



## BENEFITS TO SECONDARY SCHOOL CHEMISTRY TEACHERS WHO HAVE BROUGHT THEIR STUDENTS TO ENGAGEMENT ACTIVITIES WITH A UNIVERSITY CHEMISTRY DEPARTMENT FOR SEVERAL YEARS; CONTINUING PROFESSIONAL DEVELOPMENT BY DIFFUSION?

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**Abstract.** Outreach is often seen as only having an impact on the school students taking part rather than also having an impact on the accompanying teachers participating in university led outreach activities. A group of secondary school science teachers who have been long-term engagers in chemistry outreach at a single Higher Education Institution have been interviewed and their feedback has been grouped into several categories of impact; Pedagogical Content Knowledge, updating subject knowledge, access to the university, funding for projects, access to Learned Societies, networking opportunities and changing or otherwise affecting teaching practice. Many of these are aspects of continued professional development (CPD) that teachers are picking up subconsciously during the engagement.

**Key words:** outreach, secondary school teachers, training, school teacher fellow, Centres for Excellence in Teaching and Learning

### 1. Introduction

Outreach initiatives run by Higher Education Institutes are often focused on recruitment. The funders are interested in the value of an activity that can be demonstrated by the number of recruited students per unit cost. Therefore, big numbers reached at single events have historically been valued more highly than long-term partnerships or relationships engaging with a smaller number. However, there is little evidence to suggest that these kinds of large events result directly in higher recruitment numbers [1-7].

The School of Chemistry at the University of Bristol have run an outreach program since 2000. In 2005 the School of Chemistry became the UK's Centre of Excellence in Teaching and Learning (CETL) in practical chemistry, known as Bristol ChemLabS [8-10]. Hence, the Outreach program came under the auspices of Bristol ChemLabS from 2005 and is a significant component of the Bristol ChemLabS program, extending to secondary and primary school students and their teachers and the general public [9-11]. The Outreach program run under Bristol ChemLabS features a School Teacher Fellow who has been part of the program since the CETL started. The role and impact of the STF at Bristol ChemLabS and other Higher Education Institutes (HEIs) has been discussed in previous papers [12-14] and only will be briefly recapped here. In this instance the STF is a highly experienced secondary school chemistry teacher, but could be a teacher with a specialism in any of the sciences, chemistry, biology or physics. The STF was tasked with advising the School of Chemistry on congruence between the transition from post-16 study and first year undergraduate studies, supervising final year projects for undergraduates that were education based and expanding the Outreach program. Sustainability and the promotion of Chemistry is the focus of this Outreach program rather than on recruitment of new undergraduates.

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## 2. Secondary teachers interview group

A group of 9 chemistry teachers from a variety of schools types (Table 1) were identified from those that have been engaging in outreach since under the auspices of Bristol ChemLabS, i.e. for around 10 years. The teachers may have changed schools during this time but this is of no consequence as Bristol ChemLabS outreach is unusual as it links with teachers rather than schools. The teachers were given the opportunity to be interviewed in person or via the telephone at a place of their choosing. All teachers were sent the questions in advance. The teachers were also asked about the impacts of outreach on their students as part of the interview. That research is reported elsewhere. The responses to the two questions relating to impacts on the teachers themselves are reported here. All ethical considerations were employed in the collection of these data.

**Table 1** Details of interviewed teachers.

Teacher	Gender	Highest Degree Qualification	Engaged with Bristol ChemLabS since:	School Type
1	M	Bachelors	2006	Urban, State Academy: Boys (mixed Post 16)
2	M	Bachelors	2008	Offshore State School: Girls (no Post 16),
3	M	Doctorate	2007	Urban Independent: Girls, (Girls Post 16)
4	F	Bachelors	2008	Rural, Independent: Girls, (Girls Post 16)
5	F	Masters	2007	Urban, State Academy: Girls, (Girls Post 16)
6	F	Bachelors	2005	Urban, State Academy: (Mixed, Mixed Post 16)
7	M	Doctorate	2007	Rural, Independent: Mixed, (Mixed Post 16)
8	F	Doctorate	2007	Rural, Independent: Girls (Girls Post 16)
9	F	Doctorate	2010	Urban, State Community School: Mixed, (Mixed Post 16)

## 3. Questions asked

Two questions were asked specifically to address the issue of the benefits that these secondary teachers gained themselves from bringing their students to outreach events.

Question 1: In your opinion and experience, how is it valuable for you as the teacher to be involved with Bristol ChemLabS?

Question 2: Do you think being involved with Bristol ChemLabS has changed or affected your practice as a teacher at all? If so how?

### 3.1 Question 1: In your opinion and experience, how is it valuable for you as the teacher to be involved with Bristol ChemLabS?

It is important to note that this question was quite difficult to answer for many of the teachers. They would talk about benefits for their students and some struggled to separate their own experience from the experience of their students. This was not unexpected. This is because the value, for any dedicated educator, would hinge on whether their student enjoyed their outreach experience and learned something from it. Many of the teachers gave initial answers like, 'Well, there shouldn't be anything other than benefit to students, you know, that's it and all it's about really (Teacher 6).' With encouragement to think about their personal development they responded with teacher-specific benefits. The feedback from the interviews was grouped into several categories.

### 3.1.1 A fun day out

All the teachers mentioned how much they enjoyed the time they spent at Bristol ChemLabS as well as the events at their schools. In general they found the lectures and demonstrations interesting and enjoyed the time spent out of the classroom. Teacher 1: ‘...just a pleasant day out.’ Teacher 2 said, ‘I haven’t been back at university [since I studied], it was nice to get away from Jersey for a few days.’ Teacher 3: ‘It’s a day out, it’s something to look forward to...’ Teacher 4: ‘I think I’m more interested than the kids actually... [the School Teacher Fellow] always jokes that I could go round and do the lectures myself since I’ve been so many times, which is true, but...nevertheless I think each time, I enjoy it...each time I can certainly see how the students enjoy it.’ Teacher 6: ‘It gives you a little shot of enthusiasm again.’ Teacher 7: ‘It’s enjoyable. We could go to [name of another university] of course, but uh, Bristol is the better option really, you do so much more’ Teacher 8: ‘...it’s an enjoyable experience.’ Teacher 9: ‘It’s fun...it’s an out-of-the-box experience for me and the kids’ Teacher feedback embellishes these thoughts by noting that after several years of engaging with Bristol ChemLabS there is no fear that these events will run other than extremely well. They comment that issues such as health and safety considerations, appropriateness of lectures and talks in terms of scientific language used and appropriate contexts and scaffolding used, support from demonstrators and technicians and the more mundane issues such as well-run breaks are all performed in a first class way. Therefore, these teachers can relax when they arrive and enjoy the day.

### 3.1.2 Pedagogical content knowledge

While many of the teachers mention learning something on their visits to Bristol ChemLabS, none of their responses relate to subject knowledge but rather to knowledge in the context of teaching, and improving their teaching confidence, as well as improving and adding to their collection of anecdotes, stories, chemistry applications and demonstrations to do in their classes. This kind of learning, the learning of how to teach something and make it relevant to those you are teaching and the learning of the skills that make this possible falls under the concept of Pedagogical Content Knowledge or PCK as described by Shulman [15-17]. Teacher 1 is the only teacher who explicitly denied that he had learned anything subject related in his engagement at these visits, ‘I don’t think I learn a great deal, I mean I worked in industry for 15, 16 years anyway, so I’m fairly familiar with the techniques, and...the lab...’ but then, like many of the teachers he described picking up on anecdotes, stories, new applications of chemistry and new explanations or ways of thinking about chemistry concepts which they then took away with them to use in their teaching (Teachers 2, 3, 4, 5, 6, 7, 8, 9). Teacher 3 said that it was not new knowledge that he is gaining, ‘I mean I was a lecturer, so...I’m not like ‘What is that?’ I’m like, yeah, I know exactly what you’re going to say next.’ However he goes on to say that, ‘you do get some kind of CPD ideas when you hear little phrases and catch phrases and anecdotes or stories, so for my benefit as a teacher, I go “that’s a good phrase, I’m gonna use that. I didn’t know that, that’s a nice anecdote, I’m gonna use that.”’ Likewise, teachers 2, and 9 cite that they have benefited from their outreach association through picking up new ways to teach and being reminded of useful applications of chemistry techniques. Teacher 2: ‘We’ve picked up a few bits and bobs that probably we’d forgotten about and applications of chemistry that we could probably apply more in the classroom.’ Teacher 7: ‘a seed of professional development going in there,’ Teacher 9: ‘I got fresh perspective...I’ve learned a lot from [the STF] as I realised there were new ways of doing things.’

It is well documented that teaching is not just about subject content knowledge. These teachers enjoy observing another well respected professional teach their students and are happy to increase their PCK. This is another reason why these teachers engage year after year.

### 3.1.3 Keeping knowledge up-to-date

This is related to PCK, but is reported as a distinct category here. Some teachers mentioned that their outreach involvement and visits have helped to keep their chemistry knowledge current and up to date (Teachers 1, 4, 7, 8, and 9). This may be especially true for the older teachers for whom certain aspects

have changed quite substantially in the chemistry field in the time since they were at university. Those giving this answer included the older teachers in the sample. While this knowledge is not directly related to the curriculum and is not needed to teach the chemistry specified, it can add enrichment and interest to teachers' enjoyment of their subject and give them the opportunity to talk to their students about chemistry research and chemistry beyond school. Teacher 1: '...it's all just nice to see and keep in touch [with advances in chemistry] through a bit of practice...' Teacher 2: 'it was nice to be back [in a university]...I mean, I haven't been back at university [since studying]. We've picked up...[on] a few [new] applications of chemistry.' Teacher 4: 'What's very interesting is the electron microscope, I think I'm more interested than the kids actually in that bit. That's fascinating to me because when I was at school they hadn't even thought of it, now that's over 40 years ago now.' Teacher 7: 'we get the chance to ask the odd question about your more advanced techniques and things as our degrees get steadily out of date...There are more modern spectroscopy techniques we could learn about.' Teacher 8: 'Bristol ChemLabS has become an extension to my own lab at [school name]. It is a wonderful feeling to have collaboration, and with my own background in research, I feel it is necessary to keep me connected to the greater scientific community and to keep my knowledge up to date' and 'it's helped me to learn about new advances in analytical techniques, health and safety in the laboratory and there is always something new that you can learn in a research establishment and being in contact with the staff at the university is refreshing...I learn the applications of the analytical techniques which makes me feel more confident teaching them.' Teacher 9: 'Visiting the department refreshed my chemistry knowledge and...made me aware of advances in the subject.' These teachers' statements paint a vivid picture of the value for them in visiting the department and being in a research environment again. Many responses seem to contain a sense of exhilaration at being among people at the forefront of research and at the cutting-edge of chemistry. Although all the teachers have a chemistry related degree there is always the need, and a requirement of teaching contracts, to keep up to date with the subject and coming to a research intensive chemistry department provides many opportunities to do this. All the teachers have found areas of interest that they have been able to advance during the period of interaction and such an environment is another draw for these teachers.

### 3.1.5 Teacher networks

A few teachers also mentioned the value of meeting and getting to know other teachers through their outreach visits to the School of Chemistry. Teacher 3 articulates this in the context of events at Bristol ChemLabS, 'Another sort of bonus point is you get to meet teachers, so a few of the sort of teachers that you see are old hands and then you get to exchange ideas, you get to build better bridges between other [chemistry] departments. So there is a little bit, that's a...bonus on the side, as such. And that takes a long time to build up, sort of several years,' as well as the annual science lecture event they run at the school where that interaction takes a slightly different form, 'In terms of actually being with teachers, there is not much time, because you're kind of with the kids, lectures, sit down, lecture, sit down, drink, sit down, go home. So there's not a teacher bonding thing in that sort of sense...but then, some of the teachers, because it's like an email thing, so that's how I got to know John and a few others, through that, so when I'm seeing him for like the 4th time, the conversation's not, 'Hello where're you from?' It's, 'Ooh, what're you doing and what's going on here?' It's a slower process, but, it does happen.'

For Teacher 3, the networking aspect of his outreach involvement has matured over time, taking repeat visits to develop. Through arranging his own events he has got to know other teachers, lecturers and scientists as they correspond prior to the event. Teacher 5 also mentions how over time her relationships and networks have developed, generating a sense of being part of a community of science practitioners, including the STF, Bristol ChemLabS staff and other science teachers, 'I think sometimes as a teacher you feel very isolated, that you're working all on your own...and, I think particularly with chemistry because it's a practical subject, it all starts as maybe your senior management may not understand kind of quite what you're trying to do...so it's really nice, because you've got people who want you to succeed in keeping kids, keeping bright kids doing chemistry and so there's that, that sense of, we're all in this together...but that's come over time as you get to know

people, you build relationships.’ It is important to note that for both Teachers 3 and 5, these benefits are as a result of their extended engagement and that the development of these relationships takes time.

While Teacher 6 did not mention networking with other teachers through outreach, she did speak about her relationship with the STF when he was a teacher, before he took up his position at ChemLabS, and how as a young teacher her engagement with him had a huge impact on her teaching practice. She recognized that he was a ‘source to tap,’ and tried to learn from him as much as she could, and this continued when he became the STF. The relationship started for her when she was in her 2nd or 3rd year of teaching, and she quickly saw the value in out-of-classroom learning for her students. It seems that the value for young/inexperienced teachers of meeting and talking to experienced ones is an underrated and untapped potential outcome in outreach, and these opportunities could further benefit teachers.

Teacher 6 also expresses the isolation of teaching, and the importance of coming out from their classroom or corridor to interact with other professionals. Although this was in the context of seeing the STF teaching, it does highlight the potential value in having teachers interact with each other, in a way they clearly seldom get to do at school, ‘sometimes as a teacher you just need to step outside your own corridor, because we never leave our corridor, we might very occasionally see each other teach, particularly, obviously I need to do kind of line management observations on people, but, we very rarely get to see anyone else engage and interact with kids...’

Teacher 7 although nearing the end of his career, also said that, ‘any gathering of teachers has value,’ and the value for him as a teacher in attending events at Bristol ChemLabS, particularly the competitions, was the ‘networking’ opportunity, saying ‘it’s really great when there is an opportunity of [interaction with other teachers]. At Top of the Bench, you kind of send the kids away and then just let the teachers chat, or whatever, and actually that’s really, really helpful and I do appreciate that.’ These networking opportunities described by Teachers 3, 5 and 7 are accidents of scheduling and a product of the type of event, and yet to these teachers these opportunities to talk to teachers from other schools are highly valued. Four teachers mentioning the importance of gatherings of teachers and the relationships between them, and 2 teachers specifically noting the time it takes for these relationships to develop, suggests this perceived value of outreach involvement is worth exploring further. These relationships have developed organically due to teachers being in the same place at the same time and recognising the value of that interaction, which they do not get at school.

The development of these relationships has not relied on special activities being developed for teachers to engage with and also has not relied on the STF to facilitate introductions, although it could be safely assumed that this has also happened. Rather, the existing outreach activities and the organisation of school-based activities, by the teachers, have provided a valued opportunity for interaction with their peers as teachers from different schools are brought together.

### **3.1.6 Relationship with the STF, access to the university, funding for projects, and access to Learned Societies**

Most of the teachers explicitly mentioned how their engagement in outreach activities with Bristol ChemLabS had resulted in the development of a good relationship with the STF (Teachers 1-9) which had then, for some of them resulted in access to the university for a variety of other things. These range from information about admissions and applications processes, and access to speakers in these subjects (Teachers 1, 3, 4, 5, 6, 7, 8), access to other science speakers for school events (Teachers 1, 4, 5, 6, 8), access to equipment and chemical resources (Teachers 5, 6, 8), access to funding for outreach and projects (Teachers 1, 3, 5, 6, 8, 9), and information about and access to the Learned Societies such as the Royal Society of Chemistry and the Royal Society (Teachers 1, 3, 5, 6, 8).

This relationship has developed over the years through Teacher 4 attending outreach events at Bristol and through inviting the STF to give talks at events at the school. She speaks about how this relationship has helped her establish links with the University of Bristol and given her access to the university’s other resources through the STF; ‘I think it did help me establish links with Bristol [The

University of Bristol], I don't know that I'm establishing my links anymore, but certainly it's revisiting them... Certainly at the start, I found it extremely helpful, and it's very nice to know that if there's a university I can call on, Bristol is the one. For example, I emailed [the STF] to say has he possibly got a speaker for... an INSET in the evening where lots of schools came together to talk about university applications, in fact I think it was [named academic]... he came and talked. He was very good as well, but [the STF] recommended him, you see. So it's given me an access... to the university... as well as an access particularly to the Chemistry department.'

Teacher 2 kept the link going because he felt that it was of potential benefit to his career, 'for me, it's nice to keep in touch with people like [the STF]. It may benefit my career at some point down the line, you know, just links with people like [the STF]... it must be good to have links with people like that, you know to, just to see what's going on. It's sort of links, as in The Royal Society, or links with me and the Royal Society of Chemistry a little bit, so probably not so much at the moment, but, always keen to keep a link going just so I can see what's going on.' Teacher 7 describes enjoying the chance to talk to university staff who are taking on his students and that this access to academic staff is a benefit due to visiting the university for 'Spectroscopy Tours'.

Teacher 5 also mentions how through her relationship with the STF she has the opportunity to get access to resources, saying, 'It's nice because [the STF] offers opportunities... you can get trained to use the liquid nitrogen then you can come and get some and use it at school. Which is something I haven't done yet but I'm interested in doing. There's always sort of, little opportunities there... I think that's the thing, you know, I can't get liquid nitrogen. I mean I can't even get dry ice at the moment... I'm sure [the STF] would allow me... to do that. In terms of like, access, I mean access to these labs is just fantastic, you know and doing a tour of the university... the kids... they don't know how amazing that is... I mean it's amazing that they get to see the university, as such, sort of, gated community. So that has just been fantastic.'

Teacher 8's relationship with the STF enabled her to be able to apply for funding for the Royal Society Partnership grant scheme, 'our association with [Bristol] ChemLabS and the support of [the STF] helped us secure the Royal Society partnership research funding.' She says that without [the STF] she would never have known how to do that. Teacher 3 mentions that 'the relationship with [the STF] and I sort of just got stronger over the years' and that as a result Teacher 3 was also able to apply for the Royal Society Partnership grant funding with an academic in the University of Bristol School of Chemistry, 'I'm also now working... with [academic's name] and my research grant so that's something else that I wrote, part of an application, well I wrote a letter of support for trying to get kids into research labs, basically...'

Teacher 9 also articulates how the STF has been accommodating and helpful, and gave them funding to enable gifted and talented students to attend a sponsored day at the university. Teacher 6 speaks passionately about the many opportunities her personal relationship with the STF has given to her and her students. She mentions that she sees her relationship with the STF as the primary driver of her engagement with outreach activities through Bristol ChemLabS, and really, that she sees him personally and the programme as indistinguishable. She has worked with the STF to get funding and develop tailor-made activities for her students, but, as she has gained more responsibility at her school, she has become less involved with outreach as she has less time. As she says, 'I could do with handing that relationship over to somebody else in the [school] department, but I'm quite jealous of it. You know, he's my contact, he's my friend, he's, you know? So I kind of, I guard that contact quite jealously. (laughs)... Because he's just, he's such an, well the whole programme I see it as [the STF], basically, I see it as [the STF] because he's always been the person who facilitated the programme to come alive for me. Um, and yeah. I'm precious about it (laughs),' and as a result has not handed the relationship over to someone else. This means that her school engages with Bristol ChemLabS less often than they used to, although they are still involved, having decreased from 2 to 3 activities a year to 1 or 2. 161 Although she was the one who originally stated that the value of outreach was really all about the kids and that nothing else mattered, her 'preciousness' about her relationship with the STF shows that actually she is willing to protect her special relationship with the STF even at the expense

of her students' chemistry experience. She does not want another teacher to ruin the relationship she has cultivated over many years.

This seems to point towards the teacher-STF relationship as of key importance in ensuring that teachers continue to be involved in Bristol ChemLabS outreach with their students – possibly even more important to some teachers than the usefulness of the activities to their children, even though it is unlikely that any teacher would admit to that. This shows the power of the relationship between the teacher and STF, and the importance of maintaining a healthy dynamic.

### 3.2 Question 2: Do you think being involved with ChemLabS has changed or affected your practice as a teacher at all? If so how?

Four of the teachers were reluctant to say that their association with Bristol ChemLabS had changed or affected their teaching practice (Teachers 1, 3, 6, 7), but in their descriptions it emerges that many teachers have been influenced and affected by their long term association which has had an impact on their teaching and their confidence.

Teacher 1 is an example of a teacher who first denies any effect on his teaching practice, but then speaks about how the association has changed some of the focus and goals of their school's chemistry department: 'I don't think it has affected my practice as a teacher...no. You know, obviously I'm always looking for opportunities to bring people down here, so that's a major change it's made...at our department at [school name], we just decided we want to try and forge as many links, external links as possible, to give opportunities to the kids, you know, let them decide for themselves: 'Are they interested in this?' 'Are they good at this?' that kind of thing, so...maybe it's affected the focus and the vision for the department slightly, because it is part of our vision...but not necessarily my practice?' While this teacher doesn't see any change to his classroom practice, his involvement has broadened his ideas about the experiences he can give his students and convinced him of their value, resulting in him and his department seeking further out-of-classroom opportunities at Bristol ChemLabS and elsewhere.

Teacher 7 also did not feel that the association had had much effect on his classroom practice, saying, 'I think I would have to say no... I don't think there is a lot that is different as a result of that. You are being enthused and motivated yourself, going back into that lab remembering what it's all about, meeting people with similar interests and all that, it does refresh...[long pause]...but it doesn't mean we do anything severely different really, no....That's not to say it's not a very positive experience because it is for the students, but whether it changes us too much [I don't know]. I suppose...there is a bit of a seed of professional development going in there, but actually, you know, it's an opportunity for something else, I mean if we go that way, if you've got us there...' He seems to suggest that while he would not go so far as to say that he can trace changes in his classroom practice back to his outreach experience, there is something going on in terms of professional development, which Bristol ChemLabS could make more of.

Other teachers, like Teachers 3 and 6 deny any effect on their personal teaching practice, but then go on to offer opinions on the kind of teachers who might benefit most from the experience. Teacher 3 speaks about how his less experienced chemistry teacher colleagues and technicians have benefited, and Teacher 6 offers her opinion that the kind of teachers Bristol ChemLabS tends to engage with are probably already enthusiastic and wanting to learn, and that those who could do with some input are not being reached.

In her interview Teacher 6 emphasises how her relationship with the STF impacted her teaching practice, and she sees this as separate from the experience of just being involved in outreach activities with her students. Teacher 4 deflects the question, saying that her colleague would be a better person to answer this question because she began going to Bristol ChemLabS with her students as an inexperienced teacher – showing that like Teacher 3 she sees any effects of outreach involvement as more pronounced for inexperienced teachers, 'I should have asked [teacher's name] to comment on this bit really, because she came when she was really a very inexperienced teacher, because she did other things first before she started teaching. I think she always feels it's worth going on.' Teacher 3:

'I know some of my other staff where...they've come down, my technicians, and new members of staff have actually come down for...the practical training courses and they got a lot out of it, so I think it depends on what level the teacher is at. So I'm interested in like the links, student development, rather than CPD, whereas my junior staff; they've got more practical experience, my technicians have got training, enhanced training and so on; so that's it's been very valuable for them. So it depends, I think it's very much where you're at... Um, has it changed me in other ways, it might in how I deliver it [the curriculum]. No, again, it's not about teaching, it's about, it's enhanced my funny stories and quirky things and how I might see the odd bit, um, but again, you could probably say most people who've seen those demos do those demos, if they can access the chemicals, so again it's new teachers, that it would have more of an impact compared to experienced teachers.'

Teacher 3 seems to be saying that something has happened during his involvement that has enhanced his teaching, giving him ideas for teaching and delivery, but he would not go so far as to say that his involvement has had a direct CPD effect on him. However, he sees that his younger and less experienced colleagues have benefited greatly, both from their general involvement and from the staff training courses they've attended. As a more experienced teacher, he has taken something away from his experiences, but it is less concrete than could be easily evident in the classroom. This seems to fit with Teacher 7's response which moves from denial, to a sense that something is happening which is hard to quantify or even name exactly.

Teacher 6 describes how hard it is to quantify effects over such a long association, and also alludes to the intangible nature of the effect of her involvement, 'I mean it's hard to say that it affects your science teaching in the long term, because of course...I've been teaching 11 years...so if you add it up...I don't know that I could say that it affects...the way that I teach. But, it gives you a little shot of enthusiasm again. Perhaps you've reached a point where you're so jaded with the curriculum...and you go along and the enthusiasm is infectious and the kids have enjoyed it and...sometimes it can just be refreshing to see someone who can engage and lift kids...does it affect my subsequent science teaching, probably not...then I think if you're the kind of teacher who's using them [Bristol ChemLabS outreach] anyway, then you're probably quite enthusiastic, you know, out there, trying to find different stuff anyway in your everyday lessons...I think you're probably attracting from around the country those kind of teachers, the teachers who are already prepared to go above and beyond. And probably, unfortunately, the old stick in the muds, are not engaging with you.' She seems to think that rather than the outreach programme being the thing that impacts teachers' teaching, it is the kind of teacher who engages that would tend to get a lot out of any experience anyway.

The other teachers acknowledge a CPD effect more directly, although some feel it has had a small impact. They speak about how their involvement has changed the way they teach, giving them greater confidence, new skills, knowledge and the 'patter' associated with teaching their subject, as well as demonstration skills, giving these and other practical work greater focus in their teaching. Teacher 2 is one such teacher, acknowledging, 'I mean we've even used some of those demonstrations...we had some of the demonstrations before, and...we've started to use...[them] a little bit more.' In terms of changing the way they teach, he says, 'I'd say a little...being able to talk about it with a little bit more relevance. Rather than just looking at a textbook and looking at these IR graphs, learning from it that way, the pupils are actually able to look at it physically and know that they, that's the results...of something they did. And that's invaluable.' So as a result of their outreach involvement they have been able to make spectroscopy a more hands-on experience for their students.

Teachers 5, 8 and 9 were much more upfront about their perceptions of the impact on their teaching than the other teachers. They spoke gratefully about their growth in confidence and development of competency as chemistry teachers as a result of their association with Bristol ChemLabS. Teacher 9 described how her teaching had become more adventurous; she had learned more demonstrations to do, and begun to feel more confident about doing them in class, along with more 'out-of-the-box science.' She was inspired by her students' enjoyment of their outreach activities and tried to incorporate more hands-on, exciting science into her everyday classes as a result.

Teachers 5 and 8 described their growth in confidence and knowledge as a result of their association with Bristol ChemLabS. While Teacher 5 had attended specific CPD events and courses for teachers,

Teacher 8 had not, and yet the effects on their teaching practice they mention are very similar. Teacher 8 described how the spectroscopy tours she had attended with her students had affected her teaching practice because, ‘the analytical techniques are in the syllabus, and the applications of the techniques, I learned as well, it makes me feel more confident [to teach this topic].’ She goes on to say that she, ‘was getting bored in the small school and small department in an isolated area’ before her involvement which she was worried must have impacted her teaching, but she says that now: ‘my students are better informed of the relevance of chemistry and their practical and analytical skills are much better developed as a result of my involvement. I feel more confident with my teaching.’

Teacher 5 speaks at length about the impact that her involvement has had on her teaching practice. Like Teacher 6 she has valued seeing other people teaching, ‘it’s good because you get to see...quite a few demonstrations, and you think, well, I’ll do that too, I’ll put that in...part of teaching chemistry I think is about your patter. It’s about creating that enthusiasm and interest and excitement and so it’s interesting seeing someone else do that and...maybe incorporate some of that into what you do.’ Like Teacher 8 her confidence has improved, ‘In terms of my own...CPD of course it’s had a massive impact on...what I do and how I teach and the confidence I feel in terms of delivering some of the stuff...and the Festival of Contemporary Science [18] is really interesting because you can talk about quite up to date research and stuff, which is good. So in many ways it’s...had a massive impact...all positive...I mean I think it’s been manifold, that’s why it’s difficult to pin-point anything... in terms of practical CPD, it’s made me much more confident about doing practicals that I haven’t done for a very long time, and using kit.’

Both Teacher 5 and 8 have valued the sense of being part of the greater scientific community, which has impacted their approach to teaching science as well, with Teacher 5 saying, ‘in terms of, just generally exciting me about science, which I am excited about anyway, but you know, even more...making you feel like, Ooh, actually I’m a part of what’s going on rather than thirty years behind, in my textbook. That’s really important as a teacher, you know. I mean our curriculum always changes anyway, but...I could potentially be quite boring and that makes it, kind of interesting and exciting.’ Teacher 8 said something similar, ‘It is a wonderful feeling to have collaboration...it keeps me inspired and feeling connected to the greater scientific community.’

#### **4. Summary and conclusions**

Over the ten years of the School of Chemistry’s Outreach program run through the auspices of Bristol ChemLabS, a number of secondary school Chemistry teachers have engaged throughout. There are several reasons that they cite in addition to the benefits for their students which have made this long-term commitment worthwhile to them. The key role of the STF as a source of PCK for these teachers but also as an important conduit that facilitates and supports the relationship between the teacher and the School of Chemistry. The outreach events run by Bristol ChemLabS are high quality and allow the secondary school teacher to enjoy the outreach activity, knowing that their students will be well catered for. The teachers can improve their Chemistry subject knowledge, their pedagogic content knowledge, benefit from support with grant applications, network with other teachers and feel that their own careers benefit. Therefore, well organised outreach events that involve a STF or equivalent and address all the usual issues such as activities that are pitched at the appropriate level, use appropriate age-related scientific terminology and provide a very high level of activity over a long period of time, can also provide significant long-term benefits to the teacher as well as their students.

If the Higher Education Institutions (HEIs) realised the high value teachers place on their personal relationship with outreach coordinators such as School Teacher Fellows, HEIs could approach reaching children and teachers differently, so that ultimately the investment of time and money has a high impact value. A good relationship with even a single teacher, where the HEI offers support to the teacher and relevant activities for the children, suitable for different year groups, would reach many children over the course of a teacher’s career. In addition, a relationship with a teacher could lead to relationships with further teachers, and long term relationships with schools.

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