Making STEM for everyone: reaching under-served audiences

Laura Hobbs and Laura Fogg-Rogers

Abstract Three projects that use evidence- and research-based practice to engage and support three under-served audiences – children with special educational needs (Science Hunters – Lancaster University), young carers (Young Carer Chemistry Workshops at Cotton On – Science from the Start) and girls and women in engineering (Women Like Me – UWE Bristol) – are used to offer findings and insights into engaging these audiences and meeting their needs.

Many groups of people are under-represented in science, technology, engineering and maths (STEM) in the UK. This can be with respect to aspects of involvement with STEM such as entry into STEM study and careers, access to informal learning opportunities and retention and progression once working in STEM-related jobs. For example:

- only 11% of the UK engineering workforce and 5% of registered engineers and technicians are female (WES, 2017);
- only 20% of A-level physics students are girls and this has not changed in over 30 years (Macdonald, 2014);
- black children and children from low socio-economic status backgrounds are less likely to have 'science capital' and go on to choose STEM study and careers (Archer, DeWitt and Willis, 2014);
- black and minority ethnic students are less likely to progress to scientific jobs after graduating than white students (Royal Society, 2014);
- women are under-represented in senior roles in STEM (Royal Society, 2014);
- girls outperform boys at A-level physics but constitute less than a quarter of entries (Engineering UK, 2015);
- people from low-income, minority ethnic communities can perceive science centres as 'not for them' (Dawson, 2014).

This is important: everyone should be supported and enabled to reach their full potential and explore career paths and interests that appeal to them. And diversity matters: if certain groups are or feel excluded, the pool of potential workers is reduced. Diversity affects democracy and development by bringing a wider variety of perspectives and broadening the range of problems that are studied and solved.

So how can we influence people who are not already interested in science? Role modelling and representation play a huge part in this. Social cognitive theory tells us that learning is not only related to personal capabilities and experience but also to observations of others within the context of social interactions, experiences and outside media influences (Fogg-Rogers, Sardo and Boushel, 2017). Representation is important: people need to see 'people like them' doing STEM to support them in feeling that STEM can be '*for* people like them' (e.g. Macdonald, 2014; Fogg-Rogers *et al.*, 2017).

Here we describe three projects that engage under-represented groups with STEM through both subject-specific delivery and structural design to create positive environments and representation:

- children with special educational needs (Science Hunters – Widening Participation through computer games, Lancaster University);
- young carers (Young Carer Chemistry Workshops at Cotton On – Science from the Start);
- girls and women in engineering (Women Like Me – UWE Bristol).

Science Hunters – Widening Participation through computer games (Lancaster University)

Science Hunters is a Widening Participation project: it aims to reach children who may experience barriers to accessing education (Figure 1). This includes a range of under-represented groups such as being from a low-income family, having special educational needs and disabilities (SEND), being of black, Asian and minority ethnic (BAME) background, or neither parent having attended university (Lancaster University, 2019). A particular focus of Science Hunters is working with children with SEND; the project has delivered sessions to thousands of children with SEND in schools in England and runs regular *Minecraft* clubs for children in care or who are adopted and children with special educational needs.

Figure 1 'Widening Participation' aims to support people from a range of groups who may experience barriers to accessing education

The project engages children using the computer game *Minecraft*, via an inclusive and constructive approach (Hobbs, Stevens and Hartley, 2018; Hobbs *et al.*, 2019a). *Minecraft* involves placing and breaking cubic blocks of different appearances and properties to construct items and features within an immersive, physically and ecologically representative virtual world (Figure 2) and is extremely popular with children, making it an ideal tool for communicating scientific concepts (Lane and Yi, 2017; Short, 2012).

The Science Hunters approach is to provide a short introduction to a science topic, featuring practical and interactive demonstrations, and then set children related tasks and challenges within the game. The set-up is flexible and adaptable to the needs of the children, who usually work in pairs within small groups. These tasks relate to processes, solving future problems and managing environments, with children encouraged to work collaboratively and creatively. There is no defined 'result' and they are facilitated to value the process of considering and trialling their ideas, rather than producing a prescriptive 'right answer'. This both encourages scientific thinking and is inclusive to differing needs and abilities. The core audience for the project is children aged 7–11 years; however, children of all ages are welcomed and catered for – children from all school year groups, from preschool upwards, have been included in school delivery.

A challenge faced by the project is reaching girls. Surveys of attendees at public events and in school settings show no significant difference in interest in *Minecraft* and using it to learn about science between boys and girls; however, school sessions are frequently delivered to groups in which the majority or all of the children attending – who are exclusively selected by their schools – are male (Hobbs *et al.*, 2019b; Hobbs *et al.*, 2019c). Representation is a key feature of the project, alongside designing sessions to be inclusive and adaptable to a range of needs. The core team are all female (with men in the supporting team), have professional research expertise and come from Widening Participation backgrounds, including SEND. University students from Widening Participation backgrounds volunteer in supporting roles and are themselves supported by the project.

Figure 2 A wind turbine built with cubic blocks in the virtual world of *Minecraft*; image from Science Hunters

Feedback has been overwhelmingly positive; in particular, children participating in schools tell us that using *Minecraft* makes the session '*fun, enjoyable and different*' from their standard school lessons and that it helps them to understand the content being discussed (Hobbs *et al.*, 2019a). Teachers have described direct benefits for children with SEND specifically; for example, one teacher reported:

> *I just wanted to thank you and your team for your fantastic* Minecraft *workshop … It was great to see our ASD students engaged and interacting with each other during the workshop. Not only were they learning about volcanic processes but they were socialising and having fun! These students find it hard to join in many of the activities in a mainstream setting so it was amazing to see them confidently working with yourself and your volunteers. Your visit has encouraged us to set up* Minecraft *at school for our ASD students.*

All sessions are delivered to schools free of charge, with equipment and resources provided, in order that the project is accessible to as many schools and children as possible.

Science from the Start – young carer chemistry workshops (Cotton On)

Science from the Start began as a project providing play-based science-learning activities for under-5s, an under-represented group for informal science learning (Wellcome Trust, 2012) and their parents/carers

(Hobbs, 2015) and has since expanded to cater for other under-represented groups. Cotton On is a craft studio based in Morecambe (north-west England) that provides craft tutorials and works closely with Science from the Start to provide accessible sessions that engage attendees with STEM through creative media. With support from the Royal Society of Chemistry, one such project used textile-based crafts to engage young carers from the local, low socio-economic status area with chemistry (Hobbs and Ollerenshaw, 2018). Following an initial run of 12 workshops in 2017, further workshops for young carers and their families have been supported.

Young carers are children and young people aged 5 to 17 years who provide unpaid care for family members, friends, neighbours, or others because of long-term physical or mental ill-health, disability, or problems relating to old age (Clay *et al.*, 2016). More girls than boys are young carers. Providing care can have an impact on the young carers' own health, and they can be 'hidden' – a significant proportion of young carers do not disclose their circumstances to their school (Clay *et al.*, 2016). North-west England has the highest proportion of young carers in the country, and the Morecambe and Heysham district is one of the most deprived areas in the UK (Department for Communities and Local Government, 2015).

The aims of the young carer workshops were to:

- engage young carers with chemistry topics;
- embed learning in craft-based activities;
- provide opportunities for relaxation and socialising;
- support accompanying adults in engaging with young carers' learning.

They covered topics such as chromatography, wet-felting, dye and colour transfer methodologies and a range of printing techniques. They were delivered free of charge and included accessible handouts explaining the chemistry behind the activities, with space for participants to make their own notes. The young carers had to be accompanied by an adult. The sessions were attended by 13 young carers (five male, eight female), two of whom considered themselves to have a disability while one preferred not to say). They were accompanied by seven adults (two male, three female), three of whom considered themselves to have a disability while one preferred not to say (Hobbs and Ollerenshaw, 2018).

Both self-reported knowledge and enjoyment of chemistry among young carers markedly increased between the start and end of the course, with participants stating that they enjoyed the course because they got to learn about science through crafts, try different things and it '*wasn't like school*'. They also appreciated being able to socialise with other young carers who understood their situation and demonstrated skills in all areas of the Generic Learning Outcomes (Arts Council England, 2014). Accompanying adults reported that they had gained confidence, knowledge, understanding and insight, skills, support, resources and ideas, and friends (Hobbs and Ollerenshaw, 2018).

Overall, textile-based crafts were an effective channel for delivering positive outcomes for understanding, knowledge of and confidence in chemistry learning, parental engagement with children's learning, and social and peer-to-peer benefits (Hobbs and Ollerenshaw, 2018).

Women Like Me – role modelling and outreach for women and girls in engineering (UWE Bristol)

Women Like Me is a tiered mentoring project for women in engineering, based at the University of the West of England, Bristol, and initially funded by the Royal Academy of Engineering through their 'Ingenious' programme. The project pairs senior women engineers with junior women engineers, who are supported to undertake engineering education outreach in local schools and at public events (Figure 3). Based in the Bristol and Bath area, the project has supported women and children in this region and beyond.

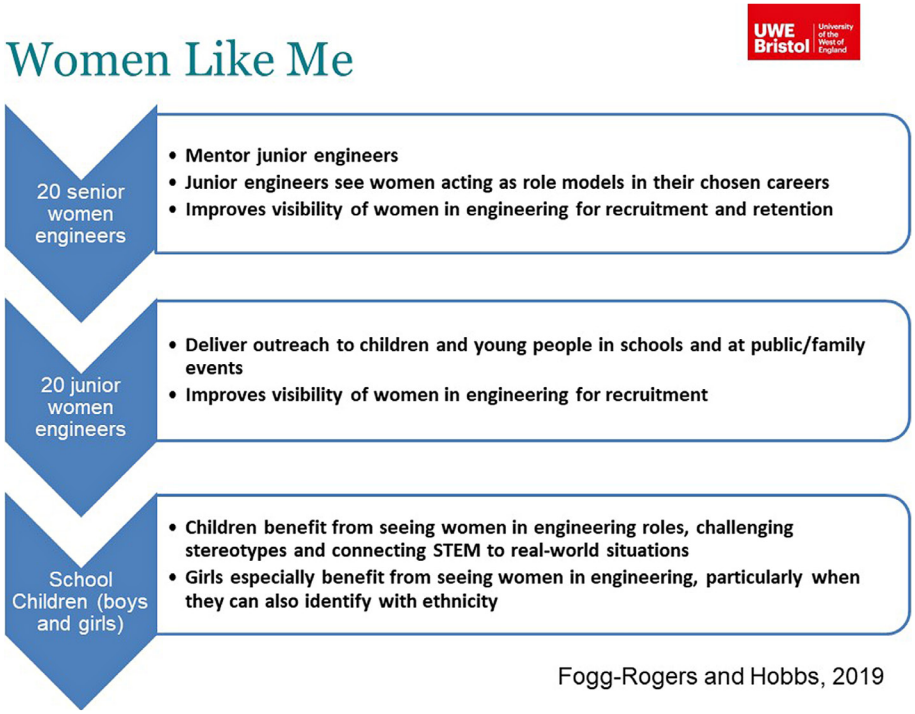

Figure 3 The Women Like Me tiered mentoring and outreach project

Only 11% of engineers in the UK are women, against the backdrop of a skills shortage in the engineering sector. The low proportion of women in the workforce means a pool of possible talent is going untapped. In order to increase the number of women in engineering, both recruitment and retention are important: more girls need to connect with engineering as a creative, socially conscious, collaborative discipline, and more women need to be supported to make a difference in the workplace (Fogg-Rogers and Hobbs, 2019). Women Like Me is addressing this by pairing mid-career women engineers with junior women engineers in the Bristol and Bath area to provide career and public-engagement mentoring.

Junior engineers deliver engineering engagement activities in local schools and at local public events, providing positive role models for young girls. Through this approach, the project will have impact both in the workplace today and for the future of the engineering profession. In the first year, 25 junior engineers and 25 senior engineers were trained in public engagement and mentoring, respectively, as well as being given access to networking and further training opportunities and support to embed outreach within their career paths.

Our junior engineers have found value in speaking to children in both primary and secondary schools and representing women in STEM careers, with one engineer writing:

> *This was an amazing opportunity for me to share my route into engineering and details of my current career … Importantly, it also provided an insight into who I am in a quest to challenge perceptions of what an engineer looks like or the sort of person they might be … I signed up to Women Like Me as I am incredibly passionate about widening participation in STEM, changing public perceptions of engineering, and ensuring that children don't have to wait until they're in their 20s to discover that engineering is a real career option, like I did!*

Teachers have also reported benefits for their students, for example:

> *I sent a letter home to the parents and it has encouraged the children to talk about engineering and find out how many of their family are engineers … It has been lovely to see children who usually really struggle to engage in lessons or find it difficult to share ideas get really excited with their designs.*

> *It was so inspiring. The demographic of the school is majority ethnic minorities and we have had some real trouble trying to inspire our girls to strive for stereotypical 'masculine' jobs.*

Against an original target of 1800 engagements with children over the course of the first phase of the project (October 2018 to July 2019), our junior engineers have engaged with children more than 10 000 times across the UK. Girls particularly benefitted from seeing women in engineering roles and engineers now feel more confident to undertake engineering outreach (Fogg-Rogers and Hobbs, 2019). We have been inundated with interest in the project, notably from mid-career female engineers wishing to support women coming up through the profession behind them. The enthusiasm and commitment shown by our junior engineers for reaching and inspiring the next generation is borne out in the volume of engagement they have achieved in just a few months.

Diversity and inclusion matters

These three projects, all very different, demonstrate the value in being able to see and engage with 'people like you', in terms of both role models and peers. In all cases, participants appreciated the opportunity to interact with people similar to themselves, with whom they could identity and who understood their situations, to share space and experiences.

How can these considerations be integrated into classrooms? Useful underpinning knowledge includes an understanding of science capital – the STEM-related influences and experiences that each person has – and how this affects how individuals think about and participate in science. A good place to start is the ASPIRES report (Archer *et al.*, 2013), which explains both the concept of science capital and its impacts; for example:

> *A young person with **high science capital** is **significantly** more likely to plan to **continue with science** after the age of 16 and to see science as being 'for me'.*

Beyond this, aspects to think about when planning an activity include:

- Is it accessible to everyone? Will all children have the underpinning experiences to be able to engage? If not, how can you adapt it for their needs?
- Representation – who is delivering the activity (would an external provider giving representation to an under-served group be of benefit)?
- Role models – who can children be inspired by (this doesn't have to be someone they see in person) and can they relate to them?
- Are you trying to reach, encourage or engage a specific group?
- If the activity is targeted at a specific group, is it set up for their needs (e.g. are the space and environment suitable for those with disabilities, does the activity require extension at home using resources that might not be available)?

- Are children being given the opportunity to interact with people (adults and/or other children) who are 'like them'?

We have compiled resources to support engaging under-represented groups with STEM subjects in a practitioner guide (Hobbs and Fogg-Rogers, 2018), which covers essential areas, including science capital, diversity, positive role models, inclusion and breaking the mould. In order to encourage everyone to feel that science is 'for them', regardless of their background, it is essential that we present it in ways that are accessible to those who may not usually engage with STEM subjects.

Information about the projects

- **Science Hunters**: www.lancaster.ac.uk/lec/about-us/engagement/science-hunters; sciencehunters@lancaster.ac.uk; @ScienceHunters
- **Science from the Start**: www.sciencefromthestart.wordpress.com; sciencefromthestart@gmail.com; @SciencefromtheStart
- **Women Like Me**: www1.uwe.ac.uk/research/sciencecommunicationunit/projects/currentprojects/womenlikeme.aspx; engineeringourfuture@uwe.ac.uk; @EngOurFutureUWE

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Laura Hobbs is a Research Fellow in Science Communication at the University of the West of England, Bristol. She also manages Science Hunters (at Lancaster Environment Centre, Lancaster University) and Science from the Start. Email: laura5.hobbs@uwe.ac.uk; sciencehunters@lancaster.ac.uk; sciencefromthestart@gmail.com

Laura Fogg-Rogers is a Senior Lecturer in the Department of Engineering Design and Mathematics at the University of the West of England, Bristol. Email: laura.foggrogers@uwe.ac.uk