Learn Chemistry

Commercial Skills for Chemists: Introduction & Overview

Tutor Guide

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National HE STEM Programme

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Tutor Guide

Commercial Skills for Chemists – Introduction and Overview

KKI Associates and the School of Chemistry at the University of Edinburgh

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Introduction

These Commercial Skills Modules have been developed by KKI Associates and the School of Chemistry at the University of Edinburgh, following a proposal to the Royal Society of Chemistry. The project has been supported by the National HE STEM project. The National HE STEM Programme (http://www.hestem.ac.uk) is a three-year HEFCE/W- funded initiative aiming to widen participation in Science, Technology, Engineering and Mathematics and enhance the skills and knowledge base of the workforce in these areas.

The RSC commented in 2011: *'Several reports sought to identify deficits in the skills of graduates in general and chemical science graduates. Employers reported a clear knowledge gap with regard to financial and commercial skills required to effectively turn ideas into business and urged curriculum development in this area.'*

As part of our proposal we decided to conduct interviews with managers responsible for graduate recruitment in a number of important UK chemical businesses, along with some smaller start-ups and one physics/engineering business as a comparison. The full results are available in a separate report but the key qualities employers (who included Syngenta, Proctor and Gamble, Sasol, Afton Chemicals) said they were looking for were these:

- *Innovation (the ability to turn an invention into something of benefit or value)*
- *Working in team-based activities*
- *Problem solving*
- *Working through formal project/process systems*
- *Integrating their specialist knowledge with others'*
- *Communication Skills*

Some telling comments were[1]:

'Of course their chemistry is a core skill but we don't interview people who don't have that'

'It's rare that people use more than 10% of the science they know at any time with us. But what we need is for them to understand, interface and interact with people from other disciplines (commercial and technical such as engineers)'

'We interview hundreds of potential 'strategic recruits' each year. Most fail their technical interviews, not because they don't know their science but because they are not good at applying what they know to problems we might ask about'

When asked about teaching apposite skills at University, the view was pretty unanimous:

'Get students to do team-based projects, using problem solving rather than pedagogic teaching, and as much as possible get them to mirror or mimic the innovation processes in a company. Integrate soft/transferable skills within the projects rather than having them separate'

We have tried to follow this advice by designing 5 modules that do reflect the development of a commercial project from an early idea stage, through checking the potential market, identifying key development stages and project costs, writing a systematic feasibility study/risk analysis, and eventually delivering a 'funding pitch' that a young researcher might give to senior managers in a company. The modules can be done separately, but all 'hang together' in this unified way.

[1] *And the view from the engineering/physics based employer was very similar*

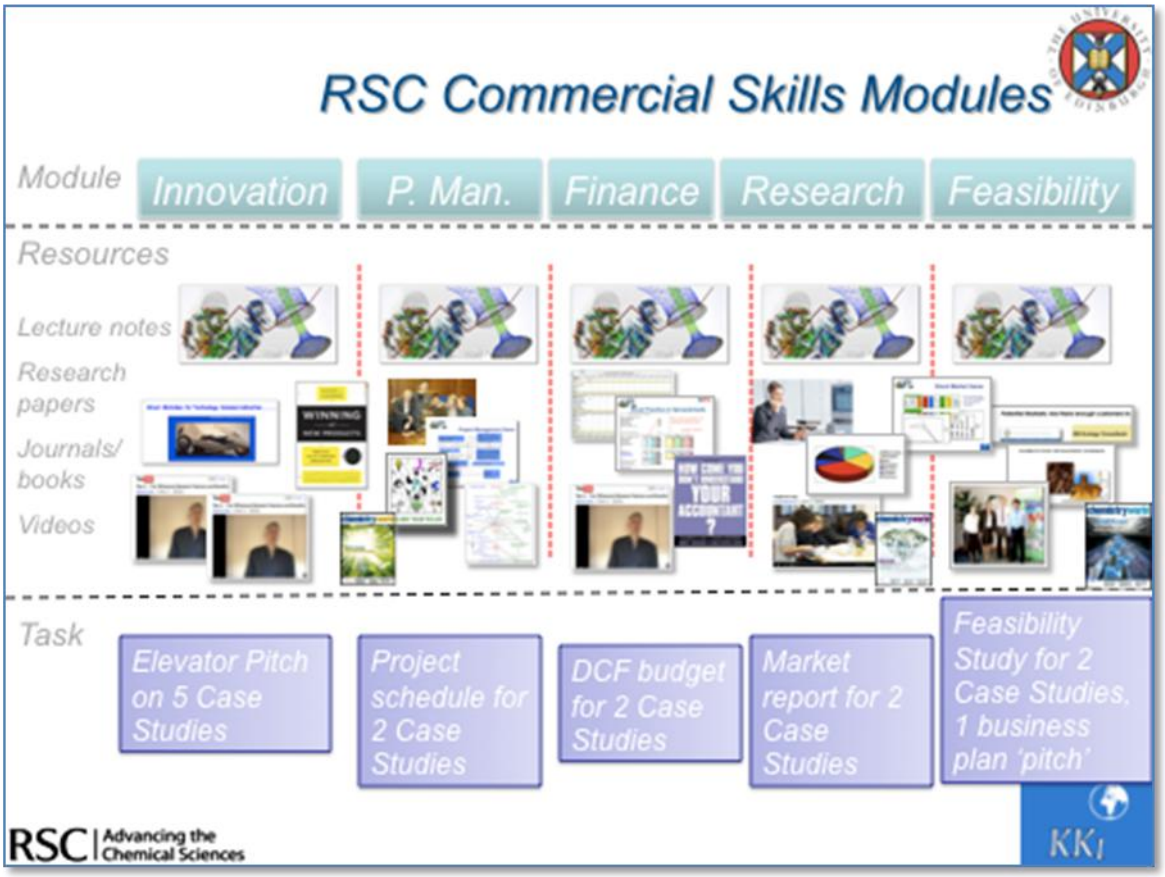
The 5 Modules are
Innovation, Project Management, Finance, Chemical Markets, Feasibility Study & Project Pitch

Rather than a traditional 'lecture course' with exams, students are given resources and asked to carry out some research, and produce assessed outputs, in teams of 4-6. Effectively what we have done is to introduce elements of 'problem-based learning' (PBL) into the modules – students are asked to use the resources to analyse problems, to support their thoughts by research, and draw conclusions from their findings.

Each Module has:

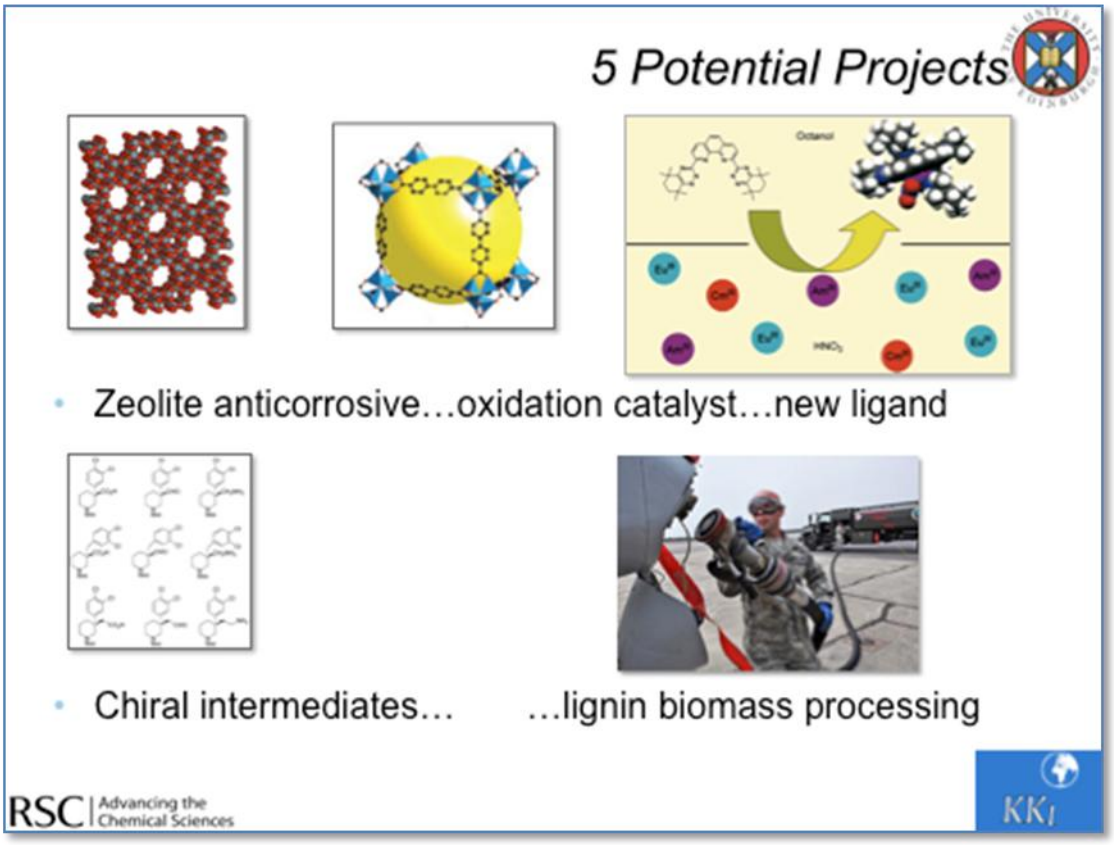
- A Student Task Briefing
- Lecture Resources, both as hard copy and online video
- Interactive Exercise(s) with Tutor notes
- Other Materials which might include extra videos, research papers or recommended reading
- Extended tutor notes with comments about the material, 'pointers' towards web resources, and examples of outputs at borderline, pass, and distinction level

Innovation is intended to be the first module, and *Feasibility Study & Project Pitch* is the integrating final module. The other 3 can be done sequentially or simultaneously. This slide shows a schematic overview of all the modules:



Student teams play the role of a group of technologists working for '*Mega Chemicals plc'*. They are asked to evaluate 5 Case studies - potential development projects coming out of *MegaChem's* R&D Group. The tasks, or outputs for each module are shown in the schematic.

Case Studies



We have developed 5 case studies to be used in conjunction with the modules. Initially, as they start the Innovation module, the students are given rather technical chemical descriptions of the potential projects. As they progress through that module it should become clear that the 'zeolite encaged zinc chromate' is potentially a low toxicity anti-corrosive pigment, the oxidation catalyst could convert natural gas to liquid methanol, the ligand could separate thorium contaminants from rare earth mines, the chiral intermediates could lead towards a new antibiotic, and the biomass process makes jet fuel from tree waste. In other words all have some apparent social and economic value.

In the subsequent modules students choose two of the five projects to focus on. The project descriptions have been rewritten to accommodate the findings from the Innovation module. The potential of the projects has been established, and the focus moves onto assessing the market, planning the main development tasks and timeline, and estimating a likely project budget. All of the projects are at least based in reality, some from (KP's) personal experience, and two come from the pages of *Chemistry World* (one of our suggested Interactive Exercises is to get students to read actual physical copies of *Chemistry World* in a 'simulated Library').

In the feasibility study module the team is asked to produce critical studies of the two projects they have chosen, using a template provided. One of us (KP) devised and used this template for client consultancy work on start-up companies and University spin-outs, but it has been successfully used by undergraduate students to produce assignments over a number of years. The student packs for this module include an example of an excellent 'distinction-level' feasibility study produced by a student in 2008. The task is to pull all the information they have gathered together and then systematically assess what it all means for the potential success of the project. Can they see which of the two projects is 'better' and can they support/justify that decision?

Final 'Project Pitch'

As a final activity the whole team should devise and deliver (or video) a 15 minute presentation about the better' project, outlining its strengths and weaknesses. A Suggested Structure for the presentation might be:

- Slides 1-2 background to the technology and its benefits
- Slides 3-5 Business model, markets, technical targets
- Slides 6-7 IP and legislative/regulatory issues
- Slides 8-9 Plans and milestones
- Slide 10-11 Money and main risks
- Slide 12 Summary

We've called this a 'Project Pitch' because it is asking for funding to carry out the project in a similar way to contestants on 'Dragon's Den' – 'we want your money, here is what you get for it'. The main difference is that this pitch is aimed at internal managers rather than external investors – a more common scenario for researchers in companies and/or Universities!

This is a good point to bring in external business contacts, alumni with business expertise etc if these are available. It makes the presentation (which is the climax of a lot of hard work) feel more of an event, and give the students a sense of achievement. It is not unheard of for companies to ask potential graduate recruits to do something similar as part of the recruitment process, so the more practice the better!

You can see a video of two student presentations from our trial week at
http://www.youtube.com/watch?v=gUwLnPj3Nto&feature=youtu.be

NB: the first presentation is entirely done by one student who had been elected as 'spokesman'. Although he does a good job, with hindsight we should have made it clear that everyone in the team has to present at least one slide's worth. The second team filmed here (from about 9 minutes into the video) do all speak.

Complete Resource Listing

Resource	*Comments*
Introduction to Modules	
Overview Tutor Guide	PDF introducing the overall package of modules, structure, organisation and assessment
Tutor Presentation	Slide briefing and FAQ for tutors
Employer Research	PDF summary of Market Research on views of chemistry employers
Specimen Exams	Potential exams on overall topic
Student Briefing	Slide briefing for students about objective of modules and overall tasks. PowerPoint and PPS versions
Student Briefing	Hard copy PDF of above
Presentation Video	Example video of Students from trial week.
Innovation Module	
Innovation Tutor Guide	How to run module, student prompts, and task assessment. Examples of output from trials, graded at various levels
Innovation Skills for Chemists	Video lecture introducing Innovation to students
Student Pack	Copies of lecture slides, details of case studies, task description, hints
Great Mistakes…	*…in Technology Commercialisation.* Downloadable PDF of refereed paper on commercialisation/knowledge transfer
Chemistry World 'Library'	Student Handout pointing them at interesting and relevant articles from 2008-11. Two of the case studies originated from these articles
Good inventions?	What makes an invention of commercial interest? KKI YouTube video
Features & Benefits	Why is this an important distinction? KKI YouTube video
Market Research Module	
M.Research Tutor Guide	How to run module, student prompts, and task assessment. Examples of output from trials, graded at various levels
M. Research Skills for Chemists	Video lecture introducing M.Research and analysis to students
Student Pack	Copies of lecture slides, details of case studies, task description, hints
Chemistry Stock Market	Student Pack of game where students buy and sell shares in small companies whose technology curiously resembling the Case Studies. As well as entertainment, this exercise 'drip feeds' bits of information relevant to the markets for these technologies
Chemistry Stock Market – Tutor Guide	How to run the game and what bits of information (web links etc) to 'drip feed' the students
Chemistry Stock Market spreadsheet	The buying and selling decisions of the teams are entered into a market simulation spreadsheet that calculates share price movement: a) from the demand for shares, and b) from 4 rounds of newsflow about the companies. There are 3 version of the spreadsheet, for 4, 5, or 6 teams
Shiny Teeth Case Study	Student tutorial pack: presentation with voiceover detailing the problems facing 'Shiny Teeth' (a real chemistry-based company). Students have to look at some market numbers, predict likely sales and recommend a business model based on their analysis
Shiny Teeth Case Study Tutor Guide	How to run the tutorial. What lessons to pull out during the tutorial and when wrapping up at the end
Resource	*Comments*

Finance Module	
Finance Tutor Guide	How to run module, student prompts, and task assessment. Examples of output from trials, graded at various levels
Finance Skills for Chemists	Video lecture introducing Finance to students. Focuses on operational and capital budgets for projects
Finance Student Pack	Copies of lecture slides, details of case studies, task description, hints. Extra slides giving overview of company accounts – balance sheet etc
Budget Templates	Spreadsheet template that students may use to prepare budget forecasts for the case studies they are researching. One version incorporates discounted cash flow calculations
SmithChem Ltd	Simple tutorial exercise showing how cash flow and profits are not the same thing, and show why we budget on a cash basis
SmithChem Tutor Guide	How to run the tutorial and the lessons to bring out
MiniGas Ltd	Tutorial exercise on spreadsheet, illustrating the distinction between fixed and variable costs, and introducing the concept of full vs. marginal costs
MiniGas Tutor Guide	How to run the tutorial and the lessons to bring out. Real life implications for industries (e.g.) petrochemicals with high fixed costs
A.CID Chemicals plc	Tutorial exercise on spreadsheet, illustrating the budgeting for a capital investment project, and introducing the concept of discounted cash flows
A.CID plc tutor guide	How to run the tutorial and the lessons to bring out – which is worse, being overspent or late on a capital project?
Project Management Module	
PM Tutor Guide	How to run module, student prompts, and task assessment. Examples of output from trials, graded at various levels
PM for Chemists	Video lecture introducing Project Management to students
Student Pack	Copies of lecture slides, details of case studies, task description, hints
The Leaning Tower of Pasta Part 1	A well-known game constructing a load bearing tower from dried spaghetti and marshmallows. Introduces team work
The Leaning Tower of Pasta Part 2	A chemical twist on the game where the brittle pasta can be treated with dihydrogen monoxide to improve its structural qualities. Illustrates research, planning, and scheduling aspects of project management
Leaning Tower of Pasta Tutor Guide	How to run the game and the lessons to bring out – team roles (e.g. Belbin tests) and why its ‘not just a game’
Feasibility Studies and Project Pitch Module	
Feasibility Tutor Guide	How to run module, student prompts, and task assessment. Examples of output from trials, graded at various levels
Feasibility Studies	Video lecture introducing M.Research and analysis to students
Student Pack	Copies of lecture slides, details of case studies, task description, hints
Template	Word template for feasibility studies. Not compulsory but advisable!
Feasibility Study examples	Feasibility studies carried out by students on previous KKI courses, not using current case studies. ‘OK pass’ ‘Good pass’ and ‘distinction’ level. May be shown to students as examples of good practice
Presentation Examples	Examples of presentations from trials graded at ‘borderline’, ‘pass’ or ‘distinction’ level. Tutor use only – for grading purposes
Presentation Example	Video of Students taken during trial week. Tutor use only – for grading purposes

Our approach to designing the Modules

This project represents a collaboration between KKI Associates and the School of Chemistry at the University of Edinburgh. Between us, we share experience of delivering skills training to chemists, we agree on teaching techniques that work for these students, and importantly, we share a vision of why this teaching and training is important for chemists in the 21st century.

Professor Colin Pulham is Director of Teaching in the School of Chemistry at the University of Edinburgh. SHEFC[2] has rated Teaching at the School as 'excellent'. In 2010 the School was awarded The Edinburgh University Students Association Teaching Awards for Best Department in the entire University. The School has close links with Chemistry-based businesses around the world, and many students use these links to participate in industrial placements later in their courses. The School currently hosts the RSC Education Coordinator for Scotland.

Dr Kevin Parker (MRSC CChem) of KKI, following a technical and commercial career at BP, now consults and trains in the area of business skills and science-based entrepreneurship. Kevin previously devised and presented a 20 credit Undergraduate course in *Innovation and Enterprise* (over 7 years) and a 5 credit post-graduate course in *Management Accounting/Business Finance* (for 8 years). The courses made use of industrial case studies and some Context/Problem Based Learning (C/PBL) materials. These have been well received, popular with students, and have had long term outcomes. For example, students on the *Innovation and Enterprise* Course have gone on to form businesses, work in industry, become patent attorneys, or themselves work in Knowledge Transfer in their post-university careers.

So between us we have experience of both the material content, and perhaps more importantly the teaching styles, that work with scientists/technologists. Students, particularly those with a science background, require a different approach from typical industrial/business trainees:

- many attendees have little knowledge of industry and commerce and we therefore start at a quite basic level
- attendees are more intelligent and numerate than average and so we can go much faster than is typical of most business training programmes
- because scientists like to discuss things, it is better to adopt an interactive teaching style, so they learn by doing, not by telling

Why have we developed these particular modules? One reason is that we do feel, like our industrial contacts, that each module forms a logical part of the whole 'route to market' which applies in both SME's and large organizations. They conceptually progress the student from invention and innovation, all the way through to 'how do we sell it and make a profit?'

The second reason is that these areas lend themselves to learning important 'soft skills', as well as the 'hard skills', which are the headline content. For example, doing qualitative market research requires skills very similar to networking and job-searching. Similarly, project management is a team task, and working with other people is a key requirement in getting projects completed. So, in completing the material the students will also learn about team working, data analysis, and presentation skills. However they will be doing it as part of a directed project ('I need to do a presentation of our financial analysis') rather than in a more abstract way ('they're sending me on a presentations skills course').

[2] *The Scottish Higher Education Funding Council*

Why have we emphasised C/PBL in these modules? It could be said that the 20th century was the 'century of chemistry'. Chemists had a hand in the development of the petrol-engine motor car (and the Oil and Gas industry as a whole), they invented ways to feed more people (the Haber process), antibiotics to help keep people alive, and chemical polymers to help clothe them. There were chemists on Shockley's team when the transistor was invented, and chemists produced the LCDs and LEDs used in display technology.

And chemistry has equal if not more importance for the 21st century. The RSC Roadmap document lists seven priority areas and picks out 41 challenges within those areas. Chemistry will be vital in water supply, agricultural production, medicine, and especially in the linked areas of energy and the environment. We will need chemistry to improve solar technology, to safely store nuclear waste, to reduce the impact of mining the rare earths that make wind power generator magnets, to understand the atmospheric chemistry of methane, to preserve and safely exploit gas hydrates, to recycle rare elements from electronic waste – and the list could go on and on.

While chemists will be central to all these issues, it is also clear that they won't do it alone. Chemists of the 21st whether working in academia, industry, NGO's, think-tanks, or Government, will need some of the following skills:

- Being able to work in multi-disciplinary teams, with joint and specific responsibilities for the project. This implies being able to communicate what you know (from your specialist knowledge) to others who need to able to understand and accept your reasoning.

- Being able to give advice in situations with incomplete information. Examples might include advice on carbon emission reduction even though we don't completely know the feedback factors that linking increased carbon dioxide to temperature. And we really aren't sure of the methane feedback/feedforward, although we do suspect at least one 'methane catastrophe' in paleoclimates.

- Being able to put things into context. Although this sounds trivial, one of the issues about energy, which confuses and frustrates those new to it, is the sheer amount of unit conversion. We can measure energy in Joules, MegaJoules/mol, kilowatt-hours, British Thermal Units, or tonnes of oil equivalent. The size of an oil barrel varies between crude oil and oil products, while metric tonnes are different to UK tons, which are different to US short tons, which are all different from deadweight tons used in oil tankers (which are a measurement of volume not weight!). Who is going to make these comparisons and conversions if not a chemist?

This is why we have adopted our approach of giving students comprehensive resources, but then challenging them to use those resources as a team, in an 'Open' PBL setting, where they will have to deal with variable quality information, in different units, and still make clear recommendations. There may not be 'one right answer' to their tasks, although we have provided hints and guidance to what we consider the essentials. Students are limited by what they can find in the time allotted, and there may well be other good information 'out there'. Meanwhile a different group of students may well find different information and reach a different conclusion. Does that ever happen in 'real life'? It does, it will happen more and more in the 21st century, and we have to prepare our students for these complex and uncertain situations.

It is clear that the modules and associated activities contribute to the development of many of the so-called “graduate attributes” of Chemistry students, i.e. the attributes that would be expected of a Chemistry graduate. For example, the graduate attributes identified for the MChem degree at Edinburgh (see the degree programme specifications http://www.chem.ed.ac.uk/about/quality/dps.html) include the following:

- Have the confidence to draw conclusions based on in-depth understanding and sound analysis.
- Collaborate effectively, with an appreciation for both leadership and teamwork, to test and enhance their own knowledge and understanding.
- Able to communicate effectively, demonstrating knowledge and understanding of essential concepts and theories, in writing and orally, to fellow students, researchers and academic staff.
- Understand and analyse critically different sets of data to reach independent, well-considered and evidence-based conclusions, drawing on their own knowledge and experience.
- The capability to apply the knowledge and understanding gained throughout the curriculum to the solution of qualitative and quantitative problems of a familiar and unfamiliar nature, both in science and in a wider context.

- An awareness of major issues currently at the frontiers of chemical research and development.

The preceding paragraphs hopefully provide compelling evidence to address any potential criticisms from academic colleagues that we should be teaching our students more chemistry rather than business skills. We have a duty to all of our students to ensure that they are well prepared both for future employment and further academic study. We firmly believe that the skills developed in these modules will significantly enhance the abilities of chemistry students to compete and thrive in an increasingly competitive global environment.

General Comments – Running the Modules

All these modules with the possible exception of the final, *Feasibility and Project Pitch* module should be carried out in spaces suitable for break-out session/team activities and not in a formal lecture theatre. Students will need internet access, both for researching the projects and for accessing the accompanying videos on the RSC's web-site. Having set the students the task it should be up to them how to organize their time and allocate work between themselves.

Students will need fairly constant tutor interaction as some are likely to 'get stuck' – this type of unstructured 'self-driven' learning presents difficulties for some. In a real business situation it is OK to say 'I don't know how to do this please can you give me some pointers' (in fact that's regarded as positive behaviour), but some students think its 'cheating' to ask for help. With this in mind we have designed Group activities as part of each module, partly for their own sake, but partly to give tutors an opportunity to find out how students are doing.

As mentioned above, the *Innovation* module should be run and completed before the students start on the on the market research, finance and project management modules, and *Feasibility and Project Pitch* should be done as a final integrative exercise.

Choosing team members

The modules should be carried out by teams of 4-6 students rather than by individuals. Our preference is to assign people to teams rather than just relying on 'friendship groups'. Graduate recruitment processes in industry often put randomised groups of students into a team task to observe how individuals cope in this situation.

One interesting way of allocating students into teams is to their characteristic 'preferred team roles'. Given a team task, some people will naturally adopt a 'come on let's do this, leading from the front' role, others will come up with bright ideas, while others will worry about details and deadlines 'look we've got to get 4 hard copies and a pdf in by 12 o'clock, not 5 o'clock'. A good team needs people doing all of these roles (between them), but clashes can occur when two or more people all want to do the same role. The roles have been most famously systematised by Dr Meredith Belbin, and the Belbin test is widely used in business, military and sports team development. If you hear people talking about 'Shapers', 'Plants', 'Resource Investigators', or 'Completer finishers' then they are talking about the names Belbin gave to some of the team roles.

Although the formal test process probably costs too much to run on a large student population, the various Belbin team roles are well described in various publications and web-sites. See here for an introduction:
http://www.belbin.com/rte.asp?id=8 and here http://en.wikipedia.org/wiki/Team_Role_Inventories

or here http://www.mindtools.com/pages/article/newLDR_83.htm

for a description of the roles. One idea might be to get students to look at the these pages and identify what they think they are. One of us (KP) is a 'Plant' and freely admits the comment on the Wikipedia page that having too many Plants in a team is not a good idea! The team role analysis works usefully for students of different nationalities: for example 'Shapers' from Japan and America will have similar innate tendencies, even if they express themselves in different ways.

'Training the Tutors'

While the modules do not need external lecturing input (it's all on video) they do need tutors to run the interactive sessions, drip feed hints to the students, and generally check that they are progressing. Not everyone will feel confident about tutoring this material, even though we have tried to write extensive tutor notes. At the trial week in Edinburgh we used a mixture of tutors – academic staff with relevant experience, students returned from industrial placements, business and admin staff from the university.

There is however, funding and expertise available for teaching business skills to postgraduate, postdoctoral and junior academic staff. Many resources, including trainers such as KKI, sources of funding, and on-line materials are available at the Vitae web-site. http://www.vitae.ac.uk/ For research council funded research students, attending these courses should be part of their 'curriculum'. In this case, attending the right 1 or 2 day training course should equip them to act as tutors on our undergraduate modules.

Using External Experts

Although there are many available to us in Scotland, we have not emphasised the use of external experts such as IP specialists, investors, professionals, in actually delivering the modules. This is because we wished to make the material as transferable as possible and for the quality not to depend on the availability of local expertise. As an example although we know many expert specialised patent agents and IP lawyers, we don't know many who are really good at explaining what they know and why. We have had our material checked by specialists where it overlaps their area but have provided the teaching content ourselves. Where we do think external experts are valuable is at the start and end of the skills training. At the start of the modules experts can be introduced as: examples of people who have used their chemistry to have useful and interesting careers; as potential employers; or as mentors who could help the students with their careers. This then gives the experts familiarity and credibility at the end of the modules, where they can make a good audience or 'judges' for the team presentations. Separately from any formal assessment by the university, it can be good for the students to get feedback and even low-key 'prizes' from the judges – in fact an enterprising School might get the experts to treat this as 'sponsorship'.

Set Text

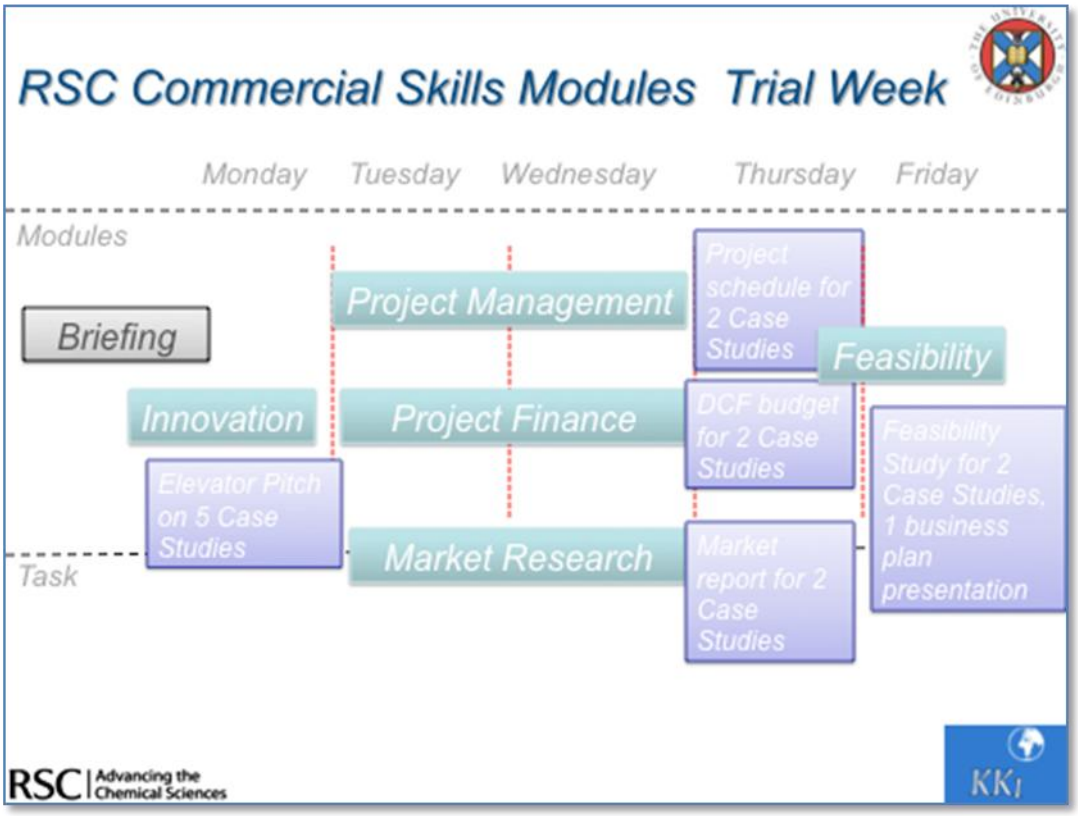
Our recommended Text Book for the course and for further reading is: *Winning at New Products*, by Robert G Cooper.

Basic Books; 4th edition (28 July 2011)
ISBN-13: 978-0465025787

Professor Cooper's book stands out from typical academic business writing by being focused on the detailed process of bringing products to market.

It has been very influential, in that many chemical companies now use Cooper's staged new project process ('Stage-Gate') for controlling and managing their development activities.

Trials of the Material – Our Experience and Student Feedback



We trialled the materials, in a preliminary form, at Edinburgh during the 'innovative learning week' in February 2012. The 'guinea pigs' were penultimate year undergraduate students on the MChem degree programme and taught Masters students. The photographs in this document were taken during this week. In addition KKI has carried out shorter trials of parts of the material with Masters and Postgraduate students at 3 other Universities in April-June 2012. The diagram shows the timetable of our week in Edinburgh.

Student comments included these:

'that was so much harder than a normal week' *'but it was so much fun!'*

Some of the interactive exercises, including the 'Leaning Tower of Pasta', proved quite entertaining:

The lessons we learned from the trial week included the following:

- The Material seemed to work well in that students learned a lot from the week
- Students felt tasks generally fair, but they needed to be told to use tutors
    - 'its OK to ask for help!'
- Importance of allowing sufficient time for activities
    - one week was definitely not long enough, although we had anticipated that
- Recognising that this is very challenging for some students
    - particularly location and sifting of information
    - very different from normal style of studying
- It's a good idea to provide time for reflection by students about what they have learned and achieved, perhaps after the final presentations
- You get a high level and quality of interaction with students both during and after the exercise – it's thought provoking for them

Subsequent to the Edinburgh trail, KP has trialled aspects of the material with post-graduate students at the Universities of Sheffield and Kent. Although these were shorter trials, they benefited from having a mixture of disciplines. Alongside chemists were life scientists, mechanical engineers, petroleum engineers, business studies, and computer science students. Their extra maturity and breadth meant that they obtained good results on the tasks, and in some cases we have used their outputs as assessment examples.

The main changes we have made after the trails have been to the tutor guides, making them more comprehensive, adding the assessment criteria, and adding extra detail and explanations to the finance module.

Assessment and Marking Criteria

We believe that these modules, done separately, would be worth 5 credits each on a typical undergraduate course. As an alternative, all the modules could be integrated into one course of one course perhaps of around 20 credits in all (as there are some overlaps). As the feasibility study module integrates findings from the market research, project management and finance modules (and indirectly from the innovation module) it would be feasible to assess the extended course on the outputs from this module alone.

Whatever the marking strategy, this module is designed as a team exercise, and a team mark should be given for each module. **We suggest marking to a broad 3 'class' scale – 'fail/borderline', 'pass' and 'distinction'**, rather than applying a formal percentage point marking scheme. This is in accord with the author's (KP) experience of producing reports in an industrial context where the response from one's boss is typically one of 'that's fine, good work', 'that's OK, can you give me a bit more detail here and here' or 'this is rubbish, please start again'. If possible students should be encouraged to revisit and improve poor work, rather than just be told 'you've failed' – this is what is more likely to happen in a real business situation. NB this does not in any way imply lowering standards – it implies 'keeping on at the students until they produce good work'[*].

Some teams expressed concern about the potential fairness of a team mark, so we have adopted the following procedure:

Each team is asked to suggest whether any members should be individually marked up or down one category

- Team gets distinction, but 'free-loader' gets pass
- Team gets pass, but outstanding contributor gets distinction

Generally as soon as students are made aware that this procedure is in place, it prompts effort from everyone – so a good idea is to let them know about it before the module starts.

As we are asking students to carry out what is termed 'open' PBL (by carrying out internet research for example) we have provided some hints for students and tutors about some of the interesting web sources they may find. Of course, one of the exciting things about open PBL is that students are quite likely to come up with new resources and findings that even we as course designers haven't anticipated! What is does mean is that they should get more credit for the quality of their research and thinking, than for getting specific 'right answers' about the project. We have identified some key points they really should find as a minimum requirement, but beyond that **it will be possible for different groups to reach different conclusions about a project, yet still both have done a good job.** Some companies deliberately use this approach – for more details, Google 'red team and blue team'.

We have provided examples of assignments at 'borderline', 'pass' and 'distinction' levels in the tutor guides for each module. With the exception of some feasibility studies in the Feasibility and Project pitch module, these were all done by students involved in our various trials. These should allow markers and examiners to gauge the spread of student achievement.

[*] *KP once worked for a manager who asked for 17 rounds of revision in an important internal document*

'I need to set some exams?!'

Some representations have been made to us that 'there have to be exams for a 20 credit module'. As we have stated above we believe that there are better ways, which we have provided, of measuring student achievement. If there is still a necessity to provide written exams, it can be done, and we have made available some examples from our previous 'Innovation and Enterprise' half course that ran from 2001 to 2008. They are Adobe pdf documents, called 'Exam2007' or similar. Marking comment/answers etc are clearly distinguished in red font.

We would consider acting as external examiners (or other involvement) if that would help Universities who are contemplating implementing these modules.

Acknowledgements

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The Course Designers - Biographies

Professor Colin Pulham – School of Chemistry, University of Edinburgh

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The Input from the University of Edinburgh School of Chemistry has been led and coordinated by **Professor Colin Pulham.** Prof. Pulham holds a personal chair in High-Pressure Chemistry and since November 2008 has been the Director of Teaching in the School of Chemistry at the University of Edinburgh. Since August 2009 he has been Deputy Head of School. He is a member of the Centre for Science at Extreme Conditions (CSEC) at Edinburgh and has research interests in the study of the effects of high pressure on molecular compounds such as pharmaceuticals and energetic materials (explosives, propellants). He has an international reputation in this area and is regularly invited to lecture at conferences throughout the world. He receives funding from a range of sources that include UK research councils, MOD, and industry.

As Director of Teaching, Colin is responsible for ensuring that the School delivers excellent teaching to its students and that the quality of the student learning experience is first rate. The high quality of the student experience within the School is reflected through the Edinburgh University Student Association Teaching Awards: the School was runner-up for the award of Best Department in both 2009 and 2010, and won the award in 2011. His leadership has ensured that the Director of Studies system within the School of Chemistry is widely recognised as being of very high quality – a view supported through a variety of student surveys and feedback.

Colin sits on several high-level committees with responsibility for enhancing learning and teaching across the University. Through his role on the Senate Learning and Teaching Committee he made a important contributions to the establishment of the Standards and Guiding Principles for Academic and Pastoral Support, which aim to ensure that all students receive appropriate levels of academic and pastoral support. In 2009 he chaired the Teaching Programme Review for Psychology. He is also an external examiner for the Open University.

Colin is a passionate teacher whose lecturing style is regularly praised by students. In 2008 he was awarded the best lecturer prize by students in the School, and in 2006 was nominated for the Chancellor's Award for Teaching. His Recent successful bids for education-related contracts include: the RSC Regional Educational Coordinator for Scotland, and a UoE Distance Education Initiative to develop on-line CPD resources for teachers.

Dr Kevin Parker – KKI Associates
kevin@kkitech.com

Dr Kevin Parker is one of the UK's most experienced and versatile consultants working in the field of technology commercialisation and technico-economic appraisal. Since becoming a consultant in 1994 he has carried out over 250 technico-economic assignments, trained over 2500 technologists and research students in commercial skills, and been instrumental in the formation of over 20 new businesses.

Kevin trained as a chemist (Edinburgh and Cambridge), and worked for 12 years with British Petroleum. Of that time 6 years was spent in R&D, (where he won BP's top internal research prize) and 6 years as a 'fast-track' operational manager. During his period in management he worked in: sales and marketing, literally 'selling oil to the Arabs' ($5m pa); international marketing, and technico-economic corporate planning.

In 1992 he left BP to graduate from London Business School's Sloan Masters Programme, with distinctions in entrepreneurial finance, environmental economics and international business development. In 1993 he founded his own consultancy *KKI Associates*, and during the period up to 1997 specialized in gaining opportunities for technological companies in Eastern Europe to export to the UK and US. He carried out over 30 broad-ranging market research and business development projects over a three-year period. As a result KKI was asked to provide training and advice to an 18 month EU PHARE project restructuring agricultural and petrochemical research institutes in Romania and the Ukraine.

Since 1995 Kevin has worked on many projects with *Z/Yen Group Ltd* the London-based commercial think-tank. With Z/Yen he has: led an engineering project for the Defence Research Agency (DRA); devised risk-based cost of capital studies for the European Fertilizer Industry; worked in financial and IT projects in the health and not-for profit sector, and carried out extensive work looking at costs and opportunities of carbon dioxide trading for companies and organisations.. In 2003 Kevin helped Z/Yen gain a DTI SMART award for its PropheZy decision support software.

KKI has worked with many technology based business start-ups, especially spins-outs from Scottish Universities. Several of these companies are regarded as being among Scotland top spin-outs, gaining SMART or similar awards, and have gone on to notable investment funding and commercial success. Kevin has carried out entrepreneurship training at 30+ Universities from Southampton to Aberdeen, and presented a paper on outcomes at the 2011 Vitae conference.

Kevin is a cub leader and carries out pro bono adult leader training for the Scout Association, and is a mentor for the Princes Scottish Youth Business Trust.