[O9] Developments across the curriculum: problem-based and context-based learning resources within the chemical curriculum at NTU

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Abstract
The HEFCE funded Chemistry for our Future (CFOF) programme provides a unique opportunity for curriculum development in our chemistry departments. A focus of CFOF is to deliver skills required by employers of chemistry undergraduates. This is supported by projects in Strand 3 of CFOF programme looking at curriculum development. The focus of Strand 3.2. - which is a partnership between NTU, Hull, Leicester, and Plymouth- is on developing resources for a problem based/context based (P/CBL) curriculum in the chemical sciences. This curriculum approach has been very successful in over 80% of medical schools who use the problem based learning methodology to teach students about clinical cases, either real or hypothetical (Vernon and Blake, 1993, Bridges and Hallinger, 1991). It is believed that the use of these types of resource could improve, add variety, and make more effective, our teaching and our students' engagement with chemistry. In this presentation, we describe the transferable problem based /context based resources that have been designed and implemented within the chemical curriculum at NTU, in a range of modules at all levels of undergraduate study - including "M"-level. Topics covered include organometallic practicals, biological chemistry, environmental chemistry, advanced techniques and surface chemistry and Catalysis.

We further describe our experiences of the design, piloting, embedding, implementation and evaluation processes - initial feedback suggests these approaches do engage students. We gauge how successful we have been in our work with students, and also aim to provide models for design and implementation of such resources that will be of transferable to others institutions.

Background
The CFOF mission statement reads: '…to help ensure that there is a sustainable chemical science base within higher education which will attract able students from all backgrounds and provide chemical science courses appropriate for students and employers in the 21st Century.'

So, what is the problem with chemistry? There has been a decline in students studying chemistry at undergraduate level. Around 40,000+ students take A-level chemistry in UK in recent years but only about 4000 enter chemistry degrees. There are many reasons that could be put forward for this. Chemistry is considered a difficult subject; students consider the courses on offer are boring and undergraduate syllabi are unattractive. It could be students feel the chemical industry has a poor image or that it offers poor career prospects, or they feel the subject is not a vocation like medicine.

Strand 3.2 of the CFOF project has involved the participation of four institutes: Leicester (lead) + Hull, NTU and Plymouth. The aims of the strand can be summed up as follows:

1. To explore blended delivery of C/PBL activity that may help attract students.
2. To link courses to career, interdiscilipinary and generic skills.
3. To effect a sea-change in teaching methods.
4. To use problem-solving at all levels.
5. To investigate the transferability of resources.

Problem-based learning (PBL) is a student-centred instructional strategy in which students collaboratively solve problems and reflect on their experiences. The underlying pedagogic philosophy of PBL is that students learn the principles and applications of a topic by tackling problems related to it. Context-based learning (CBL) is a variation of PBL, which is used in a variety of disciplines, and uses real-world situations and contexts as the basis of the curriculum.

These approaches help students in the following ways:

- They can develop their understanding of theory by investigating and solving real life problems.
- Students are encouraged to apply previously acquired knowledge, from all areas of their course, and develop new knowledge and skills in order to derive a solution to a scenario.
- They can enhance and contribute to the learning of theoretical chemistry.
- They encourage the development of softer skills like team working, presentation and communication skills. Skills which are widely sort by employers and often overlooked by traditional lecture courses.

Two main C/PBL activities have been carried out with larger groups. Firstly, a group of 28 students, studying a level 4 *Biological Chemistry* module, and then a group of 15 level 7 – MChem students studying an *Advanced Techniques* module. We now give details of the activity as well as some of our student feedback.

Sending the Right Signals: this is a scientific writing task involving a case study set within a pharmaceutical drug treatment context suitable for level 1 students studying biological chemistry. Students investigate the details of a real-life case of drug treatment 'gone wrong' though researching forensic evidence and the biological chemistry behind the drug treatment. Contact time was around 3-4 hours, which included students answering problem questions. Students spent an additional 4-5 hours in completing the assessment which has involved students writing up the findings in the form of two scientific articles (one of 1,000 to 1,500 words and one of 500 words) for readers with differing levels of understanding of science.

Student Feedback

The 1st five questions were generic in that they were used for gauging how successful the resource was for improving or exercising some generic skills and if they thought the work was interesting. Student responses were noted on a scale of 1 (strongly agree) to 10 (strongly disagree).

How much do you agree with the following comments about the activity?	**Strongly agree**							**Strongly disagree**		
Score	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gives practice and improves literature searching	12	4	3	5	2			1		1
Improves scientific writing skills appropriate to audience	13	5	5	2	1		1	1		
Helps understand what make a good scientific article/writer	3	8	6	3	4	1		1		2
The work is interesting	2	5	8	3	4	1	2	1		2
Improves scientific writing and communication skills	9	4	8		5			2		1

The same scale was used for agreement/disagreement with statements regarding the coverage and how the activity contributed to their understanding of specific biological chemistry content.

I understand/can do the following:	**Strongly agree**									**Strongly disagree**
Score	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Make sense of cell signalling theory	2	8	10	3	4					1
Danger of prescription drugs	7	8	7	2	2				1	1
Biomolecule recognition by cell receptors	3	4	5	5	6	3		1		1
Cell signalling pathways	5	8	6	4	3		1		1	
Antidepressant action	12	4	7	4		1				
Improve understanding of antidepressant side effects	13	4	5	2	2		1		1	
Differences between tricyclic and tetracyclic structure	12	8	5	1	2					
Antidepressant side effects	13	4	5	2	2		1		1	

Unlocking the Oxygen Storage Capacity of Ceria: this case study explores the synergy between theoretical (computational) and experimental (microscopy) chemistry and is suitable for masters level students. The activities involve real research-linked learning exercises (using modern research as a resource) blended within a PBL resource. The minimum contact time is 7-8 hours which includes group and individual work within two computing labs of three hours and 2 x 40 minute sessions. Students are also expected to spend an additional 4-5 hours in associated independent study. The assessment used to date has included individual coursework spread over the length of the module but group assessment would also be possible. Assessment includes comprehension exercises of research literature, computational chemistry problems using research software (energy minimiser) to calculate defect energies in ceria and solutions to a hypothetical multiscale modelling problem set within the context of a real research situation.

Student feedback
Again, the same scale was used for agreement/disagreement for statements regarding the coverage and understanding of specific scientific content.

How much do you agree with the following comments about the activity?	**Strongly agree**									**Strongly disagree**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
The activity was a good example of the synergy between experimental and theoretical / computational research.	3	4	4	2			2	2		
The work improved my understanding of how defects might form in surfaces	4	5	5			1				
I understand better energy profiles and how they might be used to investigate oxygen migration in surfaces	6	7	2							
The activity allowed me to understand how atomistic simulation results can be used in a different mesoscale simulation on a larger scale to form a multiscale surface simulation.	3	5	3	2		1		1		
The work gave a good example of both experimental and theoretical techniques available for surface investigations.	5	7	1	2						
The work improved my understanding of the importance of defects in catalysis and surface chemistry	4	6	1	2	1				1	

Two further activities have been trialled with much smaller groups of 4-5. The 1st activity was part of a level 2 *Environmental Chemistry* module and the second was part of a level 1 *Biological Chemistry* module.

The Brixham Labs: Environmental Chemistry and Testing in the Tamar Estuary in collaboration with Astra Zeneca.

The case-study uses realistic data provided by Astra Zeneca's Brixham Environmental Laboratory. Students are given data and information about the capabilities of the Brixham Labs and they are required to plan a strategy of environmental testing for the Tamar Estuary. The data and information is made available to the students working in small groups and they are required to consider environmental issues, pollution, sampling, analytical techniques, water quality, data analysis/interpretation, toxicity, and remediation.

The minimum contact time is 5-6 hours and students also need to spend a number of hours in associated independent study. Students were assessed in various ways including group or individual reports and oral presentations. We additionally used a viva interview as a form of assessment.

Student feedback

Again, the same scale was used for agreement/disagreement for statements regarding the coverage and understanding of specific scientific content.

How much do you agree with the following comments about the activity?	**Strongly agree**									**Strongly disagree**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
The case-study enabled me to make more sense of theory	1	1	2							
It improved my understanding of environmental monitoring	2	1	1							
The real context improved understanding of the range of techniques used in env. monitoring	2	1	1							
It improved my skills at writing an env. Modelling plan	2	1	1							
The context was interesting	4									
It improved my understanding of using computer modelling to make predictions	1		2		1					
It improved understanding of how a real environmental testing lab works	2	1	1							

Tale of 2 Deaths: Biological Chemistry set in a Forensic science context.

The case-study uses the real cases of two high profile deaths that occurred in the same London flat. The first happened in 1974 and the second in 1978. Students examine the forensic evidence, verdicts of each case, and the career of the eminent forensic scientist Prof Cedric Simpson who was the coroner for both cases. One of the cases involved possible abuse of the pharmaceutical alcohol dependence treatment and students learn about the biological chemistry involved throughout.

Student feedback

Again, the same scale was used for agreement/disagreement for statements regarding the coverage and understanding of specific scientific content.

How much do you agree with the following comments about the activity?	**Strongly agree**									**Strongly disagree**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
The case-study enabled me to make more sense of theory	1	1		1	1					
I understand the importance and relevance of biomolecules	2			2						
The true story context is interesting	3				1					
The activity improved my scientific writing skills	2		2							
The activity improved my understanding of cell signalling	2		1	1						
Activity improved my PowerPoint presentation skills	2		1	1						
I now understand better how alcohol dependency treatment works	2		1	1						

Some pointers:

What follows is a list of important practical issues that need to be considered when planning and executing C/PBL activities. We hope that reflections on our planning or experience may be of use to others when planning any similar work.

- The C/PBL activities need to involve interesting or novel science that must be appropriate for module composition. The work needs to fit with the curriculum.
- If the C/PBL activity involves a large amount of course-work – assessment scheduling is important. Sometimes C/PBL activity can involve a deal of time working individually or in small groups in their own time, so C/PBL practitioners need to be particularly sensitive to the students overall work load, overall coursework schedule and examination schedule.
- Previous knowledge/experience: lots of new terminology – some students have better starting position than others, (i.e.) knowledge, skills, experience (inc. E/PBL)
- Need clear explanations of tasks/new information throughout activity.
- If any of the activities involve the use of distinct computing laboratory facilities and sessions then the following may need to be considered:
    - There may be potential for software licensing issues, if specialist software is used and if the facilities are part of a different department or school with differing operational protocols.
    - Obvious practical issues must not be forgotten: room booking / type of room / layout of room. The type, layout and organisation of the work space is of importance if the activities are of a three hour duration and involve many types of work. Individual and group work, computing, small-group discussions, presentations, and often all in the same session. Traditional lecture theatres may not be appropriate.

Conclusions:

We would like to finish with a few concluding remarks:

- Problem Based Learning can (and needs) to involve a range of scientific and generic skills from scientific writing through IT and programming, presentation skills, research methods, mathematical problems, modelling, team working, etc.
- Our feedback has shown that students prefer a blended approach to learning involving a variety of activity, including traditional lectures and labs, also PBL, RLT, CBL projects, individual/group work.
- Enquiry based /Problem Based Learning is useful and appropriate across all curriculum areas and at all levels.

- Various rigorous assessment models are possible, including *viva voce* style verbal interview questions, structured essays, creative and science article style writing, PowerPoint presentations, and scientific report writing.
- At higher levels we have successfully trialled a blended PBL/Research-linked teaching/ resource.
- Full resources soon available soon via: www.heacademy.ac.uk/physsci/

References

Bridges, E. and Hallinger, P. (1991) Problem-based learning: A promising approach for preparing educational administrators. *UCEA Review,* **32** (3), 3-7

Vernon, D.T., and Blake, R.L. (1993) Does Problem-Based Learning Work: A Meta-Analysis of Evaluative Research. *Academic Medicine,* **68** (7), 550-563.