Chemistry Education Research and Practice

RSCPublishing

EDITORIAL

View Article Online
View Journal | View Issue

The application of technology to enhance chemistry education

Cite this: *Chem. Educ. Res. Pract.*, 2013, **14**, 227

Michael K. Seery and Claire McDonnell

DOI: 10.1039/c3rp90006a

www.rsc.org/cerp

Technology is accepted to be an integral part of chemistry education, with the use of videos, simulations, and student response systems well reported. The first issue of *University Chemistry Education*—one of this journal's two predecessors—was published in 1997, and it contained several articles on topics that still provoke thought and research today, and many of the topics in this themed issue are directly related to issues raised in those articles.

Alex Johnstone's article in that issue '*. . . And some fell on good ground*' discusses the role of prior knowledge and cognitive load in chemistry education (Johnstone, 1997). Cognitive load theory (CLT) is now of central importance in considering technology in education, with the work of Sweller (2008) and Mayer (2005) providing a basis for considering how technology can help alleviate the load for novice learners as they engage with new material. Several contributions to this special issue resonate with the theme of cognitive load. Behmke and Atwood consider the design of online homework from a CLT perspective, by facilitating students' mastery of the stages of answering online questions in a step-wise manner. Rosenthal and Sanger contribute further to their work on online simulations. Drawing on Mayer's work on the design of e-resources, they study the sequencing of the complexity of animations and find that viewing simpler simulations before more complex ones leads to students being better able to explain what they are observing. This may be attributed to the reduction in the extraneous load of viewing the more complex animation that the simple animation provides.

John Garratt's article in the first issue of *University Chemistry Education* was also about simulations. In "*Virtual Investigations*", he argues that "fact-making" by students can be enabled by simulations where students learn by experience rather than by being taught (Garratt, 1997). In this themed issue, Akaygun and Jones present a detailed study on the process of simulation design in the context of cognitive science, using liquid–vapour equilibrium as an example. In research that is again grounded in the concept of working memory, Avramiotis and Tsaparlis examine whether computer simulations assist students' problem solving ability in the laboratory, and find that students who use simulations record a higher achievement. Similarly, Moore, Herzog and Perkins demonstrate in their study that the use of interactive simulations provides implicit scaffolding to students in guided inquiry activities. Sesen uses videos to allow students to compare their predictions with observations of events relating to surface tension, cohesion, and adhesion forces and to subsequently develop explanations for what they observe. Krause, Kienast, Witteck, and Eilks describe an online environment for students to develop their own understanding of topics at lower secondary level before progressing to upper secondary level.

Several papers in that first issue of *University Chemistry Education* address transferable skills. For example Tina Overton's article, "*Creating Critical Chemists*", argues for the need to move beyond the teaching of a series of facts towards allowing students freedom to discuss and develop their own opinions, and with this the critical thinking skills needed for genuine problem solving, especially important in a professional context (Overton, 1997). Ryan's work, reported in this issue, on facilitating peer learning demonstrates the ability of this technology to enable student debate and student-centred discussion when addressing chemistry problems. Blonder *et al.* write about the development of content knowledge, technological knowledge and pedagogical knowledge as well as technological pedagogical content knowledge (TPACK) among a cohort of teachers. They achieve this by using a professional development programme to develop video editing skills in the context of chemistry topics the teachers wanted to teach for a given pedagogic purpose. Development of TPACK also features in the work of Shwartz and Katchevitch who describe the use of a wiki learning environment in a professional development

School of Chemical and Pharmaceutical Sciences, Dublin Institute of Technology, Kevin Street, Dublin 8, Ireland. E-mail: michael.seery@dit.ie, claire.mcdonnell@dit.ie

programme for teacher leaders. This approach is shown to result in the development of a functioning collaborative team and there is some evidence that increased participation in the wiki correlates with having a more learner-centred perspective on teaching.

A theme that has emerged as a result of technological developments is that information and expert explanations on particular topics are now more widely available. The teacher is no longer in a position as sole knowledge expert and in some circumstances it may be appropriate to become co-learners with their students (Bain, 2004). This topic also featured in the first issue of *Chemistry Education: Research and Practice in Europe*—the other predecessor to this journal—in an article that discusses the need for teachers as well as students to be engaged in lifelong learning (Goodwin, 2000). The teaching role may encompass engaging students actively in learning, facilitating group collaboration and supporting self-regulated learning. Technology can often provide an effective means to achieve this. McWilliam (2009) discusses the concept of the teacher as a ''meddler-in-the-middle'', challenging students to think and understand differently by means of a learning partnership. She also recognises that the learner engagement and challenge required is often achieved using technology.

Technology in chemistry education has not always been well received – a 2008 student survey by the Higher Education Academy in the UK found that ''e-learning'' was ranked lowest of all teaching methods by students for both use and enjoyment. Reeves and Reeves (2012) suggest that this unpopularity may be to do with some implementations that involve poor design or poor alignment of the technology to the learning objectives. The articles in this issue demonstrate that technology does have a place in our teaching, but awareness of where it is appropriate and can enrich what is already done is needed. Benefits of effective incorporation include making available clear explanations as well as opportunities to practice skills and knowledge and to obtain feedback immediately (Reeves and Reeves, 2012). In addition, multimedia resources can be utilised to provide learners with cognitive scaffolding and, once an appropriate design and effective facilitation are in place, tools such as wikis and discussion boards can enhance communication and collaboration between learners. The studies reported in this issue show ample awareness of the pedagogical effectiveness of the particular technologies employed as well as careful design of the learning environment. Thus, the technology is not intended as a replacement for good teaching practice but as a means to enhance and support it.

The emerging ''flipped lecture'' or ''inverted classroom'' model, grounded in CLT, may be gaining popularity because it provides a template for when and how we should use technology in our teaching to best facilitate learning—what supports are needed before, during and after teaching. The articles within this issue contribute to this knowledge by adding to the literature on CLT as an effective basis for incorporating technology into our teaching, by further exploring the effectiveness of simulations in assisting independent learning, and by incorporating peer learning models into our curricula.

References

Bain K., (2004), *What the Best College Teachers Do*, Cambridge MA: Harvard University Press.

Garratt J., (1997), Virtual investigations: ways to accelerate experience, *Univ. Chem. Educ.*, **1**(1), 19–27.

Goodwin A., (2000), The teaching of chemistry: who is the learner? *Chem. Educ.: Res. Pract. Eur.*, **1**(1), 51–60.

Johnstone A. H., (1997), '...And some fell on good ground', *Univ. Chem. Educ.*, **1**(1), 8–13.

McWilliam E., (2009), Teaching for creativity: from sage to guide to meddler, *Asia Pacific Journal of Education*, **29**(3), 281–293.

Mayer R. E., (2005), Cognitive theory of multimedia learning, in Mayer R. E. (ed.), *Cambridge Handbook of Multimedia Learning*, Cambridge: Cambridge University Press.

Overton T. L., (1997), Creating critical chemists, *Univ. Chem. Educ.*, **1**(1), 28–30.

Reeves T. C. and Reeves P. M., (2012), Designing online and blended learning, in Hunt L. and Chalmers D. (ed.), *University teaching in Focus: A Learning-centred Approach*, Oxford: Routledge.

Sweller J., (2008), Human Cognitive Architecture, in Spector J. M., Merrill M. D., van Merrienboer J. and Driscoll M. P. (ed.), *Handbook of Research on Educational Communications and Technology* (3rd edn), New York: Routledge.

