Customising and Networking Multimedia Resources

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Letters

The article by George McKelvy, 'Preparing for the chemistry laboratory: an Internet presentation and assessment tool'[1], which describes networking multimedia images and resources at the Georgia Institute of Technology, prompts the question "Is such practice common in the UK and Europe?"

The short answer is 'no'. The UK is, however, at the forefront of such developments through the CTI Centre for Chemistry, the 'Teaching and Learning Technology Programme' (HEFCE TLTP), the 'Funds for the Development of Teaching' (HEFCE FDTL) projects and Government initiatives to provide computers for schools and colleges, as described in the SOCRATES Open and Distance Learning Report.[2] However, even in the UK few universities have attempted schemes as ambitious as that described for Georgia. The prime reasons for this would seem to be lack of time and resources. This raises the question "How can such obstacles be overcome?"

To create the resources the choice is either making one's own or obtaining, customising and networking images and materials. The latter requires the consent of the Copyright owner. For this reason Georgia Institute of Technology, which has very large freshman classes, could afford to make its own materials. This is an expensive option. For example it cost £500,000 to make the video images for the "Basic Laboratory Chemistry" laser video discs and VHS tapes and £40,000 to customise them with interactive materials for the series of CD ROMs: "Practical Laboratory Chemistry" (http://www.emf-v.com). In favour of the other route is that most publishers and copyright holders of images, e.g. the "Chemistry Images" database (http://www.rsc.org/is/cvc/chem_img.htm), are amenable to requests to customise and network materials within an institution, provided that such an institution purchases a copy of the materials, does not 'export' them to other institutions and that a modest licensing agreement is signed. This makes the customising route much cheaper and saves "re-inventing wheels" but the costs cannot be recouped by selling on the materials.

Customising existing materials is not as difficult as it is often imagined, but ensuring quality is at the heart of producing worthwhile resources. For example compression of video images is best achieved if high quality sources are used (Betacam), good quality software and hardware for capture and compression is used (MPEG), and the compression is not severe but tailored to deliver high quality images and sound. Such images, when captured and digitised, can be stored as files on the hard drive of a PC and incorporated into learning, teaching, and training packages, together with text and animations using a number of design and management packages, e.g. Toolbook and Macromedia Director. Some examples of what is possible will be published in 2001. These may involve compiling a set of images for a specific course from a variety of sources onto a CD ROM, adding subtitles for students with learning difficulties, changing the level of content, e.g. the CD ROMs on '*Practical Chemistry for Schools and Colleges*' (published in 2000) which, in turn, were derived from the '*Practical Laboratory Chemistry*' CD ROMs, and adding extra content as in the series '*Physical Chemistry Experiments*'. Adding subtitles and adapting voice-overs can be applied to produce materials in other languages for scientific and language learning purposes, e.g. a French/English version of '*Practical Laboratory Chemistry*' will be published in 2001.

To maximise availability, networking within an institution is possible. This is a process, which depends on the compatibility of the networking software and the software of the multimedia resource to be networked. Such is the variety of combinations that designing a totally generic package is a daunting task. For this reason most CD ROMs are specified as 'For single user, stand-alone computers'. What is possible, however, is that the video component can be delivered as 'streaming video'[3] to any point within the 'firewall' of an institution, using a dedicated server. Having obtained the video on a server, this can be mixed with learning, teaching and training to produce resources specific to the needs of a particular institution. The use of an internal server ensures that the material remains within the 'firewall' and the copyright conditions set by producers and publishers are met.

The way is open, therefore, for expansion of the use of multimedia materials for learning, teaching and training. This will become crucial in the future because students will increasingly be able to download the resources they need to their own PCs from central network servers.

References

1. G. McKelvy, *U.Chem.Ed.*, 2000, **4**, 46.
2. *Multimedia Resources for Chemistry in Europe*, http://mrc.chem.tue.nl
3. J. Smith, *Viewfinder*, 2000, (40), 12, see also http://webhelp.ucs.ed.ac.uk/services/media/bufvc.html. W. Garrison, *Viewfinder*, 2000, (41), 13. ["Viewfinder" is the magazine of the British Universities Film and Video Council (BUVFC) and is published four times each

year. It is designated by its issue number. See also http://www.bufvc.ac.uk]

On the need to use the Gibbs' phase rule in the treatment of heterogeneous chemical equilibria

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Misconceptions are well known to be serious barriers to effective learning. Unfortunately it is not just students who have misconceptions. In a recent paper[1] Thomas and Schwenz investigated third and fourth year students' conceptions of equilibrium and fundamental thermodynamics by means of interviews concerning various aspects of a heterogeneous equilibrium. They considered a system at constant temperature and pressure (T: not specified; p = 1 atm). The initial system consisted of $CaCO_3$ and CO_2 only and the students were asked to consider its evolution to the equilibrium system comprising $CaCO_3$, CaO and CO_2. Thomas and Schwentz assumed that the volume of the gas phase at equilibrium would be nearly double that of the initial state, as shown in Figure 1 of their paper.

The behaviour of the system is most easily understood from the Gibbs Phase Rule. The equilibrium state has only two independent components (C), in consequence of the equilibrium condition on the chemical potentials:

$$\mu CaCO_3 = \mu CaO + \mu CO_2$$

Application of the phase rule:

$$F = C - P + 2$$

with C = 2 and the number of phases, P = 3, shows that there is only one degree of freedom, F. Thus if the pressure is fixed experimentally (as Thomas and Schwentz do: p = 1 atm) the equilibrium temperature is fixed (by inference) at 898.6°C. From a purely thermodynamic point of view, this equilibrium does not differ from the equilibrium between a pure solid and its vapour.

Since pressure and temperature are constant, it follows from the above that, provided the values of the physical variables p and T are compatible with equilibrium, then equilibrium is reached as soon as the very first crystals of calcium oxide have formed, namely, before the amount of additional carbon dioxide is enough to show any appreciable volume increase. So, the process is not "*a real spontaneous change*" as stated by Thomas and Schwenz.

It is interesting to consider what would happen if the temperature were above 898.6°C, but we have to define the experimental conditions carefully. Suppose the pressure is imposed on the $CaCO_3$ and CO_2 by a piston. The pressure imposed by the piston is 1 atm. At the higher temperature, the equilibrium pressure of CO_2 is above 1 atm, so that $CaCO_3$ decomposes to generate more CO_2 in an attempt to increase its pressure to the new equilibrium value. However, the piston moves back to maintain a pressure of 1 atm, until all of the $CaCO_3$ is converted into CaO and CO_2. Under these conditions, i.e. with an imposed external pressure, $CaCO_3$ has a fixed temperature of decomposition, (898.6°C, at 1 atm) analogous to the boiling point of a liquid.

Nearly half of the interviewees correctly asserted that 'if the temperature were high enough or the pressure low enough, all the $CaCO_3$ would be consumed'. This statement was classified by Thomas and Schwentz as an 'alternative conception' falling into the category 'Using informal prior knowledge from everyday experience to explain the thermodynamics of chemical phenomena'. In other words, they judged that the students had given the wrong answer.

This example shows that, when dealing with heterogeneous equilibria, the first thing to be done is to apply the phase rule. It is simple, powerful and also aesthetically satisfying. It is a pity that it appears so rarely in papers on the teaching of thermodynamics, especially when it can be a key to understanding the system under consideration.

Reference

1. P.L. Thomas and R.W. Schwenz, *Journal of Research in Science Teaching*, 1998, **35,** 1151.

Note Professors Schwenz and Thomas were offered an opportunity to comment, but declined to take it.

Questionable questions

From John Garratt
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I enjoyed reading Byers' Communication on 'using questions to promote active learning in lectures',[1] and am sorry he was disappointed in the results. I hope that others will be encouraged by his report to try something similar and that he perseveres with his own suggestions for improvements. I have two comments that may help to explain why the students participated less actively than he hoped. One relates to habit, and the other to the need for absolute clarity.

Byers introduced his questions in a sequence of twelve lectures attended by 46 students in the final year of their undergraduate course. Compare this with Hutchinson, who refers to a greater level of participation in classes of up to 300 students.[2] Significantly, his class is held in the first year, and it runs at the rate of three lectures a week for 15 weeks, during which time it is the students' only exposure to chemistry. Thus Hutchinson's students quickly become accustomed to the idea that learning chemistry at university involves active participation. In contrast, Byers' final year students have already discovered that learning chemistry at university involves sitting passively in lectures and swatting up the notes just before the exam. They would be more likely to respond to questions in class if the practice of asking them were introduced in the first term, and systematically adopted by all members of staff.

My second point relates to the need for clarity. Students respond much better to questions when they are confident that they know what the question means and what sort of answer is appropriate. That is why, in our book,[3] most of our questions involve giving reasons for selecting one answer from the several we provide. This strategy gives the students clear and useful signposts and seems to help them to get involved quickly. Byers might find this a useful model to use, at least while the students are getting accustomed to the idea of participating in lectures. Also, he might find that students respond better if they are given a moment to discuss the question and its answer with their neighbours. Whether or not he likes these suggestions, I recommend that, before he asks a question in class, he writes down a model answer in the number of words (perhaps 20 or less) he expects from the students in a lecture and which shows the depth of thinking it is reasonable to expect. If he can't do this, then it is unreasonable to expect the students to provide an answer. Take the question "why is lead not an essential element?"; the answer "because it is toxic" is little more than a restatement of the question, and in that sense indicates shallow thinking (as Byers agrees). In fact the real problem lies with the question since the answer cannot be known, nor can it be investigated by observation or by experiment because it lies in evolutionary history. The best we might be able to do is to suggest chemical reasons why lead is incompatible with life as we know it; the question could easily be rephrased to make it clear that this is the desired response. A different style of answer would be something like "life may have evolved in an environment in which no lead was available, and so there was no opportunity to develop a use for it." But few students are likely to be in a position to adopt that train of thought, given that most of them are ignorant of the fundamental principles of life processes and of evolution. I confess to having fallen many times into the trap of asking questions that are ambiguous or require more thought than can be expected in the middle of a class. I also admit that, when I try to provide written model answers, it often takes me many attempts and usually forces me to rewrite the question. It is a salutary lesson and brings home the value of the exercise. Finally, I would like to stress the need for chemists, when asking questions about life processes, to do so from a position of secure knowledge of biochemistry and of evolution.

References

1. W. Byers, *U.Chem.Ed.*, 2001, **5**, 24.
2. J.S. Hutchinson, *U.Chem.Ed.,* 2000, **4,** 1.
3. J. Garratt, T. Overton and T. Threlfall, *A question of chemistry. Creative problems for critical thinkers,* Longman, 1999