Raising Aspirations in Science Education (RAiSE) pilot
Final evaluation report

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1 EXECUTIVE SUMMARY

The RAiSE programme is delivered through a partnership of Education Scotland, The Wood Foundation, Scottish Government and participating local authorities It aims to enhance the confidence and skills of primary school practitioners to improve learning and teaching in science, technology, engineering and mathematics (STEM) education. The pilot was established in 2016 and worked in partnership with eight local authorities. The pilot has since been extended to an additional four local authorities, but this evaluation is only of the initial cohort.

Each participating local authority is provided with two years of funding to recruit a dedicated Primary Science Development Officer (PSDO). Under the stewardship of a National Education Officer for Primary Science, their role is to lead and coordinate professional learning and support practitioner networking and collaboration to ensure a higher quality of STEM learning, engagement and experiences for primary pupils. The RAiSE programme articulates closely with the STEM Education and Training Strategy (Scottish Government 2017). The programme's structure, learning and approach influenced the strategy and links well with the Developing the Young Workforce (DYW) programme (Scottish Government, 2014).

RAiSE aims to contribute to raising attainment and achievement in primary science and STEM, tackling inequity and inequality in learners' experiences and opportunities to achieve.

In 2017, The Wood Foundation commissioned the Robert Owen Centre (ROC) at the University of Glasgow to externally evaluate RAiSE. This report discusses the methods and findings of this evaluation.

Key Findings

PSDOs have been a critical component in the implementation and delivery of RAiSE. They have supported and facilitated teachers in building capacity and improving confidence, skills and abilities to teach STEM. Through engaging with RAiSE, 71% of teachers have reported an increase in their confidence in relation to the pedagogy of science and 76% in relation to the content of science.

More confident teachers have had a direct impact on learners with 87% of teachers reporting that the programme has enabled learners to experience challenge in their learning. 77% of teachers stated that they have seen pupils' aspirations increase regarding science and technology careers.

There has been an increase in parental and community engagement, showing that engagement and aspiration is going beyond teachers and learners. This has been particularly evident where RAiSE has facilitated community STEM events and fairs, often using schools as hubs and involving partner organisations.

A fundamental role of PSDOs has been the development and enhancement of partnerships and networks. It can be evidenced that this is a critical success criterion of RAiSE. The links

and relationships built between learners, teachers, communities, colleges, universities and businesses have created opportunities for shared learning across sectors and for STEM skills and activities to be linked to real-world contexts. Bringing together school communities and industry has enhanced learning opportunities for all.

In addition, PSDOs and local authority colleagues highlighted that the creative and practical learning opportunities supported by RAiSE have seen STEM activities promote inclusion and engagement, particularly for learners that can find literacy, numeracy and non-practical subjects challenging.

The evaluation of the pilot highlights the success of the RAiSE model across all local authorities. This is due to the model's flexibility and adaptability. Local authorities have been able to develop bespoke plans to reflect their local context, conditions and priorities. This has been exemplified through the delivery of more than 600 tailored career long professional learning (CLPL) opportunities, this has included team teaching, remote online delivery, cluster working and other events designed for sharing good practice.. There have been 6400 practitioner engagements with RAiSE activities between August 2017 and March/April 2019.

Sustainability has been a key focus from the outset of the programme. The PSDOs and the National Education Officer have worked closely to ensure that local developments were firmly embedded as effectively as possible. PSDOs have identified, empowered and built the skills of motivated primary teachers to develop a network of likeminded practitioners. Their role has been to support teachers in their own, and other, schools to build confidence and expertise more widely in the system. These networks are designed to continue to grow and develop beyond the lifetime of the programme.

There is sufficient evidence to recommend that RAiSE is made accessible to all local authorities across Scotland given that the model adds value to local systems, particularly in facilitating and enhancing collaboration around STEM and DYW, as well as articulating with the National Improvement Framework (NIF) (Scottish Government 2018). It clearly contributes to the Government's STEM Education and Training Strategy (Scottish Government 2017a) and is coherent with the findings regarding the developing Regional Improvement Collaboratives (RICs) (Scottish Government 2019).

2 THE RAiSE PROGRAMME AND CONTEXT

2.1 THE RAiSE PROGRAMME

The RAiSE programme is delivered through a partnership of Education Scotland, The Wood Foundation, Scottish Government and participating local authorities. The ambition of the programme is to 'enhance the confidence, skills and networks of primary school practitioners to ensure the delivery of high-quality, impactful and engaging Science, Technology, Engineering and Maths (STEM) education.'[1]. The pilot programme was established in 2016 and has worked in partnership with eight local authorities:

Tranche 1 local authorities – commenced work in January 2017

- City of Edinburgh Council
- Moray Council
- The Highland Council
- West Dunbartonshire Council

Tranche 2 local authorities – commenced work in August 2017

- Angus Council
- Dumfries and Galloway Council
- Fife Council
- Glasgow City Council

RAiSE originally partnered with 10 local authorities. The primary reason for both early withdrawals was the challenges associated with recruiting and releasing a seconded PSDO from their substantive school-based post. Although teacher shortages, particularly in STEM subjects, are recognised as a national issue, the extent of the challenge varies between authorities.

Each participating local authority is provided with funding to recruit a dedicated PSDO to lead and develop high-quality professional learning and to support practitioner networking and collaboration to ensure a higher quality of STEM learning, engagement and experiences for primary children.

These officers are supported by the National Education Officer for Primary Science who is employed by The Wood Foundation and based within Education Scotland through a

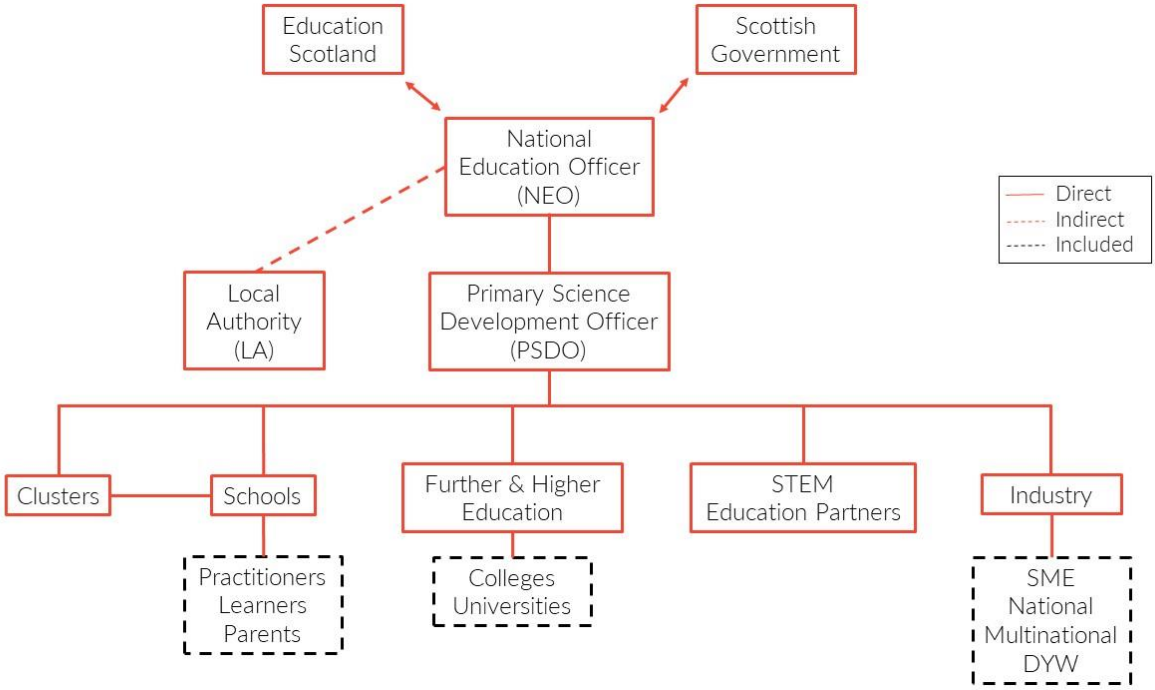
[1] https://www.thewoodfoundation.org.uk/developing-young-people-in-scotland/raise/

collaborative worker agreement to ensure coordination and sharing of best practice across the network. This arrangement ensures continuity of leadership, a fundamental success criterion identified in the programme development.

The programme initially focused on building practitioner confidence in primary science. However the model allowed wider STEM, and in one instance STEAM (which also includes Expressive Arts), approaches to be adopted.

RAiSE aligns with the STEM Education and Training Strategy (Scottish Government 2107) and (Scottish Government 2014). It aims to raise attainment and achievement in primary science and STEM tackling inequity and inequality in learners' experiences and in their potential to achieve.

The following diagram illustrates the RAiSE model and relationships critical to its success:



(RAiSE, 2019)

The RAiSE National Education Officer works in close partnership with both the Scottish Government and Education Scotland as its agency for improvement. This is to ensure that RAiSE is aligned to, and reflects, key educational priorities and policy areas. The National Education Officer works closely with the PSDOs ensuring they are supported to achieve the programme's objectives[2]. This involves the PSDOs regularly meeting and collaborating as a national network to share good practice and learning.

The local authorities and National Education Officer work strategically to develop the programme objectives in the local context. This can include reporting, event planning,

[2] Appendix 1 provides details of the RAiSE objectives, but generally they seek to build teachers' confidence, skills, networking and opportunities to develop quality STEM learning.

school visits and knowledge sharing regarding national policy drivers, which inform the PSDOs' work.

The key role of the PSDO is to secure improvements in the confidence of primary practitioners in STEM through working directly with schools, practitioners and pupils. Often the PSDO will engage with clusters of schools to take forward work which develops transition programmes.

Critically, the PSDO develops and fosters key strategic relationships with influential STEM education partners, further and higher education establishments and local and national industry. These partnerships add value to practitioners and schools in their delivery of relevant and motivational STEM learning experiences and opportunities.

Given the funding arrangement for RAiSE, an external evaluation was warranted with findings intended to evaluate programme success and inform development and scalability of the model. The Robert Owen Centre at the University of Glasgow was appointed as the external evaluator as the local authorities involved began their operational activity in January 2017. The external evaluation of RAiSE was funded by The Wood Foundation. This report is informed by the Robert Owen Centre's experience in this field, including prior and ongoing national evaluations of other major CLPL programmes and educational initiatives.

2.2 CONTEXT

International and local research evidence (Summers 1994; Harlen 1999; Jarvis and Pell 2004; Murphy et al. 2007) suggests that 'thus far progress in enhancing primary teachers' skills, knowledge, and attitudes in the field of science has been slow' (van Aalderen-Smeets and van der Mollen 2015, p. 710). It is arguable that until recently this situation has been mirrored in Scotland. The Science and Engineering Education Advisory Group (SEEAG) report (Scottish Government 2012) highlighted the need for a focus on promoting the confidence and competence of primary teachers to effectively teach STEM education (Section 2.1, p.4). The Scottish Government responded to this situation in its policies and funding of programmes, including the Scottish Schools Education Research Centre (SSERC) Primary Cluster Programme in Science (PCP), as well as RAiSE. These use complementary approaches to tackle the need to enhance primary teachers' capacity and skills to effectively teach science and STEM with an emphasis on promoting educational equity, scientific literacy and developing a workforce for the future.

The Scottish Government produced a STEM Education and Training Strategy (Scottish Government 2017a) informed by a major review of the demand for and supply of STEM skills in Scotland. This reported that promoting practitioner skills regarding STEM education is a continuing priority of the Scottish Government and that there is a need for ongoing upskilling, as well as updating, of practitioners' knowledge of the opportunities within STEM careers and industries. The strategy highlights that there should be investment in, and

prioritisation of, CLPL for teachers to embed and deliver STEM careers awareness in their teaching.

The Scottish Government STEM Education and Training Strategy (Scottish Government 2017a) includes a significant commitment to developing CLPL through various approaches in order to reach early years practitioners, primary and secondary teachers, technicians and community learning and development practitioners. The strategy identifies support for local authorities to take strategic action to improve STEM learning in primary settings, citing the RAiSE programme as a vehicle for improvement (Scottish Government 2017a). Employers, learned societies and universities are also seen as key partners in supporting STEM learning and CLPL (Scottish Government 2017a).

Research has shown that teachers' professional development is much more likely to be successful when it involves collaboration between staff (CUREE 2011). The external evaluation analysis will reflect on how the findings align with what is known about programmes that are effective in promoting the confidence, skills, knowledge and enthusiasm of education practitioners in relation to the teaching of sciences. For example, research, including that cited in The Evidence for Policy and Practice Information and Co-ordinating Centre (*EPPI*-Centre) systematic reviews of research evidence (Hargreaves D. 2003; Hopkins and Harris 2001; Cordingley et al 2003 and 2007) has identified key features of CLPL that are likely to impact on the skills and knowledge of teachers and ultimately on pupils' learning. These studies stress that at the core of effective CLPL is reflection and professional learning (Harris et al 2005). Such reflective CLPL is seen as central to school improvement and transformation (Gray 2000; Harris et al 2005; Harrison et al 2008).

Research also suggests that there is an association between teacher self-efficacy (domain specific confidence) and pupil self-efficacy. Increasing teacher confidence, in any given area, has an impact on pupil learning gains (Ross 1992). Teachers' reported sense of self-efficacy is, therefore, one of the characteristics that has been linked to student achievement and student motivation (Midgley et al 1989; Anderson et al 1988; Lowden et al 2015).

3 THE EXTERNAL EVALUATION

In 2017, The Wood Foundation commissioned the Robert Owen Centre at the University of Glasgow to externally evaluate the RAiSE programme. The evaluation adopted a mixed methods approach with an emphasis on collecting detailed qualitative evidence from stakeholders to understand the impact of the programme and key factors involved in each of the local authorities.

3.1 EVALUATION SCOPE

The evaluation focused on three main interrelated areas.

Area one: Evidence of impact and step change

An initial focus of the research was on the extent to which the programme promoted a step change for primary practitioners, building their skills, confidence and enthusiasm. The research addressed whether it increases the science capital of practitioners through the creation of robust networks and partnerships to foster opportunities to share, collaborate, mentor and co-create.

The evaluation design placed an emphasis on collecting detailed qualitative accounts and evidence that elicited examples of impact and highlighted processes involved in the implementation and impact of the programme. This 'narrative' aspect of the evaluation became increasingly important, both in terms of identifying rich examples of impact and process, as well as highlighting factors that informed the development of the programme. The triangulation of the various sources of evidence allowed for a fuller understanding of what progress RAiSE is making against its stated objectives, in what ways, and why. The research instruments were developed in collaboration with the programme's management team, The Wood Foundation and relevant stakeholders. The research design process also drew on relevant research literature and was informed by the Robert Owen Centre's team's experience in the field. The research also considered whether RAiSE had added value to existing initiatives and networks, or whether there were more effective alternatives.

Area two: RAiSE's position in the landscape

This evaluation also explored the extent to which the programme enhanced opportunities for practitioners and local authorities to align with other national education priorities such as the NIF, Scottish Attainment Challenge (SAC) and DYW. It addressed whether the programme has developed the ability of practitioners to better recognise opportunities within creative approaches to science and STEM education to help deliver upon other national priorities such as literacy, numeracy and gender balance. The evaluation examined whether the programme has contributed to the development of a progressive and engaging science curriculum across the participating schools, clusters and wider authorities and how this was achieved in different contexts. This included identifying key factors and indicators that are associated with such developments including having a standards framework,

opportunities for professional recognition, consistency of support, ownership of resources and regional support and networks.

Area three: Programme approach and delivery

The third area the evaluation focused on was providing formative feedback and examples to inform the programme as it developed and was implemented. This included making emerging summary findings available to the RAiSE leadership teamand local authority partners to inform possible improvements and measures to promote effectiveness and sustainability in various contexts.

Running across these three key areas were the following main research themes:

- Impact on practitioners
- Impact on learners' engagement, experiences and aspirations
- Opportunities for collaboration and partnerships

The evaluation, therefore, sought to demonstrate whether the programme was making a positive difference to participating primary teachers' confidence, skills and professional capital to enhance their teaching of STEM and to assess whether this was happening in a way that contributed to other strategic educational priorities. Finally, the findings from the evaluation were meant to provide formative feedback to inform the development of the programme at local and national levels.

3.2 EVALUATION APPROACH AND EVIDENCE BASE

The evaluation adopted a mixed methods approach to address the research themes. This included quantitative methods of pre and post programme surveys that were further supported and explored with the use of qualitative methods including focus groups, interview and documentary analysis.

The RAiSE pilot was already underway in some local authorities prior to the Robert Owen Centre's involvement. In these authorities, local evaluations were conducted in order to inform programme direction. Therefore, the evaluation drew on secondary information and data as well as conducting post-hoc surveys and in-depth interviews and focus groups with key stakeholders. In those authorities that had yet to implement their programme the research team were able to collect baseline data and then comparative follow-up data. Over the course of the evaluation rich examples of practice were gathered to provide narrative that highlighted how the programme operated in different contexts (e.g. dispersed rural models, learning community and cluster models and multi-partner models). The factors and processes key to success were investigated.

The evaluation design, particularly the research instruments, was informed by the initial experiences and insights from PSDOs and local authority colleagues. Where appropriate, this dialogue was also used to inform and build PSDOs' self-evaluation capacity. An independent sub-group to advise on, and inform, the design of the evaluation tools was engaged to ensure that the methods were practitioner-led.

The main evaluation activity and evidence base

The main evidence base for this evaluation report includes:

- Interviews with all of the PSDOs, relevant senior leadership personnel in the pilot local authorities and the National Education Officer
- Interviews with key personnel from Education Scotland who hold strategic roles relevant to the programme and/or national education policy.
- Focus groups with:
    - ♦ PSDOs
    - ♦ Teachers
    - ♦ Pupils
    - ♦ Parents
- Review of RAiSE self-evaluation reports and routine summary reports from PSDOs regarding progress, developments and impact.
- Electronic surveys, including numbers of responses:

Tranche	Survey Type	Pre programme	Post programme
1	Teacher	N/A	36
	Headteacher	N/A	8
2	Pupil (P2-P4)	2322	1428
	Pupil (P5-P7)	2816	1760
	Teacher	368	102
	Headteacher	66	13

The evaluation evidence is predominately qualitative with an emphasis on individual interviews and focus groups. This method is particularly suitable for capturing the nature and detail of impact, illuminating the processes involved. The findings from this study are robust given the range of interviews and focus groups conducted with key stakeholders, which allowed these accounts to be triangulated and considered parallel to the programme's own evidence. This approach also allowed the evaluation to be sufficiently agile to reflect the evolving nature of the programme. The pupil surveys deployed across participating authorities demonstrated that pupils were enthusiastic about science lessons and STEM learning more broadly, emphasising that RAiSE and STEM education in general has an enthusiastic audience. Beyond the purposes of this evaluation, these survey results proved useful for the participating local authorities, providing insights on learners' perceptions of science and science education in their local context.

In addition to providing evaluative data, the research team worked closely with local authorities to ensure that the findings informed their RAiSE action plans. This had some implications for the pacing and timescale of the surveys. However, with support from The Wood Foundation regarding timescales, the evaluation adapted and gathered data in strands that reflected RAiSE activity in the local authorities. The nature of the qualitative evidence gathered over the evaluation has enabled the team to provide detailed accounts of impact and the processes responsible for both facilitating and inhibiting this. While the survey data has been useful in providing feedback to the local authorities to assess learners' views on school and subjects etc., their value to provide a comparative assessment of impact on learners' self-efficacy has been limited. Indeed, as more has been learned about how RAiSE operates it is likely that a standardised instrument would be of limited use to assess general impact.

Approach to analysis

The qualitative data collected in the form of interviews and focus groups was recorded, transcribed and then coded to identify key themes related to the impact of RAiSE. This data was the key focus in reflecting and evidencing the impact of the programme. The unstructured, open questions supported further exploration of individuals' and groups' perceptions and experiences of the programme.

The quantitative data collected from surveys focused on initially assessing pupils' variations in self-efficacy pre and post-programme. Due to a low response rate of follow-up surveys, analysis was limited. Given the flexibility of the RAiSE model, it is recommended that standardised surveys as a method of evaluation are not the most effective tool for data collection from primary pupils. Further surveys were undertaken as baselines and follow-up with Tranche 2 teachers and headteachers. These were collated and analysed for recurring themes that further supported the discussions undertaken during interviews and focus groups.

Challenges to analysis

Throughout the evaluation process the team encountered some challenges that are not dissimilar to those of comparative programmes. The evaluation methods were adapted to best capture meaningful data regarding the programme's impact. The main challenges were:

- Surveys were not the most effective method of data collection with pupils. Response rates for the follow-up surveys were low, making pre and post-programme data incomparable. This data was partly skewed as surveys were primarily received from particular areas making national analysis difficult.
- Headteacher engagement was lower than expected through the formal survey methods, which meant that it was not possible to get a comparable impact rating for all schools involved.

Although a number of challenges arose, this did not detract from the evaluation's ability to assess the impact that the RAiSE programme has had. In fact, it could be argued that the final evaluation design reflected the flexible nature of the programme and emphasised that a more qualitative approach was warranted to explore contextualised impact and associated perceptions and experiences.

4 KEY THEMES EMERGING FROM THE EVALUATION

This section summarises the main findings and themes emerging from the combined evidence base.

4.1 IMPACT ON TEACHERS' CONFIDENCE

One of the strongest and most consistent themes emerging from the evaluation is that the programme has increased practitioners' confidence and skills regarding teaching of STEM education. The role of the PSDO in building teacher capacity within and across schools in their local authority to address RAiSE objectives gathered momentum as the pilot developed. This included facilitating cadres of teachers to work with colleagues to provide CLPL, model STEM teaching and advise across their learning communities and clusters. One example of this approach has been Glasgow City Council's Primary STEM Leaders (PSL) programme devised and delivered through RAiSE as part of STEM Glasgow**.** This cohort of practitioners self-selected to participate and, supported by their headteachers, engaged in the initiative to enhance collaboration across the city and upskill fellow practitioners with experiential CLPL opportunities. The PSLs deliver CLPL sessions to colleagues in their own establishments increasing confidence, capacity and promoting wider STEM learning opportunities. These PSLs are responding to an identified need regarding limited CLPL in relation to STEM subjects and are systematically supporting the development of sustainable skills. . Internal evaluations have shown that these PSLs have raised the profile of STEM within their establishments and promoted their own confidence, as well as that of their peers regarding STEM education.

The initial impact of Glasgow PSLs exemplifies the facilitation role of RAiSE within a local context. Participants reported their engagement heightened the profile of STEM in their setting among pupils, staff, parents and the wider community. They also stated increased confidence, not only in their own abilities to teach STEM, but that of their colleagues too. The majority expected to continue the PSL role in the next academic year and support the next cohort of PSLs.

> *"It really has transformed my own knowledge, understanding and teaching. I feel much more confident in my science pedagogy and better able to not only meet learners' needs, but also provide progressive and enjoyable science experiences for them."*
>
> Primary STEM Leader, Glasgow

"Having the support of STEM Glasgow has been hugely beneficial for our school. The level of training offered to our Primary STEM Leader was of a very high quality and the continuing support available has been hugely beneficial to us. The teaching of STEM subjects in our school has been totally transformed and there is a real buzz in the classrooms when it comes to STEM."

Headteacher, Glasgow

In each of the pilot authorities, PSDOs, teachers, headteachers and local authority colleagues reported that PSDOs had effectively developed primary and early years teachers' confidence, skills and capacity. This was achieved through a process of direct CLPL input to model and support good practice, as well as through the development of teams of teachers in learning communities. These teams work to mentor and support colleagues in schools to enhance the teaching of STEM. This impact has been further enhanced through PSDOs developing networks of partner organisations and individuals that offer teachers advice and resources. This has included utilising social media to share ideas and good practice.

One typical example of reported impact on practitioners' confidence included:

"I see the teachers [have] gone back and used it [CLPL] with their class and applied it or a skill or resource that we've recommended and shared with them…then they have had the confidence to want to share that in a public forum with other practitioners, that they've felt confident enough to say look what we did…We're seeing much, much more of that [teachers adopting ideas from RAiSE CLPL] and I think it is indicative of the fact that teachers are feeling more confident, they're trying new things, which I don't they would have tried before had they not come along to a training session."

PSDO, Dumfries and Galloway

This confidence was reflected in local teachers' reports of impact on building practitioners' capacity to adopt approaches and take it back to their schools, including building pupil leadership.

"It just keeps going and because you're involving more people to do it, to start with it was [a teacher], who was leading it and because it's grown, other teachers are doing it …we're involving all those other people to get on with it and also the kids are leading a lot of it."

Teacher, Dumfries and Galloway

PSDOs frequently reported seeing a positive change in teachers' confidence following their involvement with the programme. Examples include teachers volunteering to present and contribute to local STEM events and conferences showcasing what they have implemented in their schools following RAiSE inputs. Others provided video clips of their work, including embedding technology, to disseminate via Education Scotland. PSDOs noted that

previously these teachers would not have had the confidence to do this. Illustrative quotes included:

> *"It was all quite practical, and it was reinforcing what you were doing but it gave you the confidence to then take that forward. So, if the training hadn't been good, then there's no way we would have got to where we are…They've [PSDOs] come out and done the BBC Microbits and it gave me the confidence to start up a coding club in the school which is now running and very popular with the girls."*
>
> Teacher, Dumfries and Galloway

> *"We have feedback from head teachers that say that it's quite transformed the teaching of STEM within their school [that] we've built the confidence of the STEM Leaders and they are talking to their peers in the schools, they're delivering [CLPL]. Some of the feedback we're getting from [teachers] at the moment, it has enthused the rest of the staff, the rest of the staff want to be involved."*
>
> PSDO, Glasgow

Teachers spoke of how having access to quality CLPL tailored to their needs, appropriate resources and being able to refer to online advice facilitated by PSDOs had improved their confidence to teach STEM. Opportunities to network and discuss STEM teaching approaches were also valued by teachers and further developed their confidence.

In alignment with RAiSE objectives, pre-programme surveys showed that:

81% of teachers sought to promote their confidence in relation to the pedagogy of science;

77% of teachers wanted support to promote their confidence in relation to the teaching content of science;

93% of teachers sought to promote opportunities for learners to apply their skills and knowledge in new contexts, including in STEM;

87% of teachers wanted support to promote pupils' aspirations regarding science and technology careers;

89% of teachers sought to promote opportunities for learners to experience challenge in their learning in new contexts, including in STEM.

The follow-up survey of teachers revealed that:

71% of teachers reported RAiSE activity had promoted their confidence in relation to the pedagogy of science:

76% reported that RAiSE had promoted their confidence in relation to the teaching content of science:

87% of teachers believed that RAiSE had promoted opportunities for learners to experience challenge in their learning including in STEM;

77% stated that RAiSE had promoted pupil aspirations regarding science and technology careers.

These survey responses are in line with the qualitative accounts of teachers regarding the impact of the programme.

Prior to being involved in the programme, headteachers were most likely to indicate they would like support from RAiSE for most of the STEM categories offered in the survey with slightly less prioritising support for collegiate activities and leadership opportunities for teachers. Headteachers were particularly interested in support that *promoted teachers' confidence in relation to teaching pedagogy of science* (95%) and *confidence in relation to the teaching content of science* (96%). While headteachers prioritised these aspects of support it is worth noting that teacher collegiality, self-evaluation and leadership are important contributing factors to effective teaching as highlighted in HGIOS4 (Education Scotland 2015) and research on strategies to promote effective education systems and research (e.g. Shah 2012).

The follow-up survey of headteachers found the majority of respondents reported that RAiSE had a positive impact. All of the headteachers surveyed post-programme reported that RAiSE had promoted teachers' confidence in relation to the pedagogy of science; promoted teachers' confidence in relation to the teaching content of science; promoted pupils' aspirations regarding science and technology careers; and promoted science activities in the curriculum throughout the school. 75% of headteachers agreed that RAiSE had *increased interdisciplinary learning approaches where science is incorporated into a range of common primary topics throughout the school* and *increased teachers' reflective practice and self-evaluation*.

4.2 IMPACT ON LEARNERS' ENGAGEMENT WITH STEM

Across the headteacher and teacher interviews and focus groups, participants consistently reported that the positive impact of RAiSE activity on practitioners' confidence and skills regarding STEM education had resulted in improved pupil engagement with STEM and associated improved reasoning skills and vocabulary. This, in turn, motivated teachers regarding STEM education.

> *"…Pupils are seen as being much more engaged and ready for STEM. We give the children the [positive] experience and the [skills] and they want more. That then inspires their teachers. It has a huge domino effect."*
>
> STEM Development Teacher, West Dunbartonshire

Similarly, PSDOs frequently observed the impact of enhanced teacher confidence and skills on learner engagement during their RAiSE activity in schools.

> *"The fact that the children are clearly so engaged and so enthusiastic and are loving the lesson and also that they've then had the confidence to want to share that in a public forum with other practitioners, that they've felt confident enough to say look what we did. That's certainly for me that gives me a real sense of satisfaction and achievement because you can see it having a direct impact on the pupils and how they and how enthusiastic they are about it."*
>
> PSDO, Dumfries and Galloway

The RAiSE activity was also reported as promoting learners' STEM-related aspirations and career awareness.

> *"I think it's given some of the kids that I work with aspirations, they realise things that they're interested in, there is actually a job for that."*
>
> Teacher, Angus

> *"I was at (a school) and they were doing a Science Skills Academy activity…where the primary school children went to the hospital to learn about biological systems…and it was just fantastic… a fantastic model. And that's linking up hospitals, where the P6 children could see examples of STEM as a career. The doctors were fantastic; they spoke about how they got into their jobs, what science they did in school, what they do in their careers. And they really pushed that science is really important, if you want to be a doctor."*
>
> Local Authority Lead, Highland

Four clusters of schools in Dumfries and Galloway engaged in an engineering programme, supported by the PSDO. In another school, the PSDO has collaborated in the creation of a 'maker space' which was supported by external funding. This innovative space has been well used by the local community and is delivering intergenerational learning experiences. Activities which feature woodworking, digital skills and fine motor skills have been developed and the school plans to expand this highly successful initiative.

Teachers noted that RAiSE activities included excellent approaches to engage girls in STEM and raise awareness of STEM-related careers.

> *"I also see the girls more engaged in it which was a big thing for me…I'm hoping to try and do a 'maker space' [and] the girls are just as engaged and interested as the boys are. In the past I wouldn't have seen that."*
>
> Teacher, Dumfries and Galloway

"The children were going around the STEM workshops, generally related to career journeys and talking about lots of things, they were so enthused and one of the girls said, 'I really like art so does that mean I could be a games designer?', Wow! Yes! That connection has just been made and you just think wow that could be the thing that that little girl needs to move on and have a STEM type career."

Teacher, Angus

Teachers discussed how RAiSE CLPL has supported them to develop STEM activities that excited learners across the curriculum to enhance their interest and engagement. An important aspect of this was developing learners' STEM language and vocabulary.

"It's their exposure to the language, it's using scientific language that they maybe wouldn't have in the past because they're getting that chance to explore and try things out themselves and then from a young age they start to think that way and maybe do see a love for science and maths."

Teacher, Angus

PSDOs working with teachers were able to observe and receive feedback about the impact of their work on learners' STEM engagement and skills. PSDOs working in classrooms enhanced the relationship with teachers and their ability to understand school context, informing tailored support.

"The teacher was reporting that they [the pupils] now use that [science] language in their conversation, and in their homework, and their English. So, they're using these structures across a curriculum…they've got the concept of fair testing, and the concept of prediction and the concept of… agreement or argument."

PSDO, Angus

Pupils in focus groups commented that they were enthused when STEM topics were applied to the real world and their excitement regarding STEM was evident. In one case, pupils discussed how they had drawn on a range of STEM concepts and approaches to tackle the local issue of litter and waste. Pupils surveyed the area around their school to assess the level of litter and classify and quantify it to help understand impact on the environment.

A learners' focus group highlighted the importance of motivated teachers who were confident and engaged with STEM.

"We're quite lucky because we have a teacher who likes to do a lot about STEM, whereas some other kids in primary school maybe don't get the

chance as much as us so therefore they don't enjoy it as much, yeah we do a lot of STEM."

Pupil, Dumfries and Galloway

In support of wider STEM engagement, pupils enjoyed participating in school activities that had a reach beyond the classroom. This included opportunities to engage parents, participate in outdoor learning and participate in engineering challenges. In one focus group, pupils shared their enthusiasm for working in teams to complete science experiments and practical work:

"We got these paper straws and we had to try and make it [a dome] so it could balance and it could all join together with tape… we were trying to make it stand get it to balance and it was really hard but it was fun…you had to make it, you know, neat and make it look sturdy so that if you blew on it, it wouldn't fall over. [You had to] use all your skills to work together and make the dome."

Pupil, Dumfries and Galloway

Pupils in the focus groups provided examples of how the schools' enhanced STEM focus was contributing to other parts of the curriculum, often in numeracy but also in other subjects such as PE where measurement was important.

"When we do Sumdog, STEM comes in there…you can get [educational] games where you have to measure distances…measure the area of a triangle…and language as well…[maths and] word problems…in PE [we] use [maths for] problem solving…in games like rugby, hockey, football, using measurements…to see how fast people are going."

Pupil, Dumfries and Galloway

Pupils highlighted that they saw their STEM learning as preparing them for secondary school and beyond.

"We learn from these STEM activities it gives us more of an opportunity for when we're in the academy and we want to do jobs involving science because anyone can do a job in science if they learn and know in primary school and secondary school."

Pupil, Dumfries and Galloway.

Overall, discussions with pupils highlighted that the RAiSE STEM activity was contributing to their development of skills for learning, life and work. For these pupils, STEM was central to the comprehension of their school subjects; critically understanding the world and their health and wellbeing, as well as how subjects are relevant to their future careers.

4.3 STEM ASPIRATION

A Scottish Government press release (Scottish Government 2017b) stated that a principal ambition of RAiSE, is that "early exposure to innovative science in the primary school classroom will encourage young people into STEM careers where there are significant skill gaps and many great job opportunities." Ascertaining the impact of the RAiSE pilot on this aspect is challenging given its longer-term nature. However, there is evidence, particularly in the qualitative accounts of teachers, parents and pupils that RAiSE activity has already contributed positively to awareness and aspirations of pupils and parental perceptions regarding STEM-related careers.

As the programme developed there was an increase in examples of RAiSE activity that included promoting schools' engagement with parents and communities building science capital and family learning. Community events, which provide opportunities for showcasing of projects and collaborating with industry, education and other STEM partners, appear effective in attracting participants. Self-evaluation feedback and teacher observations reveal high levels of satisfaction and engagement across participants.

> *"We also found that after school parental engagement events we run, typically the numbers involved drop over time, but the STEM-themed events saw the numbers sustained. Also, the children were talking about it, there was a buzz about it and other children wanted to be involved, so we're developing this as part of our curricular map."*
>
> Principal Teacher, West Dunbartonshire

In Glasgow, PSDOs and their local authority colleagues have explored how STEM can be used to promote parental engagement in pupils' learning as a means of tackling educational inequality and the attainment gap.

A number of the RAiSE PSDOs have developed 'STEM Bags' to engage parents and children in fun STEM activities, building family science capital at home. These bags contain easily sourced material that allows pupils and their families to explore everyday STEM experiences. In one example, three schools took part in a STEM Bags pilot from May to October 2018. These schools were chosen as they had Family Learning on their School Improvement Plans and were keen to support the development of the programme in Moray. Each school was given 50 STEM Bags for five experiments. Each bag had the kit required for the experiment; a note explaining the STEM Bags pilot; and an experiment sheet for parents which included background information, the underlying science and links to websites. A jotter was included to encourage pupils to record the families' learning. The PSDO's self-evaluation reporting revealed that these STEM bags have been an effective strategy to support parental engagement in their children's learning and to stimulate discussions about STEM, including related careers and issues.

In some cases, PSDOs have had input from science and STEM experts in Higher Education to develop these resources. This has highlighted a synergy with both PSDOs and Higher Education partners seeking to promote local communities' engagement with STEM and

learning. PSDOs trialled and evaluated this approach and found that it was well received by families. The lessons learned have enabled the approach to be refined and rolled out in other schools.

An Edinburgh high school, the associated cluster primary schools and early years centres worked with the PSDO to run a very successful family event held in September 2018 with pupils, staff and community engagement. More than 700 people attended over two days. This engagement is a significant achievement given the high SIMD profile of the area, proving that this type of approach can enthuse and attract community members that traditionally might be seen as difficult to engage. In Edinburgh, the PSDO had initially found that many schools were not aware of the STEM Ambassador programme and other STEM-related initiatives.

The Edinburgh PSDO also designed and delivered a science roadshow to be taken into the Pilton community during the summer holidays – an area with a high SIMD 1 and 2 profile. The PSDO worked with the University of Edinburgh and STEM professionals to deliver the event. This was well attended with more than 250 people participating. Self-evaluation indicated that community participants valued the experience. The local authority colleague stressed that having a PSDO to develop, organise and deliver this activity was key and it would likely not have happened without their presence. This activity was cited as informing schools' parental and community engagement strategies.

Across the programme, PSDOs have promoted family and community engagement with STEM at a school level, often in collaboration with other services. In West Dunbartonshire, STEM Hubs were seen by local authority and strategic stakeholders as transforming the way young people and their families learn about and engage with STEM. Schools that developed well-equipped STEM Hubs have been the focus for providing sustained learner and family engagement with afterschool and holiday STEM clubs. These STEM events have been used as part of strategies to engage with wider family groups. Teachers have reported that STEM appears to be important in stimulating interest and sustaining engagement with these families.

> *"At one family learning event […] we were building propeller boats with children, parents and grannies engaging. And I remember one granny got her boat to work and she turned around and said 'I was always rubbish at science; I'm great at this! Can I take this home with me?'"*
>
> Teacher, West Dunbartonshire

Parents in focus group discussions stated that their school's STEM events had a career and skills aspect, including sessions where parents would visit to talk about their employment.

> *"I think the other good thing that this school does is the careers events where they have parents come in and you know the kids are able to see what jobs are available and how science can feed into this and [why it is important]."*
>
> Parent, Angus

Parents cited such events, and invited speakers, as helping raise awareness of current and future STEM careers.

> *"[This is good because] If you only know what your mum and dad does or your granny then you don't know what jobs there are, what you can aspire to be."*
>
> Parent, Angus

Parents thought this was important because it helped to challenge assumptions about science-related careers. In Angus, one group of parents also spoke about how their school had been working with University of Dundee to provide STEM events facilitated by the PSDO to raise girls' awareness of STEM–related careers.

Pupils in focus group discussions stressed that STEM was important for society and saw the usefulness of STEM in everyday life. As a result, pupils believed that STEM should be taught in primary school. Discussions with pupils highlighted that they enjoyed opportunities to talk to visitors who had STEM-related careers. This appeared to be particularly evident when teachers had previous experience of STEM careers.

Discussions on gender revealed that learners are developing positive attitudes towards equality with understanding that STEM careers are not gender specific, as explicitly stated by a male pupil during a discussion on STEM careers. A female pupil in a Dumfries and Galloway focus group stated: "Yeah it used to be like women couldn't be scientists but now it's like half the people who are scientists are women." Pupils were able to recognise a variety of different careers and jobs related to STEM from more than just family connections. Pupils in one focus group discussion believed that men and women should be equal and recognised that there could be a need to change the way we refer to certain jobs and gave the example of 'fireman'. These pupils agreed that there needed to be an attitude change generally and recognised that there are still gender gap issues.

The periodic reports provided by PSDOs to the National Education Officer frequently detailed examples of parental and community engagement strategies and resources, including those that focused on raising awareness of careers that utilise STEM skills.

The RAiSE PSDOs have demonstrated creativity and impressive collaborative activity to put in place events and activities that have raised STEM aspirations and facilitated greater awareness of STEM-related careers across schools and their communities.

4.4 WIDER IMPACT OF RAiSE ACTIVITY ON SCHOOL PRIORITIES

Feedback from teachers and local authority colleagues highlighted how RAiSE STEM activities, either as science or as part of cross-curricular teaching, are promoting inclusion and engagement for pupils who find it difficult to engage with literacy and numeracy and non-practical subjects. There are examples of RAiSE-enhanced school strategies that have promoted pupil engagement and attendance among target groups of pupils, including those involved in nurture programmes. One such award-winning initiative in West Dunbartonshire involved introducing selected animals into the class for pupils to learn about aspects of STEM. From this, pupils started a social enterprise project using the animals to deliver science lessons to their peers in the school and across the authority.

RAiSE activity was also reported to be helping teachers address educational objectives more broadly, including those of the SAC. There were examples of developments where RAiSE has promoted teaching innovations with STEM enhancing numeracy, literacy and health and wellbeing. This has involved teachers using STEM topics as a way to enrich literacy and numeracy by offering opportunities for practical experience related to topics and illustration of real-world applications. STEM has also been used to improve pupil engagement and inclusion as part of nurture activities to promote mental health and wellbeing, as well as engagement with broader learning. In Fife the PSDO worked with the pedagogy team to add to the current focus on literacy, numeracy and health and wellbeing within an interdisciplinary approach. In West Dunbartonshire, the PSDO and STEM teachers have been working with the nurture team to introduce zoology topics and small animals to promote nurture strategies.

Another strong example of how RAiSE STEM activity has contributed to tackling other key priorities is the 'STEAM a Story' initiative in Fife. Here, the PSDO drew on research that showed that high-quality STEM reading content can support pupils' participation in inquiry experiences, grasp of science concepts, and understanding of the nature of science (Cervetti *et al*. 2012). As a result, the PSDO in Fife capitalised on the Read, Write, Count Campaign which gifts books to all P1 to P3 children to develop an approach that supports practitioners' planning for science and STEAM (science, technology, engineering, expressive arts and maths) activities using the books as stimuli. Stories are used as an engaging way to spark thinking about science. Reading texts with STEAM themes has been used to build learners' literacy skills, including how to read, write, and reason with the language and text, while learning STEM content and cultivating dispositions of science (Pearson, Moje, & Greenleaf 2010). The PSDO partnered with the Scottish Book Trust to develop resources to enable teachers to plan for and embed science through fiction and non-fiction texts. Support for teachers also included input from the Scottish Book Trust Regional Outreach Coordinator.

The ability of RAiSE to provide new STEM contexts that enhance learning in numeracy and mathematics was evident across the programme. A strong example of this was in West Dunbartonshire where the STEM PSDO worked closely with the Creative Maths team to raise attainment in numeracy through creativity. They engaged learners in creative and

stimulating activities that build teamwork, confidence, self-esteem and numeracy skills. This project is set to run for four years in four primary schools and their associated high school.

> *"My work with [the PSDO] has enhanced transition projects and creativity in Maths, so it's putting the 'M' in STEM; putting the Maths into a STEM context and trying to break down those barriers of children's anxiety and fear and building transferrable skills."*
>
> Creative Maths Team Representative, West Dunbartonshire

Another example from this local authority highlighted how STEM was not only contributing to promoting achievement across the curriculum, but also teachers' abilities to use data to inform their practice. This has been praised in HMIe inspections.

> *"Last year…I was asked if I could run a STEM for sustainability project across the whole school in every primary and design a challenge for each classroom and based on an area of the curriculum with which [teachers] struggle. We used data to inform this intervention and saw a need for improving data handling and measurement, so I made STEM challenges for each of those and developed how we would capture data for this. And we saw concrete improvement in both improving data handling and measurement and have evidence to say that it was the STEM intervention…it was something HMIe picked up on as a positive development."*
>
> STEM Development Teacher, West Dunbartonshire

The PSDOs and their local authority colleagues frequently commented on how RAiSE was being used to help to tackle the attainment gap and educational inequities. This is predominantly through the use of an interdisciplinary learning stance and building a STEM focus into approaches that had been used to enhance literacy and numeracy.

PSDOs and the National Education Officer have helped teachers and local authority colleagues to recognise how the RAiSE activity and objectives align with the NIF and contribute to improvements in literacy and numeracy. This has embedded the RAiSE work and promoted links with local improvement teams, collaborative partners and other programmes. For example, as previously highlighted, in West Dunbartonshire there have been links with the Creative Maths Team. The PSDOs have also worked with a range of inter-related learning and teaching programmes including the Literacy Professional Learning programme; Early Years to Primary 1 transition; Assessment and Moderation of Sciences pilot; and Learning Through Play (Early Years team). In this local authority, STEM and other areas of the primary curriculum were increasingly being seen in terms of interdisciplinary learning opportunities. The PSDO and teachers have worked with other partners to address wider STEM and educational priorities such as Improving Gender Balance (including Early Years and Health and Wellbeing) and Promoting Science Capital in association with Glasgow Science Centre, Denny Tank Museum and West College.

4.5 IMPACT OF PARTNERSHIP WORKING

A principal priority of RAiSE, that has had significant impact, is the development and enhancing of partnership working and networks that has facilitated improvements in schools' STEM capacity. The networks developed during the pilot were seen by teachers, local authority leaders and PSDOs as an important factor in promoting the sustainability of RAiSE activities and impact. This is an area where the activity and skills of the PSDOs have been key. Their networking efforts have encouraged teachers within and across schools to work together to share and support each other, developing professional learning communities. The networking has facilitated the enlisting of motivated teachers to lead STEM CLPL in their schools and clusters. This joins up existing and nascent activity and reinvigorates current networks to develop sustainable support for the quality teaching of STEM.

It can be argued that the role of networking and the PSDOs efforts to drive this process has been fundamental to its impact. The PSDOs have mobilised the sharing good practice ideas, collaboration and promoting quality developments, which have been shared across their local authorities. The PSDOs and their networks have purposely worked to embed sustainability within a challenging environment of teacher staffing levels and capacity.

Networking activity has included building links with STEM Ambassadors, local science centres, museums, universities, colleges as well as local businesses and Skills Development Scotland to promote teachers' STEM capacity in primary schools. They have also worked with SSERC, the Institute of Physics and SCEL to develop CLPL opportunities to promote teachers' capacity regarding DYW and career education standards, tackling gender bias in STEM and teacher leadership.

In Edinburgh, a strong focus on DYW has fostered engagement from a range of businesses and organisation including University of Edinburgh, Leonardo, British Army, REME and InnH2Ovate. At a Primary Engineering event, 30 teachers from 17 local primary schools and 742 pupils participated in activities supported by engineers from the aforementioned organisations. This led to the participants implementing Primary Engineer projects in their schools. Evaluations demonstrated high levels of satisfaction with a majority creating links with an engineer.

As the programme has developed, the PSDOs have worked with local and national partners to develop significant CLPL, resources, activities and programmes to offer to schools that are highly innovative, relevant to policy priorities and reflect local needs. Self-evaluation evidence reveals that these partnership ventures are having a positive impact on practitioners, schools' leadership teams and learners, as well as families in some cases.

A strong example of how such RAiSE-facilitated partnerships have enhanced local STEM education is the Goblin Kit Car programme in Fife. Pupils are supported by an engineering partner to manufacture and assemble a Goblin Kit Car. This is an engineering skills and partnership programme that develops STEM teaching through real-life, problem-solving methods using creativity, collaboration, communication and building skills. This initiative highlights how the local PSDO has worked with partners to facilitate a resource to support teachers to engage in engineering tasks with a particular focus on upper years cluster transition.

Across Fife, 12 primary schools took part in the 12-week scheme in 2018 and a further 29 schools will be involved in 2019.

The project has developed STEM skills in a real-life context and built important industry and school cluster partnerships. This has also facilitated partnerships with engineers throughout Fife with support from the DYW Business Engagement Officer. Resources and planning guides have been developed to evidence experiences and outcomes and the Careers Education Standard (Education Scotland 2015). In partnership with BRAG Enterprises, the company who has created the kit, CLPL sessions on electrics, construction and the scrutiny process have been delivered.

Pupils reported enhanced collaboration and problem-solving skills from their STEM learning activity that encouraged creative thinking outside of the classroom. Practitioners reported the scheme was effective in engaging pupils and promoting skills development.

RAiSE PSDOs have brought together partners to facilitate events and fairs which link local STEM professionals with practitioners, learners and their families. One example is the Lochaber STEM Fair. This one-day STEM Fair was a collaboration between RAiSE, Highland Council, Lochaber Geopark and DYW West Highland to engage primary practitioners and pupils in STEM at a regional level. The event focussed on the Science Capital Teaching approach and its links with DYW. The Science Capital Teaching Approach (Godec, S et al 2017) is designed to support teachers in helping students to 'find more meaning and relevance in science and, as a result, engage more with the subject'. The ideas for the approach have been co-developed between *Enterprising Science* researchers at the Institute of Education at University College London and 43 secondary science teachers in England and trialled over a four-year period. This event was an opportunity to forge cluster relationships and establish meaningful industry links, as well as providing an opportunity for practitioners to share good practice and discuss the moderation of key assessment tasks. P5 classes from eight schools from the Lochaber High cluster showcased projects, which displayed their STEM learning. Displays included work on plastics, website design and chemical reactions. Eighteen employers from a range of organisations attended the event, which introduced pupils to a wide range of STEM careers and role models, which provided inspiration and information. Self-evaluation feedback has highlighted the following impact:

- Opportunity to share good practice and start moderation activity.
- Increased links between schools and local STEM professionals and industry.
- Increased awareness of careers education resources and the importance of careers education in primary schools.
- Deepened relationship between RAiSE and DYW West Highland.
- Increased awareness of the STEM Fair model across DYW team in Highland.

The success of the Lochaber STEM Fair model has led to a commitment that it will be repeated annually thus embedding it as a sustainable opportunity.

Collaboration with outdoor and physical activity specialists has linked STEM with these

aspects of the curriculum, reported to promote more inclusive learner engagement and interdisciplinary learning opportunities.

The PSDOs have used a range of social media such as Twitter, Facebook and Yammer as well as Google Plus, GLOW and newsletters, to support and enhance networking, communication and sharing of ideas.

PSDOs have shared ideas with one another and gained valuable learning from developments in other local authorities. The programme of inter-authority meetings involving PSDOs and their local authority colleagues was seen as particularly valuable spaces for sharing ideas, peer learning and promoting inter-authority collaboration.

> *"I've been learning from other local authorities…I have been able to put colleagues involved in DYW locally in contact with colleagues in another local authority and we now have a sharing of ideas across the network."*
>
> PSDO, West Dunbartonshire

> *"I think the style of the inter-authority / PSDO meetings that happen regularly and being able to go and see what everyone else is doing [is very helpful] and being able to take those ideas and decide what is replicable in Highland."*
>
> PSDO, Highland

PSDOs have facilitated partnerships with a range of partners including local colleges. These partnerships have helped to share expertise, ideas and approaches; promoted awareness of resources and promoted a shared purpose. This was seen as benefiting teachers, pupils, college students and staff.

> *"Our partnership has worked really well. Our P4 to 7 visited a [local] college and there were students that taught them some mornings and lecturers that taught them as well, and the kids came back so enthusiastic, desperate to share with other classes as well. The College is funding this, one morning a week from September to May/June. It was phenomenal; I can't wait to do it again this year. The College gets a lot from this partnership as well. The students are applying for ITE next session and can draw on this experience of being in the classroom and planning and delivering lessons."*
>
> Class Teacher, West Dunbartonshire

PSDOs played an important role in the facilitation and coordination of partnership working with local and national organisations that promoted STEM education capacity in schools. This has added value to local systems in situations where partners often lacked information on who they should and could work alongside and how to foster these relationships. PSDOs used their local knowledge to direct partners to schools that best suited their offering. PSDOs facilitated STEM Ambassadors to develop capacity in schools promoting community and business engagement.

"Another example is the STEM Ambassadors, which [the PSDO] introduced me to…Getting professionals into the four nurseries here. It's worthwhile for the staff but also for the children to meet these people."

Principal Teacher, West Dunbartonshire

"I've also seen parents comment on the STEM Ambassadors, saying I do that in my job and offering support. We've seen businesses enrolling, such as Siemens, the director recognised the potential to contribute."

STEM Development Teacher. West Dunbartonshire

The skills and range of approaches adopted by PSDOs promoting engagement and working collaboratively with teachers and other colleagues have been evident. The PSDOs have not only made contact with relevant stakeholder groups but have engineered and created networks to implement and embed RAiSE interventions. Establishing working groups and teams of committed professionals to take forward plans and supporting these groups has been an important part of this process.

"I think one of the key things has been to develop a working party, a network of people within the city who are, you know, either taking some leadership within their school for science, or they're taking ownership of the curriculum within their school for science. So, to first of all, establish that local authority network and then to build the capacity within the network to share their learning across the rest of their school or across their cluster or indeed, across the network and begin to share ideas and information. So, it's been about facilitating a network that should be self-sustaining."

PSDO, Glasgow

In summary, one of the key characteristics of the RAiSE pilot has been the extent to which the PSDOs and the National Education Officer have developed local, regional and national networks that have facilitated collaborative partnership to address the programme objectives. This process has been one of the main factors in its success, contributing to facilitating the mobilisation of knowledge, resources and sustainability.

4.6 RAiSE AS A FLEXIBLE MODEL

One of the most prominent findings is the extent to which the model has been adapted through negotiation and collaborative discussion with local authority colleagues to reflect local context, conditions and priorities while maintaining its core objectives. The RAiSE approach has been characterised by bespoke CLPL and a range of appropriate strategies including team teaching, remote delivery online and cluster approaches. The National

Education Officer has worked closely with local authorities to ensure alignment of RAiSE objectives with local plans, policies context and needs. In some cases, the size and scale of authority warranted an additional officer to ensure reach, with additional funding leveraged from the RAiSE programme, Scottish Government and, in some cases, the local authorities themselves.

PSDOs have collaborated with community groups, businesses and others to support STEM education in the different localities. They have adopted strategies that have enabled them to adapt and support schools in remote areas. These have included visits to schools backed up by the creation of online networks and resources, developing links with local businesses, colleges, universities and other organisations.

RAiSE has reflected developments in national policies, including the STEM Education and Training Strategy (Scottish Government 2017a), DYW (Scottish Government 2014) and Scottish Attainment Challenge. Strategic guidance from the National Education Officer and Education Scotland leaders has supported consistency across the PSDO network regarding how they can articulate the complementarity of their work to these policies. PSDOs have then worked with teachers, local authority colleagues and other partners to translate relevant aspects of national policy priorities into local context-specific actions.

In Glasgow, Angus and Moray, RAiSE has deployed a variant of the same approach where the PSDOs are empowering practitioners through CLPL and these practitioners are then supporting peers and cascading learning in their own schools, clusters or across their authority. Similarly, Edinburgh has focused on building the capacity of teams of teachers to support others. In Glasgow, the PSDOs have supported the development of Primary STEM Leaders (PSLs). The first PSL cohort consisted of 23 primary practitioners from across the city. The PSLs formed a Primary STEM Network where practitioners come together, share good practice and increase their skills through experiential CLPL opportunities. They are then empowered to disseminate learning to their school colleagues. Internal evaluations have shown that these PSLs have raised the profile of STEM within their establishments and promoted their own confidence, as well as that of their peers regarding STEM education.

In Highland PSDOs are delivering CLPL workshops focusing on motivated teachers to build capacity. This is often done outwith Inverness to ensure that teachers do not have to travel to the city, increasing accessibility and, therefore, impact. It is also hoped that the emergence of the Newton Rooms will, with appropriate planning, enhance STEM education capacity across this authority.

In Dumfries and Galloway, the team of PSDOs, termed RAiSE Teachers, is working closely with their local authority leader to provide CLPL opportunities in schools supported with online systems and networks. Like Highland, the team is mindful of the challenges posed by the geography and also adopt an approach that sees PSDOs visiting schools directly to provide CLPL and support. Here, the RAiSE team includes the local authority lead and is integrated with other education teams which strengthens coherence with various policies and plans. This approach to RAiSE is also characterised by rigorous self-evaluation and monitoring to inform practice and assess impact.

In Glasgow, the PSDOs are integrated within the local authority's employability team however, have adopted the distinct branding of 'STEM Glasgow'. The STEM Glasgow team

consists of a Principal Officer, RAiSE-funded PSDO and STEM Development Officer. The branding creates an identity and fosters a sense of local ownership over the programme, which supports its embedding and sustainability. Here, PSDOs found that creating a website was an effective way to publicise activity and share information and case studies with teachers. The website also coordinated the work of the PSLs.

In West Dunbartonshire, the PSDO has been supported by the local authority leaders to work in an integrated way with other colleagues to develop a cadre of practitioners who deliver CLPL and mobilise knowledge to promote teachers' skills and confidence to teach effective STEM education in a way that also articulates with local and national SAC objectives.

In summary, the programme has adopted a very flexible, yet coherent approach that balances flexibility to suit context and meet local needs and priorities while maintaining a focus on core strategic principles and objectives. To do this successfully highlights the skills and motivation of the PSDOs and the programme's National Education Officer.

4.7 THE STRENGTH OF THE RAISE MODEL

There was consensus across the professional stakeholder groups involved in the research that the programme had supported the development of a more effective and coherent CLPL system for practitioners. Key to the positive impact of the programme on local CLPL support structures was the coordinating role of the PSDOs who act as intermediaries mobilising knowledge, good practice and quality-assured resources across the system.

Overall, the PSDOs have adopted a variety of approaches to promote the professional learning of primary teachers to improve their ability to teach STEM. The PSDOs systematically assessed the local teachers' professional learning needs through surveys and school visits, developing appropriate CLPL and other measures. This often used interdisciplinary and cooperative approaches and reflected effective strategies such as experiential and enquiry-based approaches. There was evidence of extensive sharing across the PSDO network of ideas and approaches to enhance skills, facilitated by the National Education Officer. PSDOs also led sessions at the periodic inter-authority meetings to share learning in detail and associated resources that had been shown to be effective.

One of the model's strengths was the ability of PSDOs to identify appropriate professional learning approaches that reflected context and the needs of practitioners. In Edinburgh, the PSDO sought to build teachers' professional capacity in line with GTCS professional standards, which reflected research that stated that effective professional learning takes place in the classroom with other teachers. Given this, the use of lesson study was seen as an appropriate strategy to build practitioners' pedagogical skills.

The lesson study approach focused on building the interpersonal and leadership skills of practitioners and worked in collaboration with the local authority quality improvement team to implement effective professional learning and development approaches. These strategies developed practitioners' professional skillset to enhance their STEM teaching, as

well as their wider practice and leadership.

It is noteworthy that PSDOs gathered evidence and conducted evaluations of their own CLPL activity and this helped refine and steer their work to best meet the needs of teachers and their schools. The gathering of evaluative evidence by the PSDOs has supported increased teacher buy-in as the approaches they were adopting were shown to be making a positive difference to pupils. This helped provide momentum for enhanced professional learning and RAiSE activity.

The increased enthusiasm of practitioners combined with access to quality resources has created a more robust system. For example, in Angus the PSDO believed that RAiSE had also contributed to the way teachers reflected on their practice and used data and evidence. This included using the new STEM self-evaluation framework that articulates with HGIOS4 and HGIOELC. This created the opportunity for schools to consider their STEM journey and explore the relevant quality indicators that would support their monitoring and evaluation processes. Challenge questions were used to support staff discussion and examples of good practice from across RAiSE authorities were shared to highlight the effective approaches being used.

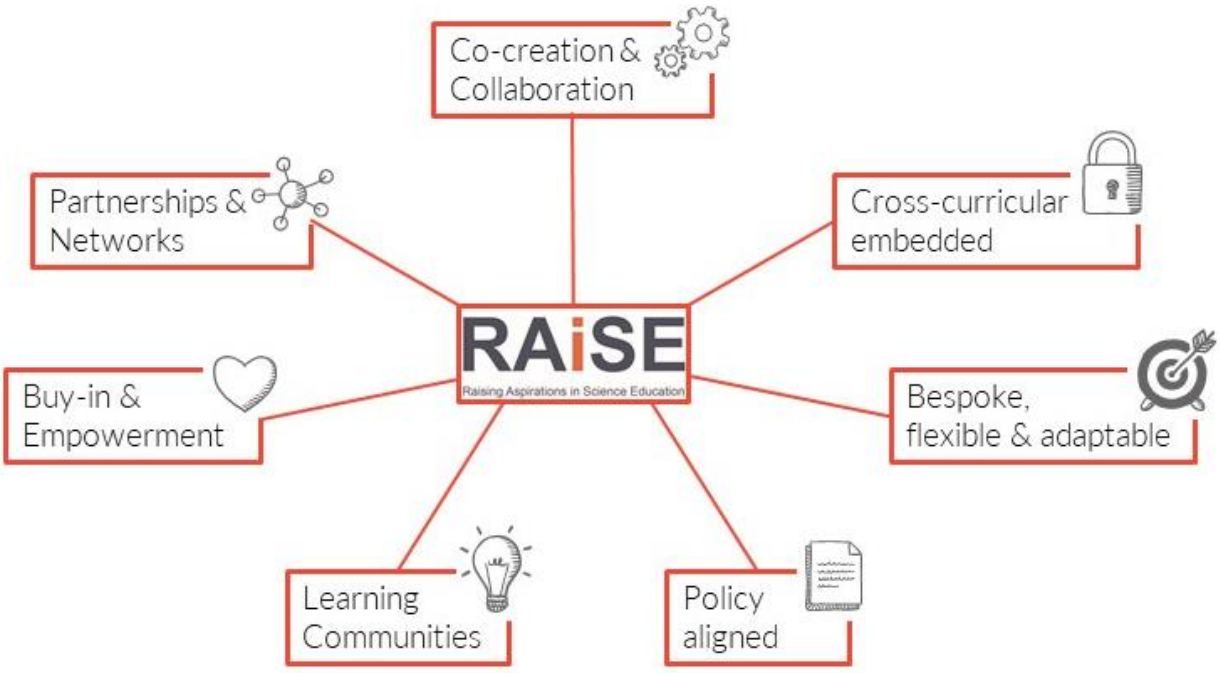
PSDOs' activities also included developing online resources and repositories that used Google Classroom and GLOW to make useful materials more widely available. Teachers valued these online resources, especially where geography inhibited access to CLPL. PSDOs also provided a valuable quality assurance and moderation role regarding this type of resource.

RAiSE was reported to make the strongest contribution to local professional learning capacity and systems where it had the systematic support of local authority leaders and the programme was integrated into the current educational systems and processes. This included close working between local authority leaders, PSDOs and other local authority personnel involved in planning and implementing educational policy and practice.

The overarching collaborative networking approach also contributed to the strength of the model. In building collaborative learning networks that characterised the model, the PSDOs were able to mobilise expertise, knowledge and resources to extend impact. This is in line with research evidence on such systems (e.g. Fullan 2013, Chapman, C., Muijs, D., Reynolds, D., Sammons, P. and Teddlie C. 2015; Ainscow et al. 2012).

4.8 SUSTAINABILITY OF THE RAiSE MODEL

PSDOs, their local authority colleagues and the National Education Officer sought to address the sustainability of the RAiSE developments from the outset. The following diagram illustrates critical components that supports RAiSE sustainability activities:



Efforts were made to embed any activities within school and local authority plans as far as possible. PSDOs identified appropriate, motivated primary teachers in their local authorities and empowered them to develop a network of practitioners who can support peers across the authority. This process was supported by local technology systems and infrastructure. Networking and collaboration were important for sustainability and building on existing expertise in primary schools and other relevant partners. In some cases, partnerships and networks extended across local authority boundaries into the newly formed RICs. PSDOs consistently worked to identify others in the local system that would be able to coordinate and sustain the developments that were emerging through the RAiSE programme.

> *"It showed me that there might be people who wanted to take it…further, so that's why I decided that the primary science mentor training and creating a network of, between 24 and 30 teachers across Moray, would help to continue that work over the next few years. They would help to drive the standards of science upwards in all of the primary schools, because they're taking their enthusiasm for science … back to the people they work with, and encouraging them to continue their learning in science, so that's where I thought that they would build capacity…"*

PSDO, Moray

> *"Sustainability is addressed by PSDO and STEM teachers modelling with teachers and then teachers taking it forward. Some teachers are quite surprised about how simple it is to introduce STEM in the classroom, how simple these activities can be but how engaging and rich these are for the young people to achieve and feel valued and to promote their STEM engagement."*

Raising Attainment Team Representative, West Dunbartonshire

In some local authorities, such as West Dunbartonshire, PSDOs and their colleagues were working to integrate RAiSE objectives and approaches with complementary strategies such as numeracy and literacy strategies, which were likely to be supported in the longer-term. PSDOs have also been demonstrating to primary teachers that much of what they are doing in school has a STEM aspect to it and were supporting teachers to integrate this into the curriculum to make it more manageable and, thus, sustainable.

West Dunbartonshire's learning communities have been fundamental to sustaining RAiSE developments. This has included developing mentors and building on partnerships with local organisations and centres such as the Scottish Maritime Museum, Denny Tank Museum and West College Scotland. A key feature of West Dunbartonshire's RAiSE activity has been the deliberate articulation with those teams and strategies focusing on promoting numeracy and literacy, to complement national priority drivers.

Highland has a strong focus on developing key partnerships, including with Skills Development Scotland. The PSDOs have worked to ensure equity of experience across the authority in partnership with the University of the Highlands and Islands STEM Hub striving to reach practitioners who are in remote areas and unable to attend CLPL in Inverness. This is likely to be complemented by the Newton Rooms. Highland is also developing online approaches to CLPL.

The cross-curricular integration of STEM and articulation of STEM with other strategies such as SAC was seen as promoting the sustainability of RAiSE and STEM developments in school and local authority plans. As one teacher explained this "gives STEM that seat at the table that it really needs. It gives it a platform for sustainability". These efforts also enable STEM and RAiSE activity to avoid being seen by teachers as an additional priority.

In Angus, the PSDO has worked in partnership with other providers throughout the education department and the local colleges and universities to develop activity and plan for sustainability. The PSDO has been growing a team of science leaders through a science leadership course. Teachers who have been involved are reported to be leading science and STEM activity within their schools and more are to be recruited to the course.

> *"It's focusing on leadership schools but in the context of STEM … they've had input on the STEM self-evaluation framework and using that to identify strengths and weaknesses in your school…I did a policy overview and provided a guide to relevant reading."*
>
> PSDO, Angus

The science leadership course has provided input from experienced leaders from other schools, as well as strategic STEM leadership insights including what that looks like in the current education and policy context. Feedback from participants has been very positive with these individuals leading STEM innovation in their schools. There is also evidence that it is facilitating their career development and promotion, including science leadership course participants becoming Principal Teachers.

In some cases, such as Glasgow and Fife, the PSDOs and the local authority team have extended the support provided through the SSERC Primary Cluster Programme including the coordination of Primary Science Teaching Trust (PSTT) activity highlighting the complementarity between the organisations.

Dumfries and Galloway is committed to exploring possibilities to sustain funding beyond June 2019. RAiSE has acted as a driver for STEM education in the region and, given the size and scale of the authority, these initial developments and systems will take some time to become embedded and fully sustainable. This process will be supported by the way the RAiSE team is integrated into the wider local authority departments and committees as well as the STEM hub group - a Scottish Government hub of partners that includes local colleges and universities, DYW and Chamber of Commerce. RAiSE is at the heart of these key groups, which should promote the sustainability of the work.

Edinburgh's RAiSE sustainability is enhanced by its partnerships and the embedding of STEM education within the new Edinburgh Learns team, which focuses on Teaching and Learning; Equity for Learning; Improving Quality in Learning (Quality Improvement); Health and Wellbeing; Learning Together (Parental Involvement and Engagement); Pathways for Learning (DYW); and Inclusion. Any CLPL relating to the teaching and learning of primary science will be screened for inclusion in an Edinburgh Learns portfolio of courses. The Strategic Lead will maintain overall responsibility for the authority's direction in STEM, including the options for support post June 2019.

One PSDO commented that concerns about teacher workload could mean school leaders might be reticent about becoming involved with RAiSE activities. However, the emergence of the national STEM Education and Training Strategy (Scottish Government 2017a) was seen as something that could influence local authorities' and schools' improvement plans and provide a driver to introduce a higher level of STEM activity.

Developments at national policy level, such as the STEM Education and Training Strategy (Scottish Government 2017a) and DYW, were seen as promoting the profile of STEM and enhance the probability of RAiSE developments becoming embedded in school planning. However, as noted previously, a key part of building sustainability was seen as establishing networks of appropriately skilled and motivated practitioners, organisations and businesses that could provide science and STEM resources, support and inputs.

PSDOs often stressed the importance of having local coordinators and advocates in place to drive and to make developments more systematic and sustainable across their local authorities. Building on existing successful local educational approaches and systems was also evident as a way the PSDOs implemented activities that were likely to be sustained and embedded. Indeed, in some cases the local approach of the PSDO was informed by existing and effective local authority approaches to promoting learning and teaching. For example, in Glasgow, the approach of the PSDO in developing PSLs reflected the local authority's model of developing teachers as leaders of learning, including researching and reflecting on their own performance. As previously described, this approach included developing teams of skilled and enthusiastic teachers to support and develop their peers.

A theme running through the local authority interviews was that there should be an emphasis on co-creating and collaboration to develop and maintain shared resource platforms regarding what proves effective in promoting teachers' ability to teach STEM. Teams in Angus and in other pilot authorities were developing dynamic and responsive websites that were regularly updated and responsive to local needs.

> *"Having these banks of information, having these video tutorials, having a website that's a central hub, creating networks and places where people can collaborate, and that's become cultural and normal – all those things are sustainable."*
>
> PSDO, Angus

Those stakeholders at a strategic level who had visited schools involved with the programme echoed the positive comments of other key informants and added that the impact of RAiSE was itself helping to promoting sustainability of developments.

> *"I think has been really successful…There's also an enthusiasm in the local authorities for looking seriously at longevity in this [RAiSE], in a way I've not really seen before in other initiatives. So, they're recognising that this has had major bonuses."*
>
> Strategic Lead, Scottish Government

As the pilot phase drew to a close, all of the PSDOs and local authority leads interviewed, as well as teachers across the focus groups, stressed that developments produced by RAiSE activity were likely to be sustained and had been reflected in future planning. In some cases local authorities had located funding to extend the duration of their PSDO posts. In other cases, where the PSDO post would no longer be sustained, it was reported that the legacy of teacher networks supported by online resources would sustain the work initiated by RAiSE activity. A number of the local authorities, including City of Edinburgh, have also created new posts that had direct responsibility for STEM education. These posts have been embedded alongside other local authority education colleagues.

At the time of writing this report, none of the eight local authorities involved in the pilot has exited the programme which is testimony to the value placed on RAiSE and indicative of the intention to sustain key developments and systems.

4.9 CHALLENGES AND MITIGATING STRATEGIES

While the evaluation has identified a number of challenges, most of which are not unique to the initiative, the programme leadership team, PSDOs and local authority colleagues are addressing these to identify mitigating strategies. In addressing the challenges, the RAiSE model has been further developed through the co-creation of solutions with local authorities,

demonstrating a flexible, relevant programme that remains fit for purpose in differing local contexts.

4.9.1 Implementation

Funding was reported as an inhibitor for some local authorities, narrowing priorities and limiting resources available for STEM, even where there was a desire to support developments such as RAiSE. However, some of those interviewed suggested that strategic planning and leadership could help ameliorate some of the financial challenges.

Some delays in the release of PSDOs from their substantive posts suggests that at least six months is required to ensure that recruitment and release of the PSDO occurs in line with programme timescales. Consideration must be given to the overall lead-in time for the programme and additional time should be factored beyond initial engagement with authorities to mitigate against possible recruitment delays. A 23 month-secondment is standard practice across local authorities. The RAISE programme is taking between nine and 12 months to become established and operational in an authority. Often, there has been no responsibility for this type of role for some time and consequently much groundwork is needed which limits the time available to expand the reach of the programme. Several of the pilot authorities are considering extensions to the PSDO role beyond 23 months in order to further the ambitions of the programme.

Local authority support including leadership engagement beyond the Director of Education has enabled PSDOs to become established more quickly in post. This is a key factor in ensuring that PSDOs are appropriately supported and resourced and that the programme links effectively to other strategic priorities within the authority. A named strategic lead ensures clear communication between stakeholders and increased efficiencies in operational delivery. The presence of these officers at the inter-authority meetings represented local perspectives, demonstrated buy-in for their PSDO and the wider RAiSE community, as well as cross-authority collaboration.

4.9.2 Practitioner engagement

PSDOs have sought to inform practitioners about the wide variety of STEM-related activities, events and CLPL opportunities available to them locally. Historically, this information has struggled to reach the right audience. This was addressed by building on and developing communication strategies that are flexible across different platforms and bespoke to local authorities' needs and communication preferences. With the use of social media platforms and electronic communications such as Twitter, newsletters, emails and websites, the opportunities offered by RAiSE were easily disseminated to a wide audience. The evaluation revealed the importance of highlighting success stories to secure buy-in from teachers and others in the system.

PSDOs supported a variety of STEM events, including local authority STEM conferences to engage with headteachers, quality improvement officers and other stakeholders. In addition to pan-authority events a number of authorities e.g. Dumfries and Galloway, Moray and Highland, have adapted their delivery of CLPL opportunities to address the

geographical challenges of their locality. Dumfries and Galloway offer their CLPL in four zoned areas across the authority to maximise the opportunity for teachers to attend. This is a critical component in the successful delivery of RAiSE activities. It has highlighted the importance of relationship building and PSDO experience and knowledge of the area, which contributes to enhanced teacher buy-in making them more likely to positively engage in the programme. This was further developed by highlighting flexibility and adaptability of RAiSE activities, ensuring teachers were clear that this was not extra work, but vehicles through which to address and deliver the demands of the current curriculum.

4.9.3 National priority development

There were reports from some PSDOs, local authority colleagues and teachers of varied responses to the STEM Education and Training Strategy (Scottish Government 2017a) across the local authorities, with the strategy yet to be fully reflected in local improvement and action plans. This process will take time but this challenge has also been tackled through national STEM developments and approaches being regularly shared across the RAISE network to support authority engagement. This has helped the pilot authorities consider their STEM developments strategically.

4.9.4 Sustainability

This challenge was examined in Section 4.8 and, as with similar programmes delivered across education, there are issues regarding the sustainability of STEM activities facilitated through RAiSE as the funding period comes to an end. As a fundamental principal of RAiSE, this has been addressed from the outset of each authority's engagement with the programme. This is critical in maintaining the progress made in delivering high quality primary STEM learning and teaching during the two-year partnership. By empowering teachers and building their confidence the activities, networks and partnerships become embedded within the schools, clusters and communities. The programme has developed a cadre of STEM Leaders well positioned to continue delivery of STEM activities and events and promotion of high-quality STEM opportunities and experiences beyond the formal end point of the programme.

In addition to developing the capacity of individuals, the programme has worked collaboratively with schools, clusters, local authorities and wider learning communities to identify additional funding opportunities to invest in local STEM resources. RAiSE has also helped foster a culture that encourages leaders to reflect STEM in local authority and school priorities and planning.

4.9.5 Evaluation

Practitioners highlighted the challenges of evidencing RAiSE-related impact of activities at school level. This is not a challenge unique to education but in fact a well-recognised challenge across sectors. By using a range of evaluation methods of both a quantitative and qualitative nature we were able to build an accurate picture of the impact of the RAiSE programme's various activities in differing contexts with multiple stakeholders. The PSDOs have tackled this issue with their teacher colleagues when looking to assess the impact of

RAiSE locally. They have used school level assessment data, bespoke baseline and follow-up assessments, as well as professional judgment, teacher feedback and observation to evidence programme impact.

4.10 OPPORTUNITIES

The RAiSE programme is a unique collaborative model of private and public partnership to fund and lead an education initiative of national significance. It has been launched and implemented at a time when there are a number of complementary frameworks and strategies in place at a national level that offer opportunities for learning, and a mandate for a continued focus upon STEM learning and opportunities.

The launch of the STEM Education and Training Strategy (Scottish Government 2017a) highlighted the national ambition for STEM. This will allow RAiSE to continue to align its objectives more explicitly to the national offer and encourage PSDOs to support this at a local level. In addition, schools are addressing a number of other priorities at this time including the NIF, SAC and DYW. This provides an opportunity for RAiSE to evidence articulation with relevant national priorities and for it to be seen as an embedded opportunity within these priorities. RAiSE can be used as a context for learning, and not an 'add-on' to the curriculum.

As the RICs become more established it is envisaged that the model will allow RAiSE to be considered as part of these systems as a proven vehicle for effective collaboration, professional learning and policy implementation. This includes a key role for RAiSE in working with the Regional STEM Advisors, Gender Balance and Equalities Officers and other national professional learning organisations as key partners to support practitioners within the RIC framework.

Local authorities have reported that there is funding available through central programmes such as the Pupil Equity Fund. Additional support to demonstrate how science and STEM can help raise attainment and tackle inequality would be beneficial.

Ongoing policy development in the education landscape is resulting in continued evolution at local authority and regional levels. This highlights the need to review and, if required, adapt the structure and implementation of RAiSE. The programme remains well connected to Association of Directors of Education in Scotland, Scottish Government and Education Scotland. The relationships will continue to provide insights and information regarding the changing environment, enabling RAiSE to remain agile and relevant within Scottish education beyond the pilot phase.

5 RECOMMENDATIONS

This section suggests recommendations that emerge from the evaluation of the pilot phase of the RAiSE programme. These complement the opportunities discussed in Section 4.12.

- There is sufficient evidence to recommend that the RAiSE programme offer is made accessible to all local authorities across Scotland. The model adds value to local systems, particularly in promoting teachers' confidence and skills and facilitating and enhancing collaboration around STEM, as well as articulating with DYW and NIF. RAiSE clearly contributes to the delivery of the Scottish Government's STEM Strategy (Scottish Government 2017) and is coherent with the objectives and approaches of the developing RIC systems.
- The evidence from the evaluation strongly indicates that RAiSE reflects effective practice regarding professional learning systems. Furthermore, the programme's ability to contribute to DWY and NIF enhances teachers' ability to engage young people in learning and to promote inclusion and achievement. This articulation with other relevant policies and strategies should remain a fundamental priority for all PSDOs and the wider RAiSE team.
- As the national education policy landscape evolves to emphasise increased school autonomy and regional systems embodied by the RICs, there is a need to consider how RAiSE can effectively promote STEM within RIC, local authority and school improvement plans. The RAiSE National Education Officer, working closely with leaders across the RICs, could demonstrate the value of RAiSE to RIC objectives and explore ways to collaborate.
- Local authority budget restrictions may present a challenge to the expansion of RAiSE. Therefore, it is recommended that joint private and public approaches be explored. The combined resources of the RICs might also offer potential funding sources.
- Any expansion of the programme would warrant additional operational resources to support the National Education Officer to increase strategic leadership capacity to coordinate activity and support new authorities.
- Given that the longer-term efficacy of the RAiSE model remains to be proven, particularly as local authority budgets are cut or limited, we suggest that The Wood Foundation and Education Scotland maintain a robust internal evaluation to monitor and assess the impact of the programme in the differing contexts.

6 CONCLUSION

The data gathered by the team evidences the development of RAiSE at local and national levels to achieve the programme's objectives. The research indicates that highly skilled and motivated PSDOs have worked with colleagues locally and sometimes nationally to develop the necessary infrastructure, CLPL and approaches to implement and sustain RAiSE. This has been characterised by PSDOs identifying and supporting motivated teachers who have become local leads in their schools and clusters to sustain the outcomes of RAiSE activity and further the programme objectives.

In addition, RAiSE personnel have worked collaboratively with practitioners, local authorities and national policymakers to ensure the sustainability of RAiSE-instigated activity and develop consistently high-quality primary STEM learning and teaching. The central RAiSE team has worked with strategic leads in local authorities to identify funding streams and align RAiSE objectives with local and regional improvement plans. RAiSE has proactively engaged with national developments and frameworks to ensure that it is relevant to national priorities, and to ensure it provides an effective vehicle to deliver the curriculum and contribute to achievement and inclusion.

The qualitative data was key in understanding the impact RAiSE activity had on pupils and teachers and this should be considered moving forward. The data gathered from focus groups, events and discussions were the most appropriate methods to capture meaningful evidence of the excitement and engagement of pupils with STEM, as well as insights from parents and teachers on STEM aspirations. Observations provided supporting evidence of the application of pupils' learning who were engaged in RAiSE activities.

A critical component of sustainability is the rigorous processes PSDOs have implemented to foster networks constructed of leaders of science learning, local and national partners and businesses. The support from local authority colleagues has proven important to integrate RAiSE with other educational strategies. The model has been welcomed by local authorities and its flexibility and adaptability have been key to the approach being valued. The wider research suggests that integration of PSDOs within relevant local authority teams will proportionally have more impact and sustainability (Chapman et al. 2016). The work of the RAiSE National Education Officer has been a key factor in supporting the PSDOs, ensuring integration of their roles within local authorities and for the overall success of the programme to date.

The RAiSE model highlights the value of local, nationally-informed and coordinated, officers working collaboratively to facilitate partnerships and CLPL, as well as mobilising knowledge and good practice. Given the developing pace of STEM in Scottish education and its worth to other areas of the curriculum and polices such as SAC and DYW, this programme and model appear to be a necessary part of the educational landscape.

7 REFERENCES

Ainscow, M., Dyson, A., Goldrick, S., and West, M. (2012) Making schools effective for all: rethinking the task. *School Leadership & Management*, 32 (3), pp.197-213.

Anderson, R., Greene, M., & Loewen, P. (1988). Relationships among teachers and students' thinking skills, sense of efficacy, and student achievement. *Alberta Journal of Educational Research*, 34 (2), 148 - 165

Centre for the Use of Research and Evidence in Education (CUREE) (2011) *Evaluation of CPD providers in England 2010-2011:* Report for schools. TDA: Manchester/CUREE: Coventry.

Cervetti, G; Barber, J; Dorph, R; Pearson, P & Goldschmidt, P (2012). The impact of an integrated approach to science and literacy in elementary school classrooms. *Journal of Research in Science Teaching*. 49. 631-658. 10.1002/tea.21015.

Chapman, C., Muijs, D., Reynolds, D., Sammons, P. and Teddlie C. (2015). *The Routledge International Handbook of Educational Effectiveness and Improvement. Research, policy, and practice, 1st Edition.* Routledge. ISBN 9781317394327

Chapman, C., Chestnutt, H., Friel, N., Hall, S., and Lowden, K. (2016) Professional capital and collaborative inquiry networks for educational equity and improvement. *Journal of Professional Capital and Community*, 1(3), pp. 178-197. (doi:10.1108/JPCC-03-2016-0007)

Cordingley P, Bell M, Rundell B, Evans D (2003) *The impact of collaborative CPD on classroom teaching and learning: how does collaborative Continuing Professional Development (CPD) for teachers of the 5-16 age range affect teaching and learning?* Research Evidence in Education Library. London: EPPI-Centre, Social Science Research Unit, Institute of Education.

Cordingley P, Bell M. Evans D, Firth A. (2007) *The impact of collaborative CPD on classroom teaching and learning: what do teacher impact data tell us about collaborative CPD?* Research Evidence in Education Library. London: EPPI-Centre, Social Science Research Unit, Institute of Education. Culture and Society, 18 1: 81-92

Fullan, M. (2013) *Great to Excellent: Launching the Next Stage of Ontario's Education Agenda*. http://www.edu.gov.on.ca/eng/document/reports/fullan.html

Godec, S, King, H & Archer, L (2017) The Science Capital Teaching Approach – engaging students with Science, promoting social justice – University College London

Gray, J. (2000) *Causing Concern but Improving: A Review of Schools' Experience*, London: DfEE.

JHargreaves, D. (2005) *Personalising learning – 5: Mentoring & coaching, and workforce development*. London: Specialist Schools and Academies Trust.

Harlen, W. (1999) *Effective teaching of science: A review of research*. Edinburgh: Scottish Council for Research in Education.

Harris, A. (2005). *Evaluating the Impact of Continuing Professional Development* (CPD) (London: DfES)

Harrison, C., Hofstein, A., Eylon, B-S. and Simon, S. (2008). Evidence-based professional development of science teachers in two countries. *International Journal of Science Education*. 30(5) 577-591.

Jarvis, T., and Pell, A. (2004) Primary teachers' changing attitudes and cognition during a two year science in-service programme and their effect on pupils. *International Journal of Science Education*. 26:1787–811.

Lowden, K., Hall, S, and Friel, N. (2015) *Evaluation of the SSERC Primary Cluster Programme in Science and Technology*. Glasgow: Robert Owen Centre for Educational Change, University of Glasgow.

Midgley, C., Feldlaufer, H., & Eccles, J. (1989). Change in teacher efficacy and student self- and task- related beliefs in mathematics during the transition to junior high school. *Journal of Educational Psychology*, 81, 247- 258

Murphy, C., P. Neil, and J. Beggs. (2007) Primary science teacher confidence revisited: Ten years on. Educational Research 49: 415–30.

Pearson, P & Moje, Elizabeth & Greenleaf, Cynthia. (2010). Literacy and Science: Each in the Service of the Other. *Science* (New York, N.Y.). 328. 459-63. 10.1126/science.1182595.

Ross, J. A. (1992). Teacher efficacy and the effect of coaching on student achievement. *Canadian Journal of Education*, 17 (1), 51-65.

Scottish Government (2019) *Regional Improvement Collaboratives (RICs): Interim Review.* Edinburgh. ISBN: 978-1-78781-539-1

The Scottish Government (2018) *2019 National Improvement Framework and Improvement Plan: Achieving Excellence and Equity*. Edinburgh. ISBN: 978-1-78781-431-8

Scottish Government (2017a) *Science Technology Engineering Mathematics: Education and Training Strategy for Scotland*. Edinburgh. ISBN: 978-1-78851-361-6

Scottish Government (2017b) accessed 14/3/19. [https://news.gov.scot/news/raising-aspirations-in-science]

Scottish Government (2014) *Developing the Young Workforce - Scotland's Youth Employment Strategy*. Edinburgh. ISBN: 9781785440335

Scottish Government (2012) *Supporting Scotland's STEM Education and Culture - Science and Engineering Education Advisory Group - Second Report*. Edinburgh. ISBN: 9781780456737

Shah, Madiha. (2012). The Importance and Benefits of Teacher Collegiality in Schools – A Literature Review. *Procedia - Social and Behavioral Sciences.* 46. 1242-1246. 10.1016/j.sbspro.2012.05.282.

Summers, M. (1994) Science in the primary school: The problem of teachers' curricular expertise. *The Curriculum Journal,* 5: 179–93.

Van Aalderen-Smeets, S. I. and van der Molen, J.H.W. (2015) Improving Primary Teachers' Attitudes Toward Science by Attitude-Focused Professional Development, *Journal of Research in Science Teaching,* 52: 710-734.

8 GLOSSARY OF ACRONYMS

RAiSE – Raising Aspirations in Science Education.

ROC – Robert Owen Centre: evaluation team conducting this external evaluation.

STEM – Science, Technology, Engineering and Maths.

PSDO – Primary Science Development Officer: local resource within participating local authorities responsible for RAiSE delivery.

RIC – Regional Improvement Collaborative: six regional clusters of local authorities across Scotland for enhanced collaborative working and opportunity for improvement at scale.

ASG – Associated School Group: This is a cluster, which includes local, early years' establishments, primary schools and the associated secondary schools.

CLPL – Career Long Professional Learning: formerly referred to as CPD (Continuous Professional Development) is the professional training and development requirement for all education practitioners.

ADES – Association of Directors of Education Scotland: representing all 32 of Scotland's local authorities' education leaders.

SSERC – Scottish Schools Education and Resource Centre: has a specific focus upon STEM education and training.

PSTT – Primary Science Teaching Trust: a funding body working with SSERC to support networks of primary science mentors across Scotland.

IOP – Institute of Physics: an international charity working to advance physics education, research and application.

SCEL – Scottish College for Education Leadership: a body which supports teachers' professional learning in leadership.

DYW – Developing the Young Workforce: a national initiative to address the work readiness and positive destinations of Scottish school leavers.

NIF – National Improvement Framework: launched in 2018, this is a plan designed to help deliver excellence and equity across Scottish education.

SAC – Scottish Attainment Challenge: Scottish Government initiative to reduce the education attainment gap in those areas of Scotland of higher SIMD (Scottish Index of Multiple Deprivation) rating.

GLOW: The national digital learning platform.

PCP – Primary Cluster Programme: Scottish education programme delivered by SSERC to expand the network of science mentors amongst Scottish primary schools.

GIRFEC – Getting it Right for Every Child: a Scottish Government commitment supporting all Scottish youngsters through their education careers.

HGIOS4 – How Good is our School (4): the current quality indicators used by schools and educators across Scotland to quality assure teaching and learning.

HGIOSELC – How Good is our Early Learning and Childcare: the current quality indicators used by early years establishments and educators across Scotland to quality assure teaching and learning.

APPENDIX 1: RAiSE OBJECTIVES

The aims of RAiSE are to:

- Build capacity at local authority level to coordinate support for science and to support sustainable and long-term improvements to science education in primary schools
- Build the confidence, skills, knowledge and enthusiasm of primary school practitioners in relation to the teaching of sciences – both in terms of content and pedagogy – through high-quality professional learning. This includes the provision of experiential learning to build capacity for the effective delivery of practical investigations
- Raise attainment and achievement in primary science with a particular emphasis on supporting learners within SIMD deciles 1 and 2 and for those most in need of support
- Support local authorities with their efforts to raise levels of engagement in primary science education, including providing opportunities to sustain and extend the impact of their participation in the SSERC Primary Cluster Programme if applicable
- Ensure learning and teaching in the sciences in Scottish primary schools reflects the principles of curriculum design to improve outcomes for learners and ensure they are challenged and motivated by their learning experiences and understand the relevance of science both to them and society
- Ensure learners develop skills for learning, life and work and that progress and achievements are assessed, monitored, tracked and reported on effectively
- Promote effective progression in learning in the sciences across sectors from early years to primary and from primary to secondary school
- Build the social capital of practitioners across Scotland by ensuring they have effective opportunities to network, share, collaborate, mentor and co-create with their peers.