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STEM Outreach activities: An approach to teachers' professional development

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Abstract

STEM outreach programmes in secondary schools are mediated by STEM teachers who are responsible for organising, implementing and evaluating the activities with a view to promoting STEM subjects. However, research investigating teachers' STEM roles and professional development through participation in outreach activities is limited. This paper explores teachers' views of STEM activities, how they understand their role as primary facilitators and the impact of their STEM engagement on their professional development.

STEM outreach provides distinct opportunities for situated and dialogic learning. Teachers who understand the pedagogic challenges inherent within these approaches could be more effective in creating the inspirational, enquiring culture that will lead to students participating enthusiastically in STEM subjects. STEM teachers' effectiveness in engaging students by demonstrating the importance and relevance of STEM subjects in the real world and engaging captivating STEM outreach partners not only supports students learning but also enhances their opportunities to develop their knowledge and skills

Semi structured interviews were conducted with eleven teachers from six different schools in the West Midlands, United Kingdom. The data reveals STEM facilitators become the 'face' of STEM to their pupils. The expertise, knowledge and partnerships STEM facilitators develop, broadens their capacity to deliver teaching imbued with real world applications and improve students' understanding of the range of new and upcoming careers available. Most importantly, participating in STEM outreach activities help teachers maintain and reinforce their own sense of identity as STEM professionals. Outreach activities provide opportunities for teachers to interact with leading scientists and obtain exposure to cutting-edge research.

Key words: STEM teacher professional development, STEM education; STEM careers; STEM outreach, Situated Learning, Dialogic Learning.

Introduction

A contemporary focus on Science, Technology, Engineering and Mathematics (STEM) subjects and careers has led to a proliferation of outreach activities for students of all age groups in UK and globally (Vennix et al 2017). Outreach includes interactive STEM workshops, STEM ambassador presentations, mentoring schemes, STEM placements, visits to industry, master classes, competitions and consultations about STEM careers, activities geared towards making STEM subjects fascinating and appealing. STEM outreach practitioners seek to enhance and enrich students' learning experience and expose them to areas of STEM that may not be delivered as part of the regular curriculum (Laursen et al 2007; Hargreaves 2010). Practitioners represent professional institutions, voluntary organisations or universities and provide crucial opportunities for students to engage in real world STEM challenges that have the potential to stimulate interest in STEM careers (Kesidou and Koppal 2004).

Outreach programmes are embedded in learning environments that should demonstrate the relevance of STEM and inspire, intrigue and motivate students to study STEM subjects beyond compulsory schooling (Turner et al 2007). However, for STEM outreach to be efficient and successful, the STEM teachers who provide the bulk of STEM teaching need to work collaboratively and strategically (National Audit Office 2010) with practitioners to ensure the right students are selected for programmes and the activities dovetail with ongoing teaching and projects. Furthermore, teachers' involvement in outreach could promote their own professional development (Royal Academy of Engineering 2013). As teachers are the vanguards of the school-university/industry partnerships, they formulate through outreach initiatives a powerful space for advancing their own continued professional development (Maistry 2008). The STEM teachers in effect are able to develop distinct

communities of practice (CoP) (Lave and Wenger 1991) which serve as engines of learning and instruments for personal development.

Unfortunately, students' access to STEM activities are heavily dependent on the STEM teachers in a particular school and the school management (National Audit Office 2010; Straw and Macleod 2015). Practitioners reveal that they often engage with the same set of schools, corroborating the notion that proactive teachers employ their services more regularly (Holman and Finegold 2010; Murphy and Machin 2011). STEMNET, responsible for coordinating outreach activities across the UK, acknowledges the need to provide more support for teachers to enable them set up STEM clubs and involve practitioners (Straw and Macleod 2015). However, teachers do not necessarily have the competencies, opportunities, motivation or enthusiasm to develop and sustain STEM outreach (Baker-Doyle and Yoon 2011). Straw and Macleod (2015) suggests that teachers do not always have the capabilities or administrative support to efficiently provide outreach services. Additionally, because STEM activities can be viewed as detached from more pressing curriculum goals, teachers are not encouraged or equipped by the educational system or their school management to be efficient STEM facilitators. Each individual school's commitment to STEM education will be influenced by the competencies, and motivation of the STEM teachers, attitudes of head teachers and STEM department coordinators. These factors account for the significant variation in STEM outreach engagement both locally and regionally and this may be the reason why some schools do not engage with STEM practitioners at all (National Audit Office 2010). Furthermore Bybee (2010) argues that although there is a lot of commitment to establishing STEM activities, the policy initiatives that will enable teachers to do this is completely lacking. The infrastructure, resources and training to enable teachers to be efficient STEM facilitators the system needs seems to be absent.

This paper presents research which explores teachers' professional development through outreach activities and underlines the need to reform teacher education and implement a framework which enables teachers to successfully engage with outreach activities thereby developing their role as STEM facilitators. Teachers' crucial role in coordinating and facilitating outreach events can be pivotal for a school's STEM education. The attitudes and enthusiasm of a teacher often influence the direction and intensity of STEM engagement. This has a direct correlation on the quality of experience gained by the students through outreach participation (Murphy et al 2011; Laursen et al 2012). Key themes the research focuses on are: teachers' perspectives on engaging with STEM outreach, how the outreach program as a whole affects their understanding of a teacher's facilitation role and professional development, and the support and education they require to effectively engage with outreach. The data presented in the paper is gathered from in-depth qualitative semi-structured interviews with secondary school/college teachers involved in facilitating STEM outreach activities.

Role of STEM outreach in supporting the learning of teachers

STEM outreach focusses on informal activities (Mann and Oldknow 2012). The aim of STEM outreach strategy is to inspire students and enable them to appreciate STEM careers. STEMNET an education charity in the UK (Straw and Macleod 2015), for example, encourages teachers to engage with ambassadors and practitioners so that their students can meet inspiring role models who work in STEM careers and participate in real life projects and workshops which will directly promote students' understanding of real world applications of STEM subjects. STEMNET provides some training and CPD for teachers, particularly with respect to how to effectively utilise the resources it supplies to schools. STEMNET also coordinates a number of STEM outreach activities, providing the

teachers with access to STEM practitioners and the support they need to set up STEM clubs. The STEMNET support and provision presupposes that teachers have the capabilities and skills required to run the STEM clubs. Teacher education is predominantly focused on the delivery of curriculum (Vennix et al 2017). The extra-curricular activities and innovative practices, resources and activities offered by STEMNET often can only be delivered by teachers who have enhanced skills, particularly the capability to network with others, manage and coordinate activities across the school and engage with the financial, social and structural issues involved in being a facilitator. Many teachers will find this a challenging experience (Baker-Doyle and Yoon 2011).

STEM activities can provide experience of hands-on STEM projects that motivate, inspire and bring learning and career opportunities to life (Straw and Macleod 2015). Teachers are expected to spearhead STEM clubs and act as coordinators of STEM outreach but there is little training provided for teachers on how to achieve this and engagement with informal outreach in STEM is not embedded in teacher education programmes. There are currently 3,500 STEM clubs across the UK and 71% of schools in a 2015 survey indicated they will run a STEM club in the future (Straw and Mcleod 2015). What STEM outreach essentially provides is a great opportunity to situate learning for students, grounding theoretical knowledge in real life situations. STEM practitioners also utilise dialogic learning strategies, supporting students to engage in interactive discourse and enhancing reflexive thinking. These skills are extremely important not only for students hoping for careers in STEM but for supporting the development of vital life skills in modern knowledge economies. STEM outreach therefore provides an opportunity for teachers to learn how to utilise new pedagogies in their practice and provide students with a broader understanding of new research and information relevant to STEM. Traditional teacher education is not sufficient to provide teachers with a comprehensive, up-to-date

understanding of how knowledge is being transmitted and reproduced in today's economy. Teachers will need CPD to continue to access STEM and keep in touch with STEM practitioners.

Practitioners and teachers working together to deliver STEM outreach promote a "collaborative learning community" thus fostering the principles of appreciative inquiry (AI) (Cooperrider and Srivastva 1987, p129). This approach repositions the focus from mere problem identification to an investigation of the range of solutions possible; students and teachers working together to understand the solutions to problems in real time (Walker and Salt 2006). This kind of pedagogic space is often informal and fosters open, honest discussions between learners and teachers. The egalitarian dialogue can enhance effectiveness and integrity amongst the students, teachers and the practitioners (Cooperrider and Srivastva 1987). Teachers are the means through which the dialogic, situational pedagogy of the STEM outreach activities can be corroborated in classroom teaching and this provides interactions with the wider learning environment. The aim of this study is to explore teachers' role in STEM outreach and how this influence their professional development.

Methodology and Data Collection

The primary aim of the study was to obtain in-depth information from those who are able to provide it rather than information which would generalise and be representative of the wider population (Creswell 2007). A phenomenological approach was adopted and this involved 'describing the lived experience' (Cohen, Manion and Morrison 2011) of the participants, including their everyday practice, activities and decision making processes. The study aimed to understand teachers' subjective experience of STEM outreach (Patton 1990). A phenomenological approach was adopted for the study as it enables an exploration of

teachers' wealth of knowledge, expertise in this field and perspectives on the impact of STEM outreach.

Semi-structured interviews were used to gather data from teachers across different state schools in the West Midlands, UK. A protocol was developed for the study based on the case study method of Yin (1984). The themes explored in the protocol were focused on the interaction between STEM practitioners and the learning environments. It was important for participants to be comfortable expressing their own point of view to the independent researcher, unconnected with the schools' management or STEM networks.

Purposive sampling was used to ensure that a diverse population of teachers involved in STEM outreach were interviewed (Cohen, Manion and Morrison 2011). This involved ensuring STEM teachers with a varied range of experience and responsibilities were recruited. The sample included teachers who specialised in all STEM subjects: biology, chemistry, physics and mathematics. Details of their role as a facilitator varied across the sample. Teacher 5 was a support teacher and Teacher 8a/8b represented two teachers from the same school who were interviewed together. It was also important to ensure our sample was recruited from diverse state schools. We used the Free School Meal (FSM) categorisation to achieve this, recruiting from categories 2 – 4 as shown in Table 1 below. The aim of our purposive sampling was to include teachers who taught students from a range of economic backgrounds. Students from low socio-economic backgrounds who are more likely to receive FSM are known to have limited out-of-school engagement with STEM careers and activities.

Teacher	Specialist Subject	Free Meal category	No. of Years of Teaching	School year they teach	Role title
1	Biology	4	-	Years 7 - 13	Head of Science
2	Biology	2	-	Years 7 - 13	Associate Head Teacher
3	Biology	2	6 years	Years 7 - 13	Acting Head of Science STEM and Environmental club coordinator
4	Biology	4	-	Years 7 - 11	Subject Specialist
5	Biology	2	1 year	-	Intervention manager in the science department STEM organiser
6	Chemistry	3	23 years	Years 7- 13	Subject Specialist
7	Chemistry	2	15 years	Years 7 - 13	Associate Assistant Head Teacher Advanced skills teacher
8a/8b	Physics	4	10 years	Years 7 - 13	Subject Specialist
9	Physics	3	7 years	Years 7 - 13	Subject Specialist
10	Physics	4	12 years	Years 7 - 13	Lead practitioner
11	Mathematics	2	-	Years7 - 13	Head of Maths

Table 1: An overview of the teacher participants in the study.

The questions of the semi-structured interview focussed on exploring the insights in learning environments created by STEM Outreach and factors that influence decision making when organising STEM outreach activities. The teachers were invited by email to participate in the study. Interviews took place at the teachers' school or at a nearby café as requested by the interviewees. Data was transcribed and thematically analysed using

NVivo. The researchers independently reviewed the themes through the phases of the analysis. All data was confidential and teachers cannot be identified.

This research has followed the professional code of practice highlighted by the British Educational Research Association (BERA) Ethical Guidelines for Educational Research (BERA 2011). It has also followed Coventry University's ethical guidelines and ethical approval was gained before conducting this research. In addition, before the start of the interviews, oral and written permission was obtained from the interviewees to record the interviews. They were informed of their participation being voluntary and were reassured about the confidentiality of their responses throughout this study. Careful consideration was also given towards protecting the participants' identity.

Findings

The findings of the study highlighted the teachers' significant role as STEM outreach facilitators, the importance of the CoP they draw on for support and information, teachers' professional development through STEM outreach and the challenges the teachers' face delivering and participating in STEM outreach.

Teacher's role and identity as STEM outreach facilitators

The findings suggest that as part of their need to collaborate with practitioners from industry and academia to organise STEM outreach activities, teachers need to develop a dual role and skills as STEM facilitators. Practitioners and teachers working together to deliver STEM outreach promote a collaborative learning community. The STEM activities centre on using the principles of appreciative inquiry (Cooperrider and Srivastva 1987), supporting both formal and informal learning through dialogic interaction. This provides a unique opportunity for teachers to learn from those in industry and engage with research scholars. One teacher

explained how a STEM ambassador challenged him to engage students creatively using dialogic interaction.

"That person came in with nothing. He didn't even use my blackboard. He didn't use my PowerPoint, he didn't use my computer; he was just standing there, but he enthused the students so much with his talk, and the way he gave that talk, that was brilliant. So you don't need resources to engage students and get them interested". Teacher 6

In effect the teachers are developing their teaching methods and learning because of their roles as facilitators. STEM facilitators appreciate the value of conceptualising learning as transactional and transformative and this is an integral part of STEM outreach. Firstly, it shapes the identity (Bandura 1986) of the teacher acting as STEM facilitator, casting them as a member of the scientific community. The teacher therefore networks with practitioners and ambassadors from the STEM community to develop their understanding of STEM. Bandura (1986) suggests that social identities influence the production of both social and cultural norms as well as self-efficacy and agency. Caza and Creary (2016, 259) argue that "professional identity is an important cognitive mechanism that affects workers' attitudes, affect and behavior in work settings and beyond". The STEM facilitators routinely discuss how their role shapes their behaviors and actions. This is particularly evident in their teaching and delivery of STEM subjects but also in their determination to provide STEM club opportunities for their students, even when they have to make sacrifices of time and effort. Some teachers see their facilitator role as a duty.

"I think, what's the point in being a teacher unless, actually, you are trying to have a positive impact on the life choices that they make? So not me as a teacher; I see

my role as… a facilitator to show them choices".

Teacher 7

"It's just organising, a lot of money and a lot of time, really. Organising the different trips and making sure that they go to what's out there you know, what's available out there. Trying to mop up as there's lots of things out there that they can do but we can't do everything, because we haven't got the money or the time to do it".

Teacher 3

Secondly, outreach practitioners and ambassadors working collegially with the teacher, seek to inspire students to join the community of scientists, engineers and technology experts who help transform the real world, creating the medicines, gadgets and research that change how we live. As such, beyond the skills and knowledge shared at an outreach event, the positioning of the STEM teacher and the relational linkages between STEM subjects and the everyday technological products and innovations are accentuated. This supports the acculturalisation of the students as well as the teachers (Lave and Wenger1991). STEM outreach that is decoupled from a transactional, transformative STEM classroom pedagogy will be weak and ineffective because it undermines the agency of students to continue to co-construct and develop their learning of STEM alongside the teacher within the school's learning environments. Once again, the centrality of the teacher as a co-learner is emphasised in pedagogic spaces where learning is interactive. This leads to the second important finding, which reveals the importance of STEM teachers benefitting from CPD in COPs.

Teachers' in STEM related Communities of Practice (CoP)

The findings from our study suggests that teachers develop tremendously from their interactions with the communities and resources that enable them to provide STEM activities

and clubs. STEMNET and other charities provide specific training and resources to support teachers' CPD so they can use STEMNET resources. However, beyond this kind of formal training, networking with other STEM facilitators, STEM ambassadors and practitioners significantly provides advantages for teachers to develop professionally. This learning is increasingly viewed as a social process (Vygotsky 1978; Bakhtin 1981). Modern pedagogies are often embedded in social learning environments to enable learners to improve their understanding of abstract concepts (Koschmann 1999). Lave and Wenger (1991) advance the notion of collaborative learning in her seminal work about how social interaction contextualises learning. They describe learning "as an integral part of generative social practice in the lived-in world" (1991, 35). Lave describes how CoPs are utilised to construct meaning and consolidate knowledge (Lave and Wenger 1986); learning objects help to mediate this meaning. STEM outreach draws extensively upon the ideas of collaborative learning by situating learning in settings of collaboration (Bakhtin 1981; Lave and Wenger 1991). Besides this opportunity for transformative learning through interactive dialogue, Bakhtin's (1981) concept of dialogism suggests a relational link between language, interaction, and social transformation. For Bakhtin, meaning is created through processes of reflection between people (Wegerif 2011). Bakhtin advances our understanding of learning as a dynamic and process-based activity (Koschmann 1999) rather than a discrete exercise taking place in the mind of one individual learner.

"Well… usually a lot of things happen by word of mouth. You know, sort of, 'Well, that was a good thing. I can pass it on to various other people.' As far as the STEM network goes, STEM network works very well."

Teacher 6

"I think the STEM network is particularly good at, you know, seeking out teachers. But, yeah, I've contacted people through STEM and through university contacts".

Teacher 9

"We do get STEM coordinators and the actual hub of distribution is brilliant and they do send out a lot; it is almost that we get too much and it's finding out which one would be best for your groups".

Teacher 8

The study showed that the opportunities STEM facilitators gained from engaging with STEM networks and organisations were different from any benefits they would have gained from being part of a department, committee or project teams. CoPs share three specific domains (Wenger et al 2002).

1. Knowledge: a common body of knowledge within the community.
2. Community: commitment to forming a group for networking.
3. Shared practice: sharing of ideas, resources and strategies.

The teachers are expanding, creating and sharing their knowledge to develop their individual capabilities. The teachers discuss how because of their networking and interactions there was an emergence of shared practice. Teachers and practitioners exchanging ideas about good practice and how best to support the students into STEM related degree programmes at university.

"You know, anything that was long-term, to me is more valuable. The long-term projects because they're always doing it, they're always thinking about it. It's there at the front of

their head… if they don't see something at the end of it, the numbers will dwindle, even if they think it is fun".

Teacher 10

This teacher is reflecting on what she has learned from sharing resources and collecting practices with the STEM ambassadors and practitioners. A CoP is unique because it evolves to support a shared goal (Wenger et al 2002), in this case, engaging students in STEM activities so they can choose STEM careers.

Teachers can be very influential in shaping a student's attitude towards a subject and their career choices (Maychell et al 1988). Students' attitudes to, perception of and understanding of STEM subjects and careers are formed and developed at different stages during their educational journey (Hargreaves 2010; Adecco 2015). Therefore, it is important that the STEM facilitators are supportive and capable through the students' educational journey to inform and inspire them. STEM ambassadors and practitioners only see students intermittently, but teachers introduce them to the STEM CoP. These STEM CoPs enable teachers to acquire most relevant and up-to-date information about STEM careers so they can advise students appropriately. Research (CEI 2012) has shown that teachers do not feel well-informed about science careers and have few opportunities to update their own careers awareness through courses or placements. STEM outreach can provide these opportunities for professional development of teachers. The teachers also highlight other ways through which their engagement as STEM facilitators improves their opportunities for CPD.

Teacher professional development through STEM outreach

The dynamic nature and innovations in STEM have made teachers' professional development a most important priority in the UK and Globally (Baker-Doyle and Yoon 2011). The

complex and multidisciplinary nature of STEM subjects have made teachers' professional development a challenging task. One emerging approach to the creation of successful professional development programs is to support the development of teacher networks, both formal and informal (Baker-Doyle and Yoon 2011).

This study indicates that in STEM outreach teachers and practitioners work collegially to inspire students to engage with STEM careers. As such, beyond the skills and knowledge shared at an outreach event, the positioning of the STEM teacher and the relational linkages between STEM subjects and the everyday technological products and innovations are accentuated. STEM outreach gives access to interesting and exciting, contemporary research information in a form which teachers can use in their class to innovatively deliver the national curriculum.

In the study teachers highlighted how participating in STEM outreach activities has directly contributed to their own understanding and benefited them personally. For instance, it has provided one teacher with a stress-free environment where she can interact and engage with her students without worrying about an exam.

"When you've got the students in the classroom, you've got a target, you've got a focus that you're under pressure to obviously cover a part of the curriculum, you've got exams in the distance in your mind, you know, you've got to be focused on that. When you do extracurricular, we can do whatever we want, it's a more relaxed atmosphere, you get time to get to know the students in a more relaxed way, they're able to come up with their own ideas. It's fun for them because they're doing what they want to do… that's probably the best thing, really spending time with the students and not having the pressure of having to get them ready for an exam or get a piece of coursework done or you know, you've got a test coming and you can't afford to waste time".

Teacher 3

Teacher 4 indicated how collaboratively working with outreach practitioners can result in effective learning environments:

“ I go to meet them and then we plan sessions together and then they'll come and say ‘look it's only because I have done a lot of work with them so they know me so they're quite happy for me to go in and co-plan’ and they'll give me ideas that will say they've got this and this: what do you think would work; yes so we co-plan and that's when it's really effective”.
Teacher 4

Teacher 7 indicated that getting involved in STEM club was very beneficial for new members of staff:

“And for the last four, nearly five years, we have had STEM club every week on a Thursday. It’s been quite beneficial for a lot of the younger members of staff in science, ones that have come into teaching. They’ve had a [chance to get] a lot of experience. They’ve helped out with the extracurricular club and it has also meant that we were able to run the two clubs, as well.”
Teacher 7

The teachers reveal how STEM activities ultimately support their personal development and they use the opportunities to create a pedagogic space for themselves, to be reflexive about their own practice, to plan and co-plan with practitioners. They are able to learn with students collaboratively in a way that is transactional and transformative for themselves as

well as the students. Nevertheless, STEM outreach presents challenges for teachers' professional identity as well as, socially and culturally.

Challenges of providing effective STEM outreach

The teachers in the study highlighted four key challenges in providing effective outreach which included administrative support, funding, time and recognition. In describing the problems developing STEM outreach, Teacher 6 expressed frustration that the students could not be provided with more opportunities.

"If we would want something like this on a bigger scale, it would be easier if the school gets involved and it is done in the school time, in an assembly or the whole of year 8s, for example, are targeted".

Teacher 6

Though the teacher is highlighting the need for more administrative support to organise the STEM outreach for more students, this is also acknowledging an apparent contradiction in the STEM outreach process, as a STEM teacher they are taking on the full commitment of running STEM outreach. The school management is not engaging with the STEM outreach process as it ought to. In these types of ambiguous circumstances (Niemi 1997), teachers begin to question their roles and responsibilities. In some cases, the teachers were burdened by playing the multiple roles of teacher and STEM facilitator.

"Everything which I bring in for the STEM club, up until now, was being resourced by myself. If I was using some chemical, if I was using some material, it all came from me. The school has to do more if they want this".

Teacher 6

On the other hand, Teacher 10 was able to negotiate the multiple roles and identities seamlessly, mainly because there was support and funding from the school management. The school acknowledged the importance of outreach events which are embedded into the school's curriculum and most importantly its ethos:

"We do have also in this school four enrichment enterprise days, where the timetable is suspended and then different year groups do different things. So the school actually does good in that, in that they collapse the timetable, or they suspend it, so these things can happen".

Teacher 10

Teachers with high level of commitment towards STEM outreach tried to offer as many activities as possible regardless of the support they had. These teachers seemed to identify the STEM provision as part of their duty and identified more strongly with the STEM community. They sought reliable practitioners, they maintained links with ambassadors and actively engaged with STEM networks. In this regard their STEM facilitator identity is a priority for them. Bleakley (2006) argues that professional identity is continuously being constructed through discourse and interaction with others. This means identities are continually being constructed and altered. This negotiation of professional identity is very challenging for teachers providing STEM outreach with little or no support administratively.

"If you could come up with a legal framework that works for doing that, then and I think very strongly, and the evidence of my department says the same, if you leave teachers to it, they're

here because they like conveying science on to students. If you leave them space, then you will get benefit. You will get them doing enrichment".

Teacher 6

There was a common view that in some schools there was a mismatch between the supposed importance of STEM and the outreach programme and the value demonstrated by the resources, time, funding and support allocated to the process. In addition to this, the teachers did not feel they obtained the recognition they deserved for STEM outreach and activities. Teachers wanted to be acknowledged for the work they were doing. There is no suitable structural or policy framework for supporting these types of activities; though the formal and informal CPD opportunities inherent in participating in STEM facilitation are implicit, there could be a more explicit formal acknowledgement of the personal development teachers undertaking STEM facilitation experience.

Discussion and conclusions

A collegial relationship between STEM teachers and practitioners places the teacher in their role as a socialised member of a professional learning community. The teacher and practitioner work together to showcase how their specialised knowledge is shared and develop by interaction. Teachers engaged in STEM facilitation benefit from being in what can be termed STEM communities of practice. In these pedagogical spaces, created by STEM outreach and facilitation, they share and collate practices and resources which improve their development as effective teachers. This kind of CPD goes beyond simply providing STEM as any event, policy, programme or practice that promotes STEM awareness (Bybee 2010) to developing a sustainable STEM network for practitioners, teachers and students to share emerging ideas and information. The STEM networks provide meaningful, practical, active

and authentic shared learning experiences (Maistry 2008).

In response, the teacher also enhances the social learning environment in the school, this is crucial to a dialogic or situational learning experience for the students (Lave and Wenger 1991; Laursen et al 2007). In these contexts, students are able to learn more effectively (Cooperrider and Srivastva 1987) and scaffold their learning with support from teachers and practitioners as co-constructors.

Furthermore, teachers highlighted the need for more recognition, as well as financial and administrative support from schools to enable them effectively support STEM outreach. Their role as teachers is complemented by their second role as STEM facilitators. However, managing these multiple, professional identities can be complex and challenging. The support they need from the school could be formalised within a framework that acknowledges the time, effort and commitment they put into supporting STEM outreach activities, particularly, those engaging in out-of-hours' work. Organised STEM networks also need to formalise the support they provide and demand that appropriate social and financial mechanisms be put in place to support teachers providing STEM outreach. STEM CoPs need to be acknowledged and researched more closely so that we can understand and balance the needs of members and the STEM community as they change with time.

Teachers' involvement in outreach can promote their own professional development. Firstly, they remain engaged with recent developments particularly in relation to university entry requirements and career options available to STEM graduates. Secondly these teachers have opportunities to interact with leading scientists and obtain exposure to cutting-edge research. However, perhaps the most important form of professional development to accrue from teachers participating in STEM outreach is the maintenance and reinforcement of their own sense of identity as a STEM professional. In essence, by participating in the CoPs (Lave and Wenger 1991) and engaging in the STEM activities and

social interactions, the teachers are developing and maintaining the networks that transform them as well as their students.

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