Research into practice: Progress informed by scholarship

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Abstract

Since 2007 a sequence of teaching innovations have been designed, deployed and evaluated in Chemistry at the University of Southampton. The development and implementation of these innovations was informed by study of the prior literature, while the subsequent evaluation of their impact has contributed to scholarly publications. The success of these innovations, and the profile-raising impact of their dissemination, prompted the funding of a departmental Ph.D studentship to support the transition from evaluative action research to genuine pedagogic research. This has led to the formation of the Southampton Chemical Education Research (SoCER) group, currently comprising two teaching fellows and three active research students. This article documents the different stages of the journey and outlines the role of scholarly activity in enhancing practice and generating research outputs.

Keywords: Scholarship of teaching and learning; technology enhanced learning; video tutorials; formative assessment; school-to-university transition

Prologue

This article presents a whistle-stop tour of a range of teaching developments in chemistry at the University of Southampton over the last eight years. My main goal in writing this article has been to illustrate the impact of scholarly activity on my own professional journey, which has taken me from schoolteacher to professorial fellow over the last nine years. All teaching-focussed academics have their own story and their own journey to follow, but there are some remarkable opportunities available for those willing to grasp the nettle. Engagement with scholarly activity not only supports the enhancement of teaching and learning (see Figure 1), but also provides a mechanism by which teaching-focussed academics can disseminate their work and develop a profile which will enrich their career and enhance their future promotion prospects.

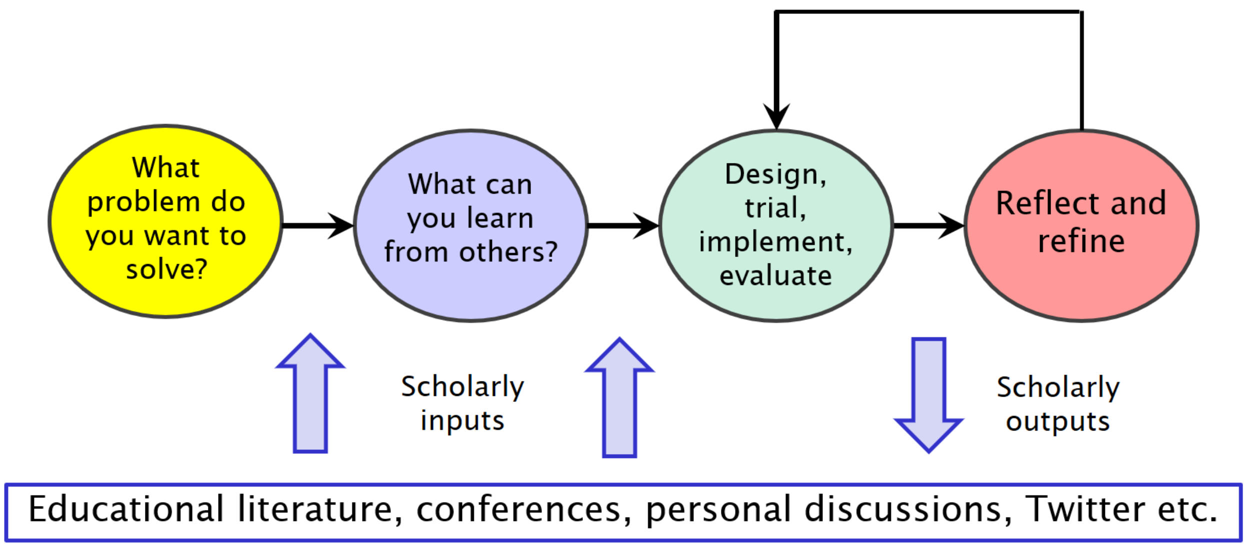

Figure 1: The role scholarly activity at different stages in the design, implementation and evaluation of teaching innovations

Introduction

This article begins with an outline of the background to the creation in 2006/7 of a teaching-focussed academic position in Chemistry at the University of Southampton, providing context for the subsequent review of the activities undertaken since that time. The article then concludes with some reflections on the experience and thoughts on the future for teaching-focussed academics.

Chemistry: Strategically important and vulnerable

In the early years of the millennium, a spate of university chemistry department closures (Savill and Highfield, 2004) and reports of others being under threat (Smith, 2006) prompted the government to recognise the threat to the long-term health of UK chemistry. The problems, which also afflicted other disciplines, were outlined in the final report from HEFCE's 'Strategically Important and Vulnerable Subjects' (SIVS) advisory group (HEFCE, 2005). In order to reverse downward trends in recruitment of students to chemistry, physics, engineering and mathematics, HEFCE provided substantial funding to support initiatives led by the learned societies intended to widen participation and enhance teaching and learning at university level (Royal Society of Chemistry, 2006). The Royal Society of Chemistry's (RSC) 'Chemistry for our Future' (CFOF) programme received £5m of funding between 2006 and 2009, to support a range of initiatives, detailed in a report by the National Foundation for Educational Research

(NFER, 2009). Chemistry at the University of Southampton was a recipient of CFOF funding which supported the creation of a 'School Teacher Fellow' position which was administratively equivalent to 'Senior Teaching Fellow'. The intention was to fill this position with an experienced schoolteacher who would work with academics to provide better support to students making the transition from school-to-university and to support the delivery of the school outreach programme. A key aim was to recruit an individual with experience in the implementation of learning technology in the classroom. In May 2007, the author of this article took up this position, which was supported by CFOF funding until 2009, after which time the post was made permanent.

It should be noted that the concept of School Teacher Fellows in chemistry had already been implemented at the University of Bristol (Shallcross and Harrison, 2007), providing a template for the role at Southampton. During the period 2007-2013, the RSC used funding from CFOF, and its successor the HE STEM programme, to second a number of School Teacher Fellows for a year to work in their local university chemistry department. The aim was to help academics to better understand incoming students, and ensure that teachers were better able to advise students regarding future opportunities (NFER, 2005). The collegiate nature of the CFOF programme led to many opportunities for those involved to share practice, prompting the establishment of a 'College of School Teacher Fellows', led by Bristol, which continues to meet regularly to this day (Shallcross et al., 2014).

Defining a role for the School Teacher Fellow

Staff at Southampton had already carried out preliminary research with first year students to collect their views on potential enhancements. Concerns raised by students were that i) many were unsure of what to expect in the transition-to-university, which was unsettling; ii) the teaching laboratory could be intimidating, particularly to those who had done little practical work at A-level; and iii) lectures were somewhat overwhelming in terms of the amount of content covered and the pace at which it was delivered. Additionally, it was determined that many students lacked confidence in their independent-learning skills, thus compounding issues ii) and iii). The subsequent discussion outlines the role of scholarly activity undertaken by the STF in informing the design of interventions aimed at addressing these issues during the period 2007-2015, and also in the dissemination of the outcomes to the wider community. These issues remain pertinent to this day, and will no doubt continue to exercise those involved in the design and delivery of university curricula for years to come.

Supporting the transition to university

Addressing the issue of students feeling unsettled prior to arrival at university was a key initial area of activity for the STF. With support from a focus group of first year students, a pre-registration 'Welcome website' was created for dissemination to incoming students shortly after confirmation in August. Two students (one male, one female) created pen portraits titled *'A week in the life…'* which helped to provide insight into life as an undergraduate. Additional material including a video virtual tour of the department, information about 1st year curriculum content and a set of frequently asked questions with student-generated answers. A review of A-level content (Read, 2007), highlighted a number of topics which were not covered by all students, and it was felt to be appropriate to provide resources to plug the gaps for those who had not encountered particular material. Inspiration was provided by CFOF partner Graham Currell at the University of the West of England (UWE), who had created a series of videos to support students' learning in mathematics and in organic chemistry with the aim of addressing gaps in pre-university knowledge (Currell, 2007). A number of similar video tutorials were created for the website to help students fill gaps in their A-level knowledge, and sparking extensive work in the production of educational video which has continued to the present day.

Since the RSC had contracted NFER to conduct an evaluation of the CFOF programme (NFER, 2009), it was important that all activities were evaluated. A survey was added to the pre-registration website to support this objective, with numerous positive responses indicating that it had achieved its aims, an exemplar being:

"It has proven to be very useful...I particularly like the 'Week in a Life'. The [FAQs help] to know how much work is expected. The virtual tour is a really detailed introduction to the School. It has helped to increase my confidence about coming to university."

The pre-registration website was updated each year and continued to be deployed until 2012 when it was replaced by alternative provision. The whole exercise proved to be a template for future innovations in that students contributed to the initial design and then to the evaluation, creating a feedback loop which supported the delivery of a high quality and impactful intervention (NFER, 2009).

Supporting the transition to the teaching laboratory

Observations indicated that many students found practical work in university teaching labs to be rather daunting in the first instance. As reported by Carnduff and Reid (2003), chemistry undergraduates “may feel overwhelmed by the amount of information provided and be unable to see the wood for the trees.” From a staff perspective, there are many pressures which impact on the amount of support given to students in the lab, including materials, disposal of chemicals and safety. Reid and Shah (2007) noted that the amount of time students spent on practical work at university level had declined markedly between 1960 and 2000, prompting them to assert that time in the lab should be spent effectively and efficiently. Carnduff and Reid (2003) proposed the use of pre-laboratory exercises to help to maximise the benefits of practical work, since they can “stimulate students to think through the laboratory work, with a mind prepared for what will happen.”

Discussion with colleagues at a CFOF meeting indicated that a system on online pre-laboratory exercises had already been developed at Bath (Mercer-Chalmers et al., 2004), and that there was evidence that these had boosted students’ performance in the laboratory through more effective preparation. This evidence of success at other institutions (see also Shallcross and Harrison, 2008), supported a successful bid for funding from the University of Southampton to develop a package of online pre-laboratory resources to support students in preparing more effectively for laboratory work. Resources were developed with the involvement of laboratory staff, who in the process developed the skills and expertise which has since allowed them to refine and enhance pre-laboratory provision at Southampton. Evaluation of the impact of pre-labs indicated near-universal approval from students in terms of the impact on their confidence in the lab, with demonstrators and staff also reporting favourable outcomes. The success of the Southampton pre-laboratory project was shared with the community, most notably as part of a collaborative project with the Universities of York and Bristol (Read, 2010a; Lowe, 2012), highlighting the fact that benefits come from working together to solve challenging problems.

Supporting the transition to lecture-based learning

To a teacher making the transition from school-to-university, it was clear that there was scope to enhance learning during lectures. Although the stereotypical fifty-minute lecture in which students attempt to copy an incoherent scrawl from a distant blackboard onto 20 sides of A4 paper may have been largely eradicated, the generally passive nature of content delivery has ramifications for student learning. A brief scan of the literature at the time showed that there was a great deal of interest in the development of ‘active learning’ strategies at university level. One influential article from Freeman et al. (2007) provided an illustration of the power of active learning in boosting student performance in introductory biology courses, where extensive use was made of in-class voting technology (clickers). Another example was found in physics education, where Bates et al. (2006) outlined the use clickers to “transform the lecture experience from a one-way transmission of information into a two-way conversation between lecturer and students”. Staff at Southampton had already considered the adoption of clickers, so this seemed to be a reasonable starting point.

Funding was obtained in the summer of 2007 to purchase a set of clickers for use in Chemistry at Southampton, initiating research into the different systems available, which was supported by a review of the strengths and weaknesses of a number of low-cost radio-frequency systems (Barber and Njus, 2007). In view of the fact that an aim of the Southampton project was that academic staff would eventually use the technology independently, it was important that the selected system had the capacity to be used ‘out of the box’. The TurningPoint RF system was chosen on the basis of the compact and lightweight nature of its handsets, and its seamless integration with PowerPoint. Although Barber and Njus (2007) reported that the handsets were not particularly robust, it’s worth noting that all but a handful of the 100 TurningPoint clickers purchased in the first are still in regular use at Southampton today alongside around another 100 which have been purchased in the intervening years.

Having acquired the clickers, the next stage was to incorporate them in teaching in an effective manner, a process which was supported by a number of articles. Beyond the aforementioned work of Bates (2006), Beatty (2004) commented that the technology could be used to “insert occasional audience questions into otherwise traditional lectures, to quiz students for comprehension, or to keep them awake”, but that this was “a waste of the system’s potential.” The point made was that in order to maximise the benefit of the technology, “an instructor must rethink her entire instructional model and the role that class time plays within it”. This grand aim provided a direction for the longer-term implementation of voting technology in lectures at Southampton, which remains a work in progress to this day.

A review of the use of clickers in large classrooms (Caldwell, 2007), with a focus on the underlying pedagogies, provided the evidence needed to convince colleagues that the technology should be trialled in the form of a chemistry quiz deployed during induction at the start of the 2007/8 academic year. Students’ responses highlighted the fact that many were a little rusty on certain A-level topics which underpinned concepts covered in a number of early, and this prompted the rapid development of introductory sessions to provide a bridge to degree-level material by revising relevant A-level content through the use of interactive clicker questions. The success of these early initiatives prompted a number of academic staff to use clickers in their lectures during the 2007/8 academic year with support from the STF. Although colleagues were positive about the use of clickers, there were instances where some were alarmed to discover the extent of the deficiencies in students’ understanding, with the acknowledgement that it was more valuable to be aware of this than not. The response from students continued to be overwhelmingly positive, with only a small number suggesting that they didn’t feel their learning was enhanced (NFER, 2009).

A desire to make better use of clickers prompted further scrutiny of the literature, supported by the timely publication of a review of their use in chemistry classrooms by MacArthur and Jones (2008). This review made a compelling case for the use of the Peer Instruction (PI) method, first developed in the teaching of physics by Mazur (1997), defined as an approach in which “new material is presented in a lecture, followed by the students entering individual answers to a multiple choice question, and then discussing their answers in small groups before selecting answers again as a group.” This had been demonstrated to lead to significant learning gains (Crouch and Mazur, 2001), as measured by using the Force Concept Inventory (Hestenes et al., 1992). Despite the evident benefits, Southampton colleagues felt at the time that it would be difficult to accommodate PI in lectures due to the high volume of content covered and the resulting lack of flexibility in terms of available time. The subsequent use of PI as part of a ‘flipped classroom’ approach, which freed up the time needed, is discussed later. This early work paved the way for clickers to be used in teaching at different levels of the chemistry degree programme at Southampton by a range of academic colleagues who now work independently of the STF.

The use of clickers: wider impacts

A fruitful collaboration began with the University of Reading, a CFOF project partner, where the team were using clickers in similar contexts. Outreach activity provided an initial focus for the collaboration, with clicker questions utilised to add interactivity to outreach presentations in order to emphasise key learning points and gauge student opinion. A light touch evaluation resulted in a joint publication (Niyadurupola and Read, 2008a), in which it was noted that the use of clickers supported the "engagement of all students in a deeper level of thinking, and the ability for the facilitator to give immediate feedback based on student responses", meaning that outreach participants were likely to "leave with a clearer understanding and recall of the message they were intended to receive." The exposure of schoolteachers to clickers during outreach events prompted some to acquire sets for use with pupils, reportedly resulting in positive outcomes for students across the ability range (Read, 2010b). It is also noteworthy that the use of clickers in outreach events still seems to motivate youngsters who have grown up in the era of the smartphone.

In addition to outreach work, the teams in Southampton and Reading collaborated on the evaluation of the impact of the use of clickers in undergraduate lectures, where some evidence of improved performance in summative assessments was collected. This work was presented at the ViCE conference in 2008 (Niyadurupola and Read, 2008b) and was followed by a publication (Page and Read, 2010), raising the profile of the activity and leading to further invitations to give seminars to share the findings with others across the UK.

The role of lecture recordings in supporting learning

Early in the 2009/10 academic year, 5 students studying on the Chemistry with Maths combined honours programme reported dissatisfaction with a timetable clash which meant they would be required to miss a lecture in either maths or chemistry (2 lectures per week). This was deemed to be unfair on the students, prompting a programme of lecture recording in which screen capture of PowerPoint content was combined with a video stream showing the lecturer in action to provide students with the most authentic lecture experience possible (Figure 2). This presented quite a challenge logistically, since several hours' work were needed to film, edit and process the recordings, a burden which was initially shouldered by the STF. Shortly afterwards, a BSc project student was allocated to work on lecture capture as a third year educational project, and the student involved took on this work for the remainder of the year.

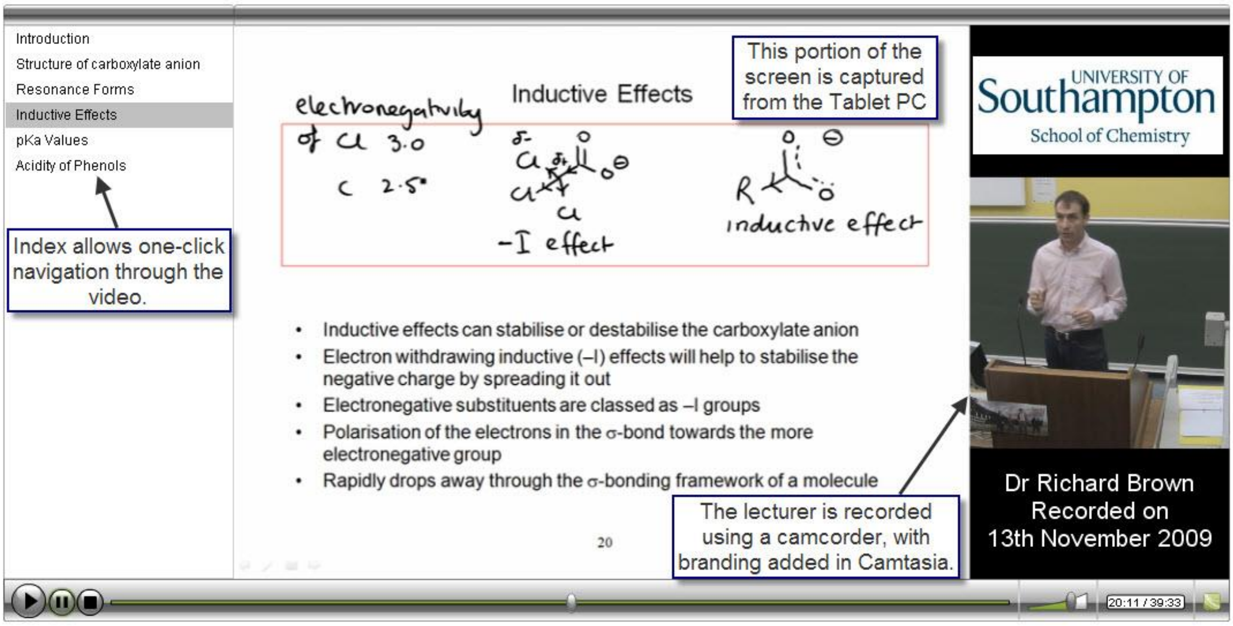

Figure 2: The screen layout of a recorded lecture

The recordings were initially only made available to those students affected by the timetable clash, before being made available to all students over the Christmas break to support revision. Usage statistics showed that this was a popular development, and provided a rich source of data for the project student to analyse leading to the publication of a paper on the topic (Andrews et al., 2010). The key findings were that students found the recordings to be valuable in allowing them to work at their own pace and in helping them to ensure the comprehensiveness of their notes. Students also valued the fact that they could view the recordings at any time of the day. There wasn't a great deal of literature on lecture capture at that time, although one study at Leeds in the area of engineering education (Davis et al, 2009) backed up many of the findings of the evaluation of the Southampton project, and notably indicated that provision of recorded lectures did not impact on negatively attendance. This latter point was important, as the main objection put forward by colleagues who were reluctant to be recorded was that attendance would drop.

As a direct result of the work done outlined above, the majority of first year chemistry lectures at Southampton have been recorded since then, assisted by the adoption of Panopto (http://panopto.com/) as an institutional lecture capture system. A key driver for doing this was to address the issues which were raised by students at the start of the CFOF project regarding the transition to lecture-based teaching, namely the volume of content and pace of its delivery. The provision of lecture recordings remains popular with students today, although the true impact on learning remains an area of interest to education researchers. In a recent paper, Mallinson and Bowman (2015) reported that a positive student response and increased usage of recordings does not necessarily lead to improved individual performance, indicating that work remains to be done to maximise their benefit.

Beyond simple lecture capture: vignettes and flipped lectures

A presentation on lecture capture at the 2010 ViCE conference (Read and Harrison, 2010), which was followed by a talk from UEA's Simon Lancaster (2010) on the same topic sparked a fruitful collaboration between the teams at Southampton and UEA. With financial support from the HEA Physical Sciences Centre, a suite of screencasts and vignettes (http://my.rsc.org/blogs/85/1310) were created to support the teaching of a range of chemistry concepts. Vignettes are short (typically ~5 mins) videos which condense material into bite-sized clips and were shared with the community as open access resources (Lancaster and Read, 2011; Read and Lancaster, 2012). Lancaster (2014) has since taken the concept further, with student-authored vignettes providing an alternative form of assessment which enhances skills that traditional presentations fail to develop.

Another area of interest which developed through collaboration between UEA and Southampton was that of lecture flipping. With sets of lecture recordings already 'in the can', there was the opportunity to trial flipped lectures by making these available to students online, thus freeing up precious face-to-face teaching time for more productive learning activities. This approach, commonly referred to as the 'flipped classroom' (Bergman and Sams, 2012), was generating interest in schools and universities across the globe. In the local trial, a range of in-class activities were incorporated into the timetabled sessions, including Mazur's (1997) 'Peer Instruction' approach to the use of clickers and the deployment of personal whiteboards for students to illustrate answers to questions which could then be displayed to the lecturer (Lancaster and Read, 2013). At Southampton, the approach is now used routinely in teaching on the Science Foundation Year, where some lectures are 'partially flipped' to release time for peer-instruction during the timetabled slots (Read, 2014). Furthermore, the idea of 'partial flipping' has been shared with colleagues at Southampton, some of whom have adopted it in degree-level chemistry teaching. This has provided a focus for an ongoing research project to ascertain the impact of partial flipping with a view to persuading others to adopt the approach.

At Southampton, an additional use of vignettes has been the development of videos based on model answers to problem sets to support students in self-assessing their own work. Such formative assessment has been an area of interest in education, for many years now (Black and Wiliam, 1998), and 'Assessment for learning' (Black, 2004) had been a focus at the school in which the STF had previously taught. The essence of formative assessment is that the evidence collected during assessment is used to provide feedback, potentially self- or peer-generated, which is intended to support future learning. This contrasts with summative assessment, sometimes referred to as 'Assessment *of* learning', which is intended as a means of measuring students' attainment level. The self-assessment exercises developed at Southampton involve students completing paper-based problem sets before marking their own work with reference to 'Talking mark schemes' generated by subject experts. A key feature of talking mark schemes is that they outline the thought processes used in constructing an answer rather than simply providing the answer itself. This approach was first utilised in supporting a cohort of second year students who were struggling with organic chemistry. Evaluative survey data suggested a very positive response, with some students reporting that their focus had shifted from unproductive rote-memorisation to more effective meaningful learning (Brown et al., 2012). This has since been adapted to a programme of vacation exercises which students complete during the summer between their first and second years, and self-assess on their return to Southampton (Read and Duckmanton, 2012). The long-term evaluation of this intervention, along with a spin-off intervention aimed at A-level chemistry students, are the subject of ongoing research projects.

Conclusions and reflections

As has been alluded to above, engagement with the wider community was a key factor in my development at Southampton. Involvement in CFOF necessitated attendance at numerous meetings, and took me to my first national conference, Variety in Chemistry Education, in Leicester in 2007. Being only 3 months into my role at Southampton, I was terrified as I stood before an army of seasoned professionals to nervously deliver a presentation outlining initiatives such as the pre-registration website and plans for the use of clickers in lectures. Although I didn't make much of an impression on the audience that day, they made a huge impact on me in making me feel welcome and at home in what remains an extremely vibrant UK chemical education community. I have since attended countless conferences and national meetings, and, as the profile of what we've been doing at Southampton has grown, I've found myself being invited to ever more meetings and conferences. This brings a range of benefits, not least of which is the opportunity to meet a wider range of inspirational colleagues from whom to learn.

As is clear from the discussion in this article, engagement with the literature has influenced how I have approached the implementation of teaching innovations, and has helped me to evaluate the impact of my work more effectively, resulting in a number of publications. Although my work has largely been that of an 'evaluative practitioner' rather than a 'pedagogic researcher', my list of publications has served me well in terms of career progression, and I strongly encourage teaching-focussed academics to be mindful of publication opportunities when designing innovative teaching approaches. With a little forethought and planning, evaluation strategies can be built into delivery, facilitating the collection of data for inclusion in articles, as illustrated with our self-assessment approach (Brown et al., 2012).

My publications have been based on what would normally be considered to be 'action research', often supported by undergraduate research students undertaking educational projects (Page et al., 2011). I have been working towards transitioning to genuine pedagogic research for some time now, but this has been challenging since the language and methods of such research can be alien to those of us with a traditional scientific background (Read, 2015). Nevertheless, progress has been made, thanks to the award in 2014 of a departmental studentship for a Ph.D student to work on an educational project, along with an MPhil studentship to be co-supervised with my colleague Paul Duckmanton, a Senior Teaching Fellow in chemistry. Through the careful management of funding, we have grown our team of research students to three, all of whom will undertake research towards Ph.Ds with support from colleagues in the Southampton Education School. We have recently established the Southampton Chemical Education Research (SoCER) group to raise the profile of our work, which aims to broaden the impact of our research to support the evidence-based enhancement of teaching at both university and school levels by working with colleagues locally and more widely.

The era of the Teaching Excellence Framework presents opportunities for those us who are focussed on education. It is imperative that we continue to share best practice in order to ensure the best possible educational experience for all of our students. Our employers may not thank us for giving away our best ideas, but, as I hope I've tried to illustrate herein, we are at our best when we work together for the common good, learning from each other and contributing to the knowledge base that underpins our efforts. These are exciting times – let's enjoy ourselves.

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