Student Ambassadors and STEM Outreach

A study of practices in the USA

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WINSTON CHURCHILL MEMORIAL TRUST

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Executive Summary

This report outlines findings from a Winston Churchill Memorial Trust Travelling Fellowship in the USA. The ambition of the Fellowship was to develop an understanding of the organisation of Science, Technology, Engineering and Maths (STEM) outreach activity in US Higher Education (HE) institutions and to explore pedagogical approaches that best support young people in effectively developing STEM identities and progressing in these subject areas. The study identifies similarities in the US and UK contexts and also some important differences.

The study highlights tensions in both countries between the demand by funding organizations for proof of impact and the urgent need to work inclusively with young people and reach wider audiences. Key differences were found in the organisation and purpose of outreach activity in the UK and US. In the US funding incentives have led to substantial involvement of academics and postgraduate students leading to an increased focus on pedagogy and the subject content of activity. The broad focus of US universities on public engagement and increasing science literacy amongst young people provides more opportunity for innovative approaches as activity is not explicitly focused on progression to HE. As a result, US ambassador programmes and ambassador training have a sharper focus on pedagogy, including subject specific pedagogies. This focus is missing in much UK ambassador led outreach activity which is generally more directly linked to recruitment to higher education.

Recommendations for UK practice:

- Investigate/identify ways to promote the involvement of academics and post graduates in the development of outreach activity.
- Investigate/ identify ways to promote collaboration across UK universities to develop more inclusive and sustained STEM interventions.
- Undertake further research into the benefits of leading activity by student ambassadors to establish that working as an ambassador does support employability, attainment, retention and progression in HE as claimed.
- Work collaboratively to develop a pilot project introducing an ambassador programme into primary schools targeting parents, teachers, and pupils with a focus on raising awareness of STEM identities and on where STEM subjects lead and range of careers available.
- Undertake further research with pupils exploring different pedagogies, how these support identification between young people and ambassadors and what pupils learn about STEM through contact with ambassadors.
- Draw on US models to develop and pilot new training schemes for ambassadors in universities and industry settings.

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About the author

I started my career as a teacher and subsequently a teacher trainer in Leicester and London. I developed an interest in the widening participation agenda during a fellowship at South Bank University and increasingly moved into working as an independent researcher and evaluator of projects aiming to develop ways to support pupil engagement and progression into higher education, particularly in science, technology, engineering and maths (STEM). I have worked closely with colleagues in universities and at the Royal Academy of Engineering on the development of outreach programmes, engaging with schools, employers and third sector organisations. After completing my PhD with the Institute of Education I am continuing my research based at University Campus Suffolk where I lead the MA programme in Education Studies.

Introduction

It is widely known that young people from lower socio-economic groups, girls and black and minority ethnic young people are under-represented in STEM study post sixteen and in STEM careers. Recent research has pointed to the importance of young people's 'self-identity' in relation to these subject areas and indicates that pupils, particularly girls, decide careers in STEM are not viable for them at an early age (Archer et al., 2010; Macdonald, 2014). It is clear that supporting young people so that they can better identify with STEM is vital if more young people progress in these subject areas.

The importance of adult figures in motivating young people and encouraging progression in STEM subjects has been widely acknowledged (Macdonald, 2014; Rodd, Reiss and Mujtba, 2013) and lack of positive role models, in the UK continues to be an issue, particularly for girls who often still see STEM careers as male domains (Macdonald, 2014). However, despite widespread assumptions that adults visiting schools or interacting with pupils in other spaces are role models, this is not an automatic process (Gartland, 2014). Indeed, there is some concern that well-intentioned schemes allowing adults to talk to pupils in schools may discourage young people from progressing into STEM careers:

> 'By allowing untrained and narrowly prepared speakers to address this key audience, it could be that these outreach programmes are doing more to discourage prospective engineers than to incite the intended excitement and interest' (Royal Academy of Engineerig. In Macdonald 2014: 25)

University students are widely assumed to make ideal role models due to their proximity in age to pupils and so are now a ubiquitous feature of universities in the UK and internationally. However, there has been very little research into the deployment of ambassadors, how they are matched with pupils and the efficacy of different models of outreach (Gartland, 2014, 2015; Sanders and Higham, 2012).

During my Fellowship, my aim has been to explore different programmes using student ambassadors in the USA where there has been considerable government funding for this activity, in order to identify successful approaches relevant to the UK. I was interested to consider a number of questions raised by my own research and the wider literature about STEM outreach and the work of ambassadors. One key question is about the organisation and funding of ambassador schemes. In the UK, the location of widening participation units within marketing and admissions departments in HE institutions and the interests of key stakeholders play an important role in the purposes and organisation of outreach activity (Gartland, 2014). Is this an effective way of organising this activity? Another question is about targeting practices and whether ambassadors can contribute to promoting engagement and identification with STEM amongst wider audiences of young people currently under-represented in these subjects. Connected to this is whether matching backgrounds of ambassadors and pupils is important and if so which aspects of young people's identities it is important to match Intersecting raced, classed and gendered identities are widely considered to be important to mentoring relationships with young people (Chen et al., 2003; Sanchez and Colon, 2005). There is some indication that shared interests are also significant (Ensher et al, 2002;Gartland 2014; Grossman and Rhodes, 2002). A further question is what pedagogical practices best support young people's identification with ambassadors and subject areas (Gartland, 2015)? A related

question to this and to the purposes of outreach activity is what training ambassadors should receive.

My Fellowship provided some interesting insights in relation to these questions. It also highlighted very clear similarities between UK and the USA contexts and revealed how many of the problems, issues and questions are shared. The study highlights a need for a collaborative approach to addressing these questions both across the UK and between the two countries, to ensure that ambassador schemes are effectively developed to engage and support new audiences of young people to identify with STEM subjects.

Research Approach

The objectives of my Fellowship at the start of my project were to:

1. Develop an understanding of the organisation of university outreach work and ambassador schemes in STEM subjects in the USA
2. Identify examples of practice that best support groups currently under-represented in STEM subjects and careers
3. Explore different pedagogical approaches used in outreach activity and their contribution to developing pupils' STEM identities, particularly those of girls, BAME and pupils from non-traditional backgrounds and disadvantaged communities
4. Share findings with HEIs, professional bodies and charities involved in STEM outreach and Widening Participation more generally in the UK
5. Develop an ambassador outreach programme locally to support and promote STEM identities among pupils in Suffolk, particularly targeting areas of multiple deprivation where achievement in these subject areas at GCSE is currently low
6. Forge long term links with HEIs in America and continue to share expertise

My fellowship centres on four case study universities in the USA where student ambassadors contribute to a range of outreach activity with younger students. I identified universities to visit through National Science Foundation funded K-12 projects I had read about, particularly focusing on institutions with a strong reputation in STEM subject areas. I then identified other interesting models of outreach activity using ambassadors in those institutions and programmes that I could focus on during the time of my visit. The four institutions I visited over a period of four weeks werehe University of North Carolina, North Carolina State University, Massachusetts Institute of Technology and Tufts University. In total I considered thirteen different outreach programmes at these institutions which included a range of science, technology, engineering and maths (STEM) outreach. The programmes varied in the extent of their engagement with young people with some offering one off events and others working with groups of pupils for several weeks, months or even years. Programmes also varied in timing and location with some based in schools and others on university campuses and public spaces owned by universities.

My intention was to find out about different outreach programmes through talking to academics, project organisers, ambassadors and school pupils. After making initial contact with academics at each institution, I felt that it would be too onerous for them to support the formal ethics applications required to enable me to work with school pupils. As a result, my study has focused on the accounts of academics, organisers and ambassadors, and while these have provided many useful

insights into this activity, it is important that future research and collaboration should engage with the 'voices' (Fielding, 2004) of school pupils to better understand how they perceive and respond to ambassadors in these different learning contexts. I have, however, made sure that the voices of student ambassadors are represented in this report and have used their own words from their accounts as much as possible.

I developed a loosely structured schedule for conversations with academics, project organisers and ambassadors with the aim of enabling participants to relate and explore their own understandings, knowledge and experiences as freely as possible (Kvale 1996; Charmaz, 2014). This schedule ensured I focused on my objectives and covered the same subject areas in each meeting. In developing this schedule, I drew on research I undertook in the UK and particularly focused on the purposes, location and setting, content and processes (Colley et al., 2003) of different programmes. During meetings I made detailed notes of what was said including the language used by participants to describe programme activity. I also observed activity where possible and gathered relevant documents about programmes and information from websites. Following meetings and observations I typed up detailed notes of what was said and made memos of my initial thoughts and impressions (Charmaz, 2014). On my return to the UK I analysed my notes and documents gathered using a grounded framework (Charmaz, 2014). This approach involved line-by-line coding of all data gathered and developing in-vivo codes using the language of participants. This ensured that I started 'from the words and actions of respondents' (Charmaz, 2014; 121). Central to grounded theory is a constant comparative method and this has been vital here. By comparing different organisers' and ambassadors' accounts of programme activity and the contexts within which activity is located, I have been able to develop insights into issues and approaches across programmes that can usefully be considered in relation to practices in the UK. While the particular details of individual programmes offer limited insights into ways forward in the UK as the contexts and funding of programmes are different in each case, this comparative approach has facilitated a more theoretically informed and macro level analysis.

I followed BERA (2011) guidelines in the research process. The research approach was approved by my own institution's ethics committee and information was provided to all participants about the research process to ensure that they were able to provide their informed consent to participate. In the interests of confidentiality, I have not referred to individual programmes by name in this report and have used the broad titles of academic, project organiser and ambassador throughout to protect the identity of individuals.

The findings from the study are organised into four sections. The first considers the purposes, organisation, funding and setting of outreach activity; the second considers targeting practices and approaches to matching ambassadors with the pupils they work with; the third section has as its focus the learning and teaching approaches developed, and the fourth section considers the benefits to ambassadors themselves and training practices. The final section of the report considers lessons learnt and implications for future practice.

The purposes, organisation, funding and settings of ambassador outreach activity

In the UK in a climate of austerity, the expenditure on outreach undertaken both by universities and third sector (voluntary and non-profit) organisations is under increased scrutiny (Havergal, 2016; Macdonald, 2014). A criticism that has been made of HE widening participation (WP) strategy is the lack of evidence this has produced about 'what works' in encouraging progression amongst under-represented groups (Havergal, 2016). In STEM outreach, critiques have also been made of a range of approaches and practices that are seen to be ineffective or counterproductive (Macdonald, 2014). There is an assumption in these critiques that the purpose of outreach activity is to promote progression to HE or into STEM subjects and careers whereas often the purposes of outreach activity appear to be more complex, responding to a range of needs and agendas (Gartland, 2014). While there are clear differences in purposes and organisation of outreach activity between the UK and US contexts, there are also many similarities.

Purposes

The purposes of outreach activity articulated by US academics, organisers and ambassadors were often multifaceted, reflecting the complexity of the challenges and issues programmes were attempting to address. The purposes of activity varied though there were a number of ambitions that featured across programmes considered in the study. Many of these ambitions articulate closely with areas of focus for university and STEM outreach in the UK.

A familiar focus of outreach activity was 'aspiration raising' with the aim to encourage progression to higher education. This featured in the accounts of organisers, academics and students across a number of programmes. Encouraging school pupils from working class, geographically remote and ethnic minority backgrounds, who are currently under-represented (HEFCE, 2013), to aspire to progress to university was a clear focus. As in the UK (Gartland, 2014), ambassadors from these backgrounds appeared particularly focused on encouraging progression amongst other groups of students like themselves and this was a strong motivation for their engagement in outreach activity. As with elite universities in the UK, the institutions visited were all keen to recruit more diverse students. One academic explained that it was hoped programmes would be an 'avenue for creating a pipeline for students who may not have thought of applying to the university'. A linked focus was to provide school pupils with information advice and guidance (IAG) about university and particularly about financial assistance available to those from poorer backgrounds. In the US fees at private universities can be as much as sixty to sixty five thousand dollars a year which was seen as contributing to pupils from under-represented groups viewing university as inaccessible.

As well as IAG about college generally, there was a shared ambition across programmes to provide young people with IAG about progression and careers in STEM subject areas. The extent of this IAG varied depending on the type of programme. Several programmes that involved short, one off interactions with school pupils focused on challenging stereotypes about who can be a scientist or engineer and, as one academic explained 'breaking down preconceived notions of what a scientist looks like'. Organisers, academics and ambassadors across programmes highlighted that activity was not focused on the school curriculum, discussing instead a focus on real world applications. As one ambassador explained, activity is making STEM 'relevant to (*pupils*) actual life and decisions they make in the future'. A further ambition of a number of programmes was to highlight to young

people that STEM subject areas are not the exclusive territory of the stereotypically 'super smart' and pursuing STEM subjects is a possibility for 'normal people', to encourage pupils who may not have confidence that STEM is 'something they can do' (Ambassador).

On a few programmes where ambassadors worked for longer periods with a selected group of pupils with an established interest in STEM, there was an additional and more ambitious focus on providing these pupils with relevant social and cultural capital to support progression to university, to develop critical thinking and, in one instance to challenge pupils cognitively and developing subject knowledge and understanding. With these groups, IAG also featured strongly with an articulated ambition for programmes to 'expand *(pupils')* ideas of what they can do…rather than just thinking about being a doctor or a nurse' (Project organiser). Engineering outreach activity, as in the UK, was focused on raising awareness of engineering as a possibility for young people as in most states engineering is not part of the school curriculum (though this was not the case in Massachusetts). One academic pointed to the need to focus on current problems the world faces and highlight how engineering can make a difference and 'help people'. There was also an emphasis on subject integrity and ensuring that what pupils experienced in these settings related to engineering in higher education and the real world.

Developing soft skills was identified as a focus of most programmes, particularly developing team working skills and communication as these were areas seen to be neglected in mainstream schooling. A further purpose of engineering outreach programmes was to develop young people's resilience. One academic talked about the need to support young people in developing 'persistence, grit and ability to deal with failure'.

A broad focus of all programmes and something less familiar in the UK, was 'giving back' to the wider community. One academic explained this difference as being rooted in the approach of government: 'in the UK it's the government's responsibility; in the US the assumption is that the government will do nothing so you've got to get on with it'. A focus on developing 'a civically engaged mindset' amongst students was described as being part of the institutional mission of one private university. Indeed, another identified purpose of outreach activity was to encourage and support ambassadors to continue to focus on 'STEM advocacy', 'community engagement and service' after their time at university. One academic explained that the outreach programme provided students from privileged backgrounds with an understanding of the educational landscape and of the experience of pupils from different and less privileged backgrounds, so that they become 'informed citizens' who continue to be 'advocates'.

A linked focus of outreach in these institutions, which is currently less well established in UK universities (Watermeyer,2015), was public engagement and using outreach to make a 'positive contribution to the community'(Academic). Accounts indicated that this was a particularly important focus at the two private universities visited where institutions do not have the same local connections as state universities. The ambition of this public engagement was to raise public awareness of research undertaken by institutions and more broadly to increase public 'science literacy'. This provided a broad and open framework for project organisers and academics to develop outreach activity.

Organisation and funding

A range of project models were considered as part of this study. These ranged from one off half day or day workshops at university sites, museums or other public spaces and one off day/ few hours or one hour interactions with pupils in school to programmes working with pupils for several months to nearly three years. In the US, as in the UK, funding plays an important role in the focus and organisation of outreach activity. Different funding sources structure activity in different ways and support a range of models and approaches.

The universities I visited were all research intensive institutions that command significant research incomes. Disseminating research widely was an agenda across these institutions and, more than in the UK, this agenda contributed to the active involvement of academics and postgraduate students in outreach activity. The increasing demand for 'broader impacts' by the National Science Foundation (NSF) and other funding bodies such as the National Institutes of Health (NIH), was also viewed as motivating faculty and research student engagement and support for outreach activity. One academic explained that the NSF impact requirement led to a focus on sharing research so outreach programmes benefit, though in a small way, from large research grants (for example receiving two thousand dollars from a three hundred thousand dollar research grant). However, programmes were often still reliant on the dedication, commitment and passion of individual academics and project organisers who gave up Saturdays and evenings, to support events.

One source of funding for projects was national bodies, particularly the NSF. The NSF funds research and education in science and engineering through grants and cooperative agreements with universities, colleges and K-12 school systems as well as businesses and informal science organisations. A few of the outreach programmes explored during this study were directly funded by the NSF or had started out through NSF funding for outreach activity. Organisers accounts indicated that once funding had been awarded for a project by the NSF, those leading the project were 'trusted to make the right decisions' and particular outcomes were not specified. This funding appeared to provide project organisers and academics with the freedom to develop new and innovative practices and allowed for longer term and more sustained engagement with pupils. However, funding for outreach from the NSF is limited to a specified timeframe, after which time other sources of funding are needed if projects are to continue. One academic also described the demanding level of reporting required by some national funding bodies, particularly the NIH.

Some activity was funded or part funded by HEIs themselves. HE funding was sometimes linked to recruitment of under-represented groups or to promoting community engagement. This was again generally longer term and sustainable. Other projects worked with different organisations, projects and departments within the universities. These collaborative working relationships appeared to effectively raise the profile of activity within institutions, provide financial and material support for activity and organise student ambassadors to support activity. While these relationships were mutually beneficial there were some identified differences in the agendas of departments and organisations.

Other sources of funding included industry or wealthy private donors and private foundations. One longstanding and well established project had been running for 15 years and was funded by private donors. However, this was not viewed as sustainable in the long term. Other smaller scale projects relied on small grants and fundraising activity. One academic described how small contributions

from industry could support small scale projects very effectively, explaining that it only costs £110 dollars to run a school based activity, as the only major expenses are transporting the student ambassadors and paying them an hourly rate. Alumni of universities and of particular schemes also contribute small amounts of funding. This small scale funding commonly supports shorter one off events and activities or subsidises longer term engagement and is largely considered sustainable.

A number of issues were identified in relation to funders. The short-term nature of grant funding from national bodies was one issue. Another was that larger funding bodies often require proof of impact through assessment and quantitative research studies, particularly controlled trials. One academic described programmes as being hard to fund 'as we don't have the metrics – some funders want hard data in relation to test scores and progression to engineering'. There was frustration that funders 'want a clean' story but that the ambitions of programmes were necessarily complex and multifaceted. In some instances, it was felt that to comply with funders' requirement would prevent reaching wider audiences; one academic explained 'we have kept our values at the expense of some funding'. Funding constraints also mean that it is difficult to fund research into programmes to develop an evidence base to support programmes and garner further funding.

Organisers and academics also described how business and individual funders have their own agendas and want to target particular programs or particular groups. One academic explained how funders often like to 'fund specific things' and gave the example of a summer programme linking baseball and science. Selectivity on the part of funders can have implications for the longevity of programmes.

Organisation of ambassadors

There were different approaches to organising ambassadors with some organisers and academics viewing them as employees who should be paid and others using them as unpaid volunteers. Arguments for paying ambassadors included that payment promotes professionalism and encourages students to take the work seriously and to be committed and reliable, that payment allows students from less affluent backgrounds who need to work to participate and that payment encourages students to value the work of teachers. However, payment of ambassadors inevitably has cost implications. One suggestion to cut the costs of outreach programmes using ambassadors was to give students credit for their contribution to programmes rather than payment. However, this was seen as problematic as students have little space in their timetables. Another issue identified was that a credit system, where a programme becomes an optional class students can take, would not allow for selectivity and organisers would lose control over the quality of ambassadors sent out to schools.

Several schemes used graduate students or post doctoral students to support outreach activity rather than undergraduates. These students were predominantly volunteers rather than paid. Arguments for using graduate and post doctoral students included that these students could be more flexible and had more available time than undergraduate students, that being involved in outreach would encourage post- graduates into teaching, that being involved in activity would encourage them to continue with community engagement post-graduation. In several programmes research students and post-doctoral researchers were used specifically to engage young people with research that institutions were undertaking and to promote interest amongst pupils in STEM

research careers. However, several organisers and academics suggested that undergraduates were best positioned to relate to school pupils because of their proximity in age.

Location and setting

Research has highlighted the importance of campus visits in supporting progression to HE in the UK (Hatt et al, 2009; Macdonald, 2014). Similarly, the value of campus visits was recognised by USA academics and organisers, as well as by student ambassadors themselves. However, the different locations and settings for programmes have implications for the ability of programmes to reach wider audiences of young people.

A number of programmes considered here were based on school sites. These programmes varied in scale, with one smaller programme working with a single middle school and another well established programme working with 400 schools. What all these programmes had in common was their inclusive approach, working with all pupils in a class. Working in schools in this way provided all young people in a class group with an opportunity to engage in a STEM activity and to work with university students from these subject disciplines. However, levels of engagement varied with the largest programme limited to one off interactions (though this program was piloting further developing the connection between ambassadors, classrooms and teachers) . Other programmes provided more substantial engagement, with ambassadors visiting schools on a weekly basis either in after school programmes or during the school day.

Another programme ran during evenings in local elementary schools and parents, pupils and teachers were invited to attend. The academic responsible for planning these activities explained that part of the value of these evening sessions was that 'the teachers are there' as well as pupils and parents. This activity was also run in local churches in order to effectively target underrepresented groups. The academic and project organiser involved with this programme discussed extending the reach of the programme by providing training so it can be run by community colleges and schools themselves instead of by university student ambassadors. This approach would enable the programme to reach more rural areas. A different model was for STEM student ambassadors to go back to the public high schools they attended and talk to pupils about going to college.

Whilst these programmes were able to reach, to varying degrees, comparatively large numbers of young people and groups of young people unlikely to access more selective programmes, disadvantages were identified with this approach. One clear issue identified by academics, project organisers and ambassadors themselves was the potential for ambassadors to encounter difficulties in managing behaviour when left in charge of whole class groups.

Campus-based programmes were viewed by academics and student ambassadors to have strong benefits, particularly in providing pupils with 'the sense of being at that university' (Academic). One academic explained how the experience of being on campus can influence pupils who may not have intended to progress to university:

> We want young people to say 'I go to that school' and bring in their parents and show them around. For kids not thinking about HE being on campus is really important, so they think 'oh yeah, I go there – I've already been there' – that makes it easier for them to go to college (Academic).

The benefits of tours of science laboratories and shadowing of ambassadors working in labs were discussed by organisers and ambassadors. One ambassador explained how tours of faculty provide the opportunity to 'see different areas and think about careers'. University owned centres open to the public organised a range of activity both based at these centres and through festivals. These spaces provide access to a wide range of resources not available in schools or other locations, creating an additional 'education space' for young people and communities.

An issue for these campus-based programmes was that unlike school-based activity, they cater for selected groups of pupils. How to select students and effectively reach target groups of diverse and underrepresented groups was discussed by all project organisers, academics and ambassadors. Several project organisers were developing links with local public schools and building networks to effectively reach underrepresented groups. Though activities held in public spaces had 'open -door' policies, these were widely taken up by school groups from affluent backgrounds and groups of international students.

Discussion

Many of the purposes of STEM outreach activity identified in these USA contexts are familiar in the UK both in HEIs and third sector organisations, particularly aspiration raising, encouraging progression to university, developing soft skills, providing information advice and guidance about progression to university and raising awareness of engineering and opportunities in STEM. As in the UK, STEM outreach activity organised by these universities is predominantly extra-curricular in focus. A focus of outreach in these programmes, also found in the UK, is providing pupils with an understanding of real-world applications for their STEM knowledge, not seen to be available within the school curriculum.

Funding constraints are an issue for university-led STEM outreach activity. Provision across USA states is inevitably variable despite the desire of organisers at state universities to reach out across the state. Organisers of outreach face clear financial and logistical challenges to reaching wider audiences, particularly young people in rural and remote areas. This issue is perhaps more acute in the USA but resonates with the situation in the UK where pupils from rural areas and areas of multiple deprivation removed from city centres are often seen as more difficult to reach. A key difference between approaches in the two countries is that in the USA NSF funding, the impact agenda and a focus within institutions on public engagement contribute to a far more active engagement by university academics and post graduate students than is found in UK universities. This contributes to a focus on subject specific pedagogies in these programmes that is frequently missing in the aspiration raising activity of UK institutions.

The focus within universities in the USA on public engagement and on promoting science literacy does not feature significantly in most UK universities. These broad foci interestingly provide opportunities for project organisers to develop innovative hands-on activity for school pupils and local communities without having concerns about meeting strict funding criteria or focusing on proof of impact on young people's subject choices or levels of achievement.

Who to work with? Targeting practices and matching backgrounds

Most 10-14 year olds do not aspire to STEM careers, and there is increasing evidence from research in the UK that young people form their long-term orientations to STEM within this age span (Macdonald, 2014: p.12). If, as research indicates, self-identity in relation to STEM subjects is significant to young people's interest and progression in these subject areas, it is vital to consider how to effectively target and develop activity to challenge aspirations and to encourage more young people to consider STEM identities as viable for themselves at this stage of development.

All the USA programmes considered in this study were focused on reaching diverse groups of students currently underrepresented in STEM subjects. This included targeting students from minority backgrounds, particularly Black American, Hispanic and American Indian; lower income (and in one case middle income) backgrounds; rural areas where there are low rates of progression and, especially for engineering outreach programmes, girls. However, programmes employed different practices and strategies to reach these groups reflecting the wider purposes of programmes. As in the UK, targeting practices varied, with some focusing on small groups of selected pupils with an identified interest or aptitude in STEM subjects and others attempting to engage wider audiences.

For some programmes, especially those located in public spaces, there was an additional and central focus on engaging the wider public and at times this included targeting both children and their parents. Given the powerful influence parents have over young people's career aspirations and subject choices (Archer et al., 2012; Macdonald, 2014) the contribution ambassadors can make in these contexts is an important consideration. The Public Attitudes Science Survey 2011 states that 'data suggests parents are somewhat more likely to see science as an activity for boys rather than girls' (Macdonald, 2014: p.19), so exploring how ambassadors may play a part in challenging gendered parental assumptions is worth further consideration.

Inclusivity of programmes

Programmes varied substantially in their aspirations regarding the extent of their reach. For some programmes reaching wide audiences was a key ambition, and it was considered of central importance to reach young people whether they have expressed an interest in science or not:

> We want to get to every kid – not just those already into science. We have teachers say 'they're terrible at school but really good with the ambassadors' (Academic).

> We aim to get women into engineering and broaden participation. We have tried to make certain that everything we do in outreach is designed to broaden participation (Academic).

Whilst inclusive, many of these programmes were limited both in the duration and the extent of interaction with young people. In one engineering programme activity led by ambassadors extended over several weeks. However, in most programmes activity was more limited to one off interactions. One academic identified this as a problem and was in the process of piloting extending a one day intervention to include a longer term online connection before the activity in school takes place to enable ambassadors to build their relationship with pupils and their teacher.

For other programmes, interactions were more extensive with pupils working with ambassadors for several weeks. However, these programmes were more selective. On one programme young people

competed for places against others locally (and on other programmes nationally). This approach was linked to a focus on recruiting young people from diverse backgrounds to the university (or other similar elite institutions). Another programme attempted to identify students who were interested in science but high levels of achievement were not required. This programme aimed to 'Identify students who may not know that they have ability – students that have not been given opportunity' (Project organiser).

For the majority of programmes social justice was considered important and working with local public schools was seen as a priority. Approaches ranged from deliberately targeting local public schools to allowing schools and pupils to self-select to engage with programmes. Programmes at all four universities were working with public schools within their immediate local area. At state universities there was an additional concern amongst some project organisers that programmes should be engaging with schools across the state, especially rural areas with low rates of progression to HE. However, the geographical distances involved posed logistical problems for some programme organisers.

Programmes were targeting a range of age groups. Several programmes targeted middle school pupils or junior high school pupils motivated by the view that it is important to engage with pupils before they make subject choices that impact on possibilities available to them in the future:

> We want to develop their understanding of careers and progression routes into science …it's important to catch them so they can take the right subject areas as these dictate future direction (Academic).

One engineering programme targeted middle and elementary schools because at these stages teachers have more flexibility in the curriculum to integrate engineering into programmes of study. This was not viewed as possible at high school. Another programme targeted elementary school pupils, their parents and teachers through evening STEM events.

Other programmes targeted high school students, often with the ambition to provide insight into real world applications for STEM, engage and motivate pupils, raise their awareness of opportunities to progress to university and to encourage diverse young people to apply for elite universities. While difficulties with behaviour were noted across age groups, particularly where pupils were working with large groups of pupils, one group of ambassadors noted that a particular issue when working with high school students was that some young people have already excluded science as a possibility for themselves:

> There's a difference between middle and high school – in high school kids have already decided that they're not into science (Ambassador).

Ambassadors also spoke of 'the friend effect' as being more pronounced with high school students and how 'one kid and their friends impact on others' (Ambassador).

Targeting teachers and parents

Several programmes aimed to work with teachers as well as young people. The ambition of one science outreach programme was to partner graduate and post-graduate ambassadors and teachers so that ambassadors become the 'teacher's personal scientist who can provide support and information with a potential partnership for 3-4 years' (Academic).

One engineering academic described how programmes were 'increasingly doing work with teachers'. The reasons for this were multiple though one was that this could extend the reach of programmes into more schools. It was viewed that teachers were receptive to engineering approaches as this was 'a great way to interest kids in learning' (Academic). This was particularly the case in Boston where in 2001 the Massachusetts Engineering Framework was brought into schools. One academic described how 'engineering is an entry to schools' as 'they think it's important' and that 'teachers are excited by the idea of problem solving and messy approaches'. An issue identified by academics in Boston was that schools have not systematically responded to engineering in the curriculum and are not effectively covering the 'different aspects of engineering'. A motive for developing one programme was to develop teachers' as well as pupils' understanding of 'different aspects of engineering' (Academic). Academics also highlighted the importance of working with teachers 'to broaden their view of what engineering is'. It was felt that there was a need to challenge teachers' understandings:

> So they don't think you have to be the most brilliant student to study engineering and to become an engineer. Taking things apart is not a pre-requisite to be an engineer. You can be good looking and be an engineer. Highlight creativity – if students are just focused on maths and science they may not be creative enough to be an engineer (Academic).

As discussed, one engineering outreach programme in elementary schools targeted parents and teachers as well as pupils through evening STEM events. During events ambassadors worked with pupils on a range of short fun STEM activities designed to promote engagement with STEM, awareness of real world applications for STEM and to promote awareness of engineering. These activities were brief and active and provided pupils and their parents to engage with many different ambassadors. It was hoped that this would challenge parents' and teachers' assumptions about who can pursue STEM subjects and work in STEM careers as well as providing some insight into the types of careers available. Similarly academics and graduate students discussed their roles during science festivals where they worked with parents and children on fun experiential learning about science and the scientific research taking place within institutions.

Matching Backgrounds

Project organisers and academics unanimously viewed ambassadors as role models for pupils. Ambassadors' proximity to pupils' age was widely seen as important to enabling young people to identify with them: '(ambassadors) teach science and look like me – it's about their age – youth and gender' (Project organiser). One academic observed that young people' receive what's said by undergraduates in a whole different way' and that young people 'identify with them'. Academics and project organisers involved with programmes where ambassadors were matched with pupils in terms of classed and ethnic backgrounds viewed this matching as important: 'seeing people that look like you can be motivating'.

The accounts of academics and organisers resonated with those of ambassadors who suggested that different aspects of their identities were important in their being able to relate to school pupils. One ambassador explained:

> ‘My identity has a huge impact and is extremely important … I think of this as being so important for that aspect of relatability and bridging that gap between who to expect to be- what role you expect to have’ (Ambassador).

Age was considered by ambassadors to be important to interactions especially with high school pupils when talking about progression to college. One group of ambassadors discussed their age as being influential, positioning them as like a ‘big sibling’, when they went back to their local high schools in rural areas where progression to college went against the norm.

Coming from the same geographical area was considered important with several ambassadors believing this supported their being seen as role model by pupils. Matching ethnic backgrounds was also seen as important by ambassadors. One ambassador described how different intersecting aspects of his Hispanic and working class identity enabled him to develop successful relationships with local Hispanic school pupils. This ambassador and others on the same programme explained that white middle class students working on the programme were not able to relate to these Hispanic pupils in the same way, explaining ‘we approach it through our identities’.

Equally, white middle class students on another programme described feeling a ’disconnect’ when working with a group of Chinese pupils explaining, ’ they make assumptions about you, language and image are a barrier’. Whereas on another programme an ambassador described how her ethnic identity helped to make ‘Chinese students feel more comfortable’, which was further supported by her being able to speak some Mandarin.

Ambassadors also discussed their gender as being important, with some suggesting that male and female pupils related better to ambassadors of the same gender. One female ambassador described how being female helped to challenge elementary school pupils’ gendered stereotypes of engineers:

> It’s definitely important that I’m a girl – boys say girls can’t be engineers and I say I am an engineer. (Ambassador)

Ambassadors’ accounts indicated that different and intersecting aspects of their identities – race, class, gender, interests and subject identities, all contributed to enabling school pupils to relate to them, enabling pupils to envisage future possibilities for themselves.

It was also suggested in ambassador’s accounts that different learning contexts and the length of interactions with pupils and opportunities for time to ‘play’ contributed to their ability to form close relationships with them. Opportunities for ambassadors and pupils to convey their cultural connections through conversations about TV, film, travel, music and food appeared to support identifications (Gartland, 2014).

Discussion

Some of these programmes considered reached large numbers of pupils. Programmes in different STEM subject areas within universities did not generally connect with each other, though a few programmes were working with other universities in different states to extend their reach. Considerable efforts were being made by academics and organisers on individual programmes to work with underrepresented groups and many programmes targeted local public schools. The reach and extent of engagement with underrepresented groups was however, limited by funding constraint, logistical issues and geography.

In the UK clear benefits have been identified for programmes working in a sustained way (Macdonald, 2014) with small groups of underrepresented students. In the USA, programmes working with targeted small groups provided young people with a depth of support, access to social networks and experience of being at an elite institution, supporting the development of social and cultural capital as well as science capital (Archer et al, 2010). However, criticism has been made of outreach activity that focuses on 'a small, select few' as this 'reinforces the idea amongst those not selected that STEM is for the elite and not open to others' (Macdonald, 2014: 12). It is argued that underrepresented groups lacking confidence in their STEM ability, if not part of the elite, chosen group, will conclude that STEM is not for them (Macdonald,2014:12).

Many programmes considered here were attempting to reach wider audiences by working inclusively with whole class groups in schools, though these programmes inevitably provided limited engagement with individual pupils. Again, criticisms have been made of this approach and particularly 'one off activity'. Arguments have been presented for the need for consistent STEM focused enhancement activity throughout young people's school career (Macdonald, 2014:6). However, it is unclear, given the organisation of funding for activity, how universities and third sector organisations in either country can develop programmes that both reach wider audiences and provide young people with consistent and long term access to activity. In the USA attempts are being made to develop an infrastructure to support the provision of STEM activity (NAP, 2016: 12). In the UK close collaboration between subject areas, universities, third sector organisations and schools would better support more long term and consistent engagement with activity for wider audiences of underrepresented young people.

Archer et al (2010) suggest that science 'appears to be constructed as "too feminized" for (many) boys and "too masculine" for (many)girls' and suggests the need to 'consider how we might bridge the gap between children and young people's everyday identities …and the identities and messages conveyed by school and "real" science' (Archer et al, 2010: 21). A significant question is whether ambassadors can help young people to 'bridge the gap' and if the classed, raced, aged and gendered identities of ambassadors is relevant to this. Indications from ambassadors' accounts in this study, reflecting my research in the UK (Gartland, 2014), are that matching aspects of students' and pupils' identities supports identification. This appears to be significant and may be particularly important for programmes where ambassadors are working with pupils within a short timeframe (Gartland, 2014).

Content, Pedagogies and Practices

The input of Academics and Educators

Unlike in the UK, where outreach activity in universities is often organised by WP units located in marketing departments, in the USA the involvement of academics and a focus on subject area knowledge and pedagogies appeared to be a priority. All the programmes considered in this study received input, to a greater or lesser extent, from academics who were subject specialists and educationalists with an interest in pedagogy. Problem based and inquiry based learning is a focus within STEM subjects in many universities and the expertise university academics have about these approaches to learning and teaching informed their thinking about outreach activity with school pupils. Project organisers leading and organising outreach were predominantly from teaching backgrounds. This expertise contributed to a sharp focus on pedagogy in the planning of the various activities.

Importantly and again in contrast to some UK university outreach activity (Gartland, 2014), academics and project organisers were keen to stress that programmes were not aiming to promote attainment within the context of the testing regime of schools. Indeed, accounts indicated programmes were often designed to act as a counterbalance to approaches prioritised in schools due to current testing regimes, focusing instead on active and experiential learning. In the USA as in the UK, there have been significant moves to experiential, active problem or project based in higher education in STEM subject areas. These pedagogical approaches are generally viewed as more effective in engaging women and diverse students (Arlett et al., 2010; Boursicot and Roberts, 2009). The benefits of experiential and active approaches, including problem based learning and design based science, with young people during outreach activity has been highlighted in research in the UK and USA (Evans et al, 2014; Schnittka et al, 2015; Watermeyer, 2015). Postgraduate or undergraduate working on programmes as facilitators for pupils has been found to support the work of school pupils and their identification with STEM subjects (Schnittka et al 2012; Schnittka et al, 2015; Watermeyer, 2012; Gartland, 2014, 2015). Organisers and academics widely discussed experiential and active learning practices in the different programmes considered here, often drawing on knowledge of particular pedagogies within academic disciplines.

In the USA, in engineering there has been a national discussion of appropriate pedagogical approaches following the drive to introduce engineering into the K-12 curriculum (Katehi, Pearson and Feder, 2009) and three principles identified to provide ‘a vision of what K-12 engineering education might look like’. These three principles are that engineering education should: emphasize engineering design; incorporate important and developmentally appropriate mathematics, science and technology knowledge and skills and promote engineering ‘habits of mind’, which include systems thinking, creativity, optimism, collaboration, communication and ethical considerations. These principles were discussed by engineering academics in relation to outreach activity and clearly informed the planning of activity. One academic explained that the focus of outreach is ‘to characterize the true nature of engineering and develop engineering habits of mind’ and how engineering can address ‘wider societal problems’ such as ‘food distribution, sociological problems, and political problems’.

Project organisers on some programmes located in public spaces had particular freedom to develop the content of sessions as their remit was broadly to develop community relations and increase

science literacy amongst young people. This extended the range of pedagogical approaches used, providing opportunities to develop creative and innovative sessions including a kinaesthetic activity where young people enact the behaviour of cancer cells and workshops to encourage young people to link art and engineering through engaging with kinaesthetic sculpture.

In engineering outreach there was a noticeable focus in activity on promoting engineering, again relating to a wider national focus on challenging the public's established views of engineering. In 2006 the National Academy of Engineering (NAE) produced a report focusing on 'changing the conversation' about engineering and specifically presenting engineering as 'inherently creative and concerned with human welfare, as well as an emotionally satisfying calling. Engineering academics and project organisers, as well as ambassadors, were keenly aware of the need to promote these key messages about engineering.

On a number of programmes academics and organisers discussed a focus in sessions on challenging young people's ideas about who scientists are and what they do and 'highlighting scientists' roles' (Programme organiser). More detailed information about careers was generally more explicitly provided during session with high school students whilst sessions with younger students focused on activity though the presence of the ambassadors was anticipated to challenge assumptions about scientists and engineers. On two longer term programmes, young people are further encouraged to consider more detailed information about STEM career routes available to them. As well as focus on careers routes, one programme also provided practical support for older students with their college application process including admissions, producing a resume and networking with students and academics.

Academics and organisers discussed the importance of 'disciplinary fidelity' (Academic) and that the experience of outreach activity should mirror experiences of subjects in higher education. On one programme a professor at the university checked the content of outreach programmes to make sure it aligns with undergraduate courses. This was emphasised by academics in engineering where there is concern that young people have very limited experience of engineering education (if any) – 'it's important for young people to understand what engineering looks like at university' (Academic).

Some partnerships between academic departments and other programmes or departments within universities shaped the content of sessions. At two institutions centres with a focus on promoting diversity and promoting active citizenship contributed to the content of sessions. As a result of this collaboration on one programme, there was a dual focus with engaging with science research and understanding science careers and 'professionalism', including leadership, identity and professional development.

Key stakeholders in programme activity, particularly running in schools, were teachers. In one engineering outreach programme teachers worked collaboratively with ambassadors to develop relevant activity. Perhaps because engineering is now part of the school curriculum in the state and because of the longevity of the programme, teachers were keen to engage with this outreach activity:

> Teachers who come into *(the programme)* usually don't have PBL experience so this is helpful – it's not connected to school's regular science curriculum – a lot of them don't include PBL so teachers look to us as a resource (Project organiser)

Ambassadors' roles and relationships

On most programmes ambassadors had substantial opportunity to make creative input though there were differences in the extent of this. On one programme, ambassadors work independently of academics and organisers to develop activity. This ambassador scheme was highly structured with resources for activity available to ambassadors online and a hierarchy of support from more senior and experienced ambassadors who were line managed by project organisers and academics. Ambassadors were free to develop a ten week programme of activity (one hour per week) for classes of elementary or middle schools pupils.

On another programme student ambassadors were viewed as totally responsible for the development of the programme: 'they build the programme from the ground up' (Programme Organiser) and on others ambassadors were able to develop activities based on their own interests and areas of expertise though again this process was overseen by a project organiser. Graduate and undergraduate students planning one off interactive sessions to be held during festivals and in a university museum were similarly given the freedom to develop activity. Students were integral to the museum space; as well as being engaged in interactive activity and workshops, their work was displayed in the museum gallery space.

Whilst ambassadors have considerable freedom to develop activity, activity is shaped by particular pedagogic expectations about the organisation of sessions. On one programme, ambassadors develop activity (ten one hour sessions) within a prescribed framework drawing on pedagogies developed by the NAE and within the engineering education department at the university. Ambassadors are expected to organise sessions into carefully timed sections: ten minute presentations, five to ten minute planning session, thirty minutes of building time and ten minutes sharing. While genuinely open ended problems were considered the most 'exciting' challenge for young people, academics and ambassadors were aware that the time constraints, age and experience of school pupils limited opportunities for these. One academic explained that sessions aim 'to build to that from smaller problems'. The ambition in these sessions is to develop the self-efficacy of young people and to challenge them to work collaboratively to find solutions to problems. Ambassadors and academics discussed the importance of 'allowing young people to fail'. Whilst ambassadors clearly enjoyed developing activity for young people, accounts and observation indicated that ambassadors' lack of experience posed some challenges. As one academic identified ambassadors, whilst having fresh and interesting ideas for activity, do not have the experience needed to 'think through all pieces of a lesson' (Academic).

Some of the Engineering ambassadors I spoke to were part of a wider national community, the 'Engineering Ambassadors Network' (EAN)[1]. The EAN holds regular workshops funded by the NSF to support ambassadors' outreach activity. Engineering ambassadors at two of the universities I visited attended these workshops and so were part of this wider national conversation about outreach activity in engineering and how to promote positive messages about the subject. On one programme, ambassadors followed guidelines from the EAN about the structure of presentations, and used the Assertion Evidence Method where slides are not used as a repository for information but to provide memorable evidence to support points made, often in the form of visual images.

[1] The EAN is described as 'a collaboration of engineering students across universities' that, resonating with the key agenda of the NAE, ' are dedicated to changing the conversation middle and high school students are having about engineering' http://www.engineeringambassadors.com/about.html

Ambassadors on this programme always presented in pairs and followed up presentations with a 'hands on activity' that complements the presentation.

The programmes considered here were all designed to support young people in developing soft skills such as team working as well as motivation and resilience. Some programmes also included sessions specifically designed to allow pupils a 'space to speak' and particularly to 'learn more about themselves'. This focus on identity was notable on two programs targeting pupils from minority ethnic groups. Sessions in both instances were developed by ambassadors who themselves were from minority ethnic groups and identified a need for a space where young people could 'open up' and share their experiences.

> We're trying to implement deeper conversations and different themes each week: trust, leadership and diversity. We want to allow them the space to communicate. (Ambassador)

On most programmes, the ambassadors' role within active 'hands-on' sessions was as a facilitator to learning, supporting pupils' experimentation or design and make activity. In being able to do this effectively ambassadors and organisers stressed the importance of subject expertise. Subject expertise was seen as valuable both to developing activity and to effectively supporting young people through being able to answer questions. Though, depth of subject knowledge was at times seen as an obstacle to being able to support pupils' learning. Using questioning effectively to support pupils' learning was widely discussed. One academic described the importance of 'directed questions to help young people move on from their frustration' while at the same time ambassadors need to allow young people to 'develop along their own pathway.' Ambassadors discussed the difficulties of balancing using guiding questions to support pupils in achieving outcomes and providing them with the freedom to develop their own ideas.

The importance of enthusiasm was also noted across programmes with ambassadors repeatedly commenting on the need to 'act really excited'. This need for enthusiasm and excitement is noted in the presentation feedback guidelines developed by the EAN: 'Does the presenter show passion, excitement and confidence?' Showing 'enthusiasm' and 'excitement' about STEM subjects was widely perceived to be vital –'a big factor' – in effectively motivating young people, and accounts indicated that young people often reciprocated with their own enthusiasm. One ambassador commented that something she really enjoys about working with young people on outreach activity is 'kids being so excited'. As with ambassador schemes considered in the UK (Gartland , 2014) when working with groups of young people, ambassadors were consciously performing identities as enthusiastic STEM students and this was viewed to be an effective strategy in engaging and motivating school pupils.

When asked about their role, it was clear from ambassadors' accounts that different learning contexts shaped the relationships they developed with young people. Where ambassadors were involved with one off STEM activity with pupils in schools there were mixed accounts of roles as being like that of 'teacher in school' to being 'a travelling salesman', 'selling science'. During one off activity and events there was certainly a focus on entertainment as being the most important part of activity; as one academic explained ' entertainment first – information follows'. There was, however, concern amongst ambassadors on programmes where encounters were very brief that there was

little time to develop relationships with pupils to support identifications; 'time restraints is one of the biggest issues we deal with… we only have 40 minutes to interact'.

Where ambassadors were working with pupils over a longer timeframe there were differences in ambassadors' accounts. On one engineering programme where ambassadors worked with pupils in school classrooms on a weekly basis, ambassadors describe their roles as like 'a project manager' where there are lots of 'moving parts and we are trying to bring it all together'. One ambassador described how her role on a summer school programme was 'like a combination of camp counsellor and private tutor' who 'plays with them during recess but is also a role model who teaches them things'.

Where ambassadors' focus was beyond STEM subjects and activity such as on promoting college and developing young people's confidence and motivation to progress, accounts were different again. Ambassadors working with pupils during one after school programme discussed how they were like 'social workers'. One ambassador explained how he had 'had a councillor at school and they did everything we do'. Another agreed observing 'councillor resonates with me. We're outside of teacher, we can engage with what's going on in their lives'. Ambassadors on this programme repeatedly referred to their relationship with pupils as 'friends'. On another programme where ambassadors visit their own old schools and talk to groups of pupils about college life, ambassadors described being 'a professional encourager – professional friend'. Several ambassadors on both of these programmes described being like a sibling 'a big brother – hopefully they look up to you'.

On another programme where ambassadors work with pupils during weekends over an extended period, ambassadors described having conversations about TV shows, food, high school and careers. One ambassador explained that this relationship allowed them to discuss young people's identities and challenge their ideas about their futures.

Teacher collaboration and managing behaviour

Both in school and where ambassadors were working with young people on campus, the active engagement of teachers was clearly important. However, the nature of collaborations between ambassadors and teachers varied widely.

Where ambassadors were working with whole class groups in schools, the input from teachers was considered particularly important. The collaboration between teachers and ambassadors was seen as a valuable part of the programme as it allowed for activity across the programme to be diverse and bespoke for individual classrooms:

> One of the cool things about (the programme) is the diversity of what's happening in the classroom …it's very much about what *(the ambassador)* wants to do and what the teacher wants to do (Ambassador).

However, there was a wide range of approaches across the programme with the extent of teacher input and involvement varying considerably. In some instances teachers were keen to use student ambassadors to support the teaching of elements of the school curriculum. One academic observed that this was not ideal and 'for undergraduates to have a good experience it's better if it's curriculum enhancement rather than curriculum replacement'. However, there were other teachers

who had no involvement in planning activity or overseeing lessons and were even described by ambassadors as seeing the time ambassadors spent in classrooms as 'time for a break'.

Managing pupil behaviour was a theme for ambassadors who were unanimous in their view that sessions worked better when teachers were more involved. One ambassador who had been working on the same engineering programme for several years emphasized the importance of teacher involvement, observing 'It's hard for us to control classes so it's really good when the teacher does that'. This point was reiterated by other ambassadors working on the same programme. One commented that at the school she was working with located in a poor neighbourhood the 'teacher … sees it as a time for a break – it's a really crazy school' (Ambassador).

On another programme, an ambassador leading a one off science outreach activity with a whole high school class commented on the benefit of teacher involvement in sessions. She explained the significance of teacher enthusiasm and interest in motivating young people: 'if the teacher is excited about your visit the kids are more engaged '..

These views were reiterated in other contexts where ambassadors were working with relatively large groups of young people, and were not restricted to school settings. One ambassador, leading a workshop in a public space made similar observations about teacher input. Where teachers were working collaboratively with her, this ambassadors described how 'students can get really excited about what they've done in the workshops and make links to what is going on in school'. To encourage appropriate and supportive behaviour amongst teachers and others the project organiser had developed a set of guidelines 'to set up the right tone for their students' that were both sent out in advance of the workshop via email and handed out at the start of the workshops.

After school club contexts were also viewed as challenging for ambassadors if they are left alone to manage groups of young people. One academic explained how this approach had been abandoned as it had been so unpopular with ambassadors who encountered real problems with behaviour and felt they were just being left to 'babysit' pupils. A group of students leading an afterschool programme discussed the difficulties of asserting their authority with pupils whilst building 'trusting' relationships. One ambassador explained, 'I need to bridge between being a teacher and being a student'.

This resonated with ambassadors' accounts on other programmes. One ambassador discussed finding it difficult to switch between teaching pupils and the relationship she had with them outside of teaching sessions during a summer school: 'you're sort of their friend – it's weird to tune out (Ambassador). Other ambassadors on different programmes, described struggling to take a more disciplinarian role during weekly sessions in schools. Managing behaviour was contrasted with influencing pupils as peers. One group of ambassadors discussed the problems of juxtaposing managing groups of young people with attempting to build friendships with them and agreed that it is 'better when someone else is in charge – a leader' (Ambassador).

On several of the programmes considered ambassadors worked in pairs or threes. Working with peers was valued by ambassadors who enjoyed collaborating with other ambassadors planning sessions, as well as listening to accounts of activity. It was noted on one programme that running weekly sessions with whole classes of school pupils is demanding for ambassadors and they need

support from both teachers and peers: 'it's very hard for ambassadors to do it by themselves – they need other people, teachers and partners' (Academic).

There was some indication from ambassadors and from observations that in contexts where pupils' behaviour could be challenging, increasing the number of ambassadors working with pupils was helpful. The ratio of student ambassadors to pupils appeared significant to both the ambassadors' experience and their ability to effectively manage groups of pupils. Whilst ambassadors running one after school programme discussed difficulties in managing the dual role of 'friend' and 'teacher', difficulties encountered in the behaviour of pupils was mitigated by the fact that there was a large group of ambassadors running each session.

Discussion

A difference between outreach activity organised by universities in the USA and university-led outreach in the UK is a focus on pedagogy. In the US pedagogy and subject specific pedagogies, were prioritised in the planning of outreach activity, a focus often lacking in UK HE outreach activity focused on recruitment. There was a widespread understanding of the need to employ different pedagogical approaches in these contexts. Active and experiential approaches, relevant to particular subject disciplines, were used across programmes, positioning ambassadors as facilitators, supporting pupils' learning. School pupils' accounts in my research in the UK, indicate these pedagogical approaches are effective in supporting identifications between ambassadors and pupils (Gartland, 2014, 2015).

An issue for ambassador led activity, especially in activity targeting wider audiences of young people where ambassadors are working with large groups, is that ambassadors are often left in charge of managing the behaviour of pupils. This positioning of ambassadors has been found to undermine identification, creating social distance between ambassadors and pupils (ibid) and undermining their positioning as 'friend'. Ambassadors' accounts indicate that classrooms in schools located in the most disadvantaged areas often pose particular challenges for ambassadors. Effective collaboration with teachers who maintain responsibility for their classroom or groups of pupils, was viewed by ambassadors to be an effective strategy. There was also some indication that increasing the ratio of ambassadors to pupils is beneficial, but there are cost implications if ambassadors are being paid.

Benefits for ambassadors and training practices

Advantages of engagement

The ambassadors contributing to this project reiterated similar views about the benefits of their involvement to students working as ambassadors in the UK. The advantages to ambassadors of contributing to outreach programmes, including increased employability, confidence and communication skills have been identified in the UK (Sanders and Higham, 2012). Academics at institutions visited during my Fellowship had undertaken studies into how working as an ambassador had affected students. Benefits identified included developing communication skills and understanding of key subject concepts (Albers, Smith, Calsdwell, McCoy, Bottomly and Parry, 2008; Carberry, Portsmore and Rogers, 2007; Pickering, Ryan, Conroy, Gravel and Portsmore, 2004). One study focused on ambassadors' perceptions of the impact of their involvement on their personal development, educational relationships and STEM knowledge which indicated that ambassadors viewed their participation as having a number of positive impacts:

> This impact is shown in increased confidence in public speaking skills, in a feeling of preparedness for careers, learning new STEM concepts ad building self-esteem (Albers, Smith, Calsdwell, McCoy, Bottomly and Parry, 2008)

Because of the focus on public engagement that existed across institutions, promoted by funding, there was a clearly expressed interest in effective science communication amongst academics, project organisers and ambassadors, particularly post-graduate ambassadors. One academic explained that 'students are interested in science communication … funding agencies are focused on public engagement' (Academic). For graduate students progressing into academic careers, there were also identified advantages to developing their 'public speaking skills' by practising speaking 'in front of up to thirty students' (Ambassador).

The benefits to students of using activity to support and develop their communication skills also extended more widely to working outside universities where communication skills are also extremely important. Academics and ambassadors indicated that 'doing this improves their skills' (Academic).

Communication skills as well as teamworking skills and organisational skills were all viewed as being developed by working on outreach programmes: 'communication skills – hugely – being organised and coordinating and sharing ideas effectively'. All of which were seen to contribute to ambassadors being more employable; one academic observed that ambassadors are 'recruited at a higher rate' than their peers.

Competition to become an undergraduate engineering ambassador was increasingly strong at two institutions. At one institution, the engineering ambassador programme was providing undergraduates with a professional identity and significant experience supporting their career development. Some ambassadors I spoke to lived in the 'engineering village' with other engineering ambassadors and played an important role in a wide range of different programmes and activities as well as outreach activity, including acting as teaching assistants supporting undergraduate students in core classes, planning and coordinating a big careers event as well as acting as the public face of the institution with perspective students and parents during tours and introductory sessions.

Ambassadors also indicated that they felt outreach activity supported their confidence and understanding of subject matter on their degree course: 'It gives you a sense of mastery – knowing something so well you can teach it to others' (Ambassador).

Several ambassadors commented on the academic challenge of 'simplifying *(information)* and keeping it accurate' (Ambassador). Ambassadors also commented on outreach activity supporting and reinforcing their own subject interests – one ambassador commenting 'I left thinking 'I love Chemistry' - it reaffirmed my interest'.

Additionally, contributing to outreach activity provided ambassadors with access to beneficial social networks. One group of ambassadors described how working as an ambassador raised their profile and helped them to build connections with academics and other students.

It was also suggested that working as an ambassador encourages progression onto post-graduate courses. This is reflected in research into the impact of working as an ambassador, which indicates that the opportunity programmes provide for undergraduate students to work with postgraduates supported this progression:

> The (activity) also gives the fellow the opportunity to build a stronger relationship with the graduate fellow, corresponding to a more positive university experience and potential enrolment in post- baccalaureate studies (Albers et al., 2008).

As well as providing career enhancing networking opportunities, one project organiser suggested that their programme provided support for ambassadors who were themselves from underrepresented groups, through being part of a 'community' of students like themselves. This was felt to be important in the 'challenging environment' of the university where the majority of students come from affluent backgrounds and private schools.

Training practices

A range of approaches were taken to training ambassadors, which linked to the different purposes of outreach activity and the different locations and learning contexts in which ambassadors would be located.

At two universities academics described particular courses run by institutions that students could undertake that were relevant to ambassador outreach activity. At one institution communication forms a core part of all students' undergraduate course where they focus on 'speaking and writing about scientific objects' (Academic). This linked to the focus on public engagement across the institution. At another institution postgraduate students have the option to attend a summer series of courses focusing on practice. One course has 'active learning 'as its focus and students are asked to plan a class.

Training for specific ambassador programmes were very different particularly in terms of the duration of training, with some programmes providing a two hour session and others two days and even two weeks. The extent of training linked to the responsibilities of ambassadors, with two weeks training provided for ambassadors who were planning and leading learning activities for whole summer schools compared to a short two hour training session for ambassadors delivering a pre-planned workshop.

Where training was provided for public engagement activity, such as workshops in museums or other public spaces and festivals, the focus appeared to be generally on 'public speaking' and 'engaging audiences' as well as practical foci on safety and how to fun activity. Where training was more in depth there was also a focus on learning theory, particularly related to 'science inquiry' and on developing new resources for activity. Engineering academics at two institutions discussed the importance in training on focusing on 'facilitating activity' and considering effective practices to support young people in their own learning:

> We train ambassadors to facilitate activity so that kids are using their own ideas – our students guide them, watch for frustration and use directed questions to help them to move on from their frustration (Academic)

On programmes where ambassadors were working with school pupils for extended periods, they were generally provided with more extensive training. This often included peer to peer mentoring and support, with one programme offering structured support through an executive team of experienced student ambassadors working with groups of newer ambassadors. These more experienced ambassadors have both a supportive and monitoring role: working with their team to support the development of the curriculum; observing sessions and also discuss the work of ambassadors with teachers to ensure the quality of provision. These programmes also provided ambassadors with information about school contexts: on one programme ambassadors have a training session about the USA education system whereas on another the Heads of Department from the schools in which they will be working, meet with ambassadors and talk about the school context, funding provision and demographics. One programme provided ambassadors with additional training more closely linked to teacher training such as sessions on developing the curriculum, classroom management, learning process and differentiation.

At two institutions engineering ambassadors were encouraged to attend conferences organised by the EAN, providing ambassadors with the opportunity to share and discuss best practices. Ambassadors at one institution were also provided with the opportunity to attend a leadership development programme with a focus on leadership theory.

Discussion

Ambassadors and organisers strongly believed in the benefits of programmes to student ambassadors. Reflecting findings of research in the UK (Sanders and Higham, 2012; Glendinning, 2011), a range of knowledge and skills were viewed as being supported by programmes including communication skills, employability, subject knowledge as well as the development of social networks both for career progression and peer support.

As well as supporting the promotion of HEIS and their research, and recruitment to institutions, ambassador programmes were also seen to be supportive of the retention achievement and progression of undergrad students within HEIs. Additionally, it was suggested that programmes provided useful teaching experience for postgraduate students interested in progressing into an academic or teaching career.

Again, in contrast to the UK, pedagogy was a focus of student ambassador training on many of these programmes. A theme running through programmes were social constructivist approaches to learning and teaching, and experiential and problem based learning.

Conclusions and Recommendations

Recent UK research suggests that young people's self-identity plays a vital part in their engagement with and progression in STEM subject areas, and that this poses considerable challenges to encouraging more, and more diverse, young people to progress into STEM subject areas. Burke (2012) suggests, 'aspirations are relational … they are formed in relation to others' and in STEM subjects 'identification with people' is increasingly seen as being more important to encouraging young people to progress in these subject areas than simply participating in STEM activity (Rodd et al, 2013; Macdonald, 2014). Ambassadors are widely assumed to be 'role models' for young people but it is clear that this is not a simple process and learning contexts within which ambassadors are located as well as intersecting aspects of their and pupils' identifies are significant to the relationships they are able to develop (Gartland, 2014).

This study raises a number of questions and issues related to the organisation and purposes of outreach activity. There is an accepted view that outreach activity should reach wider audiences and not simply target young people already interested in STEM careers – 'the brainy few' (Macdonald, 2014). Campus based programmes are viewed to have strong benefits, providing pupils with a sense of being part of a university and encouraging progression. Ambassadors play an important part in campus based activity. However, funding for activity is limited, and if a more inclusive approach is to be developed that effectively engages groups currently underrepresented in STEM subject areas, this is likely to impact on the extent of engagement for individual pupils. Current levels of funding will not enable all school pupils to attend summer schools, go on tours of science facilities and shadow ambassadors. However, critiques of outreach suggest that one off interactions are ineffective, and consistent, sustained approaches required. The increasing emphasis on the need for proof of impact also discourages engagement with diverse audiences of young people with no established interest in STEM subjects, as proving success in changing their orientation to STEM subjects is clearly problematic. Despite this difficult landscape in both the US and the UK, several of the US programmes considered here worked inclusively with whole classes of school pupils in schools. This inclusive school based approach to outreach activity is important if we are to challenge the underrepresentation of groups of young people, especially those from poorer backgrounds:

> **'**Aspirations form part of the ongoing social reproduction of privilege/disadvantage …schools(and careers services) are particularly important for disadvantaged children in that they can potentially provide a fairer distribution of cultural and social capital an opportunities for supporting, developing and informing children's interests' (Archer et al. 2013).

Ambassadors were seen by US organisers and academics as a cost effective and valuable resource, enabling institutions to reach these wider audiences of pupils in schools.

There are important differences between the two countries in terms of the purposes of outreach activity. In the UK university outreach activity is very clearly tied to 'raising aspirations' and promoting progression to university and recruitment. In contrast, in the US, there were additional purposes of community engagement and increasing the science literacy of young people and the wider public. These broader foci provided some academics and project organisers with the opportunity to develop innovative and engaging approaches to working with young people as they were unconstrained by concerns over measuring outcomes.

Another important difference is that, unlike in the UK where engagement with outreach activity is seen to have a negative impact on academics' careers (Watermeyer, 2015) academics and post graduate students in US universities are encouraged to participate in outreach by funding agendas. This was significant, influencing the purposes and approaches of outreach. In the UK outreach is often located in Widening Participation units in marketing and administration departments. In the US the landscape is very different, the involvement of academics and other educators in outreach and location of outreach activity within subject areas leads to a much sharper focus on pedagogy and subject specific pedagogy. This approach is more likely to provide young people with useful insights into different subject areas, potentially supporting more informed progression amongst young people as well as retention on courses. This involvement also promotes active and experiential pedagogies during activities which enable ambassadors to work collaboratively with pupils, supporting the development of positive relationships. My research in UK universities suggests positioning student ambassadors as subject experts in learning contexts where they can work collaboratively with pupils facilitating problem based learning and experiential activity provides opportunities for young people to connect and identify with ambassadors.

This focus on pedagogy is also evident in the training of ambassadors in the US with training in many programmes focusing implicitly or explicitly on social constructivist approaches to learning and teaching. Importantly ambassadors' accounts of interactions indicated significant benefits to them in relation to subject knowledge, progression and employability.

Recommendations for UK practice:

- *Investigate/identify ways to promote the involvement of academics and post graduates in the development of outreach activity through research funding.*
  In the UK there is currently little incentive for academics to be involved in outreach activity. Introducing incentives for academics to be more involved in outreach would support the location of subject specific outreach activity within academic departments. This would better support activity that provides young people with valuable insights into different subject areas and subject specific pedagogies. Research funding encouraging the engagement of academics and post graduate students in outreach would support this engagement. Another way to encourage engagement would be to develop an award recognised by industry for ambassador activity. Such an award could be available for undergraduates, graduates, graduate trainees and apprentices to encourage and motivate ambassadors with different levels of academic achievement to lead and develop activity with schools.

- *Investigate/ identify ways to promote collaboration across UK universities to develop more inclusive and sustained STEM interventions.*
  Individual institutions do not have the financial resources to provide sustained activity for wide audiences of pupils from diverse backgrounds. Small scale ambassador led activity is inexpensive and funding may be sourced through local organisations and businesses. While one off activity with pupils in schools may not be valuable in its own, this could form part of a more coherent approach to schools if coordinated across institutions and regions. The National Network for Collaborative Outreach provides an infrastructure to develop a

coherent approach to supporting university led STEM outreach activity. Universities could also work with third sector organisations to develop a regionally coordinated approach.

- *Undertake further research into the benefits of leading activity by student ambassadors to establish that working as an ambassador does support retention, attainment, progression and employability in HE as claimed.*
  To encourage universities and other funders to support ambassador activity it would be valuable to undertake a large scale mixed methods research study into the benefits of leading activity for student ambassadors to establish working as an ambassador does, as claimed, support retention, attainment, progression and employability.

- *Work collaboratively with primary schools to develop a regional pilot project introducing an ambassador programme targeting parents, teachers and pupils with a focus on raising awareness of STEM identities and on where STEM subjects lead and range of careers available.*
  A small scale and immediate recommendation is to develop a regional pilot project introducing an ambassador programme into primary schools to work with parents, teachers and pupils. This project would have a focus on raising awareness of STEM identities and on where STEM subjects lead and the range of careers available. Such a project could include apprentices working in industry as well as university student ambassadors in order to challenge assumptions amongst school pupils that you have to be a high academic achiever to progress into STEM careers. The STEM evenings model could be followed as this is low cost and reaches large numbers of pupils as well as their parents and teachers. There is also the potential for UK universities to link with existing programmes in the US to pilot new activity.

- *Undertake further research with pupils exploring different pedagogies, how these support identification between young people and ambassadors and what pupils learn about STEM through contact with ambassadors.*
  Further collaborative research with institutions in the US exploring pupils' perspectives about working with ambassadors would provide important insights into these learning processes.

- *Develop and pilot new training schemes for ambassadors in universities and industry settings.*
  It would be valuable to pilot training schemes that draw on US models and approaches to outreach activity and to explore the effect of this training on the work of ambassadors.

I plan to work within my own institution, other HEIs both in the UK and the USA and with STEM organisations in the UK to facilitate and support practical responses to these recommendations. I am working with Engineering UK to support the training of STEM ambassadors. I am also working with academics at Tufts to develop approaches to researching the work of ambassadors. An immediate step will be to develop a regional pilot project in Suffolk primary schools following the STEM evenings model.

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