



# Using STEM teacher networks in teacher professional development

**Key learning from the Connecting STEM Teachers  
programme and associated literature review**

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“

School students need to be more effectively engaged with STEM subjects and informed about the importance of STEM knowledge and skills in everyday life.”

Karimov

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# Introduction

There is a pressing need to provide school-aged students, particularly students traditionally underrepresented in these subject areas, with a more comprehensive understanding of science technology, engineering and maths (STEM) subjects. School students need to be more effectively engaged with STEM subjects and informed about the importance of STEM knowledge and skills in everyday life, as well as aware of their value and significance for future careers. This is especially important for engineering and engineering careers, as these subject areas are often overlooked in school curricula.

To achieve this, teachers need support to develop the knowledge, skills and STEM efficacy so they can implement changes in school practices and develop approaches that promote inclusive engagement and challenge existing patterns of participation. Interdisciplinary learning and teaching approaches have been found to make STEM subject disciplines more relevant and interesting for school students<sup>1</sup>. Student-centred approaches that involve students actively working on real-world problems are widely noted as effective in promoting engagement with STEM<sup>2</sup>. Focusing on the engineering design process (EDP)<sup>3</sup> has been highlighted as an interdisciplinary and student-centred approach to learning<sup>4</sup> that enables integration of STEM subjects through a problem-solving approach. Research indicates that relatively small changes to practices in schools that connect lesson content with students' lives and experiences can also make a difference to young people and enable them to identify their own experiences and dispositions within STEM<sup>5</sup>.

STEM teacher continuing professional development (CPD) and professional learning communities or networks present practical and cost-effective ways to promote such approaches. However, developing impactful CPD and teacher communities is difficult to achieve. To challenge existing practices and patterns of participation in schools, inclusive practices at the heart of such programmes are vital. Inclusion needs to be considered on different levels. STEM CPD/ networks should be inclusive of teachers from different subject

areas, backgrounds and career stages, and support the development of teachers' STEM efficacy. Programmes should promote inclusive approaches in schools: student-centred approaches to promote engagement among students with different levels of attainment and from different backgrounds, as well as learning and teaching approaches that effectively include and connect STEM subjects.

## The Connecting STEM Teachers programme

Connecting STEM Teachers (CST) was a national programme developed and led by the Royal Academy of Engineering (the Academy) that ran from September 2011 to July 2023. The programme promoted engineering-focused STEM engagement and aspiration among school students by supporting the professional development of teachers of STEM subjects through regional training and networking activities.

Physical resources and hands-on practical training with student-centred STEM activities were at the heart of the CST network activity. These STEM resources and activities are designed for school students aged from 9 to 14 and provide hands-on thematic learning opportunities. The goal of the resources and their hands-on practical focus is to support school students' real-world learning, promote a more integrated understanding of STEM subjects, develop reasoning and awareness of engineering and engineering careers, and encourage successful transition to post-16 and higher education.

The CST programme used a Cascade model<sup>6</sup> of CPD. CST Network meetings took place in different geographical areas across the UK termly and were organised by teacher coordinators (TCs). TCs were experienced STEM educators trained in using the Academy resources prior to organising their own regional network meetings. Regional network meetings were held after school; teachers were trained to use the resources and were subsequently given access to a free class set of resources to use in their schools. Network meetings also worked as a hub,

bringing together information about STEM activity and providers in the region. Additionally, in collaboration with network teachers, TCs led the development and delivery of enhanced learning experiences called ‘collaborative projects’<sup>7</sup>.

To give an indication of scale, at its peak in the 2020/2021 academic year, the CST programme had 50 TCs running regional teacher networks across the whole of England, Scotland, Wales, and Northern Ireland. In this single academic year, it engaged approximately 1,000 primary and secondary schools and trained just under 2,000 teachers during 180 network meetings. The Academy disseminated the equivalent of nearly 2,000 STEM teaching and learning resource boxes, reaching approximately 200,000 students.

We would like to acknowledge all our many stakeholders that supported us in our delivery of the CST programme, including funders, STEM support organisations, professional engineering institutions, delivery partners, school teachers, and the programme’s many TCs. A list of programme funders can be found on page 17.

## The report

There are many obstacles and challenges to developing impactful teacher networks and CPD. This report brings together key learnings from the most-effective practice identified through evaluations<sup>8</sup> of the CST programme, alongside findings from the wider literature.

The research literature identifies various effective features of teacher professional development including: that it is sustained over time rather than one off; that the content is relevant to participants and coherent; that it involves teachers’ collective participation and active learning activities<sup>9</sup>. Active learning includes approaches such as participating in learning activities in the role of a student, participating in discussions about practice, observing practice, and actively engaging in practice and receiving feedback<sup>10</sup>. Effective teacher professional development has been found to increase teacher self-efficacy, leading to higher levels of teacher persistence and improved outcomes for students. The literature widely emphasises the crucial role of teacher’ collaboration with peers as a significant way to support professional development, providing access to valuable resources and fostering an exchange of knowledge<sup>11</sup>. Indeed, teacher networks are increasingly recognised as a more effective mechanism for professional improvement than more traditional ‘top-down’ approaches<sup>12</sup>.

It is therefore timely to bring together findings about how to build effective STEM teacher networks

to support teachers’ professional development. This report aims to support policymakers, school leaders, and STEM and other organisations wanting to facilitate teacher professional development by building teacher communities and networks.

The authors would like to thank Professor Peter Kutnick for his thoughtful and constructive criticism of earlier drafts of this report. We would also like to thank all the teachers and TCs who gave up their time to share their views.

## Developing STEM teacher networks: key lessons

### Network formation and structure

#### *Building social capital and teacher self-efficacy*

Networks should be developed purposively to enable teachers to share expertise and develop confidence in their ability to introduce student-centred, integrated STEM learning and teaching. Teachers in networks need to feel a sense of ownership of networks, share beliefs and a sense of purpose, and build long-term collaborations. Highest impacts on teachers’ STEM efficacy and practice in schools was found in CST networks where teachers had been actively involved over several years.

#### *Building a community*

Opportunities for learning and collaboration need to be long term and sustained. As well as shared focus and beliefs, it is helpful to have a core group in a network and to build communities where there are trusting relationships between members (who often have different expertise, backgrounds and levels of experience).

### Network meetings

#### *Motivating attendance*

Participation is driven by teachers’ motivation to learn from other members. Meetings need to be of direct and immediate value to the practice of teachers with different expertise, backgrounds and levels of experience. Attendance at CST meetings was driven both by the opportunity for peer support and the availability of high-quality free STEM resources.

#### *Links to other STEM networks and resources*

It is valuable to provide access to diverse sources of information to ensure teachers’ knowledge is current. Network meetings on the CST programme provided opportunities for sharing information and ideas from a range of regional organisations including universities, businesses, and STEM organisations.

#### *Hands-on activity*

Hands-on activity is key to effective teacher professional development. Positioning teachers as students via hands-on activities with new CST

**Figure 1:**  
Developing STEM teacher networks: key lessons





resources was found to be an effective strategy in building teacher STEM efficacy and supporting STEM integration.

### **Opportunities for discussion and reflection**

Opportunities for discussion and reflection on resources and activities support teachers and can challenge them to think differently. Time allocated for reflection and discussion during CST meetings was vital for teachers to develop their thinking about practice.

### **Appropriate for location and context**

#### **Working with existing networks**

Careful consideration needs to be paid to the educational landscape in different regions. In every area, there are existing relationships and connections; understanding this ecology and building links with existing communities and networks was important to building CST teacher networks.

#### **The importance of geography**

The distance between schools is a key consideration in the development of networks. In some, particularly rural areas, distance makes face-to-face attendance challenging. COVID-19 provided direct experience of online professional development and networking for the CST programme. Online programmes can provide a potential solution for more dislocated and rural areas. However, some face-to-face interaction/additional interaction appears important to support the development of trusting relationships between teachers in such networks.

### **Working with school leadership teams**

#### **Senior leaders**

School senior leadership engagement is significant as senior leaders can designate responsibilities and set the agenda in schools. Working collaboratively with multi-academy trusts (MATs) and senior leadership teams (SLTs) in schools was a significant way to engage schools and ensure their sustained involvement in CST networks.

#### **Middle leaders**

Middle management can be key members of networks, particularly in secondary schools. They can delegate to other teachers in their schools and support teachers to share and embed activity in curricula.

### **Effective network leadership**

#### **Relevant teaching and STEM expertise**

Teachers value the expertise of fellow teachers and ex-teachers who understand the realities of life in schools. The CST programme drew on the expertise and experience of committed STEM educators with existing links to STEM organisations.

#### **Modelling practice and building communities**

There is a need for network leaders to carefully negotiate and support the building of relationships and trust among teachers in their networks. For example, by acting as mentors, sharing leadership responsibilities, creating a shared sense of ownership, and encouraging members to work together and share knowledge and experience. TCS' own subject specialism and contacts could at times limit the scope of CST networks; sharing leadership and drawing on the expertise of network members was found to address this.



# 1. Network formation and structure

## Building social capital and teacher STEM efficacy

Research into teacher communities often discusses *communities of practice* (CoP) or *professional learning communities* (PLCs). These terms refer to slightly different concepts. A CoP is 'a group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis'<sup>15</sup>. These communities are generally viewed as 'organic' and 'build on the collective experiences of their participants'<sup>14</sup>. In comparison to CoPs, the concept of PLCs originated from business organisations and has been more specifically developed in relation to education. Five identifying

features of PLCs are: 'supportive and shared leadership, shared values, vision and goals, collective learning and application, shared individual practice, and supportive conditions'<sup>15</sup>. Alongside these descriptions of relatively close-knit teacher communities, which sometimes refer to within-school teacher communities, there are increasing accounts of the role of *professional learning networks*. These are defined as 'any group engaging in collaborative learning with others outside of their everyday community of practice in order to improve teaching and learning in their school(s) and/or the school system more widely'<sup>16</sup>.

The theory of social capital underpins much research into teacher networks and communities as it provides a lens to consider how people gain access to expertise



through membership of a group<sup>17</sup>. There is increasing interest in teacher professional development programmes that support the accumulation of social capital<sup>18</sup>. There are different ways in which teacher networks/communities can be set up to build social capital among members; research indicates attention should be paid to how members are connected, the quality of the relationships between them, and the extent to which they share objectives, values and beliefs<sup>19</sup>. Some researchers suggest that a skills audit should be undertaken of members to identify valuable expertise and to plan more effectively for that knowledge to be shared<sup>20</sup>. Research also widely points to the benefits of collaboration in developing teachers' STEM efficacy, reducing work-related anxiety, and promoting commitment and achievement among students<sup>21</sup>.

While there are distinctions between these different conceptions of teacher communities and networks, if they are to be effective, a number of common features have been identified. The regional CST networks varied in terms of the extent to which they constituted a community or learning network. In some regions teachers and TCs were working collaboratively in supportive communities that functioned effectively as networks or even PLCs or COPs, while others were much more dispersed, with limited collaboration. This report highlights effective practice in building collaborative teacher communities and networks identified in the literature and through evaluations of the project. Evaluations indicated that highest impacts on teachers' STEM efficacy and practice in schools was found among networks where teachers had been actively involved in the CST networks over several years<sup>22</sup>.

## Building a community

It is important for teacher communities to have shared focus, objectives, values, and beliefs<sup>23</sup>. Teacher professional development needs to be prolonged and sustained and to feature 'multiple' and 'iterative activities'<sup>24</sup>. A core group of a teachers in networks has been found to be important to embedding knowledge and in the longevity of the network<sup>25</sup>. In the CST programme, a strong community rooted in a core group of members with a strong belief in student-centred and interdisciplinary learning and teaching approaches was common<sup>26</sup>.

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**They're normally people that regularly go to these meetings and it's the same people, I must admit and it's really nice because then we get to build the relationships with other teachers.**

Design & Technology secondary teacher

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Effectively developing trusting relationships between teachers in networks and communities is widely acknowledged as vital for successful outcomes. It creates a sense of safety to share experiences; foster collaboration, commitment, and motivation; support the sharing of information; and build collective teacher efficacy<sup>27</sup>. Establishing 'a culture of trust' requires teachers' commitment and long-term engagement<sup>28</sup>.

Establishing trusting relationships within regional networks was significant to the CST programme; these relationships contributed to individual members feeling supported and allowed networks to cater for diverse groups of teachers from different subject areas and with different levels of experience. Developing trusting relationships between members through facilitating collaboration (for example, through groups of teachers' hands-on engagement with project resources during meetings) contributed to more effective interdisciplinary working and catering for newly qualified teachers (NQTs), for whom such trusting relationships are especially significant<sup>29</sup>. However, some TCs observed that as the programme expanded, increased numbers of participants were dropping in and out of meetings, which was challenging because of the lack of trusting relationships.

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**It's quite relaxed when I talked to them (core group), because I know them very well and it makes it much easier for me to deliver because I'm much more confident with people that I know, rather than, when you've got complete strangers in there and you're not sure how they're going to react.**

Computer science secondary teacher

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## 2. Network meetings

### Motivating attendance

There are a number of ways in which networks and communities are formed. Some are 'top down', planned 'formal teacher communities' often with the ambition to implement policy initiatives and draw on outside experts. Others are more 'member oriented' initiated by school leadership teams or external organisations with 'pre-set schedules and objectives', including to share ideas and 'increase teacher knowledge of available information resources'. There are also more naturally occurring, voluntary 'formative communities'<sup>30</sup>.

It has been noted that, despite initially positive outcomes, networks formed in a top-down way are unlikely to form an effective teacher community, whereas teacher communities that are 'in-between' are often found to be more successful as they are 'driven by the members' collective desire to learn from each other's varied expertise'<sup>31</sup>.

The CST programme revolved around teachers attending regional termly meetings that took place after work, at the end of the school day. While the formation of the regional networks was initiated by the Academy via TCs, teachers' attendance at meetings was completely voluntary<sup>32</sup>. Teachers and TCs noted the vital role of access to free, high-quality resources in motivating this voluntary attendance.

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**The resources that the Network provide are absolutely fantastic. That's the key driver for, I think most people going.**

Design and technology teacher

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That meetings were of direct and immediate value to teachers' practice was seen to be key to successfully encouraging attendance at meetings. Peer support and access to opportunities were also significant.

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**The network to me, can't seem like an additional piece of work, it has to seem like, it's a group of colleagues, yes, it's professional, yes, but there has to really be a benefit to the person attending, every time. Your help has to be offered, opportunities offered, resources offered.**

TC – Science

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Important features of the CST programme commonly highlighted by teachers were the motivational and practical aspects that, when teachers engaged long term, helped build confidence and STEM efficacy inside the classroom. These took the form of up-to-date content through the resources provided by the programme; support for teachers in understanding complex content and technology, saving their time in learning; and implementing new material.

### Links to other STEM networks and resources

As well as effectively establishing trusting relationships between participants where expertise is shared, research also indicates the importance of providing access to diverse sources of information to ensure teachers' knowledge is current<sup>33</sup>. Network meetings provided opportunities for sharing information about local STEM activities and opportunities. Teachers' accounts indicated the value of information acquired through network meetings from other organisations, as these provided access to different sources of expertise:

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**I feel very much ... more connected to the STEM world in general so not just teaching. So through the meetings I've been made aware of amazing websites and resources. Also, just different opportunities – ... like the ambassador scheme and then others that are similar. The idea that there's other people in the industry who can connect to teaching without being teachers necessarily.**

Design and technology teacher

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**It had some speakers join who were ... STEM ambassadors so one woman was working with disasters to do with water and how to avoid natural disasters, like flooding ... it was like a breath of fresh air. It wasn't just people talking about school, it was ... real researchers ... giving their ... story about what their job is but also examples about how they could bring that into the classroom.**

Design and technology teacher

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However, a challenge raised by TCs was the amount of network meeting time taken up in presentations when a lot of organisations contribute to meetings. One TC observed the dangers of meetings 'full of people pontificating' (TC - maths), leaving little time for teacher interaction or for hands on working with resources.

### **Hands-on activity**

One very effective aspect of CPD with resources, as identified by TCs and teachers, was the positioning of teachers as students<sup>34</sup> via hands-on activities where teachers work with other teachers to explore and reflect on how to use the new resources. Teachers highly valued CST meetings that included hands-on activities as these meetings prepared them to effectively use resources with their students.

By experiencing firsthand use of these materials, teachers gained a better understanding of the practicalities of their use, especially in unfamiliar areas (such as coding for a biology teacher), and the challenges that their own students might encounter.

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**I try to make the sessions as hands on as possible so we can have a play with the kit and just ... feel what it's like to be the student – you know, when you're presented with this bit of kit, what's it like – what's going on in their minds – is it interesting? Is it fiddly? Is it frustrating? And all the rest of it so those hands-on activities are really important.**

TC – Science

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With the transition to online meetings due to COVID-19, teachers identified challenges posed by online network meetings that were limited to instructional videos for resource usage. Initially, moving the network meetings online due to the pandemic hindered the opportunity for hands-on interaction. To address this, the distribution of sample packs of resources helped TCs maintain the focus on positioning teachers as students. However, not all teachers actively engaged with the resources during online meetings.



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**It wasn't just me demo-ing it, they were actually playing with it as well at the same time. Whether all of them did or not I don't know. I would guess some of them just kept them in the box and just watched but I definitely know that a fair few of them were ... having a play with the kit as well because we were discussing what the problems were with it ... are there any other issues, is it fiddly, can we adapt it in some way? It was just like a face-to-face session in many ways, because they were playing with the kit they'd got that ability to ... chip in and give their honest opinion.**

TC – Science

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Active hands-on participation in working with real-world problems has been found to foster Engineering Habits of Mind<sup>35</sup> and facilitate STEM integration<sup>36</sup>. Teachers and TCs who have limited exposure and experience of engineering, commonly reported that the programme equipped them with engineering skills and provided practical examples of what engineers do, which they could incorporate into their teaching:

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**I'm not an engineer and none of my teachers are past engineers so it's actually upskilling staff, which is probably needed really to generate more engineers and architects in the future. We need to know, as science teachers, hands-on examples of, do you need to know this when you're an architect? Do you need to know this when you're an engineer, for example, which traditionally, we wouldn't have done in a lesson.**

Secondary science teacher

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Teachers benefited from relevant and timely resources that they can use with their students and were motivated and inspired by other participants in the network meetings.

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**I find, although it's a small and not particularly regular part of my kind of routine, I think it's really been an important and inspiring place to see this network of other people, other practitioners to understand ... that there are resources in place that ... can inspire the children, that help me teach, that make sense in it's up to date, it's modern. For example, during the pandemic one of the resources we had was about the pandemic, it was about how does disease spread ... I learnt a lot from it. So, I'm learning as a person as well as how to deliver the stuff and how to inspire the children.**

Design and technology teacher

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Teachers' accounts indicated that active hands-on activities during CST network meetings followed by discussion with other teachers, and trying out activities with students in schools, effectively developed their self-efficacy and confidence in using new STEM approaches with students<sup>37</sup>. Some teachers particularly benefited from the more technological resources as they didn't have the background or confidence to bring this type of material into their classrooms previously.

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**Yeah, well as I said, professional connections in terms of meeting other teachers and working with them ... it's a really good bridge ... if you think as an example, particularly the Hive ... potentially a technological bit of kit ... there have been similar things out on the market and I haven't been able to get my head round them quite as well so I think it's the pitch of it, the level that it's pitched at I think is really good. It makes sense to me, I don't have to think massively too hard about it and it's quite open ended as well. That's what I like, that there are possibilities with it, you know. You can use it in this way but ...**

Design and technology teacher

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## **Opportunities for discussion and reflection**

Time limitations in schools often constrain approaches teachers feel able to use in classrooms, and embedded didactic learning and teaching practices in schools can make it difficult to adapt to student-centred approaches<sup>38</sup>. Using network teachers' expertise is widely viewed to be vital to effective teacher networks and there is a need to allocate time for this activity. Interactions between teachers, and teachers and facilitators have been found to be very effective in changing teachers' views and changing teaching practices<sup>39</sup>.

Teachers described how engaging with hands-on activities during CST network meetings with teachers from different STEM subject disciplines provided them with interdisciplinary understanding of resources and approaches to teaching. Opportunities for discussion and reflection on resources and activities enabled teachers to consider how to embed resources in curricula, supported teachers in planning activity and at times challenged teachers to think differently about their own practice.

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**Face-to-face meetings open up ... conversations and those kind of personal conversations that you might have with somebody, you know,**

**like something you're really struggling to understand, goes 'oh right, okay, I deliver it this way'. You know, those personal ... little ... conversations you have over a coffee.**

Design and technology teacher

Discussion included teachers and TCs sharing experiences of how to work inclusively and how to support and manage student-centred learning where students work in groups, including mixed ability and mixed gender. In some networks TCs were purposively matching teachers to ensure expertise was shared. For example, in one network secondary teachers with expertise in teaching programming supported the learning of primary school teachers. Benefits have been identified in supporting collaborations between teachers from different backgrounds (for example from different subject areas, different sectors, and teachers of different ages and with different levels of experience). Evaluations pointed to the benefit of further embedding opportunities for reflection into network meetings, to provide structured opportunities for participating teachers to share practice with teachers with different experience and expertise, in using CST resources and to develop STEM efficacy<sup>40</sup>.

When the programme moved online during COVID-19, teachers described having much more limited opportunities for discussion and reflection. It was clear from TCs' and teachers' accounts that opportunities for discussion and reflection need to be carefully built into online meetings and activities (such as via break-out spaces during online meetings and shared online spaces for resources, activities and discussion) as if this is not done effectively, online meetings can become impersonal and dominated by presentations.

**I think that is probably the downside of the whole change post Covid. We definitely don't talk ... It's normally, you know, I don't know, eight to maybe ten people on a screen with the coordinator sort of explaining the agenda for the meeting. The agenda kind of just flows then occasionally there's pauses in, you know, did everybody get that ... It's certainly less personal.**

Design and technology teacher

For some of the most collaborative networks, valued interactions between the teachers and TCs appeared to continue more effectively when meetings moved online from face to face. Some TCs and teachers commented on the benefits of having other network members they were able to call on outside of meetings for support and discussion; in a few instances a 'buddy' system was purposefully arranged to support follow up, reflection and discussion beyond network meetings.

**It's not just like one person that's dominating or you know, that we're just logging in and sitting passively. You know, it's very much a discussion and ... everybody has an opportunity to speak or contribute or ask for something ... I don't feel that it's kind of limiting. [The TC] ... shares the agenda and the structure, and I suppose she's in some ways a bit of a mediator ... she's contacted both sides and sitting back but it doesn't feel it's just someone talking at us.**

Design and technology teacher



# 3. Appropriate for location and context

## Working with existing networks

In the development of teacher networks and communities, careful consideration needs to be paid to the educational landscape in different regions. In every area, there are always existing relationships and connections; understanding this ecology and building links with existing communities and networks was important to establishing CST teacher networks. TCs often worked with a wide range of existing organisations including STEM learning, The Ogden Trust, local universities, and local businesses.

Universities were useful allies for TCs who gave examples of working with local university engineering departments, linking with engineering outreach activity and working with social responsibility teams to hold collaborative events and support network activity. Local engineering companies had also offered opportunities for visits and provided space for network meetings as well as providing apprenticeship opportunities for students. Understanding and responding to local needs and priorities contributed to establishing thriving and engaged networks.

**We're very close to [university] and they've an engineering department they're hoping to grow, an IT department that they're hoping to grow ... Our local employers are also very supportive. We have ... businesses that were started locally that have a presence all over the world now ... they want our young people to come down and take those roles. So, they're super supportive of the schools and supportive of any events that I have run.**

TC – design and technology

**I've worked very closely with the social responsibility teams ... in the department of engineering and also at faculty level ... in 2019 we ran the collaborative project [at the university]. We've run a Vex robotics event at the university**

**... and we try to focus on inviting schools under the widening participation category ... we were ... set a task to try to increase the number of WP schools within our networks so, it's been really good working with a team at the university ... there's a really, really good network of support to help you with things.**

TC – design and technology

An increasingly important consideration in the operation of the CST networks was how to work effectively with MATs in different regions. Understanding if curricula and professional development opportunities are shared across Trust schools is important if networks are to effectively impact on teaching practice in MATs. Additionally, an awareness of competition for students between different schools and MATs in different areas is likely to affect collaboration.

The engagement of primary (feeder schools) and secondary schools in networks was seen as important by some TCs in effectively supporting continuity in a STEM approach for students across sectors and supporting students' progression in STEM subjects.

## The importance of geography

The geography of different regions and distance between schools is a key consideration in the development of networks. In some areas, particularly rural areas, distance makes attendance at face-to-face meetings challenging. Online CPD/networks have been noted as a potential solution, enabling collaboration and networking between teachers at a distance<sup>41</sup>. However, there can be challenges in promoting active participation in online-based communities. It is more difficult to build trust and foster the development of a sense of community online<sup>42</sup> and there can be a further issue that people often choose to be passive consumers of information while others dominate<sup>43</sup>.

During COVID-19, when the CST programme moved online, more teachers attended and often from a wider geographical area. While this attendance can be viewed as a success, this does not measure meaningful engagement with the programme. Attendance was often more casual with teachers dropping in and out of meetings or attending on a one-off basis.

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**But I think the online ones have started off where more people would go and I think that people ... drifted off a bit and it's easier to leave the meeting, isn't it when it's online.**

TC – design and technology

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This casual attendance and lack of face-to-face contact made it difficult for TCs to build a sense of community and for members to build trusting relationships where they felt comfortable to share their classroom experiences.

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**Face-to-face meetings open up ... conversations and those kinds of personal conversations that you might have with somebody, you know, like something you're really struggling to understand, goes 'oh right, okay, I deliver it this way'. You know, those personal kind of little bit conversations you have over a coffee and (online) it's just a little bit more formal I think, which is a bit of a shame. I think it would be better if it wasn't quite so formal.**

Design and technology teacher

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TCs identified potential solutions in areas where the geography made face-to-face meetings challenging and included hybrid meetings, and a mix of face-to-face and online meetings over the school year. 'Buddy' systems where teachers are encouraged to connect with others outside of meetings could also be developed.





## 4. Working with school leadership teams

### Senior leaders

SLTs are often key to establishing the conditions for successful outcomes for teacher communities<sup>44</sup>. SLT engagement with networks is significant as senior leaders designate responsibilities and set the agenda in primary and secondary schools and can promote attendance of staff at network meetings. Working collaboratively with MATs and SLTs was found by some TCs to be a powerful way to engage schools and to ensure their sustained involvement.

**The Vice President of the MAT I mentioned, she's very good ... they've got primaries and secondaries in their MAT ... she's the one who gets the schools to come in. I think, having SLT on board is hugely important because they've got the influence to be able to go, one of you is going to a meeting.**

TC – Computer science

However, challenges were also noted in working with MATs with accounts of some of these organisations being inward facing and reluctant to engage with external providers. Engaging with SLT in primary schools was often easier for TCs and primary head teachers were sometimes directly involved with project activity. One primary head described how she had attended meetings herself alongside other key staff including the school science lead. This engagement with the programme supported the embedding of STEM activity in the school curriculum across year groups.

**We made the wind tunnel, got the kids making things out of it and that one was used a lot and across the school. So, for example, Year 6 made the wind tunnel and then reception and Year 1 were experimenting with it so it was a nice sort of collaboration between them.**

Primary school teacher

School leaders in secondary and primary schools were at times able to embed multidisciplinary working in schools where teachers from different STEM disciplines/areas work together to plan activity. For example, senior leaders in secondary schools were able to establish STEM days for whole year groups in Key Stage 3.

### Middle leaders

School middle management (heads of department) can be key members of networks, particularly in secondary schools. They delegate to other teachers in their schools, ensuring consistent network attendance, and support teachers in their schools to act as bridges<sup>45</sup> to share and embed activity in schools. Middle leaders who engaged with the CST programme could embed activities and resources in subject curricula (this was noted especially in D&T), promoting an interdisciplinary approach to teaching in their subject area.

Middle leaders can also promote long-term engagement of schools with networks so that if individual teachers leave schools, the school continues to work with the network and embed STEM activity. Middle managers are also well positioned to embed STEM activity in the school curriculum and even across schools in a MAT. TCs observed the benefits of having middle managers from secondary schools, including heads of D&T, heads of computing and heads of science, involved in the network as they could delegate others to attend.

**[Middle managers involvement] They've then asked the second in science to come along to the meetings ... and they've also then ... [asked] a representative in primary, who's then come along from the same school.**

TC – Science

It was more difficult for individual subject teachers to impact on practices in schools as they were not always positioned to implement changes to curricula, or to arrange for school curriculum time to be spent on discussing the implementation of new student-centred STEM resources.

# 5. Effective network leadership

## Relevant teaching and STEM expertise

The CST programme used the expertise of committed STEM educators who were themselves teachers or ex-teachers to act as network leaders or TCs. The knowledge and hands-on experience of TCs was often highly valued by teachers and even motivated their involvement with the programme.

**I knew [the TC] so I wanted to get involved and I knew that she was really passionate about the subject so I knew that it would be worth doing and listening to what she had and what she was promoting.**

Computer science teacher

A key role of TCs was to work collaboratively with STEM Learning and other STEM organisations, local universities, and businesses, to ensure teachers have access to resources and information about valuable local STEM activities and opportunities. Alongside close links to other teachers, such links to people from wider organisations developed within regional networks can provide access to new knowledge and extend learning and practice<sup>46</sup>. TCs noted the essential role these links played in enabling access to new information.

**I think it's essential really. From being on the other side of it, from being a teacher that was trying to involve external resources, to try and track down and locate all the things that might be ... possible for me is an endless job ... So, to have somebody in the middle that's just pulling everything together, to make their lives easier feels like the best possible use of my time.**

TC – Science

## Modelling practice and building communities

The sustained efforts of moderators, facilitators and

leadership figures in teacher communities and networks are widely noted<sup>47</sup>. Establishing 'a culture of trust' in teacher networks can take considerable time and commitment<sup>48</sup>. Leaders and facilitators have to carefully negotiate and support the building of relationships, understand the needs of participants from different backgrounds, and ensure networks are inclusive<sup>49</sup>.

There was wide variation in the ways TCs worked, and time constraints impacted on the extent TCs could build close working relationships with network teachers. Some TCs facilitated and encouraged reflection on the use of CST resources and modelled effective practice from their own experience of using resources in school.

**[The TC] is extremely resourceful in that to try and ease the load or make it easier to integrate some of these projects into school, she would have a small resource of how they're approaching it [in the TC's own school] and that other people then can use.**

Design and technology teacher

A challenge for TCs, who often drew on their own subject specialist communities, was developing inclusive networks with teachers from across STEM disciplines. TCs at times worked collaboratively with network members, acted as mentors to teachers, and supported the distribution of valuable social capital by encouraging network members to work together and share their own knowledge and experience. Some TCs also worked collaboratively with network teachers in leading networks, developing a shared approach to network leadership and promoting a sense of shared ownership.

**I'm trying to do it bit more outside [network meetings] ... more peer to peer with somebody else who does feel more confident helping somebody else. So, my network, I see ... my role ... as ... partly a facilitator, to make other people also make connections.**

TC – Maths

# Closing comments from the Royal Academy of Engineering

The CST programme has shown us the value of fostering professional learning networks among teachers and educators. The programme has demonstrated the significant impact that these networks can have on teachers' confidence, knowledge and efficacy to deliver innovative teaching practices to enhance and transform the STEM curriculum.

The aim of this best practice guide is to share our learnings and inform others of the benefits of professional learning networks across the education system. We hope it will inspire other organisations to both learn from the successes, and understand some of the challenges, to develop and implement their own professional learning networks so that many more teachers, from all subjects, but particularly STEM subjects, can benefit from the value they bring.

The Academy itself is committed to using the best practices derived from the CST programme, that informed this guide, as it continues with its mission to provide equitable access to STEM education for schools in socio-economically deprived communities. Providing opportunities for pupils from these communities to progress with STEM subjects and consider a STEM career offers them opportunities for gainful employment, personal fulfilment, economic advancement, and consequent social mobility.

In ending, we share this quote from a secondary teacher of engineering and long-term TC that encapsulates the spirit of the programme:

**“My greatest achievement since joining the Royal Academy of Engineering’s Connecting STEM Teachers programme has been uniting a community of teachers who, at times, can feel very isolated. I feel that I have been lucky to have experienced a wide range of STEM activities since becoming a teacher, and there is little more rewarding than experiencing the sense of achievement students gain from these opportunities. As a coordinator for my school network, I have been able to share this experience with teachers who share my passion for STEM but maybe haven’t had the same support or chances to exploit the vast number of activities that are available in the UK. Opening up pathways for teachers to employ their passion with their own students shows that STEM is not just about individuals, single schools, or even local communities but a much wider, global opportunity for all young people.”**

Teacher coordinator for Hertfordshire and subject leader for design, technology and engineering

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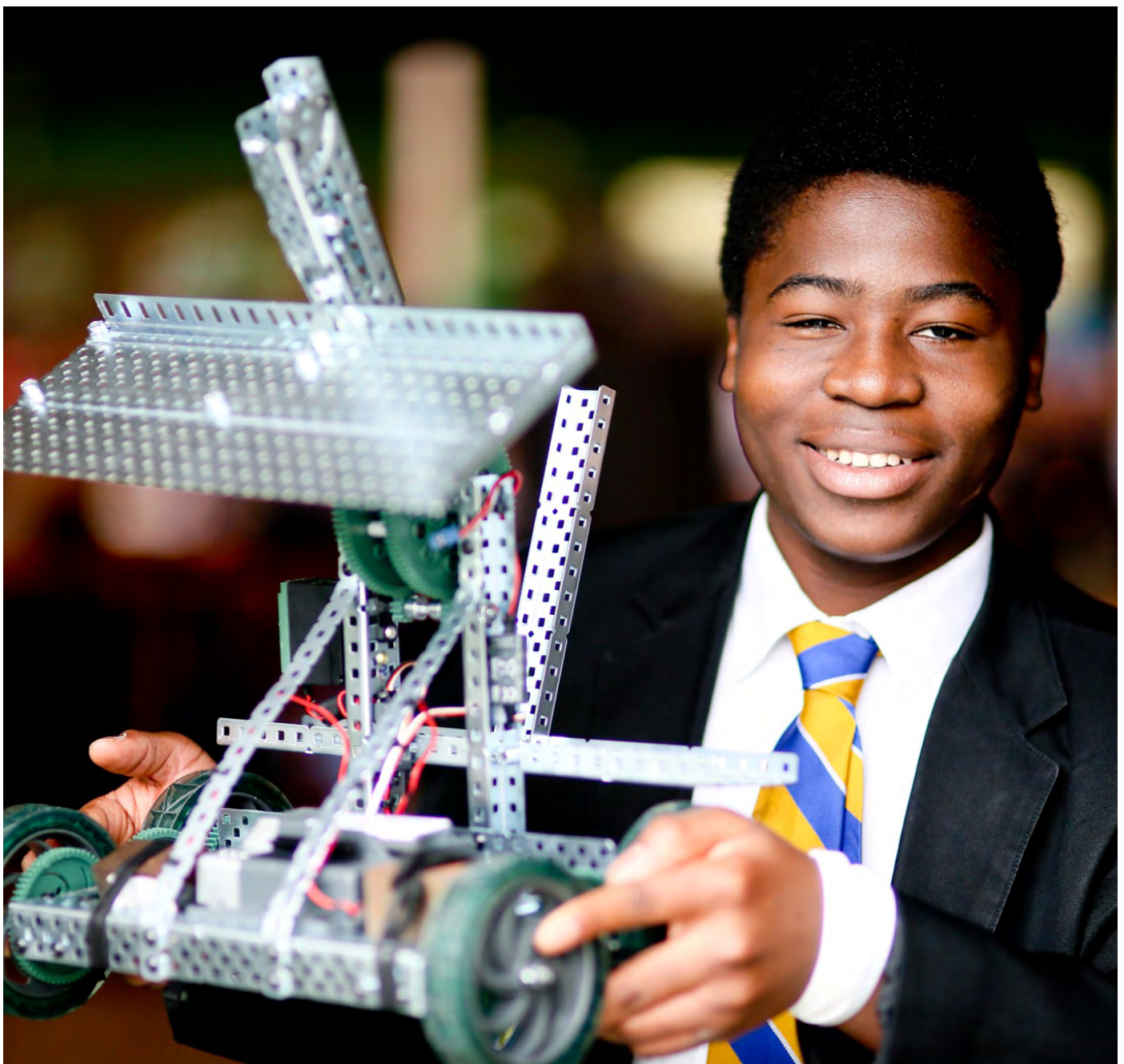
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# Royal Academy of Engineering

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