Industrial Training & Continuing Professional Development for Analytical Chemists – A Personal Viewpoint and Review

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So what is the similarity between the following professions – Pharmacy, Medicine, Nursing, Dentistry, Civil Engineering, Teaching, Chiropody, Psychology? Well the answer is that they all include an element of mandatory continuing professional development (CPD) post qualification in order to keep their registration / accreditation current. This then begs the question – why don't we as analytical chemists, responsible perhaps for public safety, the lives of others, civil defence, the future of the planet (!) etc. also require some kind of mandatory professional development within our careers?

This article is intended to outline the current issues regarding industrial training and continuing professional development for analytical chemists and highlight the opportunities, for those who are willing, to seek high quality training and development.

For over 10 years I have trained and consulted with hundreds of analytical scientists and in that time I have come to understand a lot of the strengths and weaknesses in the way which deliver post graduate education and industrial training – outlined below are what I consider to be some of the biggest issues and some of the most effective and innovative ways in which these issues have been addressed.

Identifying Training Needs

Usual ways to identify training needs	More useful ways to approach training needs analysis
• As part of the annual review process • In reaction to a problem which highlights a lack of training such as instrument breakdown or analysis failure • As a result of losing a member of staff or job role changing	• As part of regular process improvement meetings • To reduce method development and/or validation time • To improve analytical throughput • To increase the number of right first time determinations • To increase the revenue or profitability of the business or department

Table 1: Training Needs Analysis

So how are training needs identified within your department? The usual ways are shown in the left hand column of Table 1.

Note that the left hand list in the table doesn't include any reference to business or process improvement and actually taking your business or department forward - perhaps we should also consider training needs analysis in terms of the right hand column of Table 1.

There are many ways to achieve a more enlightened approach to training needs analysis but the most effective are always the most simple. I have seen a simple but very effective system based on the old saying usually employed after a disastrous issue has been discovered– 'do we have a problem or an opportunity to improve'. Laboratory staff were encouraged to note down everything that they either struggled to understand, failed to achieve analytically or which frustrated them about their daily working routine. Notes were

taken on a simple spreadsheet - which were submitted prior to the monthly 'lab meeting' and the common issues reviewed and action taken where appropriate. One notable success was the implementation of a series of training consultancies designed to improve the efficiency and automation of chromatography data processing. This may seem trivial but as a direct result of training the staff managed to increase the analytical throughput three fold for certain analyses and what's more enabled important data on the medical status of new born children to reach ward staff more than five times faster than it had previously done!

Of course there are also many professional organisations that can undertake more formal training needs analysis through staff consultation, process investigations and analysis. The only caveat to the external consultancy approach is that you should be very clear and agree well defined business / department aims or training outcomes which can be subsequently assessed for return on investment (ROI). I have seen too many certificates in training files with the word 'attended' which in reality means nothing – the word 'achieved' is much more meaningful in terms of useful outcomes and almost always is the result of a competency or process improvement assessment post training.

If you want to learn more about training needs analysis the Chartered Institute of Personnel and Development (CIPD) is an excellent place to start with the following link being particularly useful:
http://www.cipd.co.uk/subjects/lrnanddev/needs/idtlneeds.htm

Basic Laboratory Skills

Here I refer to the fundamental skills that should be the basic armoury of every analytical chemist and includes:

- Volumetry (use of pipettes, volumetric flasks etc.)
- Gravimetry (use of balances)
- pH determination
- Moisture Determination (Karl Fischer apparatus)

Basic grasp of concepts such as Molarity, how to correctly calculate and express concentration

Basic knowledge of statistical techniques in order to correctly express accuracy, deviation and error in determinations

It always amazes me that our younger (and sometimes the not so young) members of the analytical community are not equipped with these basic skills. I have lost count of the number of different ways in which I have seen analysts weighing out materials, pipetting solutions or carrying out pH determinations or the number of 'standard operating procedures' for correct use of a five place balance.

The usual reaction to this situation is to blame our undergraduate programs and academic institutions. I am strongly of the opinion that most of our university chemistry departments do provide good grounding in some or all of the above techniques. However, it is folly to assume that all our graduates come with an unshakable knowledge in these techniques and their underlying theory and to assume that no further workplace training is required. Because these skills are often assumed, a lot of knowledge on 'good practice' tends to be 'grandfathered' to younger staff either anecdotally or as part of informal training processes – a dangerous approach indeed if the 'grandfathers' knowledge or practical technique is flawed.

In one particular situation that I encountered recently a particularly keen new hire was being shown how to 'correctly' use a pH meter. With each particular instruction he asked 'why' - especially with regarded to the need to leave the filling hole of the probe covered or uncovered. Some of the responses given to these questions by the more senior chemist were fundamentally incorrect – as was the procedure for measurement that was being demonstrated!

The most effective way to overcome these problems is to build a unified training curriculum to encompass the basic laboratory skills but which includes the theory behind why each technique is carried out as it is – without understanding the principles the practice can be very erratic.

Some of the best schemes that I have been involved in designing are again simple and are often built into a typical analysis. Just think how many of the basic skills listed above could be covered by having an analyst carry out a 'standardised' HPLC analysis using spiked samples where the concentration of the analytes are known. Preparation of eluent systems, samples and standards often cover most of the practical skills listed and the data analysis covers much of the basic statistical and reporting issues. Each stage of the process can be preceded by a theory session on the background, equipment and analytical requirements followed by an observed practical session or demonstration. This method is often used for what has become known as 'analyst validation' a term of which I am not particularly fond. Each stage of the process can be monitored and the results of weighings, determinations of concentration, assay results and the assessment of error and variation can all be recorded in order to demonstrate an analysts capability of producing results which are for purpose.

Of course these procedures and schemes take time to develop and it is critical that the content is verified as being accurate. Often for larger organisations, third party companies are employed to design and implement bespoke training solutions of this type – often known as 'Induction Training'. However, smaller companies can also benefit from third party assistance through the purchase of a standard package of materials or training programme.

The main aim in all of these cases is to produce a training curriculum which is verified as being correct and which can be applied throughout the organisation to overcome any variability in the quality of the training delivered or in the information received.

There are also some very useful basic packages and materials available which deal with basic laboratory skills, some of which are cited here:

'Practical Laboratory Skills Training Guides' - LGC / RSC joint publications offering some short but highly effective guides on most of the topics outlined above including Measurement of Mass, Measurement of Volume & Measurement of pH

Basic Laboratory Skills Video – a 34 minute video published by LGC available via *www.ChemSoc.org*

LearnNet – an RSC sponsored website with details about training and development in all aspects of analytical chemistry
http://www.rsc.org/education/teachers/learnnet/index.htm

Academy Savant – produce a range of good video packages on a whole range of basic laboratory skills
http://www.savant4training.com

Statistics for Analytical Chemistry – an excellent textbook by Jane and Jim Miller which is a standard reference text in most laboratories. ISBN: 978-0130309907

Scott Van Bramer –Widener University, Chester, PA hosts a very basic but very useful site on statistical analysis which has helped me out on more than one occasion
http://science.widener.edu/svb/stats/stats.html

The Analytical Chemistry by Open Learning (ACOL) programme from the Royal Society of Chemistry also covers several of the topics outlined above
http://www.rsc.org/Education/CareersAndCPD/ACOL.asp

Theory of Chromatography and Spectrometry

Within my role as an industrial trainer and consultant I have encountered a very broad range of abilities within the delegate population. It is without doubt however that it is in the areas of Chromatography and Spectrometry theory that we can derive most benefit from training and professional development within a work base setting.

Whether training is provided to comply with a particular regulatory framework (GLP / NAMS / UKAS etc.) or for the purposes of business or process improvement, the benefits of understanding the underlying principles of the work we do are undoubted.Good professional development in this area can lead to many benefits – the most tangible are shown in Table 2.

I sometimes start HPLC (MS) or GC (MS) training sessions with a 'Critical Evaluation' exercise whereby the delegates are required to deconstruct a method that they are using and explain the instrument settings, sample preparation methodology, eluent (or carrier gas) and column selection etc. This can be

Tangible Benefits Resulting from Theory Type Training
• Fewer repeat analyses due to analyst error
• Less instrument downtime
• Reduced method development time
• Increased laboratory productivity
• Enhanced data quality

Table 2

enlightening as very often the reasons behind the choices within the method are not well understood – identifying potential problems with methods is therefore difficult if not impossible. It is always rewarding therefore to see the 'lights coming on' around the room as we progress through the training and delegates begin to more fully understand the method parameter choices and we discuss the relative merits and potential pitfalls of the methods we have studied at the beginning of the course.

Troubleshooting training is another area which can bring about great benefit both to the analyst's personal fulfillment within their role and to laboratory productivity. Most readers will perhaps view troubleshooting training in the context of identifying and fixing instrument problems – leaks of eluent or carrier gas, over / under pressure, detector malfunctions etc. etc., which are all of course important. However some of the very best examples of troubleshooting training I have seen involve a totally different approach being taken.

One particular example involved a large client who were experiencing, like most of us, issues with various aspects of their chromatographic analysis including: poor chromatographic resolution, method robustness issues, peak shape problems, baseline issues etc. Most issues were addressed within the laboratory using a variety of fixes, or the problems were 'lived with'. However over a three month period – all of these issues were recorded and included everything from method robustness issues (this assay works with batch 1234 of Excelosil as long as Frank does the analysis on instrument X on a Tuesday afternoon) to major issues with chromatographic performance such as degraded peak shape or lack of resolution which actually brought into question the validity of the analysis results. Working with the client we were able to address each of the issues within the log to identify the issues and most crucially, enlighten the delegates on the root causes of many of the problems from a chromatographic perspective – concentrating on the issues from a separation chemistry perspective as well as looking at potential hardware issues. By troubleshooting the issues from a 'separation' or chemistry perspective, rather than concentrating on the hardware issues, it was possible to identify some very basic misconceptions and knowledge gaps which once addressed, helped to improve the basic approach to method implementation and troubleshooting.

We still visit this client and undertake a very similar exercise from time to time, however instead of being a three month log we now look at an annual log and I think this highlights the benefits that this consultancy has delivered to the business.

This example raises two questions:

- Was this CPD in the true sense of the word?
- How can this type of CPD be measured in terms of return on investment?

Continuing Professional Development may be defined as 'lifelong learning and development within the role and personal development in the theory and practice of (analytical chemistry)' (CIPD). In general however, my experience is that CPD is thought of by many laboratory managers as something which the individual undertakes of their own volition in their own time. This is surely folly and inaccurate according to the definition given here. If we fail to develop our analytical chemists in the 'role' then the quality of analytical chemistry in the UK will suffer and that must be seen as retrograde. The type of CPD described in the troubleshooting example above (which would be seen as 'Training' by most) is absolutely critical to the development of both the individual and the organisation. Further – this type of exercise should continue to be recognised as CPD by the Royal Society of Chemistry when individuals submit their CPD diaries as part of the CChem, MRSC accreditation. The RSC have an excellent CPD resource at the following location:
http://www.rsc.org/Education/CareersAndCPD/

The second of the questions above is perhaps a little more difficult. Measuring return on investment is often a complex issue when training and development is broad. However the most important aspect is to have clearly defined objectives and outcomes which will normally be related to the benefits outlined in Table 2. Further, most organisations and regulators now realise the futility of training and development which is delivered without some formal measure of the training outcomes. Any exercise of types described within this article should have an assessment of 'value added' either to the individual or the business or preferably both. These need not be the fear inducing 'end of course test' but can be designed to be highly effective and might include: observation, less formal quizzes, open book exercises which are submitted some time after the training has taken place, measures of right first time determinations, instrument downtime logs etc. etc. Only by formally measuring the value added aspect of any CPD or training exercise can we truly understand the benefits to both the individual and the organisation.

In terms of useful resources there are several companies that are able to provide training materials and courses in the theory and underlying principles of Analytical Chemistry. The better suppliers should be able to provide you with everything from free seminars on more specific topics, through one day seminars on general aspects of chromatography and spectrometry, to bespoke events which are specifically designed to address company aims. The better instrument vendors should also be able to provide not only training in their specific instrument types but also the underlying principles, the best of which are usually within an 'Academy' or 'Learning Institute' type format.

Online resources are becoming increasingly popular in this area and some of the more effective resources are outlined in Table 3.

Resources	URL
• Electronic Analytical Reference Library (EARL) – Crawford Scientific	• http://www.earl2learn.com
• Academy Savant	• http://www.academysavant.com
• The Chrom-Ed Chromatography Series by Dr. R. P. W. Scott	• http://www.library4science.com
• Chromedia – Chromatography Knowldege Base	• http://www.chromedia.org

Table 3

Personal Development

Of course there is a host of CPD activities that can be undertaken by the individual in order to improve their knowledge and skills within analytical chemistry.

These might include attendance at one of the many general or subject specific conferences that have an associated academic program. I have listed some of the best of these which include a general academic program below – of course there will be more subject specific events with which one will (or should) already be familiar:

American Society for Mass Spectrometry (ASMS) – this conference held in the US every year has an outstanding academic programme of short courses: *http://www.asms.org*

British Society for Mass Spectrometry (BMSS) – the society Annual Conference also has an excellent academic program *http://www.bmss.org.uk*

The Chromatographic Society (ChromSoc) – holds regular meetings during the year which are generally of a very high academic standard *http://www.chromsoc.com*

The Pittsburgh Conference (Pittcon) – this North American conference has an excellent academic program of short courses *http://www.pittcon.org*

Further to the attendance at conferences – there are also a number of groups and societies that can facilitate access to excellent CPD resources. Some of these include:

The British Mass Spectrometry Society *http://www.bmss.org.uk*

Chromatographic Society *http://www.chromsoc.com*

Analytical Sciences Network / Emerging Analytical Professionals – a network with annual meeting sponsored by the Royal Society of Chemistry *http://www.rsc.org/Membership/Networking/InterestGroups/Analytical/ASN.asp*

Of course I have already mentioned the Royal Society of Chemistry several times and there are a number of subgroups and networks that might be used to derive useful professional development.

This brings to the final point of this discussion. I have for many years campaigned for the unification of an approved program(s) of professional development for Analytical Chemists in the UK or even within the whole of the European Union. The benefits of this should be obvious in terms of standardisation and the development of 'uniform competency' curricula for training and development as well as the benefits to the end user in terms of highly transferable skills. It would appear that the Anaytical Chemistry Trust Fund (a Sub-committee of the RSC Analytical Division) may be investigating this matter further and there are also some Europe wide initiatives being developed in conjunction with the RSC– watch this space! *http://www.rsc.org/Membership/Networking/InterestGroups/Analytical/ACTrustFund.asp*

Summary

It is essential that within our industry we view CPD and training within an industrial setting as of primary importance – and as something that can greatly benefit our organisations in terms of competitive advantage and productivity.

On the whole, most organizations have a positive outlook on training and recognize some if not all of the benefits - however few have a formal program that can be used to demonstrate to regulators, clients and those whom you wish to attract into the business, that there is a solid route for personal development in the analytical sciences, outside the training necessary for you to simple generate results. We do spend an

awful lot of time training in soft skills, management skills etc. which whilst of great importance, are often represented disproportionately against the training offered in our actual role as analytical chemists.

I would urge you to consider either for yourself or your staff, what improvements could be made to your Training and CPD activities, perhaps using some of the resources in this article, and reflect if this would bring the benefits to the individual or organization, commensurate with the time or monetary investment required - I think you might be pleasantly surprised.