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WHAT VALUE HAS CHEMISTRY OUTREACH BY A UNIVERSITY DEPARTMENT TO SECONDARY SCHOOLS? TEACHER PERCEPTIONS OF BRISTOL CHEMLABS OUTREACH EVENTS

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Abstract: This paper explores teachers' objectives when engaging their students in University outreach programme. Their perceptions of the short-term and long-term effects of outreach engagement on their students are explored. Seven out of twelve teachers interviewed (all from state schools) believed there were long term effects such as a rise in students taking science at pre-university level. Three out of twelve believed it was too difficult to tell and two believed there were no effects (both from independent schools). However, all teachers believed the activities enhanced interest and would continue to participate. Further exploration of these general findings is presented.

Key words: Teachers, Bristol ChemLabS, attitudes, outreach, university-school partnerships

1. Introduction

Teachers play an integral part in the success of science outreach events. They are one of the key decision makers in deciding whether or not to engage their students with such activities. Without a teachers' initial interest and support, students' may not have a chance to participate.

Practical science is an important part of the science curriculum for a number of reasons, Wellington [1] suggests that the reasons offered can be grouped into three broad categories: knowledge and understanding (cognitive arguments), skills and processes, and attitudes (skills arguments), enjoyment and motivation (affective arguments). Cognitive arguments are based around the idea that practical work helps to improve students' theoretical and conceptual understanding by illustrating the work they are learning about. Skills arguments suggest that practical work develops skills that are transferable. Affective arguments suggest that practical work is exciting, and can stimulate interest and motivation for a subject. Due to regular changes and additions to the national curriculum [2] and a seemingly ever increasing focus on examination results, it is often difficult for science teachers to allow time for as much practical work as they would like. Engaging students in science outreach activities may be a useful way for teachers to integrate more practical work into their students' science education. Practical science in school is essential but it is arguable that this should be supplemented with an authentic experience of what practical science in a laboratory is like in a real world context [3]. Awareness or a desire for an authentic experience for their students may be important for teachers' interest in students taking part in science outreach, where they can often experience a real laboratory and work with real scientists.

Much of the evaluation that has been conducted into science outreach programmes often focuses on student feedback. This is important, but the feedback from teachers may provide further insight than given by students, particularly if the effects are something the students themselves may not explicitly consider, such as their own motivation and confidence. When schools take part in outreach activities the teachers' evaluation of the activity and its effects on their students is extremely important. The teacher has detailed knowledge of their own students prior to any engagement and will also spend a

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large amount of time with them after their engagement, and so is best placed to see any consequences of taking part in science outreach. Teachers are best placed to be able to make a comparison before and after the event, on aspects of attitude, understanding and attainment.

Teachers' Motives in Outreach Engagement

There have been a small number of studies into assessment of teachers' motives for involving students in science outreach activities. Luehmann & Markowitz ([4] interviewed 8 secondary school teachers during a one year partnership with their schools and a local university science outreach centre, and identified motives related to students' understanding, skills, interests, performance and confidence. As they noted many of these objectives relate to learning, consistent with the pressures that teachers are often under to be accountable for their students' performances.

Luehmann & Markowitz (also pointed out teachers' decisions about whether to take part in outreach activities may be affected by the three factors of teacher decision-making [5]. These are

1. Instrumentality; is practical information available on how an intervention can be implemented?

2. Congruence; is the intervention compatible with the current approach to education?

3. Cost; will any benefits outweigh the time, effort and money invested in taking part?

Lott [6] investigated the beneficial effects on the teachers themselves when engaging their students in science outreach. The study found that teachers involved in an outreach program had a more positive attitude towards inquiry-based science teaching, using more hands-on activities and in using technology more frequently. However it was not clear whether this was a consequence of taking part in the outreach program, or a pre-existing characteristic of these teachers.

Teachers' Evaluation of Outreach

Luehmann & Markowitz identified common categories relating to outreach benefits; these being, increased access to learning and science resources and increased student learning and motivation. In particular, they concluded that whilst teachers' objectives before the outreach activity tended to relate to learning outcomes while the post event benefits were perceived to be related to motivational benefits.

A study into the benefits perceived by teachers attending activities run by Bristol ChemLabS [7] found that the most common benefit cited by teachers was the insight students gained into chemistry beyond the classroom. Also noted was the benefit of being able to take part in practical activities, and the positive effect on students' motivation and enthusiasm for chemistry. Similarly, Smart & Hutchings [8] found that teachers valued outreach related experiences for students as they provided experiences that they could not provide in the classroom.

2. Methods and Sample

The CHeMneT[1] database was used to identify teachers that had involved their students in outreach activities with Bristol ChemLabS[2] that were available to contact via telephone or face-to-face interview. Due to pressures of work some teachers who initially agreed to interview were unable to do so. In total, 169 teachers were contacted and asked if they would be willing to take part in a short interview, and over time 12 full interviews were able to be conducted. As all teachers in the CHeMneT database were invited to take part in an interview, teachers became part of the sample on a self-selecting basis. The method of sampling for this study means that there may be some response bias. It is important to consider that those willing to talk about their experiences of Bristol ChemLabS may

[1] CHeMneT is Bristol ChemLabS network of ~560 (February, 2010) of mainly Chemistry teachers in the south of England and South Wales

[2] Bristol ChemLabS is the project name for UK's only Centre for Excellence in Teaching and Learning in practical chemistry.

have stronger opinions on the programme, although these could be both positive and negative. The demographics of this sample are shown in Table 1. Teachers in the sample had attended a range of activities with Bristol ChemLabS, although half had attended A2 spectroscopy visits.

Data were collected through qualitative interviews both in person and by telephone. A telephone interview was usually less time consuming so was useful for teachers with little time to spare but both modes were offered. The interviews were also often fitted in around lessons, so a telephone interview meant that in the event of the interview not being able to be completed, it could be rearranged for another time without too much disruption for the interviewee. The interviews were conducted using a set of pre-determined open-ended questions.

Table 1: Demographics of teachers participating in in-depth interviews

	No. of Sample	Percentage of Sample
Gender of Teacher		
Male	7	58%
Female	5	42%
School Type		
State	8	67%
Independent	3	25%
FE College	1	8%
School Gender		
Male only	0	0%
Female only	2	17%
Mixed	10	83%
Activities Attended		
Spectroscopy visit	6	50%
Aspiration raising day	3	25%
Schools conference	3	25%
'A Pollutant's Tale' lecture demonstration	2	17%
Polymer chemistry workshop	2	17%
Other workshop	1	8%

3. Data Analysis

The full transcripts of the recorded interviews were analysed to look for any key issues and themes. Data were analysed with no pre-determined categories, instead categories and themes were developed through the study of teachers' responses. This is consistent with characteristics of grounded theory [9] which emphasises creating theory from data, rather than collecting data based on a theory. Rather than starting with a preconceived theory and attempting to test this, this approach entails collecting information, then building theories based upon this. Once themes were established, a comparison of the number of teachers making reference to each theme was made. Comparisons were then made between teachers' objectives and their perception of the short term and long term effects on their students.

4. Results & Analysis

Teachers' objectives when engaging in outreach

Teachers were asked 'What were your objectives in bringing students to the activity/activities with Bristol ChemLabS?' Analysis of teachers' responses gives rise to five key themes being identified (Table 2).

Table 2: Objectives identified by teachers whose students attended outreach events run by Bristol ChemLabS

Theme	No. of teachers giving responses relating to theme
School science / curriculum related	8
Students' understanding of science	7
Students' exposure to university	5
Students' enjoyment	5
Students' interest in science	3

Perceptions of short term effects

Teachers were asked 'What effects were there, if any, on students during the day and immediately after?' Through analysis of responses, the five key themes shown in Table 3 emerged.

Table 3: Short-term effects on students identified by teachers whose students attended outreach events run by Bristol ChemLabS

Theme	No. of teachers giving responses relating to theme
Enjoyment / interest	8
Motivation	4
Appreciation of opportunity	3
Positive experience of university	2
Aids understanding and school work	2

Perceptions of long term effects

Teachers were asked 'Were there any long-term effects on the students?' Responses showed around 60% identified long-term effects, whilst around 40% felt they had observed no long term effects, or found it difficult to assess whether taking part in the outreach had caused any specific effects. Of those teachers identifying long term effects, there were six themes identified (Table 4). Of the teachers not identifying any long-term effects, responses centred around 3 themes (Table 5).

Table 4: Long-term effects on students identified by teachers whose students attended outreach events run by Bristol ChemLabS

Theme	No. of teachers giving responses relating to theme
Chemistry uptake	5
Enthusiasm for chemistry	3
Helped with school work / revision	2
Long-term recall of the event	1
Aided understanding of career opportunities in chemistry	1
Encouraged university applications	1

Table 5: Responses from teachers not identifying any long-term effects on students attending outreach activities run by Bristol ChemLabS

Theme	No. of teachers giving responses relating to theme
Difficult to assess long-term effects	3
No long-term effects observed	2
Students attending are already interested in chemistry	2

Opinions on the importance of science outreach

Teachers were asked 'How important do you think engaging in science outreach activities is and why?' Through analysis of responses, six key themes related to the reasons why science outreach is important were identified. These are shown in Table 6.

Table 6: Reasons why engaging in outreach is important identified by teachers whose students attended outreach events run by Bristol ChemLabS

Theme	No. of teachers giving responses relating to theme
Aids future decisions	7
Encourages ambition / enthusiasm	5
Broadens understanding of science	5
Improves on school science	2
Improves uptake of science	2
Improves attitudes towards science	2

5. Discussion

Teachers bringing students to Bristol ChemLabS were asked about their specific objectives in doing so. The most common objectives were related to the science that students were learning in school, and students' understanding of science, supporting the science students were learning in school and providing practical experiences they wouldn't otherwise be able to get. *'It's good for them to get experience of certain things, such as[thin layer] chromatography, so that they've seen it before when they come across it again in their studies'* and *'They also get to do practical work which is just not possible in school.'*

Understanding of science objectives included aims such as broadening students' ideas about science, understanding the application of science in the real world and showing students what future study and a career could be like. *'So many of them think that science is about bearded men in white coats. I want them to think about the broader impact of science – even if they don't choose to study it they will still have to make decisions based on science.'*

It is apparent that many of the objectives stated by teachers are related to learning and understanding. This supports the finding of Luehmann & Markowitz (2007) that student learning was the most dominant factor in teachers' discussions of their objectives. Teachers usually have to justify why they want to take students out of the classroom, so such objectives are understandable. It is important to consider how these objectives can be met, and how to communicate this to teachers effectively, when designing or developing a science outreach activity.

Another objective identified is the aim of exposing students to the university environment. This is more of a general objective based upon showing students a university, and shedding some light on the

route from school to university. This suggests that some teachers are not just simply focussed on the science but are considering their students' futures in more general terms.

Perceptions of short term effects

Many teachers identified the enjoyment and interest that students showed during and after taking part. *'Well they really enjoyed it, they all seemed really keen to be doing it.'*

Enjoyment and interest was identified as an objective for some teachers (5 out of 12) but not as many as those identifying it as a short term effect (8 out of 12). This suggests that enjoyment may only be an added bonus for some teachers rather than a reason for involving students in an activity, or possibly that not all teachers considered this when initially getting involved in outreach. A number of teachers also mentioned the effect of motivation on their students. *'..when they left they seemed to be quite motivated with their science, which isn't always the case!'* Others discussed seeing an increase in motivation through an increase in the questions that students were asking about the science they had seen, or through increased energy from the students. Teachers tended not to identify motivation explicitly in the explanation of their objectives, although raising students' interest in the subject may be indirectly related to this. This supports the findings of Luehmann & Markowitz in that teachers tend to consider motivational benefits after the event, but not before.

Most of the short term effects noted by teachers were based around aspects such as enjoyment, motivation and opportunity, rather than learning and understanding. It may be that it is difficult at an early stage for teachers to identify these benefits, or it may be that the effects at this stage are more commonly related to more general education-related benefits than learning-related benefits than teachers had anticipated.

Perceptions of long term effects

The responses from teachers on their perception of long-term benefits were particularly divided. Seven out of twelve identified long-term effects for their students, two out of twelve felt there were none (interestingly both were from independent schools) and three out of twelve felt that it was too soon or too difficult to tell. This demonstrates the difficulty in attempting to establish what long-term effects there may be for students taking part in outreach activities. As one teacher noted; *'I'm sure you can appreciate that it's very difficult to attribute anything to one particular thing'*. This quote sums up the key difficulty – students do not take part in a science outreach activity in isolation, and so in turn it is difficult to measure the effect of such an activity in isolation in a study like this in which other factors cannot be controlled for. They could be affected by the school science teaching, the science they are exposed to outside of their education program, and any other science activities the school takes part in, to name but a few other factors.

For some of the teachers not observing long-term effects for their students, it was the case that they genuinely did not believe there were any, rather than that they thought they were difficult to recognise; *'I suspect not really…I suspect that what the activity does is enhance interest that is already there'*. For these teachers, it may be that the short term effects gained for students are enough to warrant making the effort to attend outreach activities. It could also be that the outreach did not live up to their expectations, but this is not consistent with later responses where no teacher responded that they would not be taking part in outreach in the future. It is also noteworthy that the students associated with both schools achieved very high grades in science traditionally. Therefore it would be virtually impossible to determine an effect based on examination grades for example and may be the reason for the mixed response from these teachers, i.e. they couldn't see an effect (possibly referring to their predicted examination grades) but wanted their students to participate nevertheless. The point made about enhancing interest in science is an interesting one – is outreach for (and should it be used for) encouraging students who are not interested in science to become interested, or to encourage the interest of those who have already shown a level of interest in the subject? It could, of course, well be both. This is a point of discussion that would be interesting to explore in future research.

For those teachers that did identify long-term effects for their students (interestingly all were from state schools), the most common effect noted was that on the uptake of science within the school. *'I*

think generally with A-level [3]and IB [International Baccalaureate] the uptake of science and the physical sciences in particular is quite high. I think they tend to choose subjects because of what they've seen at Bristol' and *'Yes, it's the best uptake of AS chemistry I've had in the 4 years I've been at this school'*

In particular, two teachers made a direct link between the increased uptake with the experience students had gained at the University of Bristol. It is interesting that teachers can be confident in their perception of particular effects of the outreach on students, while others feel it is too difficult, or can perceive none.

Other long-term effects that some teachers noted for their students were related to an enthusiasm for science. *'There's a more positive attitude when they arrive, in their approach to science.'* That some teachers pointed this out in their response to long-term effects as well as short term ones suggests that any influence on students' enthusiasm may be maintained over a period of time.

Only one teacher spoke of a long-term effect for their students related to learning. *'It comes up with revision and you can see a transferring of their skills and learning'*

As with the analysis of short term effects, there is a clear distinction between teachers' original objectives and their perception of long-term effects. In particular, one teacher noted *'And it's definitely a long-term memory – although how much actual science they take away is quite difficult to assess.'* It seems to be that when setting out objectives, teachers tend to refer explicitly to students' work within the science curriculum, but when assessing the outcomes of the engagement the focus is much more on the attitudinal and motivational effects.

Opinions on the importance of science outreach

The three most popular reasons why outreach is important were related to helping students with future decisions, encouraging their ambitions and enthusiasm, and helping them gain a broader understanding of science. Over half of the teachers interviewed noted that taking part in outreach gave their students experience of university, and helped them decide what to do in their future. *'They experience the uni side of things, and it seals their idea of going down that route'* and *'They need to be able to see what they're aiming for, and also see the sort of facilities they will be using as we don't have anything like that here for them to see.'*

Just under half of the teachers interviewed stated that encouraging ambitions and enthusiasm for chemistry was a reason why participating in outreach is important, and the same amount stated it was important to increase their students' broader understanding of science. *'It's quite a considerable motivator'* and *'Teaching doesn't mean anything unless you put it in the broader sense of things'*

What was noticeable despite the variety of responses was the consistency of teachers' beliefs about how important engaging in outreach is. Regardless of why teachers thought it was important, they all felt that importance was high, and this was represented in the intensity of responses*:*

'It's crucial' (State school teacher),

'I don't think you can put a figure on it, it's essential really' (State school teacher),

'I think it's very important because it gives them a lateral view of what's happening' (Independent school teacher)

This is particularly interesting given some teachers' view that there were no long-term effects for students, or at least no measurable ones. Although the strongest beliefs tended to come from teachers observing long-term effects, even those that did not think there were noted that outreach was important, with one stating it was *'very important'*. It seems that short-term effects for students may be important enough for teachers to want to provide outreach experience for their students, but it also questions the comments of those who do not believe there is a long-term effect.

[3] A-level (Advanced level) is the major pre-university qualification in the UK.

Although uptake of chemistry is a long-term effect identified by a number of teachers interviewed, it was only mentioned by two of the teachers interviewed as a reason why outreach involvement is important for students. *'Well if I want to increase numbers at A-level, and that's the driver, as it is nationally I suppose, then I think it's really important'*

Teachers' tendency to cite student decision making rather than the measure of science uptake suggests the majority at least are keen to see gains for their students' interests more than their own.

Summary

Teachers' views and opinions on their engagement with Bristol ChemLabS outreach are extremely important given their role in deciding whether to provide opportunities for students to engage in outreach activities in the first place, their knowledge of the students taking part, and their time spent with students and observing their behaviour after engaging in outreach. The objectives for engaging students in science outreach activities indicated by the teachers interviewed in this study were varied, but often related to their students' learning and understanding. In contrast, their evaluation of the effects on their students was often more related to their enjoyment and motivation (in the short term) and decisions on whether or not to study science (in the long-term). There was also a marked difference in opinion over whether there were in fact any long-term effects for students engaging in outreach activities, yet all teachers identified reasons why engaging in such activities was important.

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