

Sidney F.A. KETTLE
University of East Anglia, School of Chemical Sciences

WHITHER CHEMICAL EDUCATION? A PERSONAL VIEW

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ABSTRACT: It is argued that the needs of Chemistry require that Chemical Education assumes a more central role in the subject. Fewer and fewer of the students entering the subject are 'caught' by it. Just 'teaching' Chemistry is not enough, we need to see the problems that it poses for the students, not just in terms of the subject itself but also in terms of the social and psychological backgrounds of the students. The example of size constancy, which produces culture-dependent problems, is given. [*Chem. Educ. Res. Pract. Eur.*: 2001, 2, 5-8]

KEYWORDS: *chemical education; student problems; psychological factors; size constancy*

INTRODUCTION

It is not difficult to argue that Chemistry is currently either in a state of decline or of dramatic change - or perhaps both. One sees falling student enrolments in many countries⁰, perhaps followed by the loss of space within a building and even the closure of departments; the enactment of health and safety legislation¹, which has had a real impact on practical courses and also on the conduct of research; and, last but not least, the impact of the computer. In some labs, computers are more common than are test-tubes. Each wave of computer development means that more properties of more molecules are as easy to calculate - and perhaps easier - than to measure. And safer and perhaps offering more insights, too²! Restrictions on practical work have led to a proposal to make 'dangerous' demonstrations available on videotape/videodisc, a proposal which rapidly became embraced in a project to make a wider range of materials available in these media³. Yet, in a way, we can take comfort in this turmoil in the subject. A subject area that does not change is an inanimate object; historical, not dynamic and living. But what of Chemical Education? One thing is clear; as student numbers fall (and, whisper it gently, for it is more often said in private than admitted in public, average student aptitude and/or interest falls too), Chemical Education surely becomes more important. But does it, too, need to change to adapt to the emerging situation? And, if so, how? If it is not a dead subject then, following the above argument, it indeed must evolve. As to the direction of this evolution, the following represents the author's thoughts on this topic. They are personal, prejudiced, and in no way more than a contribution to the debate.

DISCUSSION

Not for the first time, it is necessary to recognise two aspects of Chemical Education. First, the physical acts involved in the education of chemists. Second, the study of the, seldom explicit, background to this education. The logistics/psychology behind the choice of information/experience sequences; the recognition of student expectation and motivation and their expression/exploitation in course content. The first of these two is the easy one. The changes in the physical act of educating chemists are in some measure determined by the technology and the market place. Increasingly, the large-volume text-books are accompanied by CD-ROMS (although the extent to which these are a real benefit and not just a 'we must keep up with the competition' response seems rather variable. They commonly make the assumption that a student is prepared to commit more time to the subject area than may be the case - not all CD-ROMs enhance the subject in the eyes of the student). The impact of technology has had its down-side, too. So, a series of audiotapes, with wide-ranging content, many of which are of real current relevance, has just come to an end⁴. Apparently, the victim of a progress which means that it is to look old-fashioned to present students with an audiotape; they need the visual too. Although the production of a home-made videotape is relatively inexpensive, the production of a CD-ROM - the logical extension of the RSC audiotape philosophy - is prohibitively expensive, although even this could change. In the lab, students spend more time at the computer keyboard and less shaking test-tubes (although, in honesty, different labs are usually involved). Which activity is the more likely to get the student more hooked on chemistry? One can argue in either direction and, in my opinion, it is in such arguments that the deeper aspect of Chemical Education, the logistics/psychology behind the choice of information/experience sequences - and their mode of presentation - together with the recognition of student expectation and motivation, becomes important. It is to this area that I now turn.

It can be argued that Chemical Education has always held a back seat in the subject. That it has more observed and offered guidance than held a key place in the way that the subject has been taught. Certainly, if one looks at the contemporary journal literature on Chemical Education this is the impression that it gives. The presentation of snapshots of part of the subject that could as well, and perhaps do, appear in a textbook or lab manual. A description of the author's, often well justified, pleasure in the success in a new teaching innovation. In greater breadth, surveys of teacher's and/or student's expectations of the subject for the future. But is this a set pattern, or can there be more? I would like to argue that the current crisis in chemistry calls for Chemical Education to move more towards the centre stage. That that which is past can be seen as preparation, background, for that which is to come. That if students can no longer, so often, be hooked on chemistry by the colours, stinks and bangs that a former generation produced in the garden shed - and perhaps have no wish to play with chemicals anyway - then a substitute has to be found. And that this substitute has to emerge from the subject of Chemical Education. A twin approach, in my opinion. Exciting teaching and a better in-depth insight into student understanding, learning and difficulties. Exciting teaching cannot be separated from the teacher - but even the best teacher can be helped, stimulated. And the more run-of-the-mill teacher also can be helped and stimulated. I may note, parenthetically, that often the resources for this are closer at hand than is realised. Teaching is all too often a private activity. Shut the door and it is you and the students. In fact, all the departmental colleagues share the same problems, rather closely, and for

obvious reasons. Communication is the key; the solutions found by one, the simple but effective techniques adopted by another, become a resource for all. Perhaps we need to move more towards team teaching, at all levels. But I digress. Whither Chemical Education?

THE FUTURE?

To become more important, more central, more relevant to contemporary problems, more essential, I believe that Chemical Education has to become a much deeper subject. That it, almost, has to throw away the 'Chemical' in its title - and perhaps treat the 'Education' bit somewhat contemptuously also. To start with the psychological and social conditions that surround an individual and which affect their outlook on the world, the way that they make choices and the way that they learn. To start with such a basis (which, of course, is not written in tablets of stone; it is there to be discovered, assessed) and to apply it in a specific field, that of Chemical Education. I can claim no expertise or special insights but I can offer an example, one which leads me to believe that there is much more out there, of real relevance, which is waiting to be recognised and applied to the subject. My example is that of size constancy⁵. To those to whom the name is new I suggest a simple experiment. Extend both arms straight ahead, the palms of the hands forward, the fingers pointing upwards. Look from one hand to the other. Not surprisingly, the hands are the same size. Now, bend one arm so that one hand is at half its previous distance away. Again, look from one hand to the other. They are still, essentially, the same size, although simple geometry tells us that one should be twice the size of the other. This is the phenomenon of size constancy. We do not see in perspective; our brains modify the message coming from the signals that our eyes produce. I first discovered this as a problem in Chemistry when I was teaching in Nigeria, although it occurs in the developed world as well. The students started laughing at the drawings of carefully perspective octahedra that I drew on the blackboard. They were incomprehensible. There was nothing for it but to stop; a period had to be spent making and studying paper cubes (easier to make than octahedra and simpler to study too). I later learnt that the first year physics course started with an obligatory course in which the students were introduced to the (perspective) drawing of simple geometric figures. A background with few railway lines converging at infinity, few straight roads and houses that were as round as straight gave little insight into the conventions of the drawings of a different world. And the diagrams in textbooks of apparently simple things like the structure of molecules, of optical isomers, of crystal structures contained a convention of which they had no real awareness. Suddenly, I saw a reason why so often it was Europeans who had charge of the new building and its plans; of the books giving exploded diagrams of the way that a car engine is put together. And why students, in all countries, find some diagrams in textbooks so difficult to understand. Hidden assumptions in our teaching which may not be valid. Of course, this sort of problem may not affect all of our students - but, if the first paragraph of this article is anywhere near the truth, it is likely to affect an increasing proportion. What to do? Well, in this particular case, it might be a good idea to build up relevant diagrams step by step, rather than make the assumption that the student will recognise what has been going on behind the scenes. Would this work? I have no idea - but it might be a task of a reoriented Chemical Education to try to find out. And to compare it with alternatives. Equally, it could mean making an alternative expository path available to the readers of textbooks. Such paths are of the essence of computer-based instruction; perhaps Chemical Education could have something to offer those who generate such packages. Something better than self-guided instinct. Of course, all of this may well have been recognised

and thoroughly studied long ago. In which case, I apologise for my ignorance. But if it has not, it needs to be.

I have given but one example, although I am sure that more exist. In a, hopefully not totally fantasy, world one can see one future aspect of Chemical Education as being that of identifying such psychological/social 'block' areas and then turning to addressing them within the subject context. If Chemistry were to become a vehicle through which individuals could overcome such handicaps it would surely be good for the individuals and, I would hazard, for the subject of Chemistry too.

Sidney F.A. Kettle is a Professorial Fellow in the *School of Chemical Sciences* of the *University of East Anglia (UEA)*. He has published over 200 papers, mostly on spectroscopy and related areas. He is currently Editor of *Spectrochimica Acta A*. He is the author of (1) '*Valency Theory*' (with John Murrell and John Tedder), (2) '*The Chemical Bond*' with the same co-authors, (3) '*Coordination Compounds*', (4) *Symmetry and Structure*, and (5) *Physical Inorganic Chemistry*. He has also published numerous articles in the *Journal of Chemical Education*, mainly on group theory and its applications to chemistry, and has been involved in staff development work in many countries.

NOTES AND REFERENCES

⁰ As far as I have been able to establish this is a problem everywhere except, perhaps, in the Pacific basin.

¹ E. Albone, *Chemistry in Britain* (April, 1999), 53.

² See, for example, 'Theoretical Spectroscopy: State of the Science' Lee, T.J. & M Head-Gordon, M. (Eds.) in *Spectrochimica Acta A*, 55, 431-747.

³ A.J. Rest, personal communication. More information on these materials, which are varied, extensive and well developed, can be obtained from Dr. A.J. Rest, University of Southampton (A.J.Rest@soton.ac.uk).

⁴ The 'Chemistry Cassette' series of the Education Techniques Group Trust of the Royal Society of Chemistry, London. At the time of writing, some remainder copies still exist.

⁵ R.L. Gregory, '*Eye and Brain*' Weidenfeld and Nicolson, London 1972, p. 151.