Launch-a-Lab

A problem solving case study in industrial chemistry and advanced professional skills

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A problem solving case study in industrial chemistry and advanced professional skills

Devised by

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Preface

'Launch-a-Lab' is one of six problem solving case studies that have been designed in order to teach analytical and applied chemistry within a 'real' life context by developing problem solving and professional skills.

Employers have long urged the Higher Education sector to produce graduates with a range of transferable skills that would make them more immediately effective in the world of work. To produce graduates who can operate in the workplace professionally, we need to go much further than just ensuring that they have a sound knowledge of chemistry, adequate practical abilities and rudimentary problem solving skills. We must ensure graduates can think critically and analytically, can interpret data and information, tackle unfamiliar open-ended problems and apply their chemical knowledge. In addition, the modern graduate must master a range of 'professional' or transferable skills including communication, team working, time management, information management, independent learning and the use of information technology.

Our approach in producing resources that address these issues in analytical chemistry has been to develop problem-solving case studies that use the contexts of forensic science, pharmaceuticals, environmental science, and industrial chemistry. These present extended problems are set in a 'real' context with incomplete or excessive data, and require independent learning, evaluation of data and information and, in some cases, do not lead to a single 'correct' answer. By tackling these cases, students are able to see the relevance of analytical chemistry and so approach the activities with enthusiasm and interest. The analytical skill developed throughout the case studies closely follow those recommended by the United Kingdom Analytical Partnership (UKAP). In addition, the transferable skills listed for each case study correlate with those identified in the RSC Undergraduate Skills Record documentation.

A Dip in the Dribble	Analytical, environmental and industrial chemistry
Launch-a-Lab	Industrial chemistry and advanced professional skills
New Drugs for Old	Pharmaceutical and analytical chemistry
Tales of the Riverbank	Analytical chemistry and environmental science
The Pale Horse	Analytical chemistry and forensic science
The Titan Project	Industrial and analytical chemistry

The case study has been extensively trialled, modified and updated. We feel that it is now in a suitable form for more widespread use. Whilst we have made every effort to ensure that this case study is free of errors and the guidelines for delivery are unambiguous, almost inevitably, we will have overlooked some detail. If users come across any errors or have any suggestions for further improvement we would be pleased to hear from you.

We thank the Royal Society of Chemistry Analytical Trust Fund for the funding of this project and the enthusiastic support of the United Kingdom Analytical Partnership (UKAP). We would like to acknowledge Tom McCreedy (University of Hull), Bob Mackison (Chemical Solutions), Jim Miller and Helen Reid (Loughborough University), and Hywel Evans (University of Plymouth) for their invaluable feedback and encouragement. In addition all the friends, students and staff at various universities who have helped shape this case study by their enthusiastic participation.

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Contents

Aims of the Case Study

This problem-based case study concerns STS Contract Analysis Ltd. (established in 1974) who is tendering for a large contract from Midshire River Authority for the analysis of organic pollutants in ground water. The students act as part of the STS management team whose task is to ensure that the company can deliver a high quality service with a suitable profit margin if they win the contract.

Who is the case study aimed at?

The case study works well with students at level 3.

How long does the case study last?

The minimum contact time required is 5-7 hours and will require the students to spend approximately 6 hours in associated independent study.

How can the activities be assessed?

Various methods of assessment can be used including oral presentations, poster presentation, CV writing, interview practice and interviewing.

What are the learning outcomes?

Students must apply appropriate knowledge of analytical and industrial chemistry to tackle an extended and open-ended problem within a 'real' context. The nature of the activities involved ensure that, in order to complete the case study, students must develop a variety of scientific (table 1) and transferable skills (table 2).

Table 1: Scientific skills

Disciplines covered	Industrial chemistry and professional skills development.
Scientific knowledge	Consider chemistry within an industrial context of validation of methods, accreditation of laboratories, design of a laboratory, choice of an instrument etc.
Handling information	Retrieving information on issues relevant to commercial laboratory.
Problem Solving	Tackling unfamiliar problems, using judgement, evaluating information, analytical and critical thinking.

Table 2: Transferable skills

Communication skills	Oral presentations, poster presentation, interview skills, interviewing skills, providing oral and written feedback, writing job advertisement, CV and letter.
Improving learning and performance	Using feedback to reflect upon group and individual performance. Drawing on the experience within the group.
Information technology	Using ICT to find information, produce oral and poster presentations, advert, CV, and covering letter.
Planning and organisation	Individual judgement, decision making, time management, planning, prioritising and working to deadlines.
Working with others	Interviewing, brainstorming, discussion, delegation of tasks and feeding back to the group.

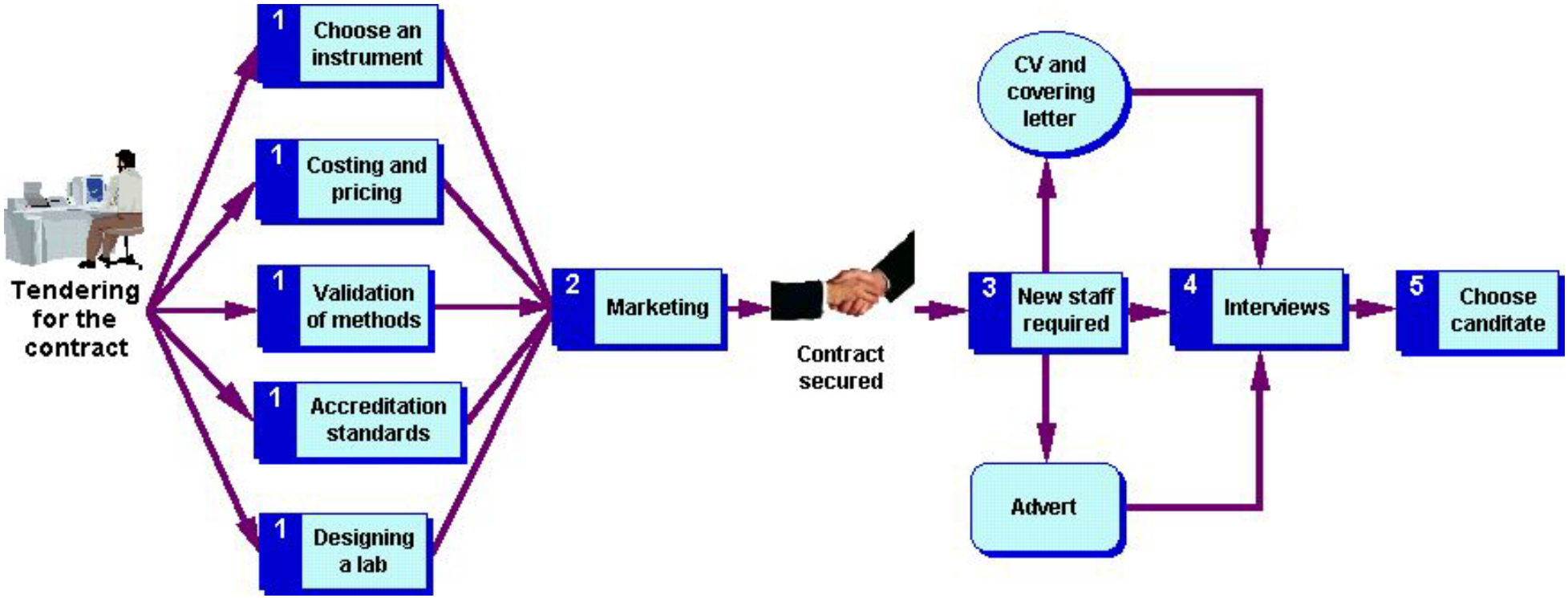


Figure 1: Launch-a-lab at a glance.

Making it Work

The class is divided into groups of 3-6 with four being the optimum number. It is advisable to randomise the groups so that each group has a range of abilities and skills. The case study consists of two main sections, industrial and advanced professional skills (see Figure 1.) These can be used together or individually.

Tendering for the Contract

The case study can be introduced by using the overhead provided (Appendix A) or the class can be briefed by the tutor.

STS Contract Analysis was established in 1974 as an analytical service to external companies and organisations. The company is tendering for the Midshire River Authority contract for the organic analysis of polluted ground water.

The students act as part of the STS management team whose task is to ensure that the company can deliver a high quality service with a suitable profit margin if they win the contract.

Each group is set one of the following five tasks related to the determination of polyaromatic hydrocarbons (PAHs) in ground water. In the next session, the students feed back their findings to the rest of the class using one overhead.

1. **Choosing an instrument**
   The students must recommend one new instrument that could be purchased for routine analysis of polyaromatic hydrocarbons (PAHs) at sub-ppb levels. They suggest a manufacturer and approximate price.

2. **Costing and pricing**
   The students consider the fixed and variable costs involved in the analysis of polyaromatic hydrocarbons in polluted ground water by HPLC-fluorescence. They then suggest the price strategy to customers for a one off analysis and a regular service.

3. **Validation of methods**
   The students identify how the pre-concentration of polyaromatic hydrocarbons from polluted ground water using solid phase extraction (SPE) would be validated.

4. **Accreditation standards**
   The students consider the accreditation standard(s) required for the laboratory undertaking environmental analysis.

5. **Designing a laboratory**
   The students design a sample preparation laboratory for organic analysis. Space is limited so it may be sensible to remind them that not everything they wish to include may fit in the laboratory. This is presented on a blank overhead plan of the laboratory.

Marketing

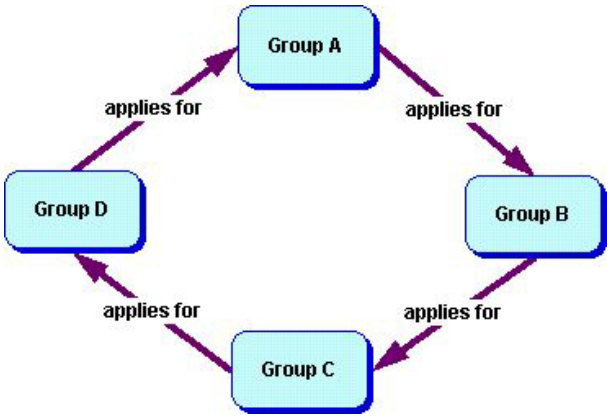
The students are informed that their proposals have been accepted and that the company is starting an advertising campaign in order to attract lucrative environmental contracts. Each group prepares a two-page brochure and these are presented in the form of posters in the next session and could be peer assessed.

Employing New Staff

With the new contract with Midshire River Authority commencing shortly, STS has an urgent requirement for new staff. Each group produces an advertisement for a new member of staff in one of the laboratories. The advertisement outlines the qualifications and qualities desirable in the new appointee and gives details of the post and remuneration package.

Students will be advertise and recruit a new chemist whilst applying for and being interviewed for a post themselves. The positions can be advertised on the notice board, electronically on the local intranet or virtual learning environment (e.g. Blackboard, Web-CT) or by handing to the appropriate group of students.

The students prepare their own CVs and covering letter. The tutor may run a CV workshop before the students submit their applications. The students apply for the jobs advertised by one of the other groups as shown below (for example).



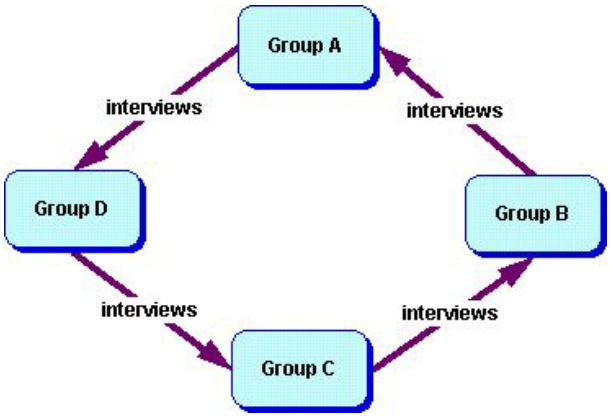
The tutor may act as 'postman' by collecting and distributing the applications between groups. These should be clearly marked with the applicant's name, group designation, and job applied for.

Interviews

Each group should collect the applications for their post from the tutor the day after the closing date. They should look through the applications and familiarise themselves with them before the interviews. All students that have applied for the post must be interviewed.

The interviews may take place over several sessions or over a shorter period of time if other tutors are available. Only the groups that are interviewing or being interviewed are present. Each student is interviewed one at a time and the interview lasts 5-minutes. Only one candidate will be successful.

The interview panel is made up of the whole group that drew up the advert for the new job. The tutor acts as an observer. The students take turns to chair the interview panel. The chairperson has the responsibility ensuring that the interviewee is at their ease, ensuring that the interviews keep to time and that each interviewer asks a question.



The students should not be interviewed by the same group of students who they interviewed.

Students should be reminded that only information supplied on the covering letter and CV should be used to make their decision.

At the end of the interviews the interview panel must make an appointment and provide written feedback to each candidate indicating areas for further development. The interviewers must give the justified reasons for their decision. The interview panel must rank the interviewees and this forms part of the mark given by the tutor.

The tutor awards each member of the interview panel a mark based on their performance as an interviewer. The interviewees are awarded a mark by the tutor based on the ranking produced by the interview panel based on how they performed in the interviews.

Debriefing

The tutor may lead a class discussion encouraging the students to reflect on what they have learnt during the activity. It is particularly useful to encourage them to reflect on the interview process and to identify the do's and don'ts for CV, interviews and interviewing.

Presentation & Assessment

Students may present their results and conclusions in several ways: -

- **Oral presentation**
  All team members get the same mark.

- **Poster Presentation**
  Group or individual peer assessed with all team members receiving the same marks.

- **Interviews (interviewees)**
  The marks for the interviewees are derived from the ranking made by the interview panel.

- **Interviews (interview panel)**
  The mark for the members of the interview panel is given by the tutor on how well the tutor considers the students have performed.

Table 3: Example assessment schemes

Group oral presentation	20%
Poster presentation (peer assessment)	20%
Performance in the interview	30%
Performance as part of the interview panel	30%
	100%

Any Questions?

1. **Do all students take part in interviewing candidates?**
   Yes.

2. **Are all students who apply for the job interviewed?**
   Yes

3. **Is the tutor part of the interview panel?**
   No, the tutor is there as an observer to encourage the interview panel to reflect upon each candidate In addition, the mark for the individual student's on the interview pane is given by the tuior.

4. **Can the interviews be carried out over a shorter period of time?**
   Yes if more tutors are available.

5. **How many students should be on the interview panel?**
   This is determined by the initial group size. This is normally between four and six students.

6. **How long should the interview session take?**
   The interviewing of 4-6 students should take about an hour if kept strictly to time.

7. **Do students interview those who interviewed them?**
   No, mutual interviewing should be avoided.

Session Plan for 5 One-Hour Sessions.

Objective	To think critically about industrial chemistry.
Session 1	1. Overall aims of the case study are described. 2. Students are divided into groups and are allocated one of the five tasks.
Task 1	• Start the preparing the oral presentation on one overhead.
Objective	To present a summary of the activity to the class. To prepare a brochure for STS contract analysis.
Session 2	1. The students feed back to the rest of the class. 2. The lecturer leads a discussion on the issues of setting up a laboratory, tendering for a contract etc. 3. The students are set the task of producing a brochure in the form of a poster.
Task 2	• Start the preparing the poster presentation.
Objective	To evaluate the brochures. To consider the employment of staff. To prepare a new job advert.
Session 3	1. Each group presents their poster. 2. The students vote for the best design. 3. The students start to prepare an advertisement for a new post in the new laboratories.
Task 3	• Students prepare advert and update their CVs. • Students need to bring at least four copies of the updated CV to the next session.
Objective	To critically review their CV. To provide feedback on the CVs of the other students.
Session 4	1. The tutor presents an overview of CV writing and facilitates a CV workshop. 2. In their groups, the students discuss each other's CV and given feedback. 3. Groups exchange jobs advertisements with relevant groups.
Task 4	• Students prepare a covering letter; a focused updated CV that is handed in for the deadline given on the advertisement. • Each group collects the applications from the tutor (or as arranged.)
Objective	To appreciate the importance of preparation for an interview. To reflect upon their skills development. To develop interview skills.
Session 5	1. The interview panel spends a few minutes discussing the applicants. 2. The interview panel interviews each candidate for 5 minutes. 3. The interview panel ranks the candidates, decides upon the person to be appointed. 4. The interview panel informs the interviewees of their decision with justification and provides written feedback to them. 5. Debriefing.

Comments on the Exercises

Over the last couple of decades, industry has increasingly used external contract laboratories for research, development and analysis because of cost savings because it: -

- Enables the company to obtain specialist skills and technical resources.
- Enables the company to manage variable workloads.
- May provide an independent certificate of analysis or report, which can be beneficial when dealing with third parties etc.

There are a number of disadvantages of outsourcing including: -

- The hidden costs of putting in place financial and legal agreements, and producing systems for placing purchase orders, dispatching samples, account payment etc.
- There may be a delay in quality assurance approvals, initial and ongoing.
- Increased project management costs, such as transferring methodology, dealing with problems and issues, monitoring results supplied by the sub-contractor, caused by the increased paper chase.
- The in-house facility that provides expertise, experience and continuity is lost if replaced by a contract laboratory. Problems would no longer be sorted out face to face and may not be identified correctly. This could have long-term consequences.

Choosing an Instrument

Sample preparation and concentration is important because of the trace concentrations of sub-ppb levels.

- Solid phase extraction (SPE) would be the choice method and this could be automated.

A gas chromatograph (GC) with capillary column has greater resolution than a packed column and this would be required to resolve the different PAHs.

- GC-MS is expensive to buy, maintain and operate.
- GC-FID would be preferred because it is an excellent robust system.

Reverse phase column on a high-pressure liquid chromatography (HPLC) could be used.

- UV or diode array detectors are not sensitive enough.
- Mass spectrometer (MS) is expensive to buy, maintain and run needing a specialist technician.
- Fluorescence detector is probably the best option for ease of use, simplicity and sensitivity.

The laboratory buyers guide is a good starting point for finding manufacturers of instruments (www.mediabrains.com/client/LabGuide/)

Scientific Instrument Suppliers*	
Hitachi	www.hii.hitachi.com
Perkin-Elmer	perkin-elmer.com
Thermo	www.thermo.com
Varian	www.varianinc.com
Waters	www.waters.com

*Please note that the URLs were correct at the time of publication.

Costing and Pricing

The students may consider the following: -

- Fixed costs within an analytical laboratory include the HPLC-Fluorescence instrument, salaried members of staff, fume cupboards, heating and lighting etc.
- Variable costs of carrying out an analysis in a laboratory (e.g. solvents, mobile phase, glassware, pre-columns, SPE cartridges, columns etc.).
- Whether you would charge a lower price if you were providing a regular analysis of PAH in water for a customer.

Rooney Laboratories Ltd., an analytical service, on www.rooney-labs.demon.co.uk gives details of the pricing they charge for analysis.

Validation of Methods

The six Valid Analytical Measurements (VAM) principles are: -

1. Analytical measurements should be made to satisfy an agreed requirement.
2. Analytical measurements should be made using methods and equipment, which have been tested to ensure they are fit for purpose.
3. Staff making analytical measurements should be both qualified and competent to undertake the task.
4. There should be a regular independent assessment of the technical performance of a laboratory.
5. Analytical measurements made in one location should be consistent with those elsewhere.

6. Organisations making analytical measurements should have well defined quality control and quality assurance procedures.

www.vam.org.uk/aboutvam/about_principles.asp

The students may also have considered: -

- The solvents for chromatography should be low absorbing solvents e.g. HPLC (Fisher) Chromsolv (Fluka), HiPerSolv (Merck/BDH). Analytical solvents should be ultrapure, e.g. Aristar (Merck/BDH), AR (Fisher) grade. They could refer to catalogues or websites e.g., www.sigma-aldrich.com
- A class glassware, calibrated balances, high quality analytical reagents and standards would be used throughout.
- Minimum of four and preferably six data points on a calibration graph (Miller and Miller, 2002).

Validation is essential so that the results are reproducible and accurate. The steps in the validation of the pre-concentration of polyaromatic hydrocarbons from polluted ground water using solid phase extraction include: -

1. A validated analysis method (GLC-FID or HPLC-fluorescence) of the extract should be used to assess the accuracy, efficiency and reproducibility of the extraction method.
2. Replication ensures that the method is working properly and there is no large sampling error providing the replicate analyses are made on separate portions of the sample. This would likely to be at least three times on each sample.
3. Recovery tests are performed on a known amount of analyte (e.g. using a known amount of the EPA 16 priority PAHs) added to water overnight to allow analyte matrix interactions to occur before extraction. This is likely to be performed about 5 times each at a number of concentrations.
4. Performing tests on the reagent blank serves to check the contamination in the reagents.
5. Undertaking tests on blank matrix materials (i.e. ground water un-contaminated with PAHs) is performed to check for the presence of contaminants.
6. Alternative method of extraction such as solvent extraction could be used to statistically compare with the results obtained.
7. Using certified reference material containing a known certified concentration is the ultimate test of a method and of the analyst. LGC offers reference materials (www.lgc.co.uk/ref.asp)
8. Collaborative studies and proficiency testing schemes between laboratories are useful to make certain that the results are comparable and hence considered reliable. A European database of proficiency testing schemes can be found at http://www.eptis.bam.de

Accreditation Standards

Accreditation standards can be defined as the formal recognition that a laboratory is compliant with certain specified international standards. The suitable standards are: -

- United Kingdom Accreditation Service (UKAS) superseded NAMAS in 1997, www.ukas.co.uk. UKAS accreditation is given for particular tests and not to the whole laboratory.
- ISO9001: 2000 is a general quality assurance standard. (www.iso-9000-2000.com/) This consolidated ISO 9001:1994 to ISO 9003:1994 into one standard.
- In 2000, ISO/IEC DIS 17025 replaced the draft standard ISO/IEC Guide 25 that had been the internationally recognised basic document for accreditation of laboratories. www.questanalytical.com/

The students may have come across the following accreditation standards but are not relevant to environmental testing: -

- Good Laboratory Practice (GLP) applies to laboratories testing pharmaceuticals, pesticides, foods, and industrial chemicals. www1.oecd.org/ehs/ehsmono/
- Good Manufacturing Practice (GMP) is mandatory if the company produces food products, pharmaceuticals or medical devices
- Good Clinical Practice (GCP) regulates clinical trials.

GLP, GMP and GCP are legally binding. However, ISO9001, ISO17025 and UKAS are only advisory so it is often a commercial decision whether to comply to them In other words, not being compliant would mean loss of business to competitors who are.

Proficiency testing schemes between laboratories are important to maintain standards of reliability of the results. A European database of proficiency testing schemes can be found at www.eptis.bam.de.

- The most appropriate scheme for environmental pollution of water is Aquacheck (www.aquacheck.co.uk).

Designing a Laboratory

The students may consider the following: -

- The number of staff working in laboratory (probably 2-3 staff at most).
- The services normally required for a laboratory are water (both ultra-pure and tap water), vacuum line, electricity, compressed air and possibly some other gases.
- The type and number of benches and cupboards depends upon the design.
- Since this is an organic sample preparation laboratory at least one 2-m fume cupboard would be required. Most designs have two.
- Fridge(s) and freezer(s) are important but do not need to be in the laboratory.
- Sinks are often overlooked and these should include a washing up sink, hand washing sinks and pot sinks for the fume cupboards.
- The floor covering should be solvent resistant.
- Space for a sample logging and reception area with a networked computer to a laboratory management system is sometime allocated.
- Laboratories require unobstructed exits in case of fires. Another fire exit would be desirable but not mandatory.

Marketing

In producing the posters, it may be useful to direct the students to web-sites of contract laboratories, to the advertisement section of *Chemistry in Britain* and the advice given by VAM on buying an analytical service.
www.vam.org.uk/advice/advice_guide.asp

The following may be included in their posters.

1. Capable of performing the testing requirement.
2. Able to perform the analysis on demand.
3. Competent in producing valid data in an acceptable format.
4. Meets required quality standards such as UKAS (called NAMAS up to 1997), ISO9001, GLP, GMP and specific in-house procedures
5. Flexible to handle the volume of work in the agreed turn-round times
6. Sufficient back-up instrumentation and qualified staff to cover unforeseen emergencies
7. Able to handle very urgent requests for testing
8. Competence to provide expert advice / interpretation of the analytical result produced
9. Willing to form long-term partnerships and collaborate on development projects
10. Provision of confidential service that is competitively priced.

Contract Laboratories*	
Butterworth Ltd.	www.butterworth-labs.co.uk
Minton, Treharne and Davies Ltd.	www.minton.co.uk
Rooney Laboratories	www.rooney-labs.demon.co.uk
Scientifics Ltd.	www.scientifics.com
Warwick Analytical Service	www.warwick.ac.uk/was
Wickham Labs Ltd.	www.wickhamlabs.co.uk

*Please note that the URLs were correct at the time of publication.

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Standards Organisations		URLs*
British Standards American Society for Testing and Materials	BSi ASTM	www.bsi.org.uk www.astm.org/
Regulatory bodies		
US Environment Protection Agency Health and Safety Executive United Kingdom Accreditation Service	EPA HSE UKAS	www.epa.gov/ www.hse.gov.uk www.ukas.co.uk
Reference Materials		
Laboratory of the Government Chemist National Institute of Standards and Technology	LGC NIST	www.lgc.co.uk/ref.asp www.nist.org/
Laboratory proficiency testing		
Laboratory of the Government Chemist Aquacheck Ltd. (international proficiency testing and benchmarking for analytical laboratories) European database of Proficiency Testing Schemes.	LGC Aquacheck	www.lgc.co.uk/pts.asp www.aquacheck.co.uk www.eptis.bam.de
Scientific Societies		
American Chemical Society Royal Society of Chemistry UK Analytical Partnership	ACS RSC UKAP	www.acs.org/ www.rsc.org and www.chemsoc.org www.chemsoc.org/networks/ukap/
Chemical/Consumable Suppliers		
Fisher Scientific Aldrich/Sigma/Fluka/Supelco Air Products Britsh Drug Houses	 BDH	www.fisher.co.uk www.sigma-aldrich.com www.airproducts.com/eurospecgas/ www.bdh.com
Scientific Instrument Suppliers		
Dionex European Instruments Hitachi Mettler Toledo Perkin-Elmer Sartorius Thermo Varian Waters		www.dionex.com www.euroinst.co.uk www.hii.hitachi.com www.mt.com perkin-elmer.com www.sartorius.com www.thermo.com www.varianinc.com www.waters.com
Directories and Buyers Guides		
Labguide (analytical equipment) Guide to buying Analytical Services		www.mediabrains.com/client/LabGuide/ www.vam.org.uk/advice/advice_guide.asp

*Please note that the URLs were correct at the time of publication.

Jobs Searching

University careers offices	URLs*	
Books & publications CRAC,	E.g. Career and Appointments Service, (2000), *What Next*, University of Hull. Hobsons graduate career directory	
UK universities and colleges		
List of UK universities UK universities sensitive map UK colleges sensitive map	www.bham.ac.uk/webmaster/ukuwww.html scitsc.wlv.ac.uk/ukinfo/uk.map.html www.scit.wlv.ac.uk/ukinfo/uk.map.colls.html	
Institutions		
American Chemical Society British Pharmacological Society Forensic Science Society Institute of Biomedical Sciences Institute of Materials Royal Society of Chemistry Teacher training agency	www.acs.org/ www.bphs.org.uk www.forensic-science-society.org.uk/ www.ibms.org www.instmat.co.uk www.instmat.co.uk/careers/careers.htm www.rsc.org www.chemsoc.org/networks/learnnet/careers.htm www.chemsoc.org/careers/careerops.htm www.canteach.gov.uk/home.htm	 Careers section Careers advice Job advertisements.
Journals		
Chemistry in Britain Chemistry in Industry Nature New scientist	 www.nature.com/naturejobs/ www.newscientistjobs.com	
Jobs Websites		
University jobs website UK university and colleges vacancy pages PhDjobs Science Jobs NHS careers Pharmaceutical manufacturing and R&D jobs. Sales, human resources and IT.	www.jobs.ac.uk www.niss.ac.uk/cr/careers/hesites.html www.phdjobs.com www.sciencejobs.com www.nhscareers.nhs.uk www.pharmajobs.com/ www.pharmavacancies.com/ www.newmonday.co.uk www.gojobsite.co.uk www.fish4jobs.co.uk	From 50+ universities advertise their jobs Links page Industrial & academic jobs for postgraduates. Chemistry or biological. European jobs
Newspapers		
The Times The Times HE Supplement The Guardian Local newspaper	www.thetimes-appointments.co.uk/ www.jobs.thes.co.uk www.jobs.guardian.co.uk	

*Please note that the URLs were correct at the time of publication.