Letters

Small numbers

From Dr Jack Hoppé, Retired, Maidstone

In his letter in the September issue of UChemEd, Greaves[1] has presented an interesting apparent paradox associated with the solubility product of $Fe(OH)_3$. Assuming the equilibrium

$Fe(OH)_3(s) \rightleftharpoons Fe^{3+}(aq) + 3OH^{-}(aq)$

then, based on the figures used, the sums are correct, the conclusion is logical and the explanation given is reasonable. Whether the explanation is right or not, it is not possible to say, particularly since other equilibria involving $Fe(OH)^{2+}$ and $Fe(OH)_2^{+}$ may well be present[2]. What we can say, however, is that the explanation can be accepted without any necessity to question whether the normal laws of chemistry apply to very small numbers (amounts). As such, this is a good example, albeit on a very small scale, of thermodynamics (solubility product) predicting that a reaction is energetically possible, but which does not occur because of unfavourable kinetics (the absence of a suitable nucleation site). Indeed, this could be a useful additional example to include when discussing the importance of both thermodynamics and kinetics in considering whether a reaction will occur.

1. Greaves R 1998 Problems with Small Numbers *U.Chem. Ed*, **2** 63.
2. Hawkes, S J 1998, What should be teach beginners about solubility and solubility products? *J.Chem.Ed.* 70 1179.

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Chemistry beats other branches of science for generating large numbers and small alike (letter from R. Greaves in Issue 2). Some of you may remember Mary Archer's beautiful demonstration of an electrochemical cell on television ("Don't Take Anybody's Word For It"). She made a cell out of a pie dish as one electrode, her gold ring as another electrode and some lemon juice as electrolyte. The question is why her ring doesn't dissolve. The redox potentials for Al^{3+}/Al and Au^{3+}/Au are -1.68 and +1.50 volts respectively. With these three electron changes, the equilibrium constant for the reaction below is 10^{161}, so Mary Archer knows full well that her ring is safe.

$Au^{3+}(aq) + Al(s) \rightleftharpoons Au(s) + Al^{3+}(aq)$

Try giving this problem to your undergraduates and see how many come back thinking they have got the answer wrong because their calculator won't cope.

From Dr P G Nelson, Department of Chemistry, University of Hull, HULL, HU6 7RX

Dr Greaves[1] asks the question of what to say to a perceptive student who works out from the solubility of product of $Fe(OH)_3$ that $1 cm^3$ of a saturated solution contains 1.2 ions of Fe^{3+}, and therefore $0.5 cm^3$ contains either 0 or 1 ion.

The answer is that, according to statistical thermodynamics, equilibrium concentration is a mean quantity over a long period of time (long enough to smooth out fluctuations). Thus $0.5 cm^3$ of a solution that is in equilibrium with solid $Fe(OH)_3$ will sometimes contain no Fe^{3+} ions, sometimes one, occasionally two, and so on, averaging over time 0.6. If the solution is removed from the solid, it ceases to be in equilibrium with it, and will then be either unsaturated or supersaturated, depending on the number of Fe^{3+} ions it happens to contain. What happens next will depend on the numbers of other iron-containing species present (e.g. $FeOH^{2+}$), and on the nature of any surfaces in contact with the solution.

1. Greaves R, *U.Chem.Ed.* 1998 **2** 63.

Reflecting on learning

From Dr Michael Gagan, The Open University in the North West, 70 Manchester Road, MANCHESTER, M21 9UN
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In a recent letter to U.Chem.Ed, Tomlinson[1] refers to the value of students reflecting on their learning experience. Tutors need to do the same, and encouraging them to do this has been part of the strategy of the Open University's staff development programme for its Associate Lecturers for several years. Indeed the term 'reflective practitioner', alongside 'facilitator of learning' has become the hallmark of the effective tutor. This approach is thoroughly expounded in the Supporting Open Learners Reader[2], and some practical suggestions are given in the Open Teaching Toolkit: *How do I know I am doing a good job?*[3]. Reflection is even described as the "core process for effective professional learning.[4]

Both these texts[2,3] recognise that tutors need not only to be effective practitioners themselves, but also to encourage their students to develop the habit of reflection on learning. The justification is that "students become more aware of how they learn, and thus enable themselves to be more proactive in managing their own study strategies," [5]. There is some evidence that students gain from this: an Open University tutor on an organic chemistry course, writing to an Examination Board, says that she sends out letters "asking students to reflect on their work and to share their insights with me."[6]. She continues: "Among my students this has been productive", although she adds "even if many of their responses are just at the intuitive level, and do not develop deeper objective thinking." Unfortunately, this is a rare example of even limited success with encouraging reflection.

In a bold experiment in 1998, the new science foundation course, *S103: Discovering science*, included short, assessed (but low scoring) questions asking students to reflect on their study and learning strategies. These questions led students to explore in a structured way how they interacted with the course materials - both successfully and unsuccessfully, and how they set about answering the questions in their assignments. They were asked, for example, to analyse and describe skills used in a particular task, like interpreting graphs; how they had formulated an answer plan, and whether they had adhered to it; if they had developed a problem solving strategy, and whether it had proved effective for a particular problem they had encountered; and which parts of a question they thought they had answered well (or not so well), and why. These questions were not set in isolation, but within the context of a detailed *Study File*, which also gave them structured opportunities to practice reflection.

These questions met with a variety of responses from students, most of which were negative. Students felt puzzled, scared, worried, bored, and affronted by them. Many students considered them a waste of time, and a large number either simply did not attempt them, or returned fairly banal answers. This suggests that they were also disregarding the similar exercises set in the *Study File*. So it would appear that providing students with encouragement and opportunities to reflect on their learning[6] is not enough. Tutors also need to convince them that spending time and effort on reflection is worthwhile.

1. Tomlinson J 1998 Reflecting on learning, *U. Chem. Ed.* **2** 35
2. *Supporting Open Learners Reader*, Open University 1996, Chapter 7.
3. *Open Teaching Toolkit: How do I know I am doing a good job?* Open University 1997
4. Reference 1, p.102
5. Reference 1, p.101
6. Wood H, *S246: Organic chemistry*, Tutor Monitor's report to the Examination Board, November 1998

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It was interesting to read the letter by Jane Tomlinson in the recent issue of U.Chem Ed[1] about reflecting on learning. In the course of teaching to which she refers, an FDTL project being developed here at UEA on 'Personal and Professional Skills for Scientists', we have made reflection about learning a central feature of the teaching. The course will eventually contain ten units of teaching, comprising about forty individual learning activities. Almost all of these activities are concerned with teaching students how to conduct themselves productively when working on problems in small group situations.

We quickly found that most students are not aware of how and why they act as they do in the social contexts of group activities. For example, laddish behaviours appropriate to the pub or to the coffee bar were evident, and do not work in serious groups. Some students became seriously confused and could not understand where they were going wrong. When we started researching our teaching, it quickly became clear that the skills of working closely with other people - talking, listening, negotiating points of view, leading and being lead, supporting, accepting group responsibility *etc.* - are not practised very much, if at all, in conventional teaching and learning situations in most HE courses. It was also clear that students would not learn the skills required without practising them and being given guidance and feedback on what they were doing and how well they were doing it.

Common sense and Educational Psychology both suggest that social skills, like other skills, are learned through repeated practice with feedback. They also suggest that this learning cycle will be speeded up if the learners have explicit knowledge which they can use to consider and change what they do, according to how successful it has been. This is where reflection plays such a key role. If we were able to instruct the students in types of behaviour which were productive - good talking and listening skills for example which are crucial to good group work - then the students can very quickly recognise these behaviours in themselves and in others and, on reflection, make adjustments and improve themselves. This is the guiding principle behind our use of reflection in our teaching activities. However, reflection by itself is not enough. Clearly, the learner must have a serious need to learn and without this the reflection becomes gratuitous, and students will quickly tell you so. It is not enough just to get the students to consider what they did and how they did it. An improvement in the skill must be rewarding in some way or other. In our course, the students assess each other very seriously - the skill of assessing colleagues, and accepting assessment from colleagues, is one of the things to be learned in the course - and unless an individual student gets the grades from his/her colleagues, they will do badly on the course and could fail. This focuses minds wonderfully and actually works very well. But this can only be done when the students have a framework for reflecting on how well they, and others, have worked. It also requires a great deal of confidence in colleagues, something which is also very important in group work, which some students find it very difficult to learn.

So, we have found that reflection on how things have gone, together with a clear framework of ideas with which to consider behaviours and events, and positive reason and purpose for changing and improving a skill has worked very well in the course we have put together. Perhaps other science skills (practical work, project work *etc.*) could be improved in the same way.

1. TomlinsonJ, 1998, Reflecting on learning. *U.Chem.Ed.* **2** 35.

Assessment of CIT courses

From Dr R B Moyes, Department of Chemistry, University of Hull

I was grateful for the sight of the paper by Murphy, Hursthouse and Stickland[1] and an opportunity to contribute to the debate on assessment of computer skills. The lack of such assessment was criticised in the *HEFCE* assessment of teaching in the 1993/4 series, and was commented on in the Overview Report[2] with the comment. Institutions emphasize the importance of acquiring general or transferable skills in addition to subject specialist skills, although it is rare to find transferable skills being assessed. It is clear that the aims of inculcating specialist and transferable skills are being achieved, but with varying success.

These skills include Computing and Information Technology (CIT). Most universities have courses to familiarise students with the local network and computer facilities, but there are substantial difficulties in bending this teaching to acceptable assessment. The problems include:

- the heterogeneity of CIT experience in the intake;
- the rate of change in software and hardware;
- the range of software available and its match to the university's provision;
- the wide range of mathematical and communication skills;
- student and staff unwillingness to recognise the value of chemistry-related CIT skills;
- staff unwillingness to 'dilute' chemistry teaching by spending time on skills development;
- lack of agreed objectives for the module;
- assignments which encourage plagiarism;
- reliability difficulties of examining using computers.

All of these make fair assessment difficult. In the 1994 Variety in Chemistry Teaching conference I suggested aims for a CIT course and produced a 'wish list' for its content, most of which is still relevant, in spite of the speed of change in this area[3].

At Hull, Chemistry students take a 10 credit (100 study-hour) module in CIT during the first or second year. Its aims are:

- To make students competent in the use of computers at a level appropriate to the graduate.
- To make students capable of using computers to enhance their learning.
- We interpret these aims in the following competence objectives (which are similar to those of Murphy et al):
- use of the university network, Windows 3.1, e-mail and the Internet;
- use of MS Word and the associated Equation Editor;

- use of Isis Draw;
- use of the Excel spreadsheet for handling data, graphical representations, templating and mathematical modelling;
- more specifically, use of the Excel statistics functions to deal with chemistry-related problems;
- use of databases, CD roms, and external reference sources.

The current work schedule is available (4), but it is updated annually to deal with local and general changes. At the beginning of the module, students are told that they have to complete a 'project'[4] which counts as 70% of the module mark. The topic must be different for each student, so that straightforward copying is not possible.

The 'practical' sessions allow students to consult demonstrators and each other. Independent working to suit student experience and ability is achieved by setting a series of exercises which are held on the Network server, and which can be tackled at their own pace. The exercises require students to enter data accurately, but demonstrate that data sets can be loaded more accurately than entering by hand.

There is a problem with setting a fair assessment in CIT early in the course because of the variable backgrounds of students. Schools and colleges now have extensive CIT facilities and the Dearing II (16 to 19) report underlined the need for CIT as part of the A level syllabus[5]. The new Chemistry syllabus includes statements to that effect. Thus most 18 year olds now have a grasp of CIT, although is does not usually extend to working with a network. Mature students often have difficulties in the beginning but more easily recognise the importance of key skills. Because of these variable student backgrounds, in the early stages of the course we correct word-processing and spreadsheet assignments (often sent by e-mail) as formative assessment, but record no marks.

Assessment of the Excel part of the module takes the form of a one-hour test of statistics and data handling. The time constraint requires students to be familiar with the computers as hand calculation is much slower and data sets can be downloaded from the server into Excel rather than entered by hand. This measures the level of competence to a large degree. The formal examination conditions require individual effort.

Assessment of 50 or more different projects is a large task, and the university's requirement that no module assessment was to be in the hands of a single member of staff raises further difficulties. Until recently this involved averaging with the mark of a colleague, but an alternative approach based on Murray's work[6] has proved highly successful. Briefly the class is divided into small groups who each mark the (anonymised) projects to a given marking scheme. The group then compare their marks and reach a second, joint conclusion. The mark is then moderated with a staff mark to ensure consistency. This has the advantage of demonstrating the ideas of standards, marking schemes, and the wide range of competence which has to be assessed. Student response has been encouraging; they have suggested a separate exercise on earlier projects should be undertaken earlier in the course.

References:

1. Murphy B, Hursthouse M, Stickland, R 1999 The idea of a closed book IT examination: a novel approach to assessing chemistry specific information technology, *U.Chem.Ed.* **3** 8
2. HEFCE, Bristol 1994, Subject Overview Report – Chemistry. http://222.niss.ac.uk/education/hefce/pubs95/00 2 95.html
3. Moyes, R, 1994, Giving Students what they want from computers, Proceedings, Variety in Chemistry Teaching (ed Garratt J and Overton T). (Royal Society of Chemistry.)
4. http://science.ntu.ac.uk/chph/improve/improve.html
5. Dearing R, Review of Qualifications for 16-19 year olds, COM/96/459, SCAA Publications, Hayes Middx. 1996
6. Murray R, 1998, How to mark 100 essays in 2 hours, Proceedings, Variety in Chemistry Teaching (ed Garratt J and Overton T). (Royal Society of Chemistry.)