability.
7. Plan and organise time systematically, demonstrate foresight in carrying out tasks, and offer suggestions for improvements to tasks/duties.
8. Demonstrate an interest in broader developments in chemical science and make a contribution to the profession of chemistry outside your direct work environment.
9. Write clear, concise and orderly documents and give clear oral presentations.
10. Discuss work convincingly and objectively with colleagues, customers and others. Respond constructively to, and acknowledge the value of, alternative views and hypotheses.
11. Demonstrate the ability to work as part of a team.
12. Exert effective influence.

Figure 1: Professional attribute of Chartered Chemist (CChem) RSC 2008

The American Chemical Society develops this further, recognising the importance of the strategic position of chemical scientists and the importance of leadership and change management. It, now, provides workshop to address this concepts, including.

- **Collaborating Across Boundaries**
- **Engaging Colleagues in Dialogue**
- **Extraordinary Leaders Workshop**
- **Innovation**
- **Leading Change**
- **Leading without Authority**
- **Managing Projects**
- **Strategic Planning**
- **Succession Planning**

(American Chemical Society 2008 http://acs.learn.com/)

The above list illustrates the increasingly complex professional life of chemists in 21st century and specifically gives recognition to the needs for chemists to understand the concepts strategic planning, organisational and personal change management and innovation

These are important in terms recognising the increasing roles and responsibility, frequent changes to practice, an increasing ethical intervention and indeed the underlying principles of assessing the adequacy of premises and practices, or the increasing levels of technical knowledge that needs to be retained.

With all these external drivers and need for future innovation and development of the professional chemist, consideration should be given to the need for continuous professional learning.

There is a finite currency to one's initial training. Judging how long it last is difficult to establish but by way of comparison, work by Mantovani, et al (2003)suggest that medical knowledge doubles every 6-8 years providing a very short half life for new knowledge. Boud and Garrick (1999), Jakupec and Garrick (2000) Wonacott (2001) underline this by stating that existing knowledge is rapidly obsolete, advocating that employers routinely need to upgrade worker skills.

Barnett (1999) goes on to set out the context of the modern work place and the worker within it. He describes working life as "supercomplex" with the need to accommodate technological, social, managerial, patterns of consumption at increasingly rapid rates. Access to increasing information provides greater options to appraise, making decision making more complex. More importantly we find in the supercomplex world that our whole understanding can be challenged. Whole approaches can be altered during our careers which can challenge our

underlying philosophy (Portwood and Thorne 2000). All this points to a need to be adaptive, responsive to change and to continuously improve (Conner 2005). Many professions and professionals struggle with this concept. The practising Chemist, however, has shown the capacity to take on this supercomplexity through the ability to adapt their role, approach and function.

Most practitioners recognise the need to accommodate change to keep up professional levels of service. There is a constant need to increase or alter knowledge base, capability and established cognitive capacities (Kerka 2001, Doncaster and Lester 2002). Increasingly, however, there is a fundamental need to provide transformational learning to alter the "how we know" (Kerka 2001, Imel 1998), and general high level capability as opposed to purely disciplinary based knowledge (Doncaster and Lester 2002),  so as to cope with the increasing complexity of the work environments. Many roles now are interdependent, going beyond job specific skills it is critical to continuously develop these skills in order to survive and prosper in the modern workplace (Overtoom 2000,Wanacott 2002).

Traditional learning models would be to return to the classroom, attend seminars or through in house training. What is often not recognised is the daily learning undertaken in the workplace.. Whether it be application of a new procedure or protocol, development of a new analytical technique, product development or otherwise the workplace offers a constant medium in which to learn.

Indeed it is interesting to note that many professional bodies are recognising that academic qualifications are of limited value and that "experience in the application of knowledge, level of skill, safety and environmental consciousness, sense of responsibility, ability to communicate and level of supervision received" (European Association for Chemical and Molecular Sciences 2008) are of equal importance. These are much softer skills than traditional hard science and it can be argued are best learnt and more importantly demonstrated in the workplace.

**Work Based Learning**
The process of learning has always taken place at the work place.  However it is only relatively recently that Work Based Learning has been afforded a recognised structure providing a basis and intellectual framework for knowledge recognition and development.

The UK government is increasingly committed to the concept of learning and skills development. As long ago as 1998, the government set out their vision in the Green Paper

"The Learning Age" (DfEE 1998). This paper set out a view that:

    a.      learning assists organisational development by increasing the skills of the workforce

    b.      through the process of learning itself, it enables the organisation to manage and respond to change.

    c.      it increases the knowledge base of the organisation, which is seen as the key to discovery and innovation,

<div align="center">(Crompton and Munro 2003)</div>

As they go on to state, developments in work based learning should be a central element of such a strategy as it develops both workplace skills and knowledge.

Wagner et al (2001) describe Work based learning as "all learning activities that are based in the learner productive activities" they emphasise the necessary relationships which underpin it

    a.  the relationship between education and the economy

    b.  the relationship of theory and practice in education processes and

    c.  the dualism of education and training and associated social and institutional divisions

There are challenges, which must be acknowledged, to a profession that has traditionally looked to academic awards as a pre-requisite to practice. Within many societies there has been a long term devaluing of vocational education or education based within the work place (Hyland 1999). What is worthy of note is that some of the most recognised professions such as Doctors, Lawyers and chemists restrict entry to their professional registers unless an element of work based learning or practice is undertaken. What must be done is to make such elements  clearly robust, assessed and valuable as a learning mechanism so that it seen in same light as other recognised practitioners and that those within and external to the profession recognise its power in terms of transformative learning.

**Promoting the Work Based Learning Model: Setting up the System**

One of the problems within education is judging when someone reaches the required standard to practise.  This is no more obvious than in chemistry which requires an ability to apply detailed knowledge in practice. Judging competency to practice  would be all but impossible if it were solely to be based, , upon classroom activity. Work based learning as a discipline takes this activity further; the judgement of success is based upon "ability to justify, analyse,

evaluate and communicate effectively" (Costley 2000) all of which are key skills outlined by the RSC (2008) in setting out the professional attributes of the chartered chemist..

Work based learning, is based on the premise that ideas are formed and re-formed through experience. Learners construct their own understanding around this knowledge. Learning supported this way, has the advantage of moving with the learner and with their own and the workplace's experience Groot and Van der Brink (2000).  The scope for Work Based Learning is not necessarily limited to employment base learning and  the term workplace is used in an inclusive manner as a base for the development of learning.
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Learning through work does not have to be limited to the individual or through  individual lone practice. Projects and collaborative work provide a ready made mechanism for learning and reflection on practice.

Early work on the learning potential of adult learning projects was documented by Tough (1983) who demonstrated that learners who undertake negotiated learning, even where this is of a formative nature (not assessed towards any form of academic work programme) can gain confidence in the management of their development. In this respect it became evident that the self directed adult learning project is a powerful tool to harness experiental development. When applied to formal professional development for chemistry professionals, the benefits could be significantly enhanced.

Project management is a very powerful mechanism to develop personal and managerial skills. Likewise projects by their very nature are organic offering constant learning opportunities, and through this a mechanism to show how you coped with such change and your considered responses to difficulties (Armsby and Costley 2000).

The benefits of project work are not limited to the individual. Projects are productive by nature (Armsby and Costley 2000), assisting the organisation in its strategic aims (Garner and Portwood 2000).
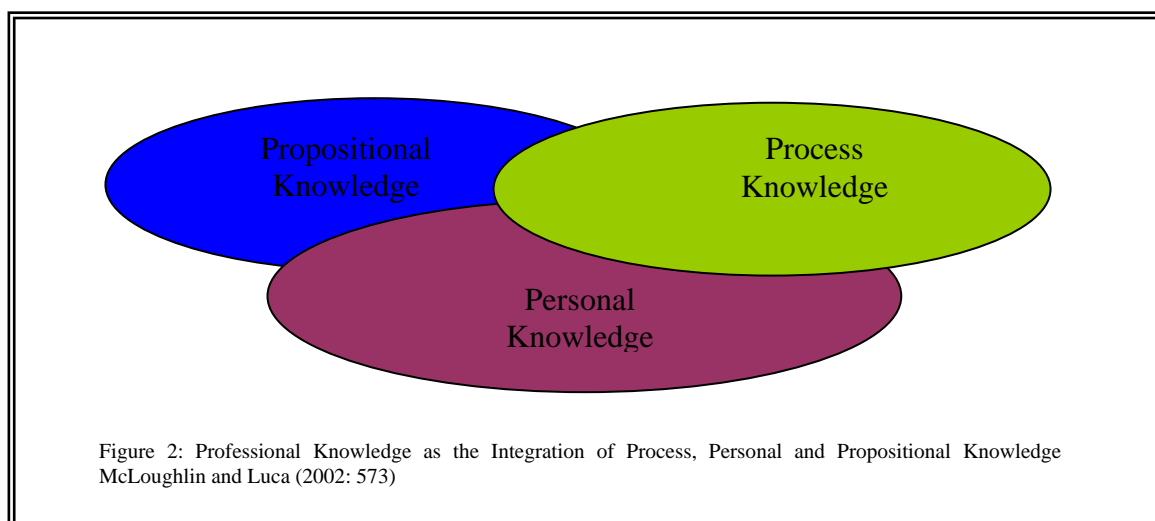
Many of the professional societies recognise  the importance of collaboration within the professional and across boundaries. The basis for collaborative learning has been researched by Lave and Wenger,1991 in their exploration of the learning potential of what they term 'communities of practice'. The basic concept is that greater learning potential exists for a group in pooling their collective knowledge than by working in isolation. This theme has

relevance to the chemistry professional in providing the potential to network with other professions and so increase the community of practice.

This ethos of a community of practice is important to embed in the profession if professional development is to be enhanced and effective. Moreover, it could be argued that the attributes of collaboration are best implemented in the context of situated learning. This could be exemplified by a professional undertaking a work place project that transcends professional boundaries. Work based learning is predicated on the ability of professional to challenge and stretch the boundaries of the local operational context (Raelin, 2008.

**Developing Professional Skills through Work and Reflection**

The development of professional skills is the subject of a paper by McLoughlin and Luca (2002). They highlight that operational skills, including personal and process skills are central to professional training.

Figure 2: Professional Knowledge as the Integration of Process, Personal and Propositional Knowledge McLoughlin and Luca (2002: 573)

What McLoughlin and Luca suggest is that propositional knowledge (subject based concepts, generalisations and propositions about cases and actions) which is normally supplied through academic institutions, need to combine with process knowledge (behaviour skills, deliberation, providing information) and personal knowledge (interpretation of and through experience, understanding of assumptions). This it is suggested can only occur through experiential learning and social interaction (Barnett 1999 and Bennett 2002).

This active learning paradigm, it is suggested, fosters a deep learning approach as it concentrates on process as opposed to fixedly focusing upon content (McLoughlin and Luca 2002). Problem solving, negotiation and communication allow learners to manage, evaluate and reflect on learning outcomes and learn through doing (MacDonald and Twining 2002).

**Work Base Learning at Middlesex University**

Work Based Learning Studies (WBL) programmes at Middlesex University use a specific approach which enables students to become effective work base learners. It utilises both reflective analysis of past learning as well as prospective design of research and development projects which provide coherent learning outcomes within a specific subject area. The programmes at Middlesex University range from Certificates to Master and Doctorate degrees. They typically involve a number of key WBL modules at undergraduate and postgraduate level,

Programmes at Middlesex University, irrespective of level, use a framework which focuses on four key elements (Garnett 2005, Doncaster 2001). These and their relationship to the Kolb's (1984) Experiential Learning Cycle (Figure 1) are describe below :

*1. Review of Learning and Recognition and accreditation of prior Learning*

The review of learning provides an opportunity for the participant to critically review and reflect upon the learning they have achieved prior to entering a Middlesex programme. Through this, students learn how to reflect on their experience, identify their own pattern of learning, analyse their own work experience, identify sources of knowledge and translate tacit knowledge into explicit knowledge.

The programmes make use of the principle of accreditation for prior experiential learning (APEL) and further develop it to progression oriented process to reflect a more prospective process in which the reviewing becomes significant to the progression. It was re-named Recognition and Accreditation of Learning (RAL).

Students at Middlesex University are awarded learning credits at appropriate levels. Theses are assessed through the demonstration of evidence of achievement and reflective analysis of learning.

*2. Programme planning*

Every WBL programme is as unique and customised as the person who creates it.

It is designed by the student - based on their interests and needs, through negotiations with the University, their advisers and their employers or organisation. Throughout, the context of the subject area and the student's practice underpin the programme.

Credits can be awarded for prior learning and may be used as a partial contribution towards a university award. In order to construct a coherent programme students are required to

establish and justify a programme of work –based studies. The planning of the programme would address the coherence of the learning outcome reflecting the subject area in which students work.

As part of the planning process students take a research methods module, in which a proposal for work based projects is formulated and where they are supported and taught research methodologies providing an 'academic' or systematic approach to the study of issues or problems arising at work, and through the resultant project work they are the engine of developmental activity in organisations. What is studied, the subject or area of study, how it is studied and the methodology are largely defined by the needs of the work environments where the worker researcher is subject to a variety of personal, interpersonal and organisational influences. This means that workers need a high level of flexibility in their choice of methods and tools to ensure credibility in the complex and context-bound research situation (Armsby 2001).

The process in Middlesex University provides a framework through a tripartite learning agreement between the student the employer and the University through which the programme is customised and academically validated. (Garnett 2001). This framework provides a mechanism for enabling the employer to become a full partner in shaping the programme.

*3. Projects*

The work-based project is the vehicle for the development and creation of subject area knowledge (Garnett 2005). It is here where through appropriate supervision and facilitation students are able to explore, analyse and develop their subject area and influence their community of practice.

Knowledge derived this way is  constructed by  individuals or groups who use a variety  of relevant methodologies and approaches which as well as addressing subject/discipline related areas refer to professional,  organisational, social and inter and trans-disciplinary  constructs. This is also underpinned by the fact that WBL projects are often collaborative and address complex real world situations.

Worker researchers have practical experience and insider knowledge and so must be aware of the ethical and methodological issues which relate to the position of the  insider- researcher and address these in the development of their methodologies (Armsby 2001)
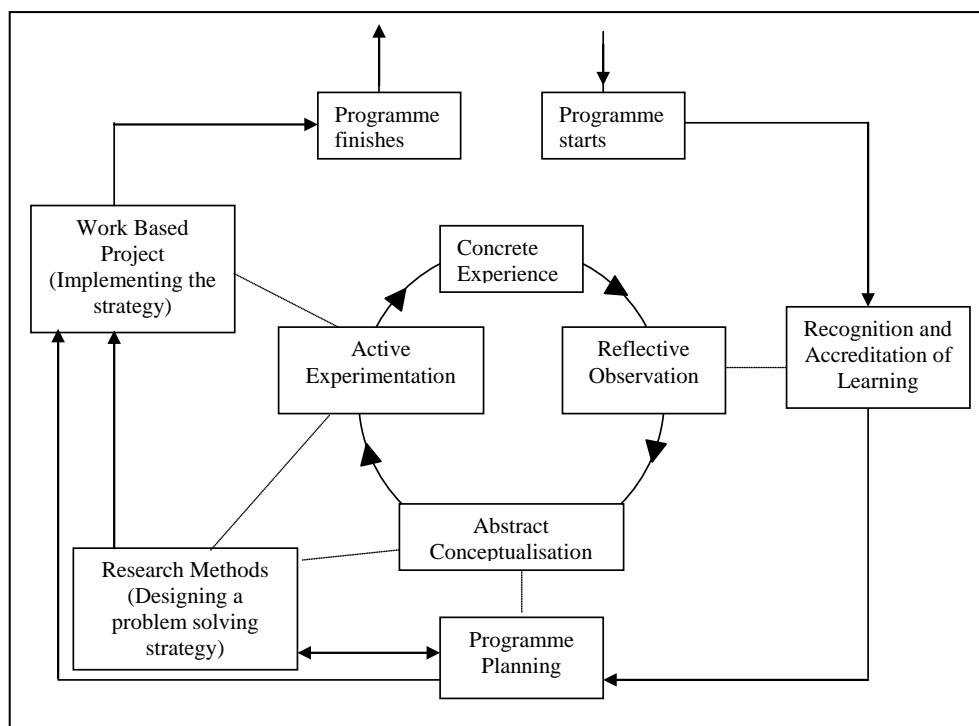
**Figure 2:** Relationship between the components of the WBL programme and Kolb's (1984) Experiential Learning Cycle (adapted from Doncaster 2001)
Key:
- Inner circle represents Kolb's experimental learning cycle
- Outer circle represents Work Based Learning Studies core modules
- Links between elements of Kolb's cycle and specific core modules shown by broken lines

**The Development of Professional Master and Doctorate (M/DProf) in the Health and Environment Fields (the Middlesex University experience)**

Professional doctorates have emerged in the past decade as a significant feature of doctoral level activity within UK universities (UKGCE, 2002).

This growth in professional doctorates reflects the changing nature of the relationship between higher education and society, underlined by the development of the knowledge based economy.

The traditional understanding of the focus of an MPhil/ PhD was that it primarily demands a significant original contribution to the body of learning, which may or may

not relate to practice, emphasising cognitive abilities and the capacity to produce highly competent researchers.

The M/DProfs established at Middlesex University are rooted in research and development projects which impact within the immediate work situation and beyond it in the professional field (Portwood and Thorne 2000)

Professional Masters and doctorates are embedded in work; they recognise that professional practice is a source as well as an application and demonstration of knowledge. This is because professional activity requires a mix of public (propositional) procedural, contextualised and  practical knowledge that crosses disciplinary boundaries which may result in major contribution to professional and academic knowledge-based development (Rounce et al 2005).

Participants in these programmes are normally mid to senior professionals with moderate to considerable professional expertise who may hold influential positions.

The M/DProf programmes offered at Middlesex use the WBL principles and mechanisms described above. This is achieved through the development of rigorous research and project work, underpinned by the examination and exploration of tacit and explicit knowledge and leadership skill of expert practioners.

**Conclusion**

This paper commenced by highlighting the standards expected of professional chemists. This is an increasingly regulated area with common standards now operating across Europe to enable trans-boundary freedom of movement.

The Work Based Learning framework operated through Middlesex University may facilitate close linkage between professional standards and academic recognition leading to higher degree awards. Individuals, project teams, organisations and professions can bring to the work based learning their own context and demonste a high level of appropriate professional skills in their practice

This paper has also highlighted the lack of current research on the use of project based learning for those in pursuit and maintenance of professional body status. The authors therefore recommend that this is a field that requires further research and development. This paper is essentially an agenda for change that may help to form a proposal to Chemical societies. We would welcome further discussion with interested bodies to take this forward.

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