ACTA DIDACTICA NAPOCENSIA
Volume 2, Number 3, 2009

# THE ADVANTAGES PERCEIVED BY SCHOOL TEACHERS IN ENGAGING THEIR STUDENTS IN UNIVERSITY-BASED CHEMISTRY OUTREACH ACTIVITIES

**Jauyah Tuah,, Timothy G Harrison, Dudley E Shallcross**

**Abstract** The value teachers put on university-based outreach activities designed for 14 -16 year olds that involves both practical and lecture activities are discussed. A variety of good reasons for attending are provided by the teachers but the role of a School Teacher Fellow in mapping the events to the curriculum is shown to be vital to the success of any event. The pre-event difficulties needing to be overcome in engaging with universities are discussed with health and safety and in particular paperwork associated with this being cited as a particular barrier to engagement.

**Key Words** Outreach, School-University Transition, Lecture Demonstrations, Workshops, School Teacher Fellow.

## Introduction

This study investigates the impact on secondary school students, of a visit to a major university chemistry department, as seen from a teacher's perspective. The engagements comprised a morning spent on polymer chemistry practical work and an afternoon where the students attended lectures. The students came from several schools and several types of school. The practical work involved a circus of polymer chemistry experiments where each station had a postgraduate chemist acting as the instructor. Two of the half hour talks were on 'Being a Student' and a talk given by a postgraduate chemist on a suitable aspect of her research. The session finished with a lecture demonstration entitled 'A Pollutant's Tale' [1]. The structure of a day was designed to mimic the daily experience of an undergraduate chemistry student in that there were both lectures and practical work.

.The main aim of this paper is to report the perceptions of the teachers who provided invaluable insight regarding how such learning impacts on their students. The study seeks to answer three main questions;

How do teachers perceive and evaluate the potential of a lecture demonstration and practical science workshop towards the learning of the science concepts of their students?

What are the teachers' views of Bristol ChemLabS outreach activities [2] a lecture demonstration and the practical science workshop in promoting positive attitudes among students towards science?

What are the limitations of the Bristol ChemLabS Outreach activities -a lecture demonstration and the practical science workshop as perceived by the teachers?

## Methodology

The sample of thirteen teachers was taken from those who accompanied students on equivalent workshops across two years of such visits. Some of the adults accompanying the schools in attendance were not teachers but schools' technical staff and non-science teachers. Only those who were science teachers were involved in this research.

*Received: 24 September 2009, accepted: 29 September 2009, published 30 September 2009*

## Teacher Questionnaires

The teachers' questionnaire comprised 11 mainly open-ended questions. The responses were categorised into common themes to produce quantitative data. Background information on the teachers was sought. The main questionnaire encompassed the pre-visit preparations, benefits and limitations of the activities as a whole and the post-visit activities

## Findings from the Teachers' Questionnaires

This section aims to provide answers to the three research question which are related to teachers' perceptions on the benefits and limitations of the outreach activities in promoting attitudes towards science and the learning of science concepts. Their pre-visit and post-visit activities were also included in order to see if such activities have had an impact on students' learning during or after the field-trip to Bristol ChemLabS. Data from the teachers' responses are not presented according to the research question because the way the questions were formulated and the responses provided by the teachers are interconnected with one another. Therefore, it would be difficult to separate the results and so the findings are presented according to the questions given in the questionnaire.

Responses show that nine out of thirteen teachers were fully involved in the organization of the trip, with the majority involved in the administrative and practical preparations (Table 1). Only two teachers' indicated that they briefed students on the outline of the day and no teachers focused specifically on reviewing the science content and the learning objectives of the workshops to be attended.

**Table 1:** *Summary of the teachers' pre-visit preparation.*

| Q1) Please describe your pre-visit preparation, if any. | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Percentage |
| 1. | No preparation… | 4 | 14.3% |
| 2. | Consent forms/letters to parents… | 3 | 10.7% |
| 3. | Checked parking/transport/booking coaches… | 3 | 10.7% |
| 4. | Health and safety talk… | 2 | 7.1% |
| 5. | Staff briefed on science content… | 2 | 7.1% |
| 6. | Briefing students on the day… | 2 | 7.1% |
| 7. | Revision tools… | 2 | 7.1% |
| 8. | Advertising trip… | 1 | 3.6% |
| 9. | Offered trip to triple science students… | 1 | 3.6% |
| 10. | Speaker came to school to talk about plastics… | 1 | 3.6% |
| 11. | Checked location… | 1 | 3.6% |
| 12. | Checked arrangements for the day (arrival/leaving time)… | 1 | 3.6% |

| | | | |
|---|---|---|---|
| 13. | Risk assessment… | 1 | 3.6% |
| 14. | Organized staff to accompany students… | 1 | 3.6% |
| 15. | Contact details given to office… | 1 | 3.6% |
| 16. | Materials cover for lessons… | 1 | 3.6% |
| 17. | Supply teacher organized… | 1 | 3.6% |
| Total number of Responses/Opinions | | 28 | 100% |

The majority of the teachers' responses (Table 2) rated the activities as being a very good way of promoting the learning of the science concepts among their students. The novelty of the lecture demonstration 'A Pollutant's Tale' enhanced the understanding of abstract concepts, while the richness of the visual and sound effects helps to build strong memories of the concepts delivered. Similarly, the 'hands-on' nature of the practical workshop was highly valued by the majority of the teachers, since their students were given the opportunities to perform experiments that are often inaccessible in school. The teachers' comments on the potential of the workshop activities also ranged from; the enjoyment towards the learning of science to the tailoring of learning to the content of national examination specifications for sixteen year olds.

**Table 2:** *Summary of the teachers' evaluations of the potential of the Bristol ChemLabS outreach activities.*

| Q2) How do you perceive and evaluate the potential of Bristol ChemLabS outreach activities such as the lecture demonstration on "A Pollutant's Tale" and the science workshop towards the learning of science concepts of your students? | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Percentage |
| 1. | Excellent/very good/good… | 8 | 36.4% |
| 2. | Visual impact/nature of the demonstrations /hands-on activities helps to remember the concepts… | 5 | 22.7% |
| 3. | Extend concepts taught at GCSE… | 3 | 13.6% |
| 4. | Explicit links are made to the syllabus… | 2 | 9.1% |
| 5. | Improved enjoyment of science… | 2 | 9.1% |
| 6. | Examine how chemistry is applied in unfamiliar situations… | 1 | 4.5% |
| 7. | Topics are relevant and in the public domain… | 1 | 4.5% |
| Total number of Responses/Opinions | | 22 | 100% |

The majority of the teachers acknowledged the 'edutainment' (educational and entertainment value) aspect of the workshops, which enhanced the promotion of the positive attitude towards science

among their students. The majority of the teachers (Table 3) believed that their students' motivation and inspiration to learn science had increased by engaging their students in such events. This was expected to ultimately impact on their students future career choices as demonstrated:

*T1: '…It is clear that the students enjoyed the session. Many of our students are likely to pursue careers in science, engineering and medicine. Attending events like this helps our students to clarify their choices.'*

**Table 3:** *Summary of the teachers' opinions about the Bristol ChemLabS outreach activities in promoting positive attitudes towards science.*

| Q3) What are your views/opinions about the lecture demonstration on "A Pollutant's Tale" and the science workshop in promoting positive attitudes among your students towards science? | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Percentage |
| 1. | Fun/exciting/interesting/in awe of/ engaging/enjoyed the sessions… | 8 | 29.6% |
| 2. | Promotes positive attitudes through providing interesting/exciting/well-pitched lectures/ fun and relevant… | 4 | 14.8% |
| 3. | Increase understanding and appreciation /confidence/interest in science… | 4 | 14.8% |
| 4. | Promotes study and career opportunities in science… | 3 | 11.1% |
| 5. | Increases motivation and inspiration to learn science… | 2 | 7.4% |
| 6. | Promotes positive attitudes by encouraging questioning… | 1 | 3.7% |
| 7. | Insight into University life… | 1 | 3.7% |
| 8. | Memorable and often referred back to by students and teachers… | 1 | 3.7% |
| 9. | Broadening understanding of what constitutes science… | 1 | 3.7% |
| 10. | Enthusiasm of University staff promoted positive attitudes… | 1 | 3.7% |
| 11. | No response… | 1 | 3.7% |
| Total number of Responses/Opinions | | 27 | 100% |

Table 4 indicates the wide range of student benefits perceived by the teachers. The majority recognised the 'authentic' nature of their students' learning beyond the classroom, with the invaluable opportunities to carry out a series of experiments using modern up-to-date facilities in the laboratories, while the lecture demonstration engaged students with experiments that are usually inaccessible in normal school settings. Besides attending the practical workshops and lecture demonstration, the afternoon session also comprised of a tour around the School of Chemistry, a talk by the Widening Participation representative, who briefly outlined university life and the benefits of attending university and a talk from a PhD student about 'Toothpaste Chemistry'. The whole experience was highly valued by the teachers. Teachers perceived that it improved the students' motivation and

interest in learning science, and encouraged them to further their studies in Post 16 Chemistry and university. This is demonstrated by the following excerpts:

*T8: "…Pupils often remark that they have been absolutely captivated by the activities which are offered at [Bristol ChemLabS]. With today's GCSE1 and KS52 courses being so book-based, it is very refreshing for them to visit a University Department that contains research activities at the forefront of chemistry and to hear highly-motivated and experienced University staff. In particular, we have found that our 'Aim Higher3' students […]. realise the opportunities which are available to them".*

*T6:"Encourages students to consider A' Level and degree in sciences.[Students]… experience what it is like to study science at University and it motivates them in their studies at school. Meanwhile, both the practical workshop and lecture demonstration are excellent in delivering key concepts with the guidance of the outreach team who have "hands-on" experience with science in a "real life context". Students can associate abstract ideas with real life experiences and observations as a result of excellent facilities and guidance from experts".*

**Table 4:** *Summary of the benefits of field trip to Bristol ChemLabS as perceived by the teachers.*

| Q4) In general what are your opinions about the benefits of bringing students for school trip to Bristol ChemLabS to learn science from activities such as the lecture demonstration on "A Pollutant's Tale" and the science workshops? | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Percentage |
| 1. | Provide an insight into chemistry beyond school/outside classroom/ e.g. University… | 8 | 21.1% |
| 2. | Practical experiences/hands-on activities/… | 7 | 18.4% |
| 3. | Improve motivation/increase interest/engagement/enthusiasm… | 7 | 18.4% |
| 4. | Encourage study of chemistry at A-level/ University… | 6 | 15.8% |
| 5. | Modern up-to-date facilities… | 4 | 10.5% |
| 8. | Improve self esteem… | 2 | 5.3% |
| 6. | Working with students from other schools/expert/ outreach team… | 2 | 5.3% |
| 7. | Helps to dispel misconceptions about science being "geeky" or "uninteresting"… | 1 | 2.6% |
| 9. | Aim Higher students (without a family background of higher education) realise opportunities available to them… | 1 | 2.6% |
| Total number of Responses/Opinions | | 38 | 100% |

[1] General Certificate of Secondary Education, a UK qualification for 16 year olds.
[2] Key Stage 5 referring to Post 16 or pre-university courses.

Not many limitations were perceived by the teachers as indicated in Table 5. However, the data revealed the lack of time teachers have to focus on preparing fully for the visits, constraints of curriculum time, and other limitations that mainly encompass the administrative or practical aspects common to school fieldtrips.

**Table 5:** *Summary of the limitations of learning science from fieldtrips to Bristol ChemLabS as perceived by the teachers.*

| Q5) Similarly, what are your opinions about limitations of bringing students for a school trip to Bristol ChemLabS to learn science from activities such as lecture demonstration on "A Pollutant's Tale" and science workshops? | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Percentage |
| 1. | Transport and parking… | 4 | 18.2% |
| 2. | Limited number of students can attend… | 3 | 13.6% |
| 3. | None.. | 3 | 13.6% |
| 4. | Cost of covering teachers… | 2 | 9.1% |
| 5. | Timing visit to fit into curriculum and exams… | 2 | 9.1% |
| 6. | No response… | 2 | 9.1% |
| 7. | Little time to organize and prepare trip… | 2 | 9.1% |
| 8. | Repetition for some students who attend more than once… | 1 | 4.5% |
| 9. | Effect on other staff… | 1 | 4.5% |
| 10. | Effect on exams… | 1 | 4.5% |
| 11. | Effect of taking pupils out of school for whole day… | 1 | 4.5% |
| Total number of Responses/Opinions | | 22 | 100% |

Nearly half the teachers' responded that there were no formal post-visit activities planned. Students at some schools did give presentations to feedback and share their experiences to those who did not go on the trip. This may have helped to reinforce the learning from the visit. Other post-visit activities included (Table 6) gave students an opportunity to use their new knowledge.

**Table 6:** *Summary of the teachers' opinions about the post-visit activities.*

| Q6) What are the post-visit activities, if any? | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Percentage |
| 1. | No formal activities… | 5 | 22.7% |

| | | | |
|---|---|---|---|
| 2. | Informal activities, e.g. discussions with friends and in class… | 4 | 18.2% |
| 3. | Feedback/presentation in class by students… | 3 | 13.6% |
| 4. | Recreate some practicals… | 1 | 4.5% |
| 5. | Report to science governors… | 1 | 4.5% |
| 6. | Write newsletter… | 1 | 4.5% |
| 7. | Follow up lessons… | 1 | 4.5% |
| 8. | Family learning event organized by students for families, friends … | 1 | 4.5% |
| 9. | None/no follow up… | 5 | 22.7% |
| Total number of Responses/Opinions | | 22 | 100% |

Two-fifths of teachers' responses' revealed that they can relate the learning of science from the workshop to the UK school curriculum (Table 7), at the same time acknowledging the activities as enrichment activities which complemented classroom learning.

**Table 7:** *Summary of teachers' opinions on how to relate learning from outreach activities to curriculum*

| Q7) How do you relate the outside classroom learning of science at Bristol ChemLabS to that of the curriculum? | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Percentage |
| 1. | Easy to relate polymer day to 21st Century, C2 unit/3AQA syllabus on oils/GCSE Chemistry/ OCR 4Chemistry… | 6 | 40.0% |
| 2. | Lectures were related to the curriculum… | 2 | 13.3% |
| 3. | Carry out similar practicals in classroom… | 1 | 6.7% |
| 4. | Informally related… | 1 | 6.7% |
| 5. | Unclassified…. | 4 | 26.7% |
| 6. | No response… | 1 | 6.7% |
| Total number of Responses/Opinions | | 15 | 100% |

The majority of the teachers acknowledged that the 'hands-on' nature of the activities (Table 8), especially during the practical workshops, gave the students the opportunity to improve and develop

[3] AQA - Assessment and Qualifications Alliance,. a UK examination board.
[4] OCR - Qualifications Curriculum Authority, a UK examination board.

their practical skills, in comparison with school learning which mostly involved written activities. They also acknowledged that there are more practical activities at Bristol ChemLabS than in the average classroom, as there are more sophisticated facilities. They acknowledged that the opportunities for learning in a different environment, instilled enthusiasm and interest in science, as evident from following excerpt:

*T9. 'Students are far more interested as it is a different environment with regards to teachers, practicals and equipment. They are more enthusiastic and focused than being in the same school with the same teacher each lesson throughout the year.'*

**Table 8:** *Summary of teachers' opinions on how their students learnt science from the workshop activities as compared to the classroom learning.*

| Q8) How do you think your students learn science from these activities at Bristol ChemLabS as compared to that in the classroom? | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Frequency |
| 1. | Gained more practical experience… | 3 | 20.0% |
| 2. | In class more written activities… | 2 | 13.3% |
| 3. | More practicals at Bristol ChemLabS than in class | 3 | 20% |
| 4. | Better/more equipment at Bristol University… | 2 | 13.3% |
| 5. | Enhances students' learning… | 1 | 6.7% |
| 6. | Bristol ChemLabS is more sophisticated | 1 | 6.7% |
| 7. | Builds on foundations done in class… | 1 | 6.7% |
| 8. | Become more secure in their knowledge.. | 1 | 6.7% |
| 9. | Worked individually so improved skills… | 1 | 6.7% |
| Total number of Responses/Opinions | | 15 | 100% |

Two thirds of the teachers indicated that there is no further improvement needed to the workshop (Table 9). A few teachers indicated that the talk on 'Toothpaste Chemistry' was seen as too advanced for their students.

**Table 9:** *Summary of teachers' additional comments for improvement.*

| Q9) Please write any additional comments or suggestions for improvement. | | | |
|---|---|---|---|
| Description | | Frequency (No. of Responses) | Percentage |
| 1. | Increase teachers' enjoyment /motivation… | 1 | 7.1% |
| 2. | More students' interactions between different schools… | 1 | 7.1% |

| | | | |
|---|---|---|---|
| 3. | None… | 9 | 64.3% |
| 4. | Toothpaste lecture too advanced and not relevant… | 2 | 14.3% |
| 5. | Would be beneficial to link outreach to new International Baccalaureate (IB) syllabus… | 1 | 7.1% |
| Total number of Responses/Opinions | | 14 | 100% |

## Discussion of Findings

The majority of teachers agreed that the impact of the students' learning of science concepts were mediated by the role of the demonstrators and School Teacher Fellow (STF) [3] in 'scaffolding' the knowledge through the repeated use of the key-concepts delivered and relating them to the chemistry the students were studying. This is exemplified by the teachers' responses on how they valued the lecture demonstration:

*T6 '…students really enjoyed listening to these. I have taken students to a number of conferences and they always enjoy the talks which have demos and interact with the audience. The environment where the talk takes place is also important. It has a definite WOW factor from the point of views of the students who won't have experienced this before. Students will remember!*

*T3 'Good- explicit links are made, linking their observations during the lecture with the syllabus. The impressive nature of the demonstrations should help build strong memories of the concepts shown.'*

*T9 '[…] has been very efficient at tailoring our needs to what he [STF] delivers so it is extremely beneficial and related to our curriculum.'*

*Response excerpts from both the teacher questionnaire and email interview to indicate the difference between the students' learning at school and university included:*

*T2 'Students get to do science out of the classroom as well as working with experts in modern & up-to-date chemistry laboratories. It is nice that they get to work with students from other schools who also have an interest in science.'*

*T3 'It opens students' eyes to life after school. Possibly dispels any misconceptions about science being "geeky" or "uninteresting". Students get to see science as more than a Bunsen Burner and sometimes dilapidated equipment.'*

*T4 '…[in school]…we do many practical but the time is limited to 1 hour, Here [Bristol ChemLabS] they were able to give a whole day to just practical, with fantastic facilities. They had much more help as there were many postgraduates [SEAs] as well as the... [Outreach team], the Lab technicians and us around so they got instant feed back to their questions. This I feel leads to a more intensive learning environment. The group were only 15 with lots of support, normally a top set is over 30 students and just the teacher, this has an impact'.*

The teachers cited limitations, as mostly practical or administrative aspects common to all fieldtrips. These included: lack of time for preparation, difficulties in timetabling visits, travel costs and costs for covering teachers on the visit and transport arrangements. These are similar to the findings by Smart & Hutching [4]. On the other hand, the responses from the email interview revealed a vital additional limitation which was not discussed in any of the teachers' questionnaires, i.e. the health and safety issues required by their employers. Teachers' comments show the evidence of pre-visit preparations of the teachers which could be seen as limitations as it takes a lot of paperwork and administrative preparations to satisfy their employers or head teachers.

*T1 '....Our school has a very specific policy on trips and extensive pre-visit preparations have to be carried out as a matter of routine. This trip was offered as a voluntary activity for students to sign-up*

*for so the numbers involved was relatively low compared to the size of the year group. Such preparations help the trip run smoothly.'*

*T4 '....They are compulsory from the LEA. It helped that Bristol University sent their risk assessment form too so that we were allowed to go. A letter to parents stated the reasons why the trip could be important to their child's education and what they would be doing on that day.'*

*T8 '…Most of these pre-visit preparations are for health and safety reasons. Thus a risk assessment is mandatory for all trips regardless of its value. Similarly, arrangements for transport and collection of pupils by parents, parking and other matters will enable the students to be controlled and marshalled more easily. Without such arrangements we could expect some difficulties in moving pupils around and in making sure that they get home safely afterwards'.*

These findings coincide with several studies, where the amount of work required by the relevant authorities or the school itself impedes teachers' ability and desire to engage students in regular out-of-classroom learning [4, 5, 6].; The consequence of this time and effort results in the lack of pre-visit preparations focused on students' learning experiences. The majority the teachers' preparations in the present study did not focus specifically on the learning objectives of the trips or reviewing the science content to be learnt. Such preparation for the students are crucial for any fieldtrip as discussed by several studies [5,; 7, 8] as are the use of worksheets as suggested by Kisiel [9] and the preparation of relevant materials prior the visits [10]. This is evident from responses in the email interview and questionnaire:

*T8 '…I took care to brief the students on the outline of the day so that they were aware of how the activity would impact on their learning and the likely improvement in their future exam grade. Further, when dealing with a large group of pupils it is important that they do not become confused by procedures and events on site.'*

*T14 '…I think that we have to prepare them, theoretically, for the lecture. Should be carried out in smaller groups for students to be able prepare for themselves or such preparations should have been done in school just before the trip.'*

In the email interview teachers were asked to give their main motivation for bringing their students to attend these activities. As expected, the teachers' responses encompassed the common themes for enrichment programmes, that it could complement the GCSE Chemistry; for motivation for the students to enhance their interest and careers in science; and to provide the students with the experience of working with new facilities available in the University but not commonly found in the classroom context. Several researchers [11, 12, 13, 14] suggest such goals can not be realised if the students are not mentally prepared or not given relevant information about the objectives or content of the science to be covered, as this is essential for effective learning to take place. Therefore, this signifies the role of the teachers should be playing in their pre-visit, during the visit and post-visit activities as outlined by DeWitt & Osborne [15].

In terms of the post-visit activities this study indicates similar trends for their pre-visit activities as the majority of the teachers had no formal activities that can directly link the learning experiences during the outreach to the classroom lessons. Only a few of them organised students' presentations and recreated elements of the practical. As suggested by Anderson et al [14] , the post-visit activities are pivotal in reinforcing new connections and complement future learning experiences. In terms of the changes to the teachers' own teaching that can be attributed to the experience at Bristol ChemLabS, the interview questions revealed that the teachers tried to incorporate their experiences gained into their lessons as evident from:

*T1 '…some of the practical demos shown could be incorporated into my own teaching practice.'*

*T4 '… I always try and do as many practicals as possible, as I believe it is better for students to investigate and solve problems, they will learn more and remember what they have done. So I try and continue the ethos of the polymer workshop.'*

One teacher who brought her students in year 2007's Bristol ChemLabS activities revealed that many of her students have opted for A-Level Chemistry in September 2009, which she believes was the result of the long-term impact of the events at Bristol that they had attended.

- Teachers' acknowledged the potential of both the activities in enhancing the learning of science concepts among the students where the content was concurrent with the GCSE Chemistry syllabus.
- Teachers also acknowledged the impact of the Bristol ChemLabS outreach activities in promoting the positive attitude towards science and revealed that the outreach programmes had encouraged and motivated their students to pursue careers in science.
- Based on teachers' comments, the majority of students liked the outreach event. The prominent benefits recognised by teachers are the educational and entertainment aspects of the programmes. The lecture demonstrations appeared to be more appealing to teachers than the practical activities, due to the visual and sound impact.
- Another significant benefit the teachers acknowledged the benefits of authentic science, i.e. the students' learning science through the hands-on as well as minds-on activities in the Bristol ChemLabS laboratories with the assistance of the trained chemistry Science and Engineering Ambassadors (SEAS[5]) and other members of the outreach team. The participants in this study also acknowledged the invaluable opportunity to experience the practical work using the advanced facilities found in the Bristol ChemLabS laboratories. The cryogenics-based lecture demonstrations, which are inaccessible in their regular school science lessons. The practical workshop and lecture demonstration were considered to have a "WOW' factor, which can impact on their students' their future career choices.
- The limitations perceived by the teachers were mainly focused on common difficulties in organising the visit.
- The teachers acknowledged that the positive impact of their students' learning at Bristol ChemLabS' events were largely linked with the roles of the STF and the SEAs during the activities.
- The 'edutainment' aspect of 'A Pollutant's Tale' lecture demonstrations, has been highly recognised by the participants of the study, simultaneous to it becoming a popular lecture and being requested by many schools since the involvement of Bristol ChemLabS in outreach education in 2005.

## Conclusion

The involvement of universities in outreach education has been in existence for decades. The use of university laboratories is an example of the importance of learning out-of-classroom and of 'situated cognition' studies in the context of university outreach as discussed by other research [16]. Similarly, 'A Pollutant's Tale' advocates the importance of learning science through cryogenics-base activities that complements formal school learning. There is a 'Wow' factor for the learners, due to the powerful elements of novelty, excitement and the educational aspect. These could eventually impact on the students learning and their future career choices as outlined by several studies [17, 18, 19, 20, 21].

## Commentary

Those responsible for outreach activities in chemistry, and other departments of, universities should be delighted to learn that activities such as those described here have considerable impact on the schools that they engage with. Often the sponsors of outreach activities ask 'how do you know what you are

[5] SEAS. These are volunteers from Science, Technology, Engineering and Mathematics who are trained as part of a UK-wide programme to act as role models and to work with young people.

doing does any good?' Academics whose main tasks are research and teaching at undergraduate level who are engaged in outreach do not have the time for detailed surveying of those with which they are engaged. It is hoped that this and the companion papers that we at Bristol ChemLabS are making available will help others answer questions from future sponsors so that more outreach activity can be undertaken.

## References

[1] Harrison T.G. & Shallcross D.E., (2007) 'A Pollutant's Tale', http://www.chemlabs.bristol.ac.uk/outreach/A_Pollutant_s_Tale.html (accessed on September 2009)

[2] Shallcross, D.E., & Harrison, T.G. (2007). Outreach. Bristol ChemLabS CETL Interim Review 2005-2007. pp 17-20. Bristol ChemLabS, University of Bristol: Portishead Press.

[3] Shallcross, D.E. & Harrison, T.G. (2006). A secondary School Teacher Fellow within a university chemistry department: The answer to problems of recruitment and transition from secondary schools to University and subsequent retention? At URL: http://www.rsc.org/images/STF%20letter%20final_tcm18-76285.pdf). (accessed on 17 July 2009).

[4] Smart, S., & Hutchings, M. (2007). The 'wow' factor: teachers' expectations of, attitudes towards and experiences of pupils learning science outside the classroom. Paper presented at the British Educational Research Association (BERA) Annual Conference, Institute of Education, University of London.

[5] Rickinson, M., Dillon, J., Teamey, K., Morris,M., Choi,M.Y., Sanders,D.,D. & Benefield, P.(2004). A review of research on outdoor learning: Executive summary (Accessed on 5 May 2008, at URL: http://www.nfer.ac.uk/research-areas/pims-data/summaries/fsr-a-research-review-of-outdoor-learning.cfm.

[6] O'Donnell, L., Morris, M., & Wilson, R. (2006) Education Outside the Classroom: An assessment of Activity and Practice in Schools and Local Authorities. National Foundation for Education Research (NFER), Research Report 803, Nottingham : Department of Education and Skill.

[7] Rennie, L.J., & McClafferty, T.P., (2001). Visiting a science center or museum? Make it a real educational experience!. In Errington, S., Stockmayer, S.M., & Honeyman, B. (Eds.), Using museums to popularise science and technology (pp73-76). London: Commonwealth Secretariat.

[8] Rennie, L.J. (2007). Learning science outside of school. In Abell, S.K., & Lederman, N.G. (Eds.), Handbook of Research on Science Education, (pp125-16). Mahwah: Lawrence Erlbaum Ass.Inc..

[9] Kisiel, J. (2005). Understanding elementary teacher motivations for science fieldtrips. Science Education, 89 (6), 936-955.

[10] Michie, M. (1995) Evaluating teachers' perceptions of programs at a field center. Science Teachers Association of the Northern Territory Journal, 15, 82-92.

[11] Orion, N., & Hofstein, A. (1994). Factors that influence learning during a scientific fieldtrip in a natural environment. Journal of Research in Science Teaching, 31 (10), 1097-1119.

[12] Anderson, D. (1999). The development of science concepts emergent from science museum and post-visit activity experiences: Students' construction of knowledge. Unpublished doctor of philosophy thesis, Queensland University of Technology, Brisbane, Australia.

[13] Falk, J.H. & Dierking, L.D. (2000). Learning from museums: Visitor experiences and the making meaning. Walnut Creek. CA: AltaMira Press.

[14] Anderson, D., Kisiel, J., & Storksdieck, M. (2006). Understanding teachers' perspectives on field trips: Discovering common ground in three countries. Curator, 49(3), 365-386.

[15] DeWitt, J. & Osborne, J. (2007). Supporting teachers on science-focused school trips: towards an integrated framework or theory and practice. International Journal of Science Education, 29 (6), 685-710. (Accessed on 5 June 2008, at URL: http://www.informaworld.com/smpp/content~content=a776626270~db=all~order=page.

[16] Luehmann, A.L., & Markowitz, D. (2007). Science teachers' perceived benefits of an out-of-school enrichment programme: Identity needs and university affordances. International Journal of Science Education, 29 (9), 1133-1161.

[17] Lopez-Garriga, J., Munoz-Sola, Y., Torres., V., Echevarria, Y., Nazario, W., Jesus-Bonilla, W., & Camacho-Zapata, R. (1997). Science on wheels: A coherent link between educational perspectives. Journal of Chemical Education, 74 (11), 1346-1349.

[18] Bruce, B.C., Weismann, M., & Novak, M. (1997). Science education outreach: Physics demonstrations, lectures and workshops. The Journal of Illinois Science Teachers Association, 23 (2), 8-12.

[19] Lee, N.E., & Schreiber, K.G. (1999), The chemistry outreach program: women undergraduates presenting chemistry to middle school students. Journal of Chemical Education, 76 (7), 917-918.

[20] Caleon, I.S., & Subramaniam, R. (2005). The impact of a cryogenics-based enrichment programme on attitude towards science and the learning of science concepts. International Journal of Science Education, 27 (6), 679-704.

[21] Caleon, I.S. & Subramaniam, R. (2007). Augmenting learning in an out-of-school context: The cognitive and affective impact of two cryogenics-based enrichment programmes on upper primary students. Research in Science Education, 37, 333-351.

## Authors

**Jauyah Tuah**, Ministry of Education, Brunei, e-mail: Darussalam.jauyahtuah@yahoo.com.

**Timothy G Harrison**, School of Chemistry, University of Bristol, Bristol, UK, e-mail: t.g.harrison@bristol.ac.uk

**Dudley E Shallcross**, School of Chemistry, University of Bristol, Bristol, UK, e-mail: d.e.shallcross@bristol.ac.uk

## Acknowledgments

Jauyah Tuah wishes to thank the Ministry of Education, Brunei Darussalam, Tim Harrison wishes to thank the Bristol ChemLabS project and Dudley Shallcross thanks the Higher Education Academy for a National Teaching Fellowship.