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Development of the School Science Club at Cardiff University

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Abstract

Challenges faced by schools include how to make science interesting, relevant and engaging for their pupils. This can perhaps be made more difficult by staff members not having direct experience in many areas of the science they are tasked to teach, and therefore lacking the confidence to teach in these areas (Murphy et al., 2007). Within the higher education sector, there is demand for researchers to actively engage with the local community (Linder and Spear, 2003; Wynne, 2006). Working with eight schools, we co-developed a programme that both highlights academic research and complements the Key Stage 2 national curriculum with the aims of improving science aspirations, knowledge and confidence in Key Stage 2 (Year 6) children, supporting teachers in the delivery of areas of the curriculum identified as challenging, and increasing science communication and engagement within the university. We delivered two separate sessions with all eight primary schools, interacting with approximately three hundred and fifty pupils. Overall, the project had a positive impact on teachers, children and academic staff. Key findings indicated that 92.9 per cent of 348 children surveyed felt that they had learned something new, while 85.7 per cent surveyed felt they were more interested in science, and 14.3 per cent reported no change in their feelings towards science. The School Science Club represents a collaborative engagement project which highlights the requirement of accurate co-development and outcome settings from both the university and school in order to have a positive impact on all those involved. Findings suggested improvements in planning and delivery for future such endeavours.

Keywords: science, Key Stage 2, school, co-development, university

Key messages

- A co-production approach between the university and schools was key in the success of this project, helping us develop a range of activities that were fit for purpose, tailored to the learning objectives of the schools involved and ensuring pupils were engaged effectively.
- Building a rapport with the pupils and teachers was important in ensuring engagement with the interventions, which was facilitated through two visits to the schools, and a visit to the university by the schools, and interventions that pupils could do in between these visits.
- Engaging Key Stage 2 students is a new skill, which was refined by using an external evaluation company who could evidence which areas worked well and which required improvement.

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Introduction

Universities can be perceived as ivory towers, with public-funded research kept behind laboratory doors. Therefore, there are repeated calls for more transparency in research being undertaken (Wynne, 2006; Bates et al., 2010). A number of grant providers ask for detailed information regarding public engagement as part of the funding deal and, perhaps more importantly, regarding how the impact of these engagement processes is measured. Universities are therefore keen to build their public engagement profile and, as such, are looking for novel and effective ways of approaching public engagement. This can have a beneficial effect on both the local community and the university (Hart and Northmore, 2011), as well as on the science communicator, who can develop a better understanding of current students' expectations and requirements, and a greater understanding of schools' engagement and the current schools educational system (Diment and Jenkins, n.d.).

We wished to improve the quality of our outreach activities to showcase the breadth of research at Cardiff University. Engagement prior to the start of this project consisted of ad-hoc appearances at local events and small talks to interested members of the public. None of the previous engagement projects included measurable impact.

Through a member of staff at the university, we were introduced to a cluster of schools within the Newport area of South Wales. The schools within this cluster included: Gaer Primary, Pill Primary, Clytha, Maesglas, Ysgol Gymraeg Cwmbrân, Tredegar Park, St Woolos and Glasllwch. These schools currently work together to co-develop teaching material, moderate assessments and pool resources across the region. Therefore, the schools were chosen due to participation in this cluster, as well as due to geographical location.

We met with the teachers of all eight schools during the summer of 2017, and participated in a discussion regarding the science curriculum in Wales. The teachers reported that some areas of the curriculum were hard to relate to with current classroom teaching practices. These included numeracy, data analysis, graphical representation, scientific bias and writing. We were able to develop several interactive activities based on the current research portfolio at Cardiff University, which could be employed to fulfil these curriculum gaps. As evidenced in previous publications and activities (NCCPE, n.d.), this co-development process was integral to the design of the programme.

The activities were centred on two, three-hour school visits facilitated by a university lead, and a final 'showcase' university visit by all pupils taking part. The university visit would encompass a tour of the facilities, several interactive activities, and talks by current PhD students regarding their area of research and how they became a scientist. This plan was chosen in part due to the availability of the university lead, financial limitations and time constraints within the schools. Thus, we developed sessions and activities to achieve the following aims:

- improve science attainment within this cohort of pupils
- showcase the university and the research being undertaken
- improve the public engagement activities within Cardiff University
- use research at Cardiff University to fulfil the following curriculum points: numeracy, data analysis and graphical representation, bias, and scientific writing.

As with all public engagement initiatives, funding can be difficult to obtain. This project was led by a postgraduate research associate, who was employed on the project part time. Working with a school cluster was a distinct advantage, as the cluster was able to pool resources for such activities. We were also supported by the Waterloo Foundation

(www.waterloofoundation.org.uk/) and the School of Pharmacy and Pharmaceutical Sciences at Cardiff University (www.cardiff.ac.uk/pharmacy-pharmaceutical-sciences).

Programme activities

The programme consisted of two, three-hour school visits, although in some schools there were up to three separate classes taught in one visit. Finally, all pupils involved in the project were given the opportunity to visit the School of Pharmacy at Cardiff University. This took place over the course of two days. All Year 6 pupils at each school who were taking Key Stage 2 science were invited to participate; this consisted of approximately three hundred and fifty children split across all eight schools.

School visits

We undertook two separate school visits under the following themes: The Body and Bugs, and The Skin, Brain and Drugs. These sessions were co-designed to show the range of research at Cardiff University, and to fulfil the following curriculum points: numeracy, data analysis, graphical representation, bias and scientific writing. The design of the sessions is described below.

Session 1: The Body and Bugs

In the first session, the differences between bacteria and viruses were explained, how they live inside our bodies, and how antibiotics are developed to fight the harmful ones. Within this session, we discussed the scientific notation of bacterial numbers and how these are applied, and specifically that the human body is home to an average of 39 trillion ($39x10^{12}$) individual microorganisms, and how that might relate to the number of human cells.

Practical 1 – Handwashing: During this session, we also introduced the idea of bias within scientific testing. We told the children that we had developed two new types of handwash – one was extremely powerful and had been developed by the university lead; the second, was 'rubbish' and had been made by a rival. Pupils were split into two groups of 15, and each group was given either the 'powerful' or the 'rubbish' handwash and asked to wash their hands as normal. In fact, each pupil was given the same lotion, a fluorescent germ gel (www.glogerm.com), which acts to show the efficacy of the handwashing technique. The university lead then used a UV light, which showed the 'germs' on the pupils' hands; consequently, we found that pupils who used the 'powerful' handwash had not washed their hands quite as well as the children who had used the 'rubbish' handwash.

Practical 2 – School swabbing, grime detectives: To continue the bugs theme, we brought sterile swabs to the school with agar plates. After a discussion about bacteria and where they are commonly found, pupils could choose any area of the school to swab and were then tasked with inoculating the agar plates. This allowed the children to think of areas that may become contaminated with bacteria, and it got them using microbiological techniques that they would not usually come across at Key Stage 2. Post-inoculation, the children washed their hands thoroughly and the bacterial cultures were grown at Cardiff University.

Images of the pupils' agar plates were shared electronically with each school, and under the guidance of the teacher, the pupils were tasked with counting the individual

colonies and expressing this number in standard form. One pupil commented: 'I enjoyed doing science with James because we got to do lots of different experiments. One of my favourite experiments was the "swabbing" experiment. It was really fun to do because they let us swab anywhere! I swabbed down the toilet … Everyone was disgusted by the results.'

Practical 3 – Antibacterial honey, can you taste the difference?: Cardiff University is currently identifying an antibacterial honey. To demonstrate this area of research, we described to the pupils how the university is working with honey bees to identify new antibiotics which might be used to combat antibiotic-resistant strains of bacteria (www.cardiff.ac.uk/pharmabees). For this, we allowed the children to taste different types of honey and explained the importance behind pollinating insects.

Session 2: The Skin, Brain and Drugs

The second session, The Skin, Brain and Drugs, took place approximately four weeks after the initial visit. It consisted of two practicals and a recap of Session 1.

Practical 1 – Reaction times: During the second classroom session, the pupils were introduced to the nervous system and discussed the effect that drugs such as alcohol and caffeine have on reaction times. To demonstrate this we used a dropping ruler technique (www.scienceworld.ca/resource/reaction-time-ruler/). Instead of using alcohol or caffeine to show the differences in reaction times, we asked the children to repeat the experiment at different times of day.

Practical 2 – Nerves: We next investigated the use of callipers to demonstrate the sensitivity of different parts of the body. We asked the pupils to put digital callipers on their skin (back of hand, back of neck, arm) at set measurements. We then asked the pupils to record at which measurement they could not discern the difference between a single point and two points (Backyard Brains, 2017). During this session, we also discussed the results of their previous experiments, and the pupils were put into groups and asked to start drafting a poster for presentation at the university.

Visit to the university

For the culmination of School Science Club, all pupils were invited to Cardiff University's School of Pharmacy and Pharmaceutical Sciences. The children were taught about the brain, biofilms and aspects of the university's research through a series of games and short lectures; for many pupils, it was their first experience of a university setting. It was the project's intention to bring the children into an academic environment to dispel the myth that academia is distant and inaccessible. Having them acclimatize to university settings at an early age will hopefully raise aspirations for them to advance to higher education.

Brain games: In this series of games, the children got to learn about the brain through a series of interactive activities, such as the custom-built Brain Dome – a bouncy castle in the shape of a brain. Inside were some fact sheets with information about the brain – how it weighs 1.2 kg, how it has 86 million neurons, and how the surface area of the brain would be 2,500 cm^2 if the folds of the cortex (the outermost layer of the brain) were flattened out (www.cardiff.ac.uk/psychology/about-us/engagement/brain-games). The pupils also played on the university's Stroop mats, a game where they learned about colour perception, and how the brain and eye process information (Figure 1).

Figure 1: Pupils using the Stroop mats (source: author)

Figure 2: Pupils using the 'blast a biofilm' project, adapted from Victoria Marlow (Microbiology Society, 2017) (source: author)

Blast a biofilm: In 'blast a biofilm', which was based on the outreach pioneered by Victoria Marlow (Microbiology Society, 2017), the children were shown the importance of brushing teeth, through a demonstration using water pistols. The players needed to 'blast' bacteria off an enlarged set of model teeth, a task that becomes more difficult when they are coated in a sticky gel – the biofilm (Figure 2).

Lecture theatre: The pupils were also introduced to real-life scientists through a series of short talks. Researchers were invited to speak to the children about the research they are doing at the School of Pharmacy, from PhD students who discussed the development of foods for patients who cannot swallow, to a student on the pharmacy master's course, who spoke about how being a pharmacist has inspired her to be a strong, independent woman.

Evaluation

Although both teachers and academics were happy with the session plans, we were keen to know if the project had an impact on the children, good or bad. As this was the first time we had undertaken such a large engagement project, we were also keen to find out what worked and what did not, and, most importantly, what we could improve on to increase the longevity of the project.

To enable us to do this, we used the service of an external evaluation company. The rationale for using external assessors was to ensure that we did not introduce bias into the reports. The science communicator was expected to build a strong rapport with the children, and therefore we felt that questionnaires handed out and completed in his presence might only focus on the positive points. The question of bias was also considered for the teachers, as we could have simply asked for these forms to be filled in between sessions and after the process.

We met with the external evaluators during the development stage of the project, and decided on the range of evaluation methodologies shown in Table 1, consisting of questions at baseline, at the end of Session 1 and at the end of the project, as well as a follow-up post-project with pupils, teachers and the university lead.

Baseline questionnaires: A baseline questionnaire was conducted to understand the pupils' thoughts and attitudes towards science. Questions included:

- I enjoy science (Yes/No/Not sure)
- I would like to be a scientist (Yes/No/Not sure)
- People like me become scientists (Yes/No/Not sure)
- Science is important for everyone (Yes/No/Not sure)
- Describe science in three words.

Pupils were then asked to draw what they thought a scientist looked like. For this, they were not given any prompts.

General reporting methods: Quantitative data for large numbers of respondents are presented as percentages. These have been rounded, and when totalled may be slightly more or less than 100. Quantitative data were analysed for all student questionnaire respondents.

Qualitative data, such as responses to open questions in surveys and all interview feedback, were analysed thematically. To fit within the evaluation budget, we analysed qualitative data from student baseline and post-activity questionnaires for a random sample of 25 per cent of respondents in each case. Where appropriate, representative quotations have been used to illustrate findings. All quotations have been anonymized to maintain confidentiality.

The full programme and tight timetabling during the university visit meant there was insufficient time for the university lead to distribute end-of-project questionnaires to all pupils. Instead, the evaluation company interviewed a sample of pupils across a range of abilities from observed schools.

Due to the financial constraints of the project, we were only able to conduct a follow-up survey with one school. This school was picked at random from the cluster.

Table 1: Evaluation methodologies employed within the School Science Club

	Students	Teachers	University lead
Baseline	352 baseline questionnaires		
Session 1	348 post-activity questionnaires		
Session 3 and end of project	5 paired interviews		
Post-project	22 post-project questionnaires 1 whole-class post-project focus group discussion 2 paired interviews (4 interviewees)	5 post-project reflective logs/ interviews	1 post-project interview

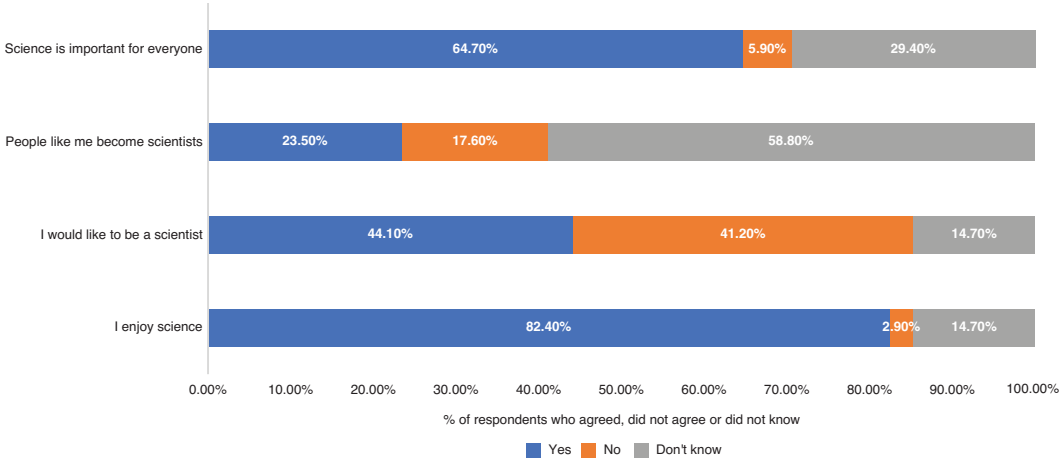
Findings

Baseline: In the baseline questionnaire, all pupils were asked to write down three words that describe what they think of science. The word cloud in Figure 3 shows the words that appeared more than once in their answers, from a total of 352 responses.

From the initial baseline questionnaire (Figure 4), we were able to ascertain that most pupils (82.4 per cent) 'enjoy science', which is consistent with the positive words they associated with science. Across all schools, almost two-thirds (64.7 per cent) of pupils thought that 'science is important for everyone'. Fewer than half (44.1 per cent) indicated that they 'would like to be a scientist', and only 23.5 per cent thought that 'people like me become scientists'. These percentages present a picture of pupils recognizing the wider importance of science, but not necessarily relating this to themselves or their personal circumstances.

Figure 3: Describe science in three words – word cloud (source: author)

Figure 4: Respondents' views of science prior to the start of the School Science Club (percentages from 352 responses) (source: author)



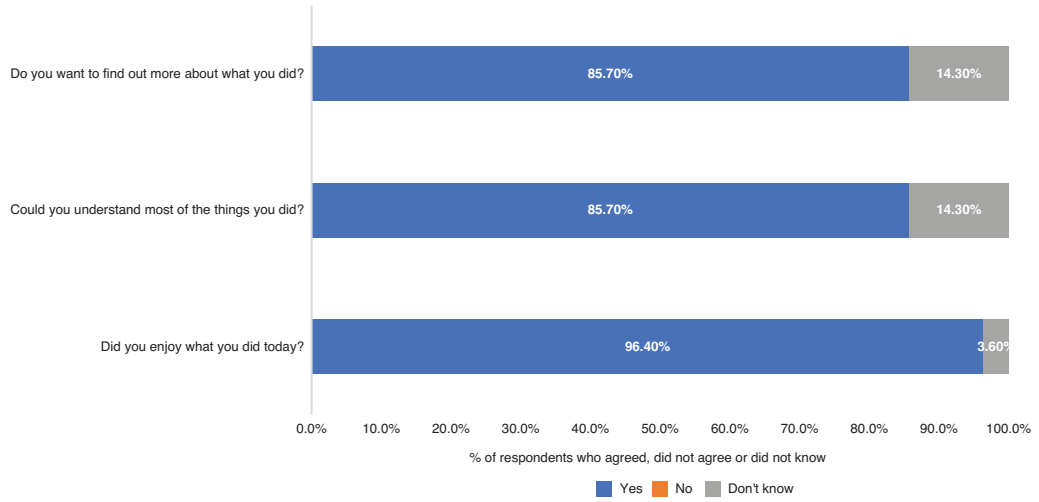
Draw a scientist: Further insight into pupils' opinions about science at the outset of the project was captured by their drawings of a scientist. The vast majority of these were 'traditional' representations of a male figure wearing a white coat, with many also wearing spectacles or safety glasses. Hair was a significant feature on male and female figures, with over half of the drawings being labelled 'crazy hair' or 'mad hair'. Many of the drawings featured test tubes or flasks and/or the label 'potion', with 'explosion' being another common label. A rudimentary analysis of these drawings suggests that while most of the pupils in the project already enjoyed science, and a majority also understand its importance, they have a limited view of contemporary scientists and what their jobs entail.

Feedback following the end of Session 1: Pupils from all schools completed a questionnaire at the end of Session 1 (N=348; Figure 5). Their feedback indicates that this session was a very positive experience, which pupils could comprehend, and which covered topics about which they wanted to learn more. Almost all (96.4 per cent) pupils enjoyed Session 1. Those who answered 'don't know' included pupils who expressed a general dislike of science, and others who described the session as 'OK' or 'alright'. Further evidence of positive experiences for most pupils were 85.7 per cent reporting that they understood what they had done or heard about, and the same percentage wanting to find out more about the specific topics that were covered.

The vast majority (92.9 per cent) of 348 pupils answered 'yes' when asked if they learned something new in Session 1. By far the most reported examples of learning were related to bacteria, particularly the number of bacteria in the human body, and that there are 'good and bad bacteria'. Most (85.7 per cent) pupils of those surveyed (N=348) reported that Session 1 increased their interest in science. Several of the respondents who selected 'no change' indicated that they already liked science or were interested in science before this session.

University visit: Due to time and financial constraints, post-project questionnaire feedback was obtained from pupils at one school (N=22). It was supplemented by a focus group discussion with this cohort, and interviews with pupils from two randomly selected schools during the university visit. As shown in Figure 6, all questionnaire respondents enjoyed the visits by the university lead to their school, and most (77 per cent) enjoyed their visit to the university.

Figure 5: Pupils' understanding and enjoyment after Session 1 (percentages from 348 responses) (source: author)



Independent observation by the evaluation company found that generally pupils were most engaged when they were involved in activities, as evidenced by their attentiveness to instructions and diligence when carrying out investigations. In contrast, it was observed that pupils were less engaged by some of the scientists' talks at the university, which were sometimes pitched at too high a level and used language and terms that the pupils did not understand, such as the word 'molecule'. They were also

Figure 6: Post-project questionnaire completed by one school following the university visit (N=22) (source: author)

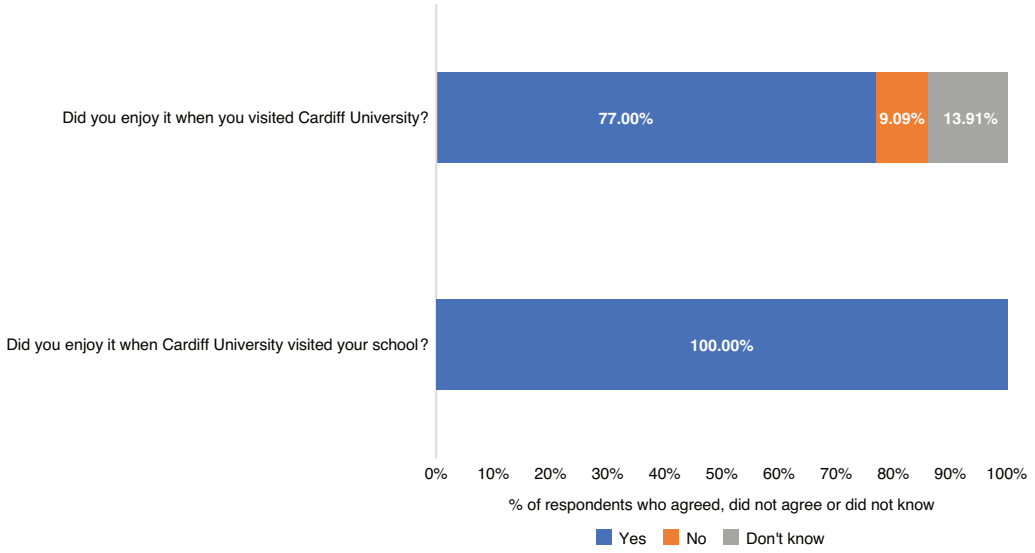


Figure 7: A representative selection of posters produced by pupils (source: author)

less engaged by elements where instructions were less clear, or activities did not have a clear purpose or defined beginning middle and end.

End-of-project posters: Before the final university visit, the children had been working on posters, summarizing everything that they had learned at School Science Club. Hard copies of all submitted posters were displayed throughout the university building, so that children could see their own poster and those of their peers. The posters were judged by volunteer members of university staff, using the following criteria: originality, design, scientific accuracy and conclusions. It was found that each school had different access to technology, so therefore we provided no guidelines for the design, and the posters could be submitted either as hand-drawn designs or as electronic designs. Figure 7 shows a representative selection from over forty posters produced by pupils.

Post-project feedback

Pupils' suggestions: Post-project, 80.9 per cent of student respondents (N=22) reported that their interest in science had been increased by the whole project. They were asked in survey and interview to explain why the project had any effect on their interest. Most pupils attributed increased interest to the practical nature of activities undertaken and the variety of science that was covered. The percentage of pupils who reported via questionnaire that they learned something new was similar to Session 1, at 90.5 per cent, with the remainder being unsure.

Further insight into attitudinal impacts was provided by pupils being asked in Session 1, end-of-project questionnaires and interview what they thought about the scientists they met. In all cases, pupils only mentioned the university lead who had visited their school, and all comments about this individual were positive. Teachers also highlighted their pupils' positive reaction to the university lead as a role model. In addition, they welcomed the inclusion of female scientists from a range of backgrounds and cultures during the university visit, with the caveat that some of their presentations needed to be pitched at a different level to make them more engaging for the target age group. The pupils' main suggestions to improve the project centred on including more investigations or hands-on experiments, and widening the scientific topics that were covered in those investigations:

> I think you could have a few more experiments as I love them! And you learn better when you enjoy it! And I enjoy experiments!

Teacher experiences: Teachers rated the project highly. The main explanations for these views were: the enthusiasm of the university lead; effective communication between the schools and the university lead, including joint planning; and the provision of opportunities for pupils to participate in scientific investigations and activities that schools could not usually accommodate, particularly bacterial swabbing:

> [The university lead] was very enthusiastic and was able to provide new opportunities for our pupils that we would not have been able to deliver.

> The most successful and essential part of the project was the effective working relationship established between the schools and the university lead person. This was vital in the success of the project.

> The children looked forward to [the university lead's] visits. I think he was ideal for the role of the 'face' of the university and everything was pitched at a suitable level for the children.

Teacher highlights: Teachers also described some other specific aspects of the project that they thought were particularly successful. They cited pupils being exposed to the wider significance of the science that was covered, an engaging and meaningful introductory session, and the curriculum relevance of activities and investigations:

> The introductory session was good as it enthused the pupils ready for the project. We were also able to hit areas of the curriculum that have proven difficult in the past, such as scientific bias.

> I feel that the simplicity of the investigations was also key as this meant that the investigations set by [the university lead] were both easy to facilitate and resource in a range of classroom environments with a mix of children.

Teacher outcomes: In terms of outcomes for themselves, all teachers reported that the project introduced investigations and resources that they can use in their own teaching practice, and that could have potential impact on their approaches to teaching aspects of the science curriculum in future:

> I have been able to improve my recognition of opportunities to meet hard-to-hit skills such as bias, making adaptions, reflecting and improving investigations. Most lessons can be taught again in future years as we were given some resources to keep and use again.

> The project has allowed us to develop correct use of scientific language and terminology linking to their scientific work and learning. For myself, it has been a fantastic opportunity and I have loved working alongside Cardiff University and with [the university lead]. It … has helped me consider other ways of developing our science curriculum within our own school.

Discussion

The feedback from pupils and teachers about the Cardiff University School Science Club was overwhelmingly positive. There is sufficient evidence to conclude that it delivered positive outcomes for the Year 6 pupils and teachers who participated. A feature of this project was the involvement of a cluster of schools that had previously worked together on a programme to enhance their science teaching and learning. This feature enabled the university to develop relationships which have strategic potential for engagement and outreach around science, technology, engineering and mathematics.

The main success factors as described by teacher feedback centred around: the co-development process; the importance of activities being practical and related to daily life; access to equipment not usually available to schools; and having an inspiring role model. Teachers also commented that the children developed: 'a much better understanding of scientific content and skills. The themes selected have helped increase and maintain pupil engagement throughout the term, allowing children to have a much more confident understanding of commonly difficult areas.' This is one of the main aims of the School Science Club and it is clear that by using the independent evaluation we were able to identify that these aims were being met.

There is scope to improve the university-based activities for future programmes. One point highlighted by the teachers in feedback was the use of scientific language during the university lecture sessions – words used were above the level of the audience and included several specific scientific terms. This is an area commonly encountered in public engagement, and projects such as this provide a useful approach

in demonstrating academic research to a lay audience. This is something commonly used within grant applications and, as demonstrated in other engagement activities (Hart and Northmore, 2011), it can have a beneficial effect on securing future grant proposals. Other areas for improvement included the calliper investigation in Session 2, which was highlighted to be enjoyable, but which generated a wide range of results from which it was difficult to draw conclusions. Future projects would therefore be centred around 'tried and tested' experiments where reasonable discussion could be had and conclusions could be drawn.

One outcome that was not anticipated was the impact of the engagement project on the university. The university lead described how the project had enthused him and colleagues who were involved to want to engage with primary school pupils in the future. He also cited enhancement of his communication, organizational skills and future career perspectives as personal impacts, along with learning about the Key Stage 2 science curriculum. For early career researchers, these are important points for CV building, experience and future roles.

From our findings, we can therefore make the following suggestions for similar projects in future.

Planning and development:

- Adopting a co-development approach ensures cohesive programmes of activities that fit with curriculum priorities and are appropriate for target age groups.
- Involving teachers in co-development provides insights on latest educational methods and curriculum developments.
- Documenting and sharing specific aims for each stakeholder group would ensure that all stakeholders were fully aware of one another's ambitions, and would aid monitoring of progress and evaluation of outcomes.
- Planning evaluation activities as an embedded part of any programme would have maximized teacher buy-in and commitment to the evaluation process.

Delivery:

- Rehearsing individual activities and investigations (which could be via phone/video discussion) with teachers would help optimize both their suitability for audiences and their impacts. Rehearsal could also enhance provider confidence, should this be an issue.
- Helping teachers promptly with all queries or questions related to a project maintains their enthusiasm and develops their knowledge. This is particularly important with teachers who are not subject specialists.
- Integrating visits to schools with visits to the university can widen the range of learning opportunities for pupils. The former was particularly successful.
- Ensuring that university-based activities are of a quality consistent with activities delivered in-school, both in terms of their scientific content and their structure/format, would have enhanced enjoyment and outcomes from this element.
- Wherever possible, ensuring activities are delivered by charismatic individuals who are prepared to learn about the target audiences and develop a rapport with them. This has a greater impact and provides a more enjoyable experience for audiences.

Future perspectives

Given the success of this pilot project, we are keen to run similar programmes in the future, to include more schools, and build on the co-production element of the

project, through further teacher continuing professional development, the creation of a website where teachers can access online tools, resources and lesson plans, and a series of filmed demonstrations for teachers to emulate. The School of Pharmacy plans to submit an application in response to a call for proposals from the Education Endowment Foundation and the Wellcome Trust to improve the science attainment and/or progression of disadvantaged pupils.

When asked about what the programme meant to the School of Pharmacy, Head of School, Professor Mark Gumbleton, said:

> Making science appealing and relevant to school children within a university environment only helps stimulate their aspirations and belief that a university education is for them, no matter what their background. As a school, it has been a privilege to have hosted their experience.

Conclusion

The main success factors identified through our evaluation were: the co-development process; the enthusiastic approach of the university lead; and the 'real world', contemporary nature of the science featured, particularly at the in-school sessions. By having several sessions and a final university visit, we found that we were able to engage with the pupils more effectively, including setting tasks for them to complete as their usual schoolwork in between interventions. This, again, was a key aspect in the co-development approach and ensured that the tasks set during the intervention complemented the teaching plans and syllabus of each school. The visits allowed the university lead to build a rapport with the pupils and teachers, which was important in ensuring engagement with the interventions.

In addition, knowing the learning objectives of the schools allowed us to develop engaging activities around subjects that were perhaps already familiar to the children, rather than totally new concepts. By working with a cluster of schools in this way, they were able to share ideas and knowledge gaps with us, and to ensure that the interventions were pitched at the correct level and correlated with their teaching plans and syllabus.

Using an external evaluation company was a really important contribution to the work. They carried out questionnaires and interviews with pupils and teachers during and post project, highlighting areas that could be improved upon during the programme. We found that, by the end of the project, 80.9 per cent of pupils reported that their interest in science had increased. In addition, all teachers reported that the introduced investigations and resources could be used in their own teaching practice and could have impact on their approaches to teaching aspects of the science curriculum in future. The evaluation helped us identify further ways to refine aspects of the project, and these have been implemented for current and future engagement activities.

The project not only benefited the schools, but also inspired early career researchers and others involved to engage more frequently with schools and Key Stage 2 children. Upskilling researchers to be effective science communicators is one key aspect of future career progression. Given the impact of, and requirement of, public engagement and dissemination within scientific grant applications, this project provides a clear pathway for skills development for researchers, and positive outcomes for students and teachers.

School Science Club is seen as a mechanism for drawing young people who might not otherwise have considered it into the science arena. And this will not only

benefit the children – it benefits the whole of society. The talent that these pupils have is an untapped resource of unknown value which may only be realised through, and encouraged by, interventions such as the School Science Club.

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Notes on the contributors

James Blaxland is a lecturer and researcher in microbiology within the Zero2Five Food Industry Centre at Cardiff Metropolitan University. James regularly presents his research at both academic and public outreach events, and leads on a number of public engagement activities, notably arranging for schools and colleges to visit the university for 'taster days' and involvement in the design of new food science T levels.

Rhys Thomas is part of the Cardiff University's School of Pharmacy and Pharmaceutical Sciences, designing engagement activities and developing public engagement within the university as a research and engagement assistant. He is frequently involved in the public engagement of science, where he co-ordinates projects from Key Stages 2–5.

Les Baillie is a professor of microbiology within the School of Pharmacy and Pharmaceutical Sciences at Cardiff University. Les is a lead of the Pharambees outreach project, where he is using bees in an attempt to find new drugs to treat hospital infections because of the problem of antibiotic-resistant bacteria. The Pharmabees team regularly visits schools across Wales and beyond, hoping to increase pupils' knowledge of science and encourage them into the scientific arena.

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