

Developing 14-18 Year Old's Interest and Participation in Physics by Training them to Deliver Outreach to Primary School Children

D S Williams^{a,b,*}, H N C Yeung^{c,*}, N Fatima^{d,*} and E Pridmore^{e,*}

a Physics in the Freezer,

Registered Charity 1210019, United Kingdom

b Planning and Business Intelligence, University of the West of England, Bristol,
Coldharbour Lane, Bristol, United Kingdom

E-mail: david@PhysicsInTheFreezer.co.uk

c Li Ka Shing Faculty of Medicine, The University of Hong Kong,
21 Sassoon Road, Pok Fu Lam, Hong Kong

E-mail: christyyeung629@gmail.com

d The University of Buckingham Medical School, Milton Keynes University Hospital,
Fleming Drive, Eaglestone, Milton Keynes, United Kingdom

E-mail: noorsabir2005@gmail.com

e Exeter College, The University of Oxford
Turl Street, Oxford, United Kingdom

E-mail: Ellie.pridmore@gmail.com

The physical sciences can struggle to engage teenagers, sometimes being perceived as complex or daunting. To combat this, Badminton School developed its 'Science Outreach' programme enabling students to deliver liquid nitrogen-based shows in 25 schools each year and at national events such as WOMAD, the UK Big Bang and the Northern Ireland Science Festival, appearing on these events' main programmes. Science Outreach encouraged practical work through participation in exciting demonstrations, kept students involved in science as they became more able to deal with the abstractions of Physics, and developed valuable communication skills. Meanwhile their primary school audiences were inspired by engaging presenters who were just the right age to be perfect role models. This contribution describes how the programme developed, gives insight into how similar models can be adopted, and presents insights from programme participants into the positive effect it had on their further education.

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*Speaker

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1. Introduction

1.1 Background

For 14 years, the lead author developed a Physics based outreach programme taking pupils from the private girls' school he taught in (in the United Kingdom) into the community, to deliver talks and workshops for primary school children and the wider community.

At the start of the project the school was opening its laboratories once per year, inviting a single local feeder school's pupils in for science talks and demonstrations, benefitting 60-90 children. This also contributed to the school's requirement to do work for Public Benefit as a charity.

The aim was to increase the number of interactions to at least 3 schools, so all the key feeder state schools would be covered, but the model being used had two limitations – teacher time and lab space. In addition, the lead author wanted to ensure Public Benefit work reached all parts of the community and not just children attending schools that were recruitment targets.

1.2 Limitations of the Existing Model

Events hosting 60-90 children involved most science teachers and used the majority of the school's lab space and impacted teachers and learners in the school:

- Teachers needed to set and mark work for the classes they missed, and it was difficult to find enough staff to cover these teachers
- Children missing too many lessons attracted complaints from fee-paying parents
- There was limited space to accommodate displaced classes

Switching to holding events near to the end of the school year (after exam classes had left) would not have solved the issues:

- Teacher resistance remained, as staff would normally use this time to prepare for the next year
- External schools already had packed timetables in the summer term
- Issues with displaced classes and cover remained as teachers don't usually teach an entire morning or afternoon of exam classes

2. Developing a Student Led Model

2.1 Finding a Viable Solution

The first event went ahead using the existing format while a new model was considered. This was a science day based on Chemistry for Year 5 pupils (aged between 9 and 10 years old). Sixth Form students volunteered but in a change from previous years, they were given training to prepare them to lead group work with the visiting children.

The day itself was a huge success, but it was particularly noticeable that the Sixth Form students did an outstanding job leading the group work – breaking concepts down to make them more understandable by the much younger visiting children and generally communicating with them in a more accessible way than adults might have done.

Being aimed at primary school pupils, the chemistry covered was easily mastered by the Sixth Form pupils, and it was decided to pursue a model where the lead teacher worked with students to deliver fun, engaging science through student performers, who would also be acting as role models. A show based on primary school relevant curriculum concepts drawn from the states of matter topic was developed, resulting in a very engaging liquid nitrogen show that could safely be performed by Sixth Form students with sufficient, appropriate training.

2.2 How the Programme Grew

To manage the presenter training requirements, the Sixth Form took on a leadership role and by 2022, the school was visiting 25 primary schools each year and reaching around 1,500 young children in the Bristol area.

Our reputation had grown outside of the Bristol area by showcasing our speakers in events run by the Institute of Physics, Lancaster University and CERN giving pupils the opportunity to perform at large events such as the UK Big Bang (Figure 1), the Cheltenham Science Festival, the Northern Ireland Science Festival and several music festivals including WOMAD and the Colours of Ostrava.

Throughout this time there was only one teacher involved in the training and logistics of the Science Outreach programme, with around 2½ hours a week timetable remission being given to run the programme and conduct visits. With such a small time allocation, each expansion of the programme was enabled by giving more responsibility to the Sixth Form team and the programme developed from “simply” providing an introduction to science communication and an opportunity to work with materials school level, to a rounded, student led training programme that gave event organisation and delivery skills to participants.



Figure 1 Students age 14 -17 years old presenting at the 2023 UK Big Bang.

3. How Safety and Training Were Addressed

3.1 Safety

With almost all Science Outreach events using liquid nitrogen and often strong magnets, it was vital to keep visitors and performing students safe. Sixth Form science students already had both the skill set needed and the maturity needed, so they – and the rest of the Six Form volunteers – received extensive training on safe working with cryogenic substance (and strong magnets).

Students were directly instructed during their first set of demonstrations, and were required to review method statements when progressing to “Level 2” table demonstrations.

After passing an oral and practical assessment with the lead teacher, the most safety aware Sixth Formers, many of whom would have worked with the programme for several years, became trainers for their peers and for younger girls starting to present from Year 10 upwards.

It is important to note that the lead teacher was part of every visit. This enabled him to watch each student and develop enough knowledge of their capabilities and awareness to make a balanced judgment about whether they were suitable to help train, mentor and supervise others.

This individual knowledge of presenters was vital to maintaining our excellent safety record with cryogenic substances – which involved just 2 small blisters in 14 years of pupils working with liquid nitrogen!

After training and events, non-judgmental feedback was shared by the leaders to help develop individuals' skills; sometimes this meant steering them towards working with less dangerous materials – or at the other end of the scale, accelerating them in to training or mentoring roles.

3.2 Training

Presentation training was in some ways less critical, but used the same model with a (different) team of trusted students running it more independently. Typically, a student would do their first talk, with a script, in Year 10 or emulating a teacher in Year 12, often with more experienced students taking part in the same event to provide a mentor for newer recruits.

Presenters would then be given constructive feedback and those with a particular flair for presenting would be channelled towards training roles to help develop other new presenters.

For all aspects providing easily accessible documentation was key, although more so when preparing speakers. SharePoint was harnessed to provide resources with narratives and scripts for all demonstrations, along with method cards. Most demonstrations had individual videos, and several examples of various teams' best talks were made available to encourage all to strive for the highest standards.

More recently Microsoft Forms was used to create self-marking quizzes to check that groundwork was being done, backed up with in person validation. Presenting assignments were also designed as a skill ladder to make sure there was always another level to strive for:

- Scripted talk
- Simple table demonstrations
- Free-form talk
- More complex demonstrations
- Trainer
- Assessor



Figure 2 A Sixth Form student-led training session.

as in Figure 2) with equipment and then a quality assurance session where they role-played running the table demonstration with an assessor. The role-play element was vital to success as it built the kind of confidence needed for these interactions.

For a talk, training and assessment would involve practice run throughs and performance notes. The practical element would be covered by close supervision during a student's first talk.

Table demonstrations are the most daunting type of work as visitors are from a wide range of backgrounds and can ask anything. When preparing for this style of communication, students were expected to be familiar with the material, to undertake practice sessions (which were sometimes led by students

4. Model Benefits and Former Student Perspectives

4.1 Benefits

Over a decade, the Science Outreach programme evolved into an endeavour where students with preferences for all areas of the curriculum, not just science, gained transferrable skills. This including researching new demonstrations, some of which were written up, including *Using a Superconductor to Demonstrate Lenz's Law* (Figure 3, D Williams et. Al 2019) which enabled 7 pupils to become published authors while still at school.

Some of the best presenters were non-scientists and they helped to raise all the team's presenting level. Meanwhile the more technical minded students helped others to gain confidence in practical work, and the more logistically minded helped to organise sessions and presenter rotas. Each member of the team raised others' skills, and this filtered down to the Year 10 girls.

The material delivered by students tended to be much more engaging for younger children, partly because the Sixth Form students tended to word things in a way that was more accessible for children and partly because the students were much closer in age than a traditional teacher, making them more relatable.



Figure 3 Students helped to research and publish a demonstration using a superconductor to illustrate Lenz's Law

4.2 Community and Inclusion Benefits

“Science outreach is an inclusive platform where everyone has the right to thrive and prepare for a STEM career. The process of working with people from diverse backgrounds increased the sense of belonging of women of colour in the world of STEM and created a safe space for them. The program allowed critical thinking and developed students' skill of learning and understanding difficult concepts. Students felt that the skills developed could help them overcome academic hurdles and were determined to deal with difficult concepts.” N Fatima

4.3 Transferable Skills Developed by Students

“Students joining the program gained a lot of transferrable skills, of which the top two identified were communication and leadership. Being part of the science outreach leadership team involved communicating with a wide range of people, from Mr Williams, to other teammates, as well as the diverse group of audiences. Leadership was a key part of the program which honed the skills of efficiently delegating tasks and working together as a team. All the skillsets from science outreach are transferrable for future careers and help us excel in different roles.” H N C Yeung

4.4 What the Outreach Programme Gives Back

“For students not looking to pursue a career related to science, the program gave them an opportunity to experience and learn about things that they would never have otherwise come into contact with. It is important to expose people to new knowledge and ideas in all subjects, no matter the age. Fostering curiosity in the world is crucial if we want to inspire others to engage critically and informatively with difficult concepts. Through science outreach, students discovered deeper understanding of the world, one that is so much more magical and complex than we might first believe.” E Pridmore

5. Summary

With a clear framework, a focus on safety and by imparting a sense of a shared goal it was possible to develop a team that benefitted audiences and members alike.

Many efforts are targeted at older children preparing for examinations and providing outreach targeting younger children at primary school fills an important gap. Including unusual demonstrations such as the Liquid Oxygen Bridge (Figure 4) can also help foster excitement and curiosity.

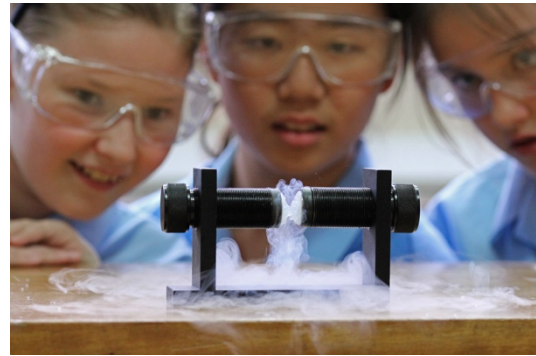


Figure 4 Wow-factor demonstrations such as the liquid oxygen bridge enthused younger children.

It's important never to underestimate what young people can achieve when they have a clear understanding of expectations and are given the support they need to achieve them.

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