# STEM Connections: A model for empowering academics to deliver outreach by reducing barriers to engagement

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## SUMMARY

STEM Connections worked with academic staff to develop their skills and confidence to communicate with any audience. Through creating a demonstration of their area of expertise and speaking with school-aged students, the academics hear a range of perspectives and repeatedly practice pitching their presentations. This project aimed to develop staff, engage the public, and work in partnership with local cultural institutions – in this case CV Life. Training has been provided by third-party organisations, by the project team and by the partner institution in both years.

Over two years, the project has worked with 23 academic members of staff across 17 different areas of research. Events have been run with 19 schools, either within those schools or at Coventry Transport Museum, reaching a total of 944 students with high-quality interactions. As of January 2024, the online resources have received over 36,000 views. Demonstrations have been used outside of the STEM Connections project for interactions with visitors, VIPs, funding bodies, and also filmed by TV crews for media work. Several staff on the project have mentioned STEM Connections in promotion cases and award nominations. Produced materials have complimented academic teaching and have been used to explain concepts more effectively during lectures. All the project resources and staff involved can be found at www.warwick.ac.uk/stemconnections.

The project targeted 5 key elements of outreach that are challenging for academics and may make engagement more difficult for them. This paper reflects on those challenges and how the project worked to reduce the barriers to engagement.

## INTRODUCTION

The necessity for scientists to engage the public has been described for decades (The Royal Society, 1985). The House of Lords (Parliament, 2000) suggested a 'crisis of trust' between scientists, engineers, and the public. The Royal Society (2006) highlighted the need to "increase the profile of science, scientists, and institutions to the public". This problem will continue with the development of new technologies, for example transport electrification: a collective approach should be taken to reduce barriers between academics and the public.

Outreach built into undergraduate engineering programmes boosts the 'transferrable' skills of graduates (Fogg-Rogers, Lewis and Edmonds, 2017; Muñoz-Escalona, Rigmand and Dunn, 2019). Taking part in an established programme boosts the outreach confidence of academics (Stylinski *et al.*, 2018; Fogg-Rogers and Moss, 2019). Public engagement has been recommended as a consideration in reporting impact through the Research Excellence Framework (BEIS, 2016; Copley, 2018).

There is support for outreach at a high level, but quality outreach requires experience and practice to be effective, and staff must have the confidence and opportunity to engage. Here, we describe a model for an outreach project, STEM Connections, designed to empower academics to present to new audiences. The project targeted barriers that make engagement challenging for academics, and this paper reflects on how a culture of engagement within the university could be supported by an approach that reduces such barriers.

## BARRIERS TO ENGAGEMENT

Perhaps the most intuitive barrier is that the audience may be uninterested in academic content. However, activities can be designed to create an enjoyable and impactful intervention. Being a relatable presenter, linking university knowledge to curriculum context, and making the activity interactive makes outreach more enjoyable.

Further, academics face time and resource pressure so must ensure that any activity is beneficial to their university role. Designing an activity that accurately describes their area of expertise makes outreach more impactful for the academics themselves. To make it easier for academics to engage the experience needs to be efficient and make the most of their time. Finally, outreach projects need to be valuable, with visible outputs.

The following sections review these barriers.

*Relatability*

Role models can be a positive influence on students' career aspirations (Nauta, Epperson and Kahn, 1998; Crawley *et al.*, 2014; García-Holgado, Díaz and García-Pĕalvo, 2019; Nowiński and Haddoud, 2019). However, students from low socio-economic backgrounds are less likely to have interactions with role models in STEM careers through, for example, familial networks (Archer *et al.*, 2013). Their exposure to scientists and engineers may be limited to examples given in education. However, there is a lack of diversity in the people who appear in textbooks in the UK (Henri, Coates and Hubbard, 2023). Scientists should be seen as people and not as faceless and inaccessible 'boffins' for people to build trust.

However, telling a personal story is not generally a daily academic task. The style of academic writing, where the first-person narrative is almost totally absent, leaves little room for personality. It can, therefore, be challenging for academics to include this personal narrative into descriptions of their topic.

Additionally, academics having opportunities to relate to each other, network, and work in a community is beneficial (Fidalgo-Blanco *et al.*, 2022).

*Authenticity*

Authenticity in outreach is important for both the deliverer and the audience. By linking an activity to teaching or research at the university, the audience receives insights into what Higher Education may hold for them. For the academic, reporting impact against their subject area is important for their career progression. However, delivering an activity to a public audience on a technical subject is challenging, especially exchanging sufficient high-level knowledge for a two-way communication.

While professional outreach teams can deliver activities, they can lack the authenticity and personal connection to research and teaching of 'traditional' academics. Following the recommendation of the Royal Society (2006): *"mentors, technical help, and direct support from science communicators"* were suggested as part of a necessary support system. Balancing the experience of these science communicators with the authenticity of the academics, maximises value and efficiency.

There is good engagement from staff for 'classic' experiments such as bicarbonate of soda and vinegar rockets but there are fewer activities that are authentic interactions with current research. This is intuitive: incorporating proven demonstrations into an event is

easy but not authentic; developing an entirely new demonstration that accurately explains a high-level concept is difficult.

*Interactivity*

The landmark "Thinking Like an Engineer" report (Lucas *et al.*, 2014) suggests that we need more interactivity in education to develop the problem-solving skills needed for technical STEM careers. It lists 'engineering habits of mind': skills that are essential to the 'core engineering mind', which can all be built into outreach activities. For example, rather than simply showing the audience a demonstration, the presenter can ask for predictions. The audience are then *visualising* and imagining what might happen when the presenter changes something. They might *find a problem* that explains why the demonstration did not work first time and *adapt* their thinking to *solve the problem* and suggest an *improvement*. These are all habits suggested in the report.

Further, for an interaction with a role model to be impactful it should be an active, rather than a passive experience (Blickenstaff, 2005). A role model simply dictating their life story will not engage students as effectively as a two-way conversation.

*Efficiency*

Outreach activities must carefully balance the complexity of the message with the prior knowledge of the audience, the skill of the presenter, the resources available, *etc*. Navigating these factors requires flexibility and confidence – skills that are usually only gained through experience. Additionally, designing an engaging activity that explains complex concepts in an interactive, authentic way is time consuming.

The design and delivery of these activities is the area of expertise of outreach professionals, so their input can make the process more efficient for academics. High workloads are cited as a barrier to academic career progression (Khan and Siriwardhane, 2021), therefore, for the involvement of academic staff in outreach to be sustainable and ethical, the support of professional staff is beneficial.

*Value*

A common issue with outreach activities is that they are delivered and done – it can be difficult to capture and document impact from them. Documenting outreach and engagement in academic promotion cases is relatively novel and academics need support in how to effectively achieve it.

## THE STEM CONNECTIONS MODEL

STEM Connections was designed by the WMG Outreach Team (referred to as 'the Co-ordinator'). It aimed to utilise the experience of the outreach team to empower academics, create materials and activities for them to deliver themselves, and inspire young people to consider STEM careers.

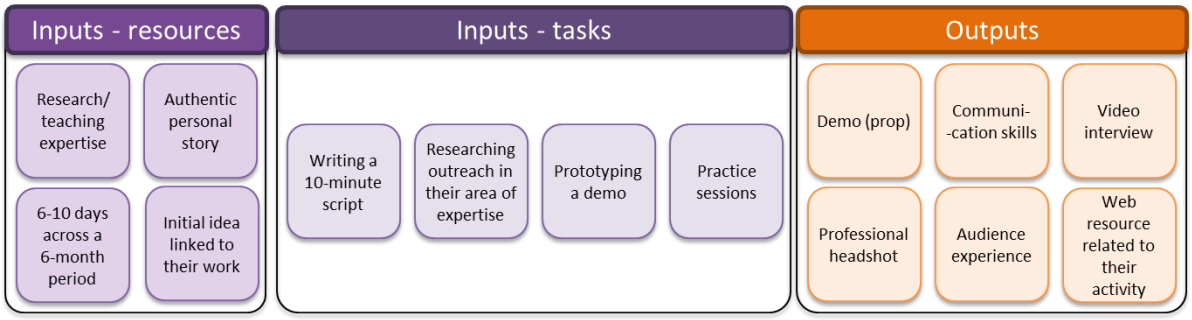
The networks of the WMG Outreach team provided access to schools in Coventry, but additional support was considered necessary for this project from a Cultural Partner. Museums and libraries are often at the heart of communities and are places that people have had positive experiences with and they may, therefore, be more likely to trust information that is delivered in that environment in the future. Entradas and Bauer (2017) highlight the need for STEM to engage the public in diverse theatres, thus the project was run in partnership with CV Life, a local cultural institution comprising museums in Coventry, to embed it within the local community.

### Design

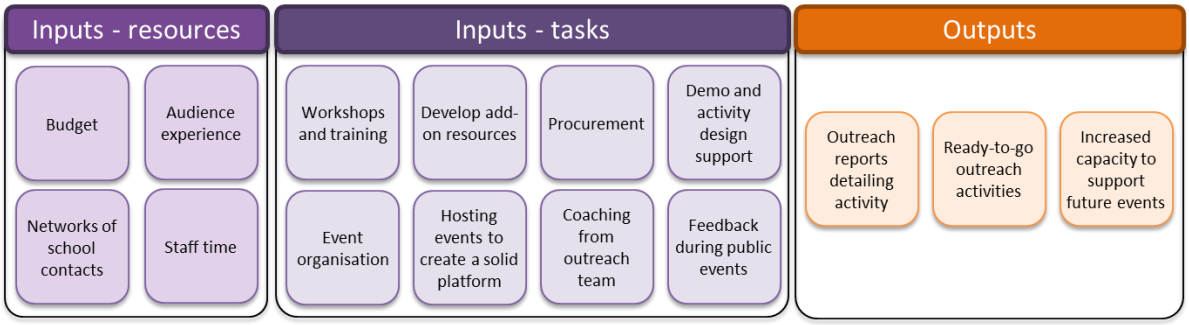
The project involved several stakeholders. The university, the cultural partner, the community, schools, students, teachers, academics, and the outreach team themselves. The stakeholders who created and delivered material (as opposed to the audiences) brought their own experience and expertise to the project. The various outputs of the project also benefited the groups differently. Figure 1 examines the resources, tasks, and outputs and how they relate to each stakeholder.

*Figure 1. A diagram of the inputs, separated into resources the stakeholders entered the project with and the additional tasks that needed to be undertaken, and the outputs that benefited each group as a result of the project.*

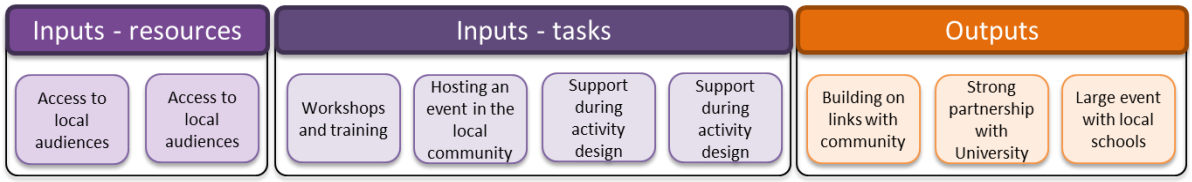
a) Academic




b) Co-ordinator




c) Cultural partner




Through combining the expertise of these stakeholders and producing visible outputs, the project aimed to tackle the five challenges listed above. Table 1 details how the outputs relate to each challenge.

*Table 1. A summary of the STEM Connections design in relation to five elements of effective outreach that may be challenging to academics and how the project design aims to address each one*

| **Principle:** | **Addressed by:** |
|---|---|
| 1. Relatability | Academics visiting schools, cultural institutions, and public events.<br>Academics are trained to share their personal stories while explaining technical concepts. |
| 2. Authenticity | Co-ordinator and technical services input on building demonstrations that stay true while being safe for public use.<br>Co-ordinator input on the activity, drawing on their experience to inform topics and language that is relevant to schools and society. |
| 3. Interactivity | Each activity must have audience participation and interaction at its core. |
| 4. Efficiency | Co-ordinator to lead on procurement and event management, and support design phases. |
| 5. Value | The outputs will be made visible through web-presence and designed to be useful beyond the end of the project. The activities will be logged and reported on. |

## Implementation

Academics from across the Science, Engineering and Medicine Faculty were invited to take part in the project. In total, 11 academics were involved in 2022 and 12 in 2023, representing 4 departments, and leading to the development of 17 different activities. The project was supported by Co-ordinator, technicians, and additional staff from across the University.

The Co-ordinator supported each academic over 6 months to develop an idea linking their own area of expertise to an interactive activity. Templating guides were produced to guide academics through the process of designing a robust and technically accurate activity.

CV Life prepared training days for the academics on the project and shared their valuable experience of engaging the public within the museum environment. Further training was provided by third-parties with an emphasis on storytelling skills for the academics to include personal details of their journey through science alongside technical details.

The Co-ordinator organised a series of school events to support academics' confidence in the delivery of their activity. A selection of academics presented to students in rotations, effectively giving each school a 'mini museum showcase'. Schools were chosen in alignment with widening participation strategies, targeting students within the primary-to-secondary school transition as a time when an intervention would be impactful (Harrison and Waller, 2017). The project resulted in a final showcase event held at Coventry Transport Museum, based in the very centre of the city. The number of events, audiences, and number of students are summarised in Table 2.

*Table 2. A summary of the events run in the STEM Connections project across 2022-2023*

| Year | Event name | Audience | Number of schools | Number of students |
|---|---|---|---|---|
| 2022 | School roadshow | Primary | 4 | 210 |
| | | Secondary | 1 | 180 |
| | | **Total** | **5** | **390** |
| | Showcase | Primary | 3 | 90 |
| | | Secondary | 1 | 20 |
| | | **Total** | **4** | **110** |
| 2023 | School roadshow | Primary | 6 | 380 |
| | | Secondary | 0 | 0 |
| | | **Total** | **6** | **380** |
| | Showcase | Primary | 0 | 0 |
| | | Secondary | 6 | 64 |
| | | **Total** | **6** | **64** |
| | | **Grant totals:** | **Schools:** | **21** |
| | | | **Events:** | **13** |
| | | | **Students:** | **944** |

The online resources (www.warwick.ac.uk/stemconnections) aimed to provide further opportunities for academics to be role models to young people. There are video interviews

with the academics, and learning materials for teachers that can provide context for points in the curriculum to improve the representation of scientists and engineers to young people.

## DISCUSSION: OVERCOMING BARRIERS TO ENGAGEMENT

After the final event in the original project scope, staff in both cohorts were invited to provide feedback on their experience of the project. These quotes are included in an anonymised form as part of a discussion of each barrier.

1. *Relatability*

Training in storytelling aimed to support academics with the skills they need to use personal elements in their activities. An extra benefit of these training sessions was to provide the opportunity for the academics to practice with each other. Through these sessions staff were able to network and realise the power of their own narratives.

> *"The STEM Connections project was a great opportunity for us as academics to expand our reach of our story telling into the local community and inspire young people, which is such a powerful and important vision."*
>
> Cohort 1 Academic

> "*The added benefit of being introduced to and networking with other researchers across WMG and the wider university has also been quite beneficial.*"
>
> Cohort 2 Academic

2. *Authenticity*

17 demonstrators were made as part of the project, each one in a different field of study. Throughout the process the academics were keen that these demonstrators should be accurate reflections of the topic and not just a fun 'toy'.

> *"Working on STEM Connections 2 was an incredibly fulfilling experience, the engagement from the pupils with the demonstrator and how well they followed the underlying scientific principles of the demonstrator."*
>
> Cohort 2 Academic

3. *Interactivity*

The Co-ordinator encouraged academics to 'test' their activity with each other in practice sessions, considering what would happen following the introduction of the concept and demonstration of initial elements:

- What can students change?
- How will those changes impact what they see?
- What can they learn while they are 'playing'?

Asking questions of the audience and using their answers to guide the activity in different directions encourages students to use the *Engineering Habits of Mind* (Lucas *et al.*, 2014). It is a good example of *two-way communication* – a key principle of engagement.

> *"I have learned a lot during the project. Mostly thanks to the training sessions that we had (one in Coventry Transport Museum and the one in the University's conference centre). These training sessions were very practical and informative. I have learned about the importance of student engagement. I can apply the knowledge I gained not only in doing outreach activities but also in my day-to-day teaching."*
>
> Cohort 1 Academic

4. *Efficiency*

In this model the Co-ordinator handled procurement, liaison with event organisers, *etc.*, allowing the academics to focus on the message in their activity and prototyping props and materials. The incorporated training aimed to accelerate staff through this experience-building process.

> *"… a bonus was attending training to learn how to be an effective science communicator to young children which was eye-opening and extremely useful in explaining the scientific topics, not only to the pupils but other adults as well."*
>
> Cohort 2 Academic

The fact that 17 unique demonstrators were made and used at least once in this project, with the vast majority of them being used multiple times, is a marker of success in this project being efficient enough to create a low barrier to participation.

5. *Value*

Value was built into the STEM Connections project through producing legacy resources that are hosted on the university website. Academics reported value to their own abilities:

> *"Engaging in outreach connections has been a valuable experience for me. Participating in outreach activities has helped me to develop my ability to communicate complex research findings to the students. Those skills are vital for enhancing the impact of our work to the public."*
>
> Cohort 2 Academic

> *"A better insight into how to create impactful outreach and developed skills that I can use in future projects. I feel more resilient, more comfortable in my academic and communication skills, and I greatly enjoyed seeing something I made come to life."*
>
> Cohort 1 Academic

The project also created strong links between departments and the Cultural Partner. This has led to an increase in collaborative working and outputs.

> *"Beyond the work with schools, it has been the catalyst in establishing lasting strategic engagement partnerships with Coventry Transport Museum and between [departments]. This has laid the foundation on which much of [department's] engagement has been built… demonstrating to the wider faculty that public engagement can facilitate industry engagement, student engagement and create research opportunities.*
>
> Cohort 1 Academic

## Other impacts

The website and interview videos for STEM Connections have been viewed over 35,000 and over 1,400 times, respectively (as of January 2024). The videos have been shared by the academics on social media and their profile webpages to build their online presence. Two academics have been presented with awards that specifically mention their contributions to STEM Connections (University of Warwick, 2022, 2023).

The project has also contributed to:

- Science festivals (National Astronomical Meeting 2022, International Caithness Science Festival 2022, Big Bang Fair 2023).
- Public festivals on campus.
- Ph.D. Thesis chapter on outreach (Mehta, 2022).

- Departmental education team away day.
- A prop in a popular science TV show (BBC, 2022).
- Open days.

## CONCLUSIONS & RECOMMENDATIONS

The STEM Connections model is a valuable tool to empower academics to engage the public. It creates visible assets that can be used to demonstrate the academics' involvement and enhance their profile. The activities can be linked to reports that are strategically useful to the university as well as to the academic. Staff involved have secured funding for further engagement activities, won awards, referenced the project in promotion cases, used the activities in additional events, and remained an enthusiastic community.

Recruitment of a wide range of academics from across the breadth of departments in the faculty proved challenging. The second cohort of STEM Connections featured several academics who had been given a personal recommendation to get involved from the first cohort, demonstrating the value of the experience.

We recommend the replication of this model as described in the 'Design' section. In addition to the reflections on the five identified barriers, the following recommendations are made:

1. Create a roadmap of the project, outlining tasks, responsibilities, and deadlines.
2. Template documents should be produced for each task to guide academics.
3. Foster a community feeling for academics from different disciplines to interact. A community is more likely to stay engaged with future outreach projects.
4. Design activities that can be used in multiple contexts so contributions will be beneficial beyond the initial project scope.
5. Log the activity and plan reports that will document the project.
6. Create a visible presence through websites, social media, video content, and news stories.

STEM Connections has created a community of staff who have continued to engage with the outreach team beyond the end of the project, delivering activities of their own as well as supporting existing university programmes. Putting academics front-and-centre of outreach

activities was transformative in this case. With the right mentorship and support from professional outreach practitioners, this project benefitted staff, the local community, partner organisations and the University as a whole.

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