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Making Every Person Count in Maths

A Framework of Professional Learning and Leadership Development for Whole-School Improvements in Mathematics

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Abstract

This position paper explores the design principles underpinning a large-scale professional learning and leadership development programme for staff in inner-city schools in Nottingham, England. The 'Making Every Person Count in Maths' framework embodied a design research process targeting sustainable improvements in the quality of mathematics teaching and attainment in a selection of underperforming inner-city primary and secondary schools by prioritising developments in leadership, teaching and in-class support, and children's learning experiences. The framework is underpinned by eight design principles. These span three agendas which we believe are instrumental for sustainable school improvement in the identified priority areas: forensic analysis of needs and quality assurance; leadership development; and professional learning for teachers and other staff involved in the teaching and learning experience. We theorise the origins of the design principles and show how we used the principles to ensure a high degree of coordination of these agendas in the structure and contents of all programme activities to target the three priority areas. Our belief is that the high degree of coordination of these agendas and subsequent programme activities via the clearly articulated design principles made it more likely for involved schools to make sustained improvements in identified priority areas. Although subject Mathematics provided an initial context of application for this framework, we make the tentative claim that these design principles may transcend subject-specific boundaries to have application in a wide range of school-improvement activities.

Introduction

Professional development of staff and leadership that is closely aligned to identified needs and priorities are key elements of sustainable school improvement initiatives (Greany, 2018) that seek to go "beyond temporary gains in achievement scores to create lasting, meaningful improvements in learning and school performance across an entire school." (Hargreaves & Fink, 2004). However, our professional experience working in inner-city schools in two cities in England, is that school improvement activities and professional learning activities are frequently disconnected and dealt with as separate processes and with different audiences, due in part to constraints on funding, capacity, expertise and time. In response and supported by school-improvement funding made available by the national Department for Education, we developed and coordinated a large-scale professional learning and leadership development programme targeting whole-school

improvements in mathematics leadership, teaching and learning experiences – the 'Making Every Person Count in Maths' (MEPC) programme. This funding and programme provided a unique opportunity to design and trial an improvement framework that foregrounded a careful interplay of three agendas – forensic analysis and quality assurance, leadership development, and professional learning, with subject Mathematics providing a specific context of application. By treating the development of this framework as an 'engineering research' design exercise (Burkhardt, 2006), our aim was to investigate if this coordinated approach to school improvement would lead to a better product or process in identified priority areas – in this case, sustainable improvements in the quality of leadership, teaching, and learning experiences in subject mathematics in involved schools.

By adopting the mantle of both designers and researchers, our intention in this position paper is to explore:

"how the lessons learned in order to make decisions about the design procedure, problem analysis, and design solution can be made explicit and public to serve the needs of a larger community." (Edelson, 2006, p. 101)

We do this by describing, rationalising and theorising our design process, and elaborate eight principles underpinning our design framework. The principles are:

1. strong alignment between strategic, tactical and technical levels of design;
2. leadership development is prioritised and professional development activities are directly supported by school leadership;
3. professional learning activities are directly relevant to participants' and students' needs and focus on improving students' outcomes and learning experiences;
4. professional development activities are part of a strategic and long-term improvement plan and target the whole school community;
5. sustainable improvement is supported by ongoing research of practice and impact evaluation;
6. professional development activities enable and support participants to evaluate their practices and to have autonomy and ownership over (changes to) these practices;
7. professional development activities include, where possible, a combination of theory, modelling by experts, opportunities for practice and application in local contexts, and coaching;
8. professional development activities prioritise both subject-specific content knowledge and pedagogical knowledge, with some additional focus on more general strategies for supporting students to become independent learners.

The first principle facilitates the coordination of all agendas across programme activities. Principles 2 to 5 reflect the processes and structures that foreground the two agendas of quality assurance and forensic analysis, and leadership development. The final three principles foreground the third agenda of sustainable professional development and learning.

Our view is that designing the MEPC programme around these principles ensured strong coordination of quality assurance, leadership development and professional learning agendas, hereby empowering involved schools to embed sustainable improvements in leadership, teaching and learning. In so doing, this model provided a blueprint for our future school-improvement work, transcending the boundaries of subject Mathematics to apply to all school-improvement activity. A key contribution of this paper, then, is to explain and rationalise our design process and principles, to explore why we believe this approach leads to sustained improvement and change, and to make tentative suggestions as to the value of these principles for others involved in school-improvement and professional development activities.

To achieve this, we start with an overview of the MEPC framework, associated programme activities, and key programme priorities. Then, we elaborate and theorise the underlying eight design principles and exemplify how these principles have been operationalised in the structure and contents of the framework to address quality assurance, leadership development, and professional learning agendas. We position our approach as design research and engage specifically with literature about school improvement and professional development and learning to validate and situate our approach. We conclude by considering limitations, opportunities for further research, and implications for practice for others involved in school improvement and professional development activities.

Overview of the MEPC Framework

Background

In January 2018, a collection of educational organisations representing partnerships of Primary and Secondary schools in Nottingham City in the midlands of England were awarded just over half-a-million Pounds of funding from the Department for Education to plan, develop and deliver a seven-month long (September 2018 – March 2019) large-scale mathematics professional development programme – what became known as the 'Making Every Person Count in Mathematics' (MEPC) programme. At a policy level, a key aim of the funding was to provide additional resources for schools most in need to improve school performance and pupil attainment via a range of school-improvement activities (DfE, 2017). At programme level, this translated into broad aims for facilitating whole-school improvements in the quality of teaching and learning experiences and attainment in subject Mathematics for 40 inner-city Nottingham schools - 33 primary, 6 secondary, and one all-though school (Primary and Secondary combined) for children with severe special educational needs (SEND). Mathematics was chosen as a focus area given challenges with underperformance in this subject, particularly for children from poorer socio-economic backgrounds. As such, the performance of children from disadvantaged backgrounds was a stipulated priority. Involved schools were selected on their 2016 end-of-year academic results for Years 6 (Key Stage 2 – age 10-11 years) and 11 (Key Stage 4 – age 15-16 years) for Primary and Secondary schools respectively. Key eligibility criteria were low attainment and high numbers of children on roll from disadvantaged communities. For some schools, participation was mandatory due to very low attainment data; for others, a significant funding allocation to schools enabled leaders to release staff and commit to programme activities. At this time, both authors were employed by the lead organisation responsible for coordinating the programme design and activities – Transform Trust and

Teaching School Alliance. This trust comprised a partnership of 18 Primary schools located primarily in Nottingham City. The first author was the Mathematics Lead across the trust and was tasked with designing and supporting the delivery of MEPC programme activities. The second author was the Trust Development Director, with responsibility for overall programme coordination and strategic leadership.

Priority areas

Given the importance of mathematics as a gateway for future study and career opportunities (Smith, 2017) and the high levels of anxiety around the study of mathematics for children and adults alike (Dowker, Sarkar & Looi, 2016), the MEPC programme was underpinned by the philosophy that every member of the school community - including school leaders, teachers, teaching assistants, tutors, parents and children themselves - has a responsibility for supporting children's attainment and positive experiences in mathematics. This 'whole school' improvement strategy targeted three broad priority areas, the combination of which embody quality assurance and forensic analysis, leadership development and professional learning agendas.

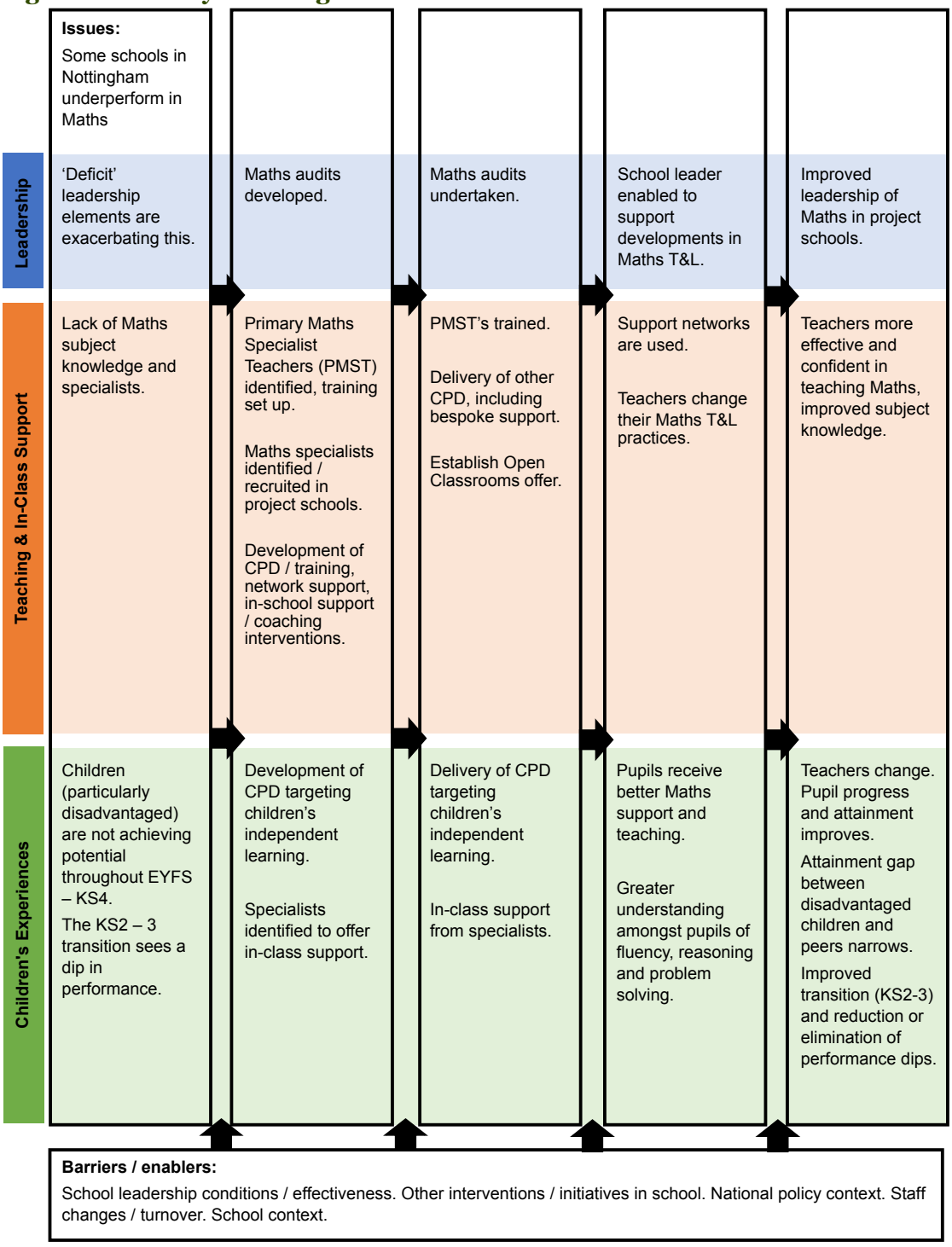
1. Leadership: Dedicated support for school and subject leaders to ensure a clear vision for mathematics teaching and learning and to facilitate strategic and sustainable improvement activities.

2. Teaching and in-class support: Dedicated professional learning activities targeting improved specialised content and pedagogical knowledge of all adults involved in the delivery of mathematics teaching and learning activities, including specialist mathematics teachers, non-specialists teaching mathematics, and learning support staff.

3. Children's experiences: Dedicated activities for improving children's attitudes towards mathematics and their 'mathematical mindsets' (Boaler, 2015) and for supporting children to become independent and reflective learners.

These priority areas gave rise to the theory of change for the overall programme shown in Figure 1, depicting the key issues the project aimed to address, the programme inputs and activities, outputs, both short and longer term intended impacts, and potential barriers.

Figure 1 – Theory of Change for the MEPC framework



Programme strands and activities

This theory of change was translated into a conceptual framework that structured programme activities around the three priority areas (Figure 2). The strands of this framework were operationalised empirically and practically via a series of targeted activities spanning quality assurance, leadership development, and professional learning foci (Table 1). These included twenty-seven professional development courses, eight open-classroom experiences showcasing elements of classroom practice, and a number of in-school quality assurance, needs analysis and leadership support activities. The professional development courses were held centrally on specified days and times and

schools released staff to attend these sessions, while the open-classroom experiences were held in schools in the wider educational community partnership to showcase an aspect of classroom practice in which the schools had specific expertise. Involved schools were signposted to specific programme offerings based on the findings of the in-school baseline needs-analysis audits to support with identified priorities. However, all programme activities were made available to all schools and school leaders could ultimately select which programme activities to engage in. Discussions with school leaders on the impact of involvement in selected programme activities was a main feature of the end-of-programme follow-up audits.

Figure 2 – 'Making Every Person Count in Maths' programme elements

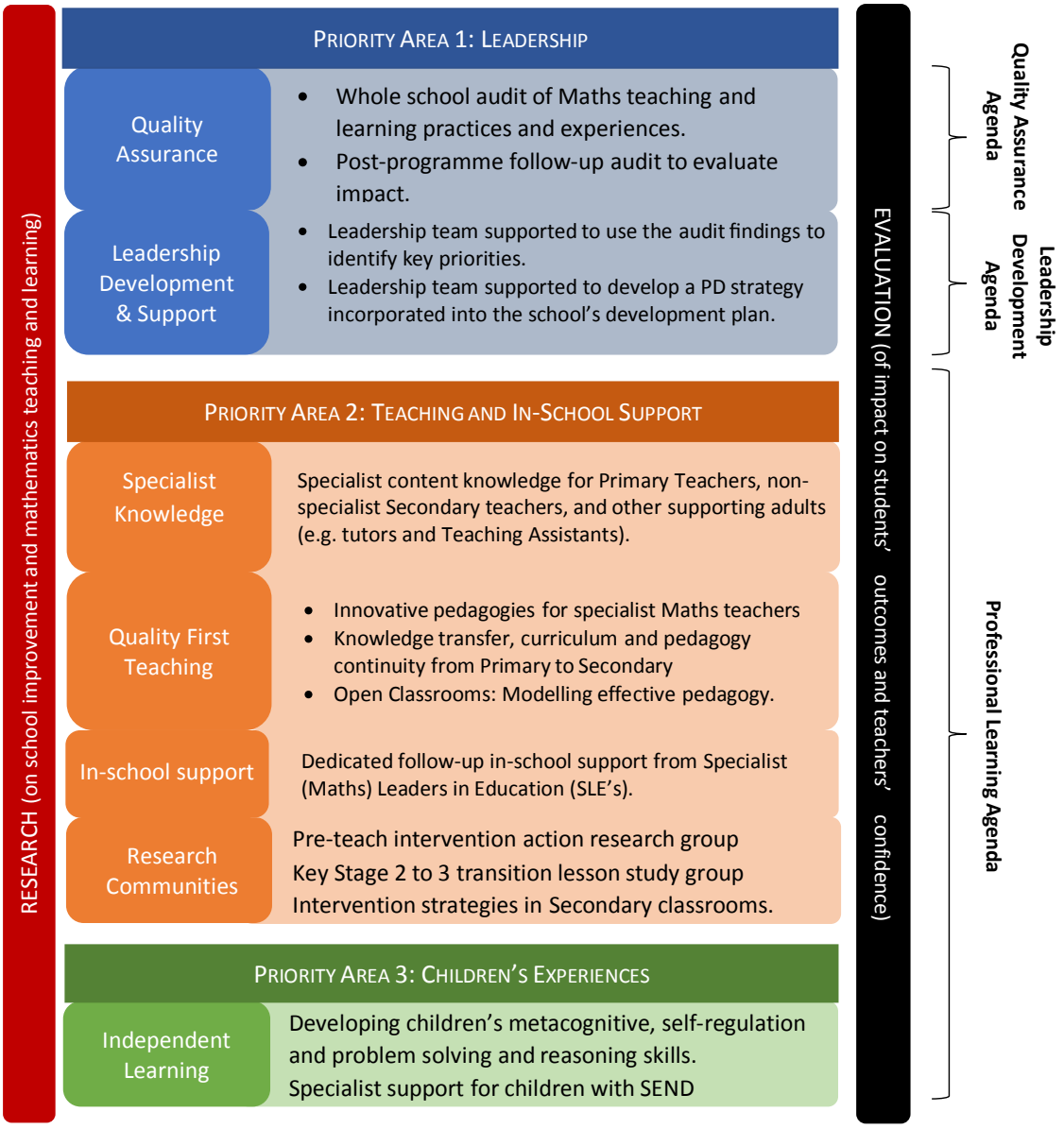


Table 1 – MEPC professional development activities

Phase	Priority Area	Strand	Programme Title	Activity Duration	Professional Development Model+
PRIMARY	Leadership	Leadership Development & Support	Primary Subject Lead Networks	3 x ½ days	Community of Practice
	Teaching	Specialised Content Knowledge	Maths Mastery in the Early Years – transition from F2 to Y1	½ day	Cascade
			Developing Number Fluency at KS2	½ day	Cascade
			Developing Number Fluency at KS1	½ day	Cascade
			Strategies for Teaching Fractions at KS1	½ day	Cascade
			Strategies for Teaching Fractions at KS2	½ day	Cascade
			Getting to Grips with Ratio and Proportion	½ day	Cascade
			Getting to Grips with Algebra	½ day	Cascade
		Quality First Teaching & Pedagogy	Primary Maths Specialist Programme	7 x full days + 1 day conference	Transformative
			Problem-solving strategies at KS1*	½ day	Cascade
			Problem-solving strategies at KS2*	½ day	Cascade
			Getting to Grips with the Maths No Problem Scheme and Way of Working	½ day	Cascade
			Mastery Lesson Design and Planning	1½ days	Cascade
			Differentiation in Mixed-Attainment Classes	½ day	Cascade
			Strategies for using Multiple Representations	Full day	Cascade
			Developing Effective Mastery Assessments	Full day	Cascade
			Modelling and Scaffolding Maths Concepts Effectively	Full day + open-classroom visit	Coaching or Mentoring
	Children's Experiences	Independent Learning	Building Positive Attitudes and Attributes in Mathematics – Metacognition strategies	3 x ½ days	Transformative
		Independent Learning	Using Learning Environment and Bookwork Structure to Support Children's Learning	Full day + open-school visit	Coaching or Mentoring
SECONDARY	Leadership	Leadership Development & Support	Secondary Subject Lead Meetings	3 x ½ days	Community of Practice
	Teaching	Quality First Teaching & Pedagogy	Creative Approaches to Developing Mathematics Fluency in Secondary Classrooms	3 x full days	Cascade
			Developing Confident Problem-Solving Skills at Key Stages 3 and 4	2 x full days	Cascade
	Children's Experiences	Learning & Metacognition	Tackling misconceptions, collaboration, independent learning and problem solving in Secondary Maths	4 x ½ days	Cascade

Phase	Priority Area	Strand	Programme Title	Activity Duration	Professional Development Model[+]
PRIMARY & SECONDARY	Leadership	Leadership Development & Support	Maths Facilitator Skills Training	½ day (repeated x 2)	Coaching and mentoring
	In-School Support	Leadership Development; Quality First Teaching	In-school support from a subject specialist	9 full days	Coaching and mentoring
	Teaching	Specialised Content Knowledge	Specialist Maths for Teaching Assistants*	6 x ½ days	Transformative
		Quality First Teaching & Pedagogy	Open classrooms – showcasing and deconstructing effective practice	8 open classrooms	Community of Practice
	Children's Experiences	Intervention	Action Research Workgroup: Transition & Pre-teach Intervention*	1 x full day and 2 x ½ days (AR)	Action Research
		SEND	Lesson Study Workgroup: Supporting Inclusive Classrooms*	1 x full day and 2 x ½ days	Action Research

*Programme activities in shaded cells are referenced in the discussion below.
[+] The significance of different professional development models is discussed in the next section (here).

Over the seven-month duration of the programme, 468 teachers, teaching assistants, tutors, subject leaders and school leaders from the involved 40 schools were afforded access to this array of quality assurance, leadership development and professional learning activities. To monitor and evaluate outcomes, both internal and external evaluations were conducted. Internal evaluations, most commonly via feedback forms, afforded participants opportunities to reflect on the quality of programme activities and key learning. They also served a formative function (Edelson, 2006) for directing our ongoing design of the professional learning offer. In addition, an externally commissioned summative evaluation sought to measure both process and impact of our improvement approach on teachers' practices and confidence, leaders' self-efficacy, and children's attainment. Unfortunately, significant survey fatigue rendered the results of the external evaluation inconclusive and additional evaluation is needed to accurately validate impact.

With Figure 2 and Table 1 providing reference points, below we rationalise, theorise and exemplify the structure and contents of the MEPC framework and associated programme activities. We do this by elaborating on the eight design principles that informed the framework, and the agendas that infuse these principles.

Theoretical underpinnings: Design research for coordinating quality assurance, leadership development and professional learning agendas

Design research

> *"Educational design research is the systematic study of designing, developing, and evaluating educational programs, processes, and products." (Van Den Akker, Gravemeijer, McKenney & Nieveen, 2006a, p. i)*

Situated in a theory of social learning, design research is suitable for working with "procedural ambiguity, ill-defined problems, and open systems that are socially multi-level, and multi-timescale" (Kelly, 2006, p. 166) – hence the applicability of this approach to the design of our large-scale teacher professional learning and leadership development framework. As indicated previously, our development and subsequent analysis of this framework represented a deliberate attempt at a specific type of design research – 'engineering research' design, the primary aim of which is the development of a new or better product or process. Direct impact on practice provides the main measure of quality, with new insights about the practice serving as an additional outcome (Burkhardt, 2006, p. 121). For the MEPC programme, we sought new insights into whether a particular way of integrating quality assurance, leadership development and professional learning activities (the 'improved product') would lead to long-term changes in the quality of leadership, teaching and learning experiences in subject mathematics (the 'main quality measures'). In addition, and consistent with the aims of design research methodology (Edelson, 2006, p. 101), we also wanted to explore if our design approach could be transformed into a generalisable theory that transcends the subject boundary of mathematics to have application across a range of school-improvement activities.

Our approach embodied the following characteristics deemed common to design research projects (Kelly, 2006; Van Den Akker, Gravemeijer, McKenney & Nieveen, 2006b):

1. Interventionist: the research was aimed at designing an intervention in the real world.
2. Iterative: the design process incorporated cycles of design, evaluation and revision, with insights from ongoing needs analysis activities with involved schools used to directly inform the contents of professional learning activities.
3. Process- and Utility-oriented: the design targeted an improved approach to school improvement and an understanding of the usefulness and effectiveness of this approach for supporting schools with sustainable school-improvement activities.
4. Theory-oriented: the design process and consequent programme framework were based on theoretical propositions; and field testing of the design contributed to theory building about school improvement and validation of the framework.

5. Collaborative: the design process facilitated ongoing collaboration and input from varied parties, including programme designers, participants (teachers, school leaders, support staff), commissioned school-improvement and quality assurance specialists, and commissioned subject-specialists.

6. Multi-level: the design process explicitly targeted a high degree of coordination of activities targeting all levels of the school organisation.

We engaged these characteristics in the design process using a combination of both craft-based and research-based approaches (Burkhardt, 2006), drawing on both professional experiences of working in schools and recommendations of best practice drawn from research literature.

To support our engineering design approach, we drew on Burkhardt's (2009) three aspects of educational design – technical, tactical and strategic. These provided a helpful structure for directing our attention to different 'levels' of the design process, and, so, for enabling a high degree of coordination and coherence between programme activities. *Technical design* is the design of individual elements of a product or programme. *Tactical design* is the overall internal structure of the product or programme and includes specification of the core design principles as informed by research. *Strategic design* is the overall structure of the complete set of products or programmes, considers how the programme will relate to and impact on the end-user, and incorporates relevant role-players from across the education spectrum. Although there is no hierarchy of importance between the aspects, all three need to be carefully coordinated to ensure that the designed product works effectively. This understanding influenced our first design principle for the MEPC programme framework.

Design Principle 1: Strong alignment between strategic, tactical and technical levels of design

Figure 2 provides a *tactical-level* overview of the MEPC programme elements and sets out the key strands around which programme activities were organised. These strands were operationalised at a *technical-level* via a series of targeted activities, including twenty-seven professional development offerings (Table 1), eight open-classroom experiences in both Primary and Secondary settings, and a number of in-school activities including audits of mathematics provision and analysis of needs by external specialists, and strategic support for subject and school leaders. A crucial *strategic-level* dimension of our approach was the coordination of the findings of the comprehensive *whole-school audits* of mathematics provision conducted in each of the 40 involved schools and the contents of the final professional development and open-classroom offering. This reflected our deliberate intention to synchronise forensic quality assurance activities (conducted with leadership) with professional development and learning activities (for all staff) to ensure targeted, coordinated and sustainable whole-organisation change. The audits were conducted by nationally recognised school improvement specialists together with relevant school, subject and phase leadership teams. They served three purposes. First, they identified the individual needs of each school, which was then used to directly influence and inform the focus of the supplied professional development offering. Second, they supported individual school leaders to identify strategic development and improvement proprieties. Third, they were used as a quality assurance measure, with an abridged post-programme follow-up audit used to assess the quality of engagement, gauge impact and identify further areas for development. Following the baseline audits, each school received personalised communication signposting to relevant professional development activities

and in-school support opportunities. This approach ensured that the schools were directly engaged in professional development activities that were relevant to their local contexts and immediate priorities – a further *strategic-level* design element. By including subject, phase and senior leaders in the auditing process, this also served as a leadership development opportunity, giving all leadership levels insight into the school priorities and buy-in to the programme activities. Other *strategic-level* design elements included: ongoing dedicated support for school, phase and subject leaders to support and quality assure staff engagement in programme activities and to evaluate impact; follow-up in-school support for participants from external mathematics specialists to ensure transfer of learning from programme activities attended in out-of-school settings; and, a professional development offering catering for *all* members involved in mathematics provision, including specialist teachers and non-specialist support staff (tutors and teaching assistants), to target all aspects of the students' mathematical learning experiences.

In keeping with our commitment to a research-based approach, the programme structure, strands, and activities were underpinned by research on school improvement, professional development and learning, leadership, and general and maths-specific pedagogic strategies (explored in more detail in the next section). This research established core philosophical ideas for application across all programme activities (tactical level), directly informing the focus of individual programme activities (technical level). Facilitator Training sessions ensured consistent messages and pedagogical practices between tactical and technical levels of the programme. Participants were also offered opportunities to participate in separate Lesson Study and Action Research communities to investigate issues directly relevant to their local contexts in a more rigorous way. Ongoing and regular evaluation of programme activities by the delivery team provided crucial insights as to areas of impact and areas for further development to inform future strategic-level improvement priorities.

In short, the MEPC framework was engineered as a highly coordinated approach to school improvement, with careful alignment between strategic, tactical and technical elements of programme design facilitating coherence of quality assurance, leadership development and professional learning agendas. This supported a comprehensive offering of professional development and support that directly targeted identified priorities at all levels of the school organisation – leadership, teaching and learning, and children's experiences – and with all activities underpinned by common and consistent thinking and pedagogies. It is our view that this high degree of coordination supports long-term sustainable impact in school improvement activities, as consistent with other professional development frameworks that yield positive impact (Timperley, Wilson, Barrar & Fung, 2007; Cordingley et al., 2015)

School Improvement

Following a comprehensive survey of school academies, alliances and partnerships across England, Greany (2018) identified five key fundamentals common to school organisations that facilitate sustainable school improvement:

(F1) establish sufficient capacity
(F2) analysis of needs
(F3) deploy and support leadership
(F4) access to effective practice and expertise
(F5) monitor improvements in outcomes.

As will be discussed below, these fundamentals span a combination of, primarily, quality assurance and leadership development agendas which, when coordinated strategically, facilitate the design of professional learning activities that are closely aligned to individual and collective schools' needs and priorities. As such, these fundamentals proved helpful for informing the focus of a number of our framework design principles targeting the 'leadership' priority area (Priority Area 1) in the MEPC framework.

Design Principle 2: Leadership development is prioritised and professional development activities are directly supported by school leadership

Strong leadership with clear vision is central to the success of any school improvement initiative (Day et al., 2009; McAleavy, Riggall & Fitzpatrick, 2016). This is particularly true for schools in poor socio-economic areas, with leadership – alongside high-quality teaching – being important determinants of whether children are afforded effective and safe learning experiences. Furthermore, our professional experiences and observations evidence that persistent issues with the quality of teaching and learning inevitably stem from leadership deficits at subject and/or senior leadership level. As such, school improvement initiatives in schools with ongoing low attainment require a substantial investment in leadership development alongside teaching and learning to ensure sustainable change and improvement.

Since all schools in the MEPC programme were characterised by high proportions of pupils from poor socio-economic backgrounds and with low attainment, a focus on leadership support and development were necessary design elements of the improvement framework (F3). This leadership development and support targeted all levels of leadership in the school, including senior leaders (headteacher and deputies or assistants) and mathematics subject leaders. To begin with, to ensure that leaders were able to fully commit themselves and staff to all programme activities, schools were given a substantial funding allocation to fund release time and cover. In addition, schools could also request further support from central programme team if sufficient staffing or leadership capacity was not available in school (F1). With capacity established, the analysis of needs (F2) involved senior and subject leaders working together with nationally accredited school improvement specialists (F4) to conduct the comprehensive whole-school baseline audits of mathematics teaching and learning provision. These audits sought out commentary from all members of the school community to agree on school improvement priorities. This ensured that offered professional learning and development opportunities were relevant to the needs of the school community and, so, would be actively supported by leadership – both of which are considered to be key components of effective professional learning experiences (Collin & Smith, 2021; Cordingley et al., 2015). These auditing experiences also served as an important source of leadership development, with the external specialists modelling a rigorous and comprehensive quality assurance and forensic analysis process (F3). Then, school and subject leaders were engaged in ongoing in-school support (9 days-worth) by external school improvement and mathematics subject specialists, facilitating the development of long-term school and subject development plans and monitoring activities (F3). Post-programme audits, supported by the external school improvement specialists, offered leadership the opportunity to evaluate overall impact and identify further improvement needs (F5). This auditing loop also facilitated a degree of quality assurance and accountability of each involved school for external reporting purposes to funders. Importantly, the external mathematics subject specialists maintained a supportive and developmental role in their work with subject leaders, acting as a coach to affirm and challenge their strategic plans and monitoring and

quality assurance activities. This ensured that subject leaders could treat the experience as a development opportunity rather than an evaluative exercise. However, as part of our commitment to an iterative design process, formative inputs from external specialists were sought to inform the contents of the professional learning offer to ensure relevance to current and changing needs.

Design Principle 3: Professional learning activities are directly relevant to participants' and students' needs and focus on improving students' outcomes and learning experiences

Schools with persistent low attainment need support on specific elements of teaching practice, and generic support that is not tied closely to the local context or to identified priorities does not lead to sustainable change (Cordingley et al., 2018; Stoll, Harris & Handscomb, 2012). By strategically designing the auditing dimensions into the MEPC framework, we ensured that we would be able to deliver in-school support and professional learning experiences (Priority Areas 2 and 3) that were directly linked to both collective and individual context-specific needs and priorities (F2). To this end, the auditing process included lesson observations and classroom visits, analysis of students' work, and conversations with leaders, teachers, supporting staff (for example, teaching assistants), students and governors. This ensured a wide perspective on students' and teachers' learning needs and experiences. These audits then supported each school to map specific areas of priority, informed the programme and contents of the wider professional development offering, and signposted individual schools to specific professional development activities to ensure maximum relevance to participants' needs (F4).

Design Principle 4: Professional development activities are part of a strategic and long-term improvement plan and target the whole school community

To ensure sustainable improvement from involvement in professional learning activities, these must be directly linked to school priorities and impact must be evaluated in relation to changes in those priority areas (DfE, 2016a). By designing in the deliberate coordination of audit findings with the contents of professional learning activities, and by including school and subject leaders in these quality assurance processes, we modelled a strategic process for integrating targeted professional learning activities into long-term improvement plans (F3).

A further strategic-level element of the framework was the design of programme of activities to target *all* members of the school community involved in supporting students' mathematics learning (F4) – hereby supporting a 'whole-school' improvement focus. The varied audiences targeted in the baseline audits provided invaluable information about the specific needs and priorities of different groups within the school community (Priority Areas 2 and 3), and this information was then used to inform the programme offering. To this end, we distinguished between professional learning activities targeting specialist teachers and non-specialist teachers and non-mathematics specialist (such as teaching assistants and tutors). For specialists, professional learning activities foregrounded a focus on 'Quality First Teaching' (see Figure 2) by exploring innovative teaching strategies. For example, the *Problem Solving at KS 1 and 2* activities (Table 1 – shaded cells) explored ways of supporting children to engage in problem solving activities across a range of topic areas. By contrast, for non-specialists the 'Specialist Knowledge' strand was prioritised.

For example, the *Specialist Maths for Teaching Assistants* course ran over six half-days and focused primarily on supporting participants to develop a deeper conceptual understanding of topics. However, since many teaching assistants work with smaller groups of children who struggle in mathematics, pedagogic strategies for children with maths-specific learning difficulties were also foregrounded.

An omission from the final offer was an activity targeting support for parents. Given the importance of parental involvement for supporting children's learning (Castro et al., 2015), we recognise this as a shortcoming of the programme offering. This is an area of focus we aim to research further and address in future school-improvement work.

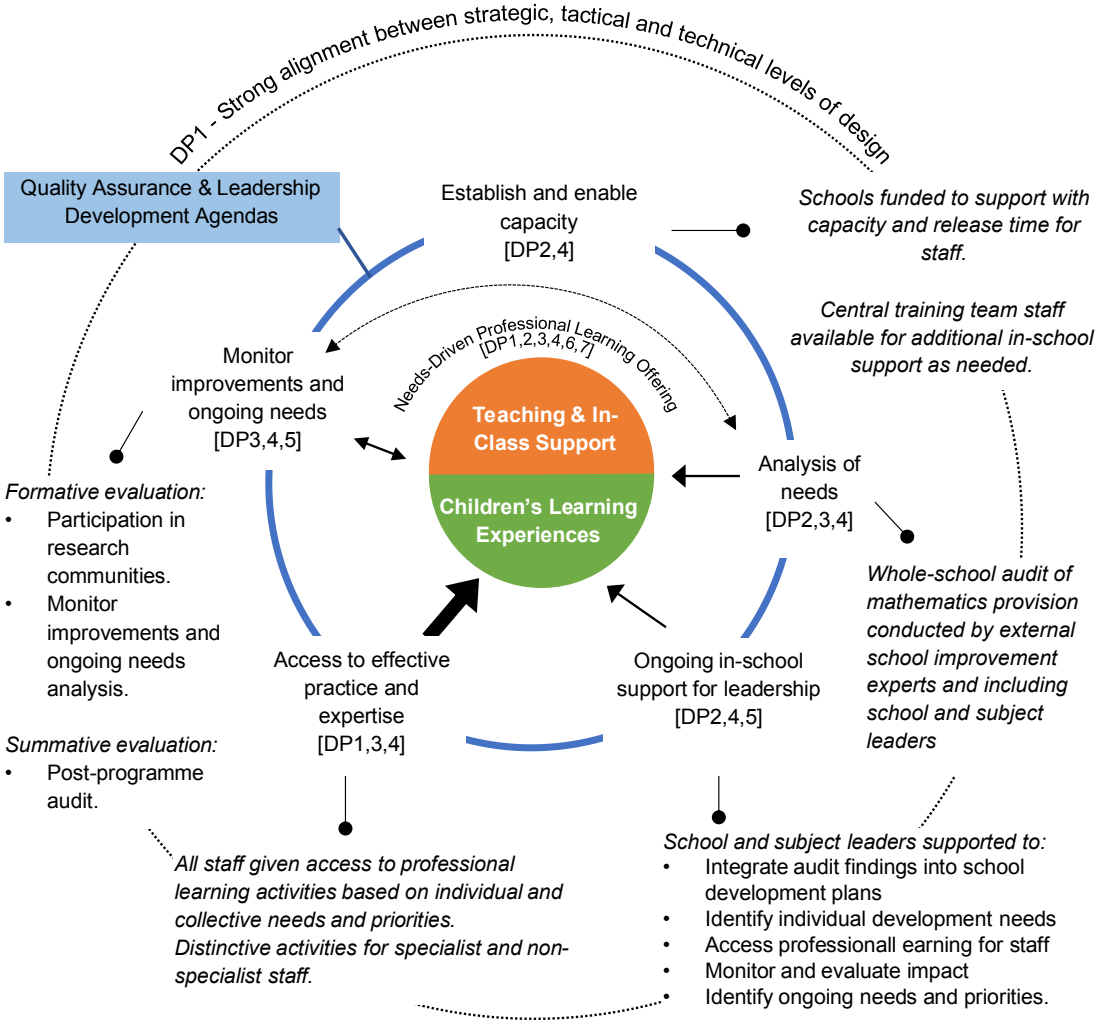
Design Principle 5: Sustainable improvement is supported by ongoing research of practice and impact evaluation

Sustainable improvement requires regular evaluation of needs and impact and reflection on current practices. We operationalised this principle in two ways. First, the auditing activities modelled a form of forensic analysis and evaluation to identify needs and priorities – which is consistent with Greany's (2018) fundamental principle of monitoring improvements in outcomes (F5). Second, we applied an expanded understanding of monitoring in our design process to include a focus on schools actively researching their own practices. Recognising the value of research for informing classroom practices (Brown & Zhang, 2017), we see the capacity to 'particularise theory' (Leinhardt, Young & Merriman, 1995) as an essential element of sustainable school-improvement. As such, we designed in opportunities for schools to engage in collaborative 'Research Communities' (see Figure 2) focused specifically on trialling and evaluating strategies for improving children's learning experiences and independent learning behaviours (Priority Area 3). The *Action Research Workgroup: Transition* & *Pre-teach Intervention* community provided teachers with the opportunity to design and trial bespoke context-specific intervention strategies for students in their local settings. The *Lesson Study Workgroup: Supporting Inclusive Classrooms* community provided a collaborative space for teachers to develop shared resources targeting children with special educational and learning needs, to trial and observe the use of these resources in live teaching sessions, and to reflect collaboratively on learning and impact.

In sum, these four design principles, embodying quality assurance and leadership development agendas, facilitated a dedicated focus on the 'leadership' priority area (Priority Area 1) in the MEPC framework. In addition, they ensured that the developed professional learning activities were closely aligned and responsive to individual and collective needs and priorities. This interplay of design principles and agendas is shown in Figure 3.

The remaining three design principles relate specifically to the structure and contents of the professional learning activities (the 'inner circle' in Figure 3) targeting, primarily, improvements in teaching and support (Priority Area 2) and children's learning experiences (Priority Area 3). These principles are underpinned by research on professional learning and development, and it is to that topic that the discussion now turns.

Figure 3 – Coordinated quality assurance, leadership development and professional learning activities and associated design principles



Professional learning and development

The professional learning agenda in the MEPC framework is embodied within a comprehensive offering of professional learning activities directly informed by schools' individual and collective needs and priorities identified via the quality assurance and forensic analysis processes. This agenda was operationalised via design principles focused on giving participants agency and autonomy to transform their own practices, supporting participants to transfer learning to local contexts and settings, and enabling participants to develop varied knowledge and skills to enhance children's learning experiences.

Transformative professional development

We make an important distinction between professional learning and professional development in our work with teachers, with the latter referring to the collaborative processes and activities that teachers engage in to develop, challenge, and reflect on their understanding of subject-specific content, pedagogic strategies, and more general aspects of educational practices. For us, the primary aim of professional development, then, is to facilitate deep and sustained professional learning, and to support teachers and school

leaders to reflect and question their existing understandings and practices and the values and beliefs that underpin these. In other words, to challenge their professional identities (Sammons et al., 2007). This priority is consistent with others professional development activities that have effectively supported changes in teacher's practices (Cordingley et al., 2015; Timperley, Wilson, Barrar & Fung, 2007).

This perspective foregrounds a 'transformative' agenda (Kennedy, 2005), ensuring that participants play an active role in the learning process and act with professional autonomy. This transformative agenda increases capacity for professional autonomy – or what Hargreaves and Fullan (2015) refer to as 'professional capital', which we believe is a necessary condition for supporting schools and school communities to take ownership of school improvement processes. As shown in Table 2, this agenda is more likely to be facilitated through specific types of professional development activity that enable participants to have autonomy and ownership of their learning and development. Consideration of the above prompted our sixth design principle.

Table 2 – Spectrum of Professional Development Models – adapted from Kennedy (2005)

Model of Professional Development (PD)	Outcome	Purpose	
Training	Skills-based approach where passive participants receive training from an 'expert' to update their competence.	Transmission	Increasing capacity for professional autonomy ↓
Award-bearing	Relies on completion of an award-bearing programme that is externally validated.		
Deficit	Designed to address an externally perceived deficit in teacher performance.		
Cascade	Teachers attend training and cascade learning to colleagues in local contexts.		
Standards-based	Teachers develop their teaching around a collection of professional actions which evidence that a certain standard of teaching has been achieved.	Transitional	
Coaching/mentoring	Centrality of a one-to-one relationship between professionals to supports professional learning.		
Community of practice	Similar to coaching but involving a wider collection of professionals who support each other's professional learning.		
Action research	Participants engage collectively in a research process to investigate issues relevant to their practice.	Transformative	
Transformative	*" … the key characteristic of the transformative model is its effective integration of the range of models described above, together with a real sense of awareness of issues of power, i.e., whose agendas are being addressed through the process."* (Kennedy, 2005)		

Design Principle 6: Professional development activities enable and support participants to evaluate their practices and to have autonomy and ownership over (changes to) these practices

The far right-hand column of Table 1 lists the professional development model associated with each programme activity in the MEPC framework and demonstrates how we operationalised this principle in the framework design to prioritise development in teaching and in-class support (Priority Area 2) and children's learning experiences (Priority Area 3). By engaging this principle in the design process, we ensured that participants had access to a collection of professional learning experiences embodied within a combination of cascade, coaching, community of practice, action research, and transformative models of professional development, since these are more likely to facilitate a transformative agenda (Kennedy, 2005). By contrast, training, award bearing, deficit and standards-based models of professional development were downplayed. The potential for once-off sessions to function as training rather than cascade models was offset by the in-school support element that directly aided participants to cascade learning to wider staff teams. Furthermore, this extensive in-school support element, reinforced by several community-of-practice research activities, and quality assured through the follow-up audit process, spearheaded a transformative agenda for equipping teachers and leaders with the capacity for increased ownership and autonomy over school-improvement activities.

Enabling transferability of learning to local contexts

Joyce and Showers (2002) argue that it is the combination of theory, modelling by experts, opportunities for practice and application in local contexts, and coaching, that affords the greatest potential for the transferability of learning from training environments to classroom practice (see Table 3). Theory provides a common language and understanding around which to frame a learning experience, giving insight into the underpinning rationale of the professional development approach and an evidence-base of tested practices shown to impact learning. Experts help to mediate and translate this theory into workable classroom activities, support participants to improve their understanding of the evidence, and offer alternative perspectives that challenge teachers' beliefs and expectations about how students learn (DfE, 2016b). Opportunities to apply learning in local contexts are vital for enabling participants to translate learning into practices relevant to local needs and priorities, followed by opportunities for reflection, discussion and deconstruction (McDonald, 2014). Experts support this process by modelling effective practice and coaching participants via observation and feedback (Cordingley et al., 2015).

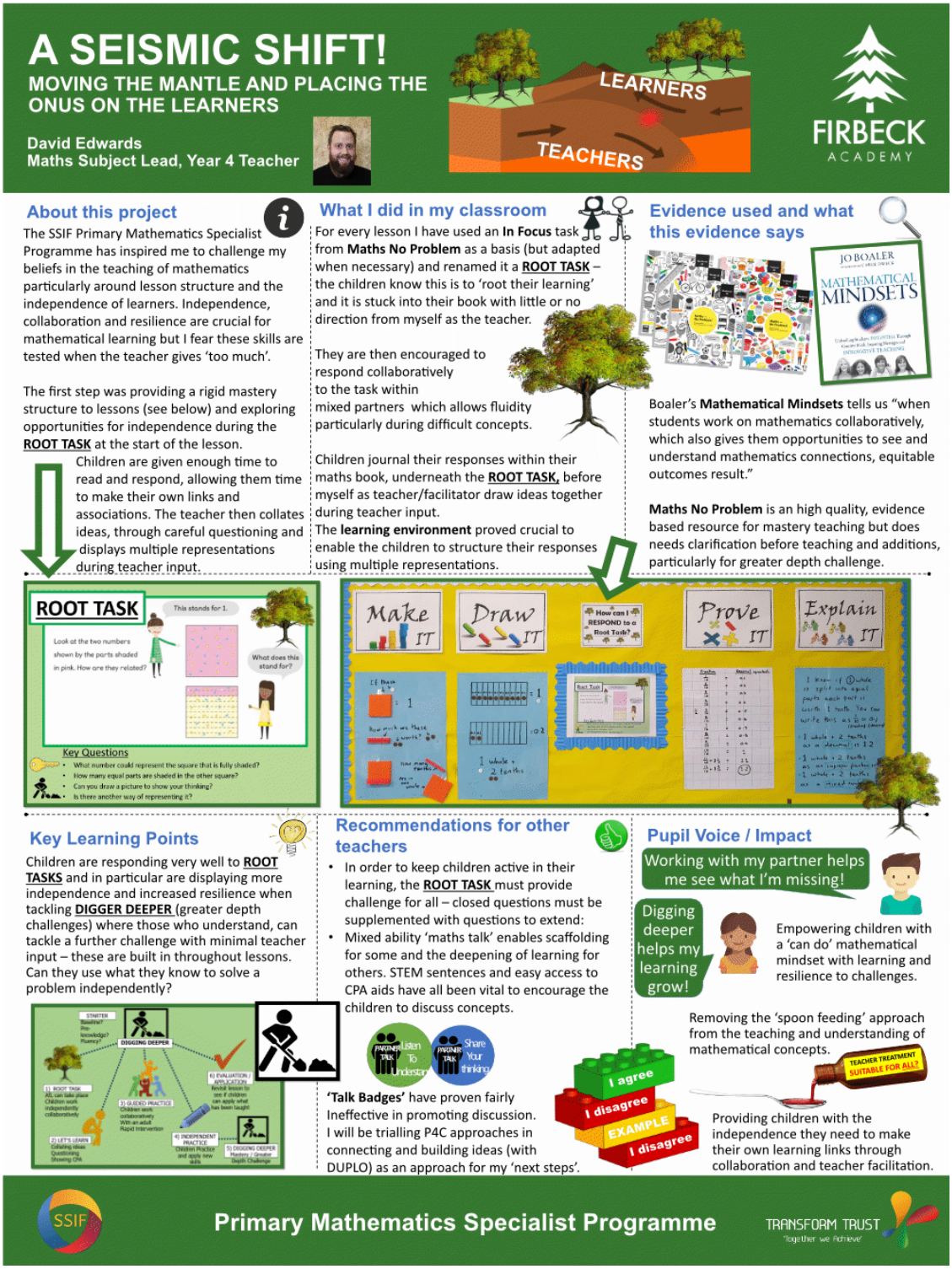
Table 3 – Effects of training and coaching on teachers' implementation (Joyce & Showers, 2002)

	OUTCOMES (% of participants who demonstrate knowledge, demonstrate new skills in a training session, and use new skills in the classroom)		
Training Components	**Impact on Knowledge**	**Impact on Skill**	**Transfer to Practice in the Classroom**
Theory	10%	5%	0%
Theory + Modelling	30%	20%	0%
Theory + Modelling + Practice	60%	60%	5%
Theory + Modelling + Practice + Coaching	95%	95%	95%

Design Principle 7: Professional development activities include, where possible, a combination of theory, modelling by experts, opportunities for practice and application in local contexts, and coaching

The *Primary Maths Specialist Programme* (Table 1) evidenced each of these elements and characterised a full commitment to a transformative model of professional development for challenging teachers' professional identities. For the thirty-nine involved teachers, this programme comprised seven full-day contact sessions and explicitly targeted the development of participants 'content knowledge for teaching' (Ball, Thames & Phelps, 2008) by engaging with mathematics-specific specialised content knowledge and pedagogical content knowledge. These contact sessions were supplemented with in-school coaching and support by an external mathematics specialist to facilitate transfer of learning to local contexts. In addition, participants also engaged in a personal action-research project in their local school setting and were supported to share their learning with the wider staff team by facilitating a professional learning experience during a staff meeting and presenting a poster session to senior school leaders at a mini-conference (Figure 4).

Figure 4 – A Primary Maths Specialist participant's action research project write up



For shorter courses (for example, half-day content courses), the 'coaching' dimension was again facilitated via the in-school support element. All sessions, irrespective of duration, included theory on content and pedagogical knowledge (see Principle 8 below) and modelling of classroom strategies. Exposure to additional expert modelling was facilitated via carefully orchestrated open-classrooms experiences, top-and-tailed by pre- and post-lesson discussions. Dedicated *Facilitator Training* sessions prior to the launch of the programme offering ensured collective understanding of the importance of this combination of elements, with the first author quality assuring all materials prior to each professional learning activity.

Combined focus on content knowledge, pedagogy and independent learning strategies

The understanding that gave rise to our final design principle was summarised by Cordingley.

> *"All the reviews [of effective professional development] found that pedagogy and subject knowledge were equally important; the strongest single review went further to state that CPDL [continuous professional development and learning] focussed on generic pedagogic strategies is insufficient, particularly in maths, and that it is important to consider several alternative pedagogies for specific pupils too." (Cordingley et al., 2015, p. 5)*

Design Principle 8: Professional development activities prioritise both subject-specific content knowledge and pedagogical knowledge, with some additional focus on more general strategies for supporting students to become independent learners

Given the mathematics-specific focus of the MEPC framework, we drew heavily on Ball, Thames, and Phelps' (2008) work on domains of mathematical knowledge for teaching to frame activities targeting the development of teachers' practices (Priority Area 2). This ensured a dedicated focus in all programme activities on both subject matter knowledge (SK) and pedagogical content knowledge (PCK). The extent to which elements of SK or PCK were prioritised was influenced by the target audience of each programme activity. Activities targeting subject specialists (e.g. teachers and maths subject leaders) prioritised the development of PCK over SK. By comparison, activities targeting non-subject specialists (e.g. teaching assistants and tutors) prioritised SK over PCK.

Additionally, and specifically in support of the priority for impacting children's learning experiences (Priority Area 3), the MEPC framework included a selection of professional learning activities focussed on general and mathematics-specific strategies for supporting independent and reflective student learning, drawn from research about cognition, self-regulated learning, and positive dispositions and mindsets (Boaler, 2015; Cragg & Gilmore, 2014; Kilpatrick, Swafford & Findell, 2001; Quigley, Muijs & Stringer, 2018; Willingham, 2009). Our motivations here stem from an understanding that most curricular, teaching and assessment processes foreground the domains of mathematical content, knowledge forms, and competencies; however, underlying cognitive challenges and deficiencies (including with working memory, central executive functions, visuospatial and language systems) can have a significant impact on mathematical learning and experiences (Cragg, Keeble, Richardson, Roome & Gilmore, 2017). In addition, both teacher's and children's attitudes about mathematics directly influence their learning experiences (Boaler, 2015; Ramirez, Hooper, Kersting, Ferguson & Yeager, 2018). As such, sustainable improvements in children's learning experiences in mathematics require teachers and leaders to put systems and strategies in place that reduce emphasis on memorisation, support children's independent learning behaviours, recognise the impact of cognitive structures on learning, and engender positive mathematical mindsets. This commitment is reflected in the suite of professional learning and research activities in the MFEC framework specifically targeting children's learning experiences:

1. Using learning environment and bookwork structure to support children's learning
2. Building positive attitudes and attributes in mathematics

3. Tackling misconceptions, collaboration, independent learning and problem solving in secondary maths

4. Action research workgroup: Transition & pre-teach intervention

5. Lesson study workgroup: Supporting inclusive classrooms

Conclusion

In alignment with the perspective that "School leadership is second only to classroom teaching as an influence on pupil learning" (Leithwood, Harris & Hopkins, 2008), the MEPC framework represented a deliberate design research process targeting sustainable improvements in Primary and Secondary school mathematics by prioritising three focus areas of improved leadership, teaching and in-class support, and children's learning experiences. The framework was underpinned by eight design principles. These represent a cross-section of agendas which we believe are necessary for sustainable school improvement – namely, forensic analysis and quality assurance, dedicated leadership development, and professional learning and development of teachers and other staff involved in mathematics lessons. These design principles directly informed the structure and contents of all programme activities and ensured a high degree of coordination of these agendas to target the three priority areas. This approach was motivated by our belief that this high degree of coordination of agendas and subsequent programme activities via clearly articulated design principles would make it more likely for schools to make sustained improvements in identified priority areas. In this, we viewed the contribution of this design research process as the production of "new theories, artefacts, and practices that account for and potentially impact learning and teaching in naturalistic settings." (Barab & Squire, 2004, p. 2) for the 468 teachers, teaching assistants, tutors, subject leaders and school leaders from the involved 40 schools who participated in the programme.

Our design and implementation processes were not without challenge, and the 'use-inspired' (Stokes, 1997) and 'exploratory' (Edelson, 2006) nature of our design research process presented a number of risks and limitations across all of our design principles. We experienced a constant tension in our roles as both programme designers and as researchers - needing to show impact to support leaders, staff and children and to meet funding targets, and at the same time seeking to understand the true value of our design process. Ensuring consistency of the intended philosophical and pedagogical approaches across the large number of activities proved equally challenging, despite our explicit attempt to coordinate strategic, tactical and technical levels of the design process (Design Principle 1). Although we attempted to mitigate these risks by grounding our design principles and consequent framework in theory and research (Edelson, 2006), the common difficulties associated with "theorising practice and particularising theory" (Leinhardt et al., 1995, p. 404) were ever present, and we experienced some issues with maintaining fidelity to our intended approach. Predictably, staff changes and absences, together with a degree of participation fatigue from involved schools towards the end of the programme (Design Principles 2, 5 & 7), impacted on engagement and in-school follow-up quality assurance and evaluation activities. And, understandably, priorities arose in schools for other school improvement and subject areas, drawing capacity and focus away from MEPC activities (Design Principles 3 & 4). Despite our attempts to design transformative professional learning experiences that imbued participants with ownership over changes to their practices (Design Principles 6 & 7), many participants were restricted by wider school practices and policies favouring centralisation and standardisation of

curriculum and pedagogy – as characteristic of a neo-performative education system (Wilkins, Gobby & Keddie, 2021). In addition, and as acknowledged previously, there remained gaps in our professional learning offer. Additional focus on parental engagement and further strategies for supporting children's learning experiences would have complemented our primary focus on subject-specific content and pedagogical knowledge (Design Principle 8).

Despite these challenges, we received largely positive feedback from involved school leaders and participants. This was particularly with respect to the value of the high degree of coordination of quality assurance and forensic analysis findings with leadership development and professional learning activities for all staff, thus enabling the targeting of local needs and priorities. We have also seen improvements in the quality of mathematics teaching and leadership in some involved schools, evidenced via business-as-usual monitoring activities. However, we recognise that although the availability of this anecdotal 'formative' evidence (Edelson, 2006) was instrumental for informing our iterative and responsive design process, further rigorous summative evaluation of both *implementation process* (of the adopted framework) and *impact* (on students' attainment) (Fox, Grimm & Caldeira, 2016; Parsons, 2017) is needed to validate our belief regarding the sustainable impact of this coordinated school-improvement approach.

Although subject Mathematics provided a relevant context of application, the design principles were framed in general terms to reflect our contention, albeit as yet untested, that the principles transcend subject boundaries. As such, our future work endeavours will explore if and how this approach to school improvement, underpinned by these design principles, has applicability in a wide range of school-improvement activities, including: the development of teaching practice across all subject areas; leadership development at all levels of the organisation; skills development for staff (teaching and non-teaching); and development activities with parents and the wider community. This future work will inform adaptations to the design principles, hereby evidencing our commitment to the ongoing and iterative design research of our improvement framework. Our hope is that positive experiences in this regard will signpost the value of this approach for leaders, teachers, those involved in professional development, those involved in teacher training, and many others seeking sustainable improvements in leadership, teaching and learning practices in schools.

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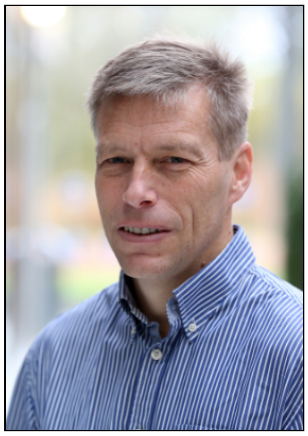
About the Authors



Marc North is an Assistant Professor of Education at the University of Nottingham in the United Kingdom and currently works as a tutor on the Primary Postgraduate Certificate in Education Programme. Marc started out as a secondary Mathematics teacher in South Africa, before moving to work in a professional development role with teachers in schools in rural and disadvantaged communities. His experiences in these communities affirmed his belief in the importance of numeracy and mathematical literacy for engagement in real-world activities, and he was a key role-player in the authoring and implementation of a national Mathematical Literacy Curriculum in South Africa.

More recently, he has led Mathematics across an association of Primary Schools in Nottingham City in England and worked on several research projects supporting the development of innovative teaching and learning experiences in secondary mathematics in both school and further education college settings.

Marc has a specific research and professional interest in working closely with beginning and experienced teachers to explore teaching strategies and resources that support children who find Maths difficult and which reduce emphasis on memorisation - such as using representations and real-life contexts. In this, his professional and research practices draw heavily on the Realistic Mathematics Education and Visualisation traditions. In his spare time, he is particularly passionate about riding his bicycle, pretending to play his guitar, saving earthworms from pavements and eating chocolate – but not all at the same time!

Sarah Heesom *writes*: I have over 20 years' experience of forming and leading education partnerships and projects focussed on people development within schools. This has involved set-up of a Teaching School Alliance and Academy Trust. As part of this work, I have led a range of project, business and teaching teams. My background also includes work in the private and voluntary sectors with experience of creating and running staff engagement programmes and charitable foundations.

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I have specialised in the support of Deputy and Headteachers acting as facilitator and coach over the last 10 years, working with colleagues to find solutions to organisational challenges and gain insight into our own leadership behaviours, confidence and thinking.

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