Shining a light
on inclusive science teaching and learning (7-14 years)

Bridging the primary and secondary transition by tackling educational disadvantage in the science classroom.

A report on the Smarter Choices Project by the Science & Engineering Education Research and Innovation Hub (The University of Manchester) supported by the SHINE Trust and the Comino Foundation.

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Foreword

This important report addresses one of the biggest challenges facing our schools, that of breaking the link between economic disadvantage and educational outcomes, focusing in particular on science. As such, it develops ideas and practical suggestions that are worthy of wide attention.

Central to the ideas that are developed in the report is a process of collaboration within schools and between schools. In this way, expertise is shared and encouragement is provided to explore new possibilities for supporting the inclusion and learning of all students. The involvement of university researchers brings further insights into this process.

At the heart of collaborative processes like this is the development of a common language with which colleagues can talk to one another, and indeed to themselves, about detailed aspects of their practice. Without such a language of practice, teachers find it difficult to experiment with new possibilities.

Much of what teachers do during the intensive encounters that occur during the busy school day is carried out at an intuitive level. Furthermore, there is little time to stop and think. This is why having the opportunity to plan together and see colleagues at work is so crucial to the success of attempts to develop practice. It is through shared experiences that colleagues can help one another to articulate what they currently do and define what they might like to do. It is also the means whereby space is created within which taken-for-granted assumptions about particular groups of learners can be subjected to mutual critique.

Under the right conditions, evidence-based approaches of the sort explained in this report help to make the familiar unfamiliar in ways that stimulate self-questioning, creativity and action. In so doing they can lead to a reframing of perceived problems that, in turn, draws the teacher's attention to overlooked possibilities for addressing barriers to participation and learning. In this way, differences amongst students, staff and schools become a catalyst for improvement.

Mel Ainscow
Emeritus Professor of Education
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The opportunity to look more closely at the issue of how science teaching and learning supports our more vulnerable pupils is both timely and significant. In an area such as Greater Manchester there are many social challenges that impact on a young person's education, especially notable when transitioning from one school to another. Although this project was undertaken at the most difficult time of the CV19 pandemic, we found ways to successfully inspire and support teachers to collaborate, reflect on and adapt their practice. It has provided opportunity for us all to take time to think about the realities of our science classrooms and listen attentively to the needs of our pupils. This report is offered to invite further professional dialogue and partnership, so that together we can move forward in enhancing inclusive science learning for all pupils.

Dr Lynne Bianchi
SEERIH Director
The University of Manchester

1. Introduction

Research from the Education Endowment Fund (2018) shows that there is a gap in science outcomes between disadvantaged pupils and their classmates at every stage in the education system. The Science Capital research (Archer et al 2015; Nag Chowdhuri 2021) also highlights evidence that many children experience school science as 'abstract, disconnected and irrelevant to their lives'.

The gap first becomes apparent at Key Stage 1 (ages 5-7 years) and only gets wider throughout primary and secondary school and on to A-level. In order to address this issue the education system needs to collaboratively focus on and challenge these gaps by developing interventions that are rooted in robust evidence. Changes in teaching and learning need to be embedded and sustainable, which is best achieved when teachers have support to professionally and critically reflect together.

Defining educational disadvantage is also highly problematic due to the various and intersectional ways in which disadvantage plays out in society which include, but are not limited to, English as an additional language (EAL), poor attendance and Special Educational Needs (SEN). Research reports that educational disadvantage starts in the womb, with the importance on free maternal and child health care having influence on children's later education outcomes (Education for All, 2010).

Several contextual factors are found to limit a child's academic achievement in school, and these are increasingly impacting on particular groups, including ethnic minorities, refugee/ asylum seekers, immigrants, young people who have spent time in care, and poorer pupils (OECD, 2016; Strand, 2014). Literature shows that numerous factors are measured to decide whether a child is from a disadvantaged background, such as the area a child lives in, ethnicity, socio-economic status, gender, and religion (Heath et al., 2018; Schwartz et al., 2015; Coughlan et al., 2014). The Department for Education (DfE) in England associates the definition of a disadvantaged pupil with the eligibility of receiving free school meals (Long and Bolton, 2015; Foster and Long, 2017). This definition is also supported by Ofsted as they refer to disadvantaged pupils as 'those pupils for whom the pupil premium provides support'.

For a child to be eligible for the Pupil Premium, they must have (Long and Bolton, 2015):

'...been eligible for free school meals during the past six years, children who are in care, and children who were previously in care but left in particular circumstances such as adoption'.

Eligibility for free school meals (FSM) and reduced-price lunches; family income below a certain threshold; residence in a potentially deprived area; or low progression neighbourhoods identified by indices of multiple deprivation are all indicators of a lower socio-economic status (SES) and efforts for widening participation agenda are targeted by government in the United Kingdom and elsewhere (Banerjee, 2016). Interventions and policies, such as free compulsory education, free school meals etc. seek to remediate the unfair underrepresentation and underachievement of children in such contexts.

With regard to science education, there is limited evidence to suggest that educational interventions have been able to raise pupil performances in standardised national tests nor widen participation in the UK (Banerjee, 2016). However, there are teaching frameworks to support teachers to reflect on and develop ways to promote children's engagement and identification with science that are influencing practice at classroom level, namely the Science Capital and The Primary Science Capital Teaching Approach (Archer et al, 2015; Nag Chowdhuri et al, 2021).

In these studies, a focus was placed on Key Stage 3 and 4 (11-16 years) pupils, where teachers were encouraged to 'tweak' their existing practice to make science more relevant to the pupils. These focused on striving to be socially just so as not to exclude underrepresented groups in STEM fields. The social justice rationale is founded on the belief that:

- It is important to address social inequalities.
- Science can provide a route to social mobility, so more efforts should be made to include under represented communities.
- Scientific advances mean that people will need to be increasingly STEM-literate if they are to be active citizens who can have a say in society.

These reflective approaches have resulted in almost 70% of teachers' classes recording notable impact across four areas of research including children's science identities, science trajectories, science agency and out-of-school science engagement (Nag Chowdhuri et al, 2021). This study involved collaboration with practising teachers to also seek to bring about change through reflective professional activities focused on enhancing pupils' experience of science learning in schools in areas of high socio-economic disadvantage. We have sought to more thoroughly understand the reasons linked to underachievement of disadvantaged pupils in primary and lower secondary science education in seven schools in Greater Manchester.

Government policy describes disadvantage as those pupils who are allocated 'Pupil Premium' funding which includes pupils in year groups who receive free school meals (FSM); pupils with no recourse to public funds; looked-after children (as defined by the Children Act 1989); children who have ceased to be looked after by a local authority in England and Wales because of adoption, a special guardianship order, or child arrangements order; and pupils in year groups in receipt of child pension from the Ministry of Defence (DFE 2021). In appreciating these factors, it is intended that this study further explores the implications of disadvantage specifically on science learning in mainstream primary and secondary. The additional challenge of working across two phases of education also focuses attention towards the commonalities in teaching and learning approaches being used, or potentially that can be used, to remediate the challenge of disadvantage towards improved achievement and enjoyment of science learning.

Notably in Baars et al (2018) research, they explain that the majority of primary schools, both high and lower-performing, reported that the transition to secondary school could pose a risk to disadvantaged children's aspirations and attainment if the primary school, secondary school and parents did not work together to support pupils. High-performing primary schools in their study tended to diminish risks to disadvantaged pupils' aspirations in science learning by forging links with local secondary schools and creating collaborative partnerships. Such partnerships involved providing information and guidance to parents and enabling secondary school visits. Seeking to establish what actions and interventions can be undertaken at science lesson level, as opposed to whole-school structures, was a key aim of this project.

Inevitably the timing of this project has incurred additional challenge, in particular the way in which the CV19 pandemic has influenced the way and amount of science teaching undertaken, and the proportion and nature of disadvantage affecting pupils (Green, 2020; Children's Commissioner, 2020).

Similar findings were found in Canovan and Fallon's (2021) research and that of the Wellcome Trust (2021) which focused on the impact of CV19 on primary science. Here they noted that teachers found difficulty in adapting the science curriculum for home learning due to the lack of resources within households, exacerbated in those of disadvantaged pupils and compounded by whether parents had the knowledge to assist their children and rectify misconceptions.

Working across the primary and secondary phases provides opportunity to explore the approaches schools and teachers adopt to maintain consistency and progression in science learning for disadvantaged learners. Tytler, et al. (2008) identify that secondary school processes of streaming, tracking and setting can perpetuate the negative influence of disadvantage. In particular, they state that the impact of streaming especially for those in the lower streams can include a curriculum lacking challenge, decrease in material coverage, greater discipline problems, and a devaluing of these students. In this project, shared discussions and collaborations have been brokered between science teachers in primary and secondary schools in areas of high socio-economic disadvantage. Co-teaching has not been feasible due to the constraints of the pandemic, yet professional discussion, debate and reflection has led to shared insights into science teaching and learning for disadvantaged pupils at primary (5-11 years) and Key Stage 3 (11-14 years).

Read more about the Smarter Choices project in this Primary Science Journal Article

2. Project Aims

The project involved primary-secondary teacher collaborations seeking to improve learner outcomes in science across Key Stage 2 to 3. Through a supported teacher development programme focused on enhancing professional collaboration between teachers of science in primary and secondary schools, it sought to:

- review the needs and experience of pupils, with specific consideration of features of educational disadvantage and how this influences science learning.
- identify the areas of greatest disparity or misunderstanding in the teaching of science across primary and secondary school, with a view to narrowing the opportunity gap.
- identify and refine sustainable routines of collaborative practice across primary and secondary school to improve science outcomes of educationally disadvantaged pupils.

Three key areas of outcomes are expected (as aligned to DfE Standards of Professional Development Guidance 2017):

1. **Improved Pupil Outcomes** for educationally disadvantaged children (identified through Pupil Premium allocation and those identified to be 'not on track to gain the expected standard' at age 9-10 years):
    - o building stronger primary school foundations of scientific understanding demonstrated through improved achievement data (pupil voice, lesson observation, work scrutiny etc).
    - o increasing attainment demonstrated through standard school progress measures.
    - o enhancing learning opportunities by improving teacher understanding of pedagogy and assessment of progression in science between age 11-12 years (primary-secondary school transition years).
2. **Improved Pupil Outcomes** for all children through the focused enhancement of socially just teaching approaches in science by:
    - o focusing on common language for science and working scientifically skills between teachers and pupils.
3. **Indirect Professional Development Impact** for teachers by:
    - o professional development in the use of action learning sets improving skills, subject pedagogical knowledge and confidence through teacher-to-teacher collaboration.

Table 1 provides a summary of the challenge the Smarter Choices project was seeking to tackle.

Questions of the project	Description
What problem is it trying to solve?	The perceived disconnect between pupils' experience of science learning across the primary and secondary phases, with particular focus on how to improve the experience of disadvantaged pupils at this stage in their learning career.
Why is it trying to solve it and for whom?	To support inclusion and progression of learning to improve pupil outcomes in science.
What are the active ingredients to be used?	Cross-phase teacher CPD related to: developing a shared understanding of the features of disadvantage influencing pupil's experience of learning science. Collaborative lesson research to: design and trial teaching approaches that enhance science learning experiences for disadvantaged pupils.
What are the expected implementation outcomes?	Greater shared understanding of the features of disadvantage impacting on pupil's learning of science within and across schools in the same geographical area. Improved knowledge of methods to remediate the negative influence of disadvantage within the science classroom. Sustained relationships between science teachers in primary and secondary schools, with established routines for dialogue about sequencing the science curriculum.

Table 1: Overview of project detail

3. Theory of Change

OVERARCHING AIM: Tackling the disadvantage gap in science through professional and pedagogic collaboration across the transition

Aims

1	2	3	4	5	6
Review the experience of pupils, with specific consideration of low attainers in science	Develop sustainable routines of collaborative reflective practice across primary and secondary school	Identify the areas of greatest disparity or misunderstanding in teaching science across primary and secondary school	Co-create approaches to improve pupil outcomes, and ensure improved rates of progress to reduce learning gaps	Translate the insights into various modes of communication, open for professional peer review	COVID contingency – Support pupils in participating schools to directly engage with STEM professionals

Inputs

Staff time
Project lead; Researcher; 2 x Project Mentors (Sci Ed specialists); Administrator; Research support (transcription); Finance officer

Additional experts in fields of
Vocabulary/Tier2 language; Educational disadvantage and inclusion

School clusters
2 clusters: Manchester – 1 secondary & 3 primary; Rochdale: 1 secondary & 2 primary
Involvement of: Head teacher Head of Science Department/Science Subject Leader Teachers of upper primary and lower secondary school

Activities

Recruit
2 secondary schools and associated feeder primaries

Literature review and ethical approval

Transition Deep Dives

Regular meetings
as clusters, whole project, governance groups, 1-1 school & mentor, SEERIH team for reflection

Portfolio
Individualised to each school

CPD input
Programme of CPD, virtual and in-person, with additional extras due to CV19 out-of-school learning

Dissemination
Interim and final reports; conference presentations; journal articles and academic papers

Outputs

School characteristics
WP data gathered during recruitment

Participant and pupil engagement/ impact
recorded in school portfolios

CPD Programme outcomes gathered through deep dive observations, polls, surveys and portfolios

Reports on Transition Deep Dive results
verbal and written report provided to school and notes and report retained for project monitoring and reporting purposes

Dissemination metrics
3 annual reports; 6 interim reports,
1 final report
1 Journal publication
At least 1 x national conference presentation
1 x academic research paper

Outcomes for the schools

Science lessons become more accessible to all learners

Progression within lessons, topics and year groups is accelerated for all

Science teachers and leaders have a range of strategies in place to support their colleagues in lessons to provide an inclusive and progressive learning environment for all pupils

Methods of collaboration tested and ready for legacy implementation between local schools

Profile of science in school raised

Sector awareness of key issues related to disadvantage and transition

Impact

Attainment gap closed for disadvantaged learners in science across the transition

Enhanced knowledge of multiple tags of disadvantage and their impact on science learning in primary-secondary schools

Sharing of practice in wider Greater Manchester networks, supporting insight into issues related to transition and disadvantage

4. Project process

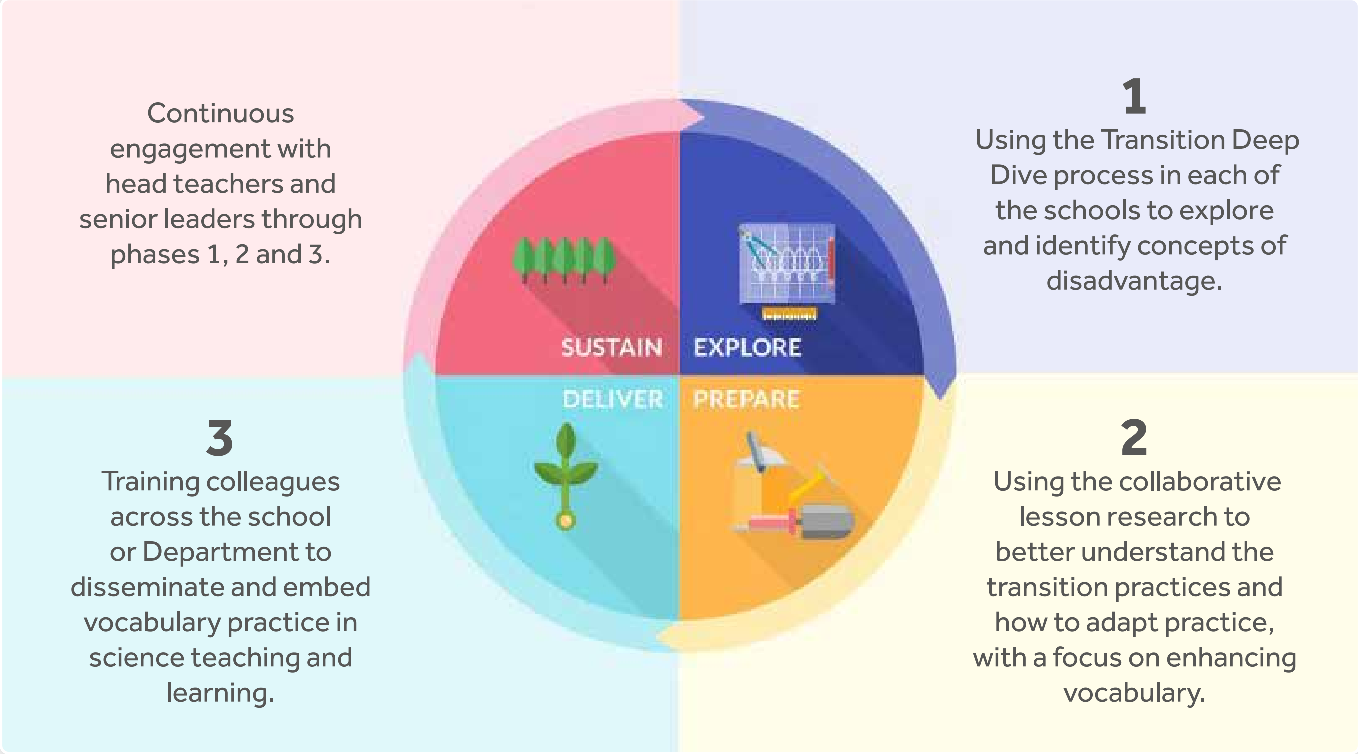
2 cohorts of schools were established. These were located in two areas of Greater Manchester (Rochdale and Blackley). Cohorts included one secondary school with 2 or 3 link primary schools (notably schools in a close geographical area).

Science subject leaders, Heads of Department and Year group teachers were involved for approximately one day per half term across three years of the project. In the final year, additional teachers were involved through the dissemination of approaches across Key Stages or departments.

The project was developed and managed by the SEERIH team at The University of Manchester working with the senior leaders and head teachers of the schools involved. A core programme of activity was outlined, which was supplemented by additional events required due to the disruption caused by the school closures resulting from the CV19 pandemic (Appendix 1).

All schools reside in areas of Greater Manchester with high proportions of socioeconomic disadvantage, Rochdale and Central Manchester.

The project process involved three key phases, that are mapped in the diagram below to the Education Endowment Foundation's Implementation guide (2019). The consideration of means by which to 'sustain' practice was addressed throughout the project, working with the Head teachers and senior leaders in the schools to recognise the shifts in understanding and pedagogy that were taking place. By working with them regularly, as a strategic governance group, they were kept informed and responsive to the outcomes of the teachers' activities.



Adapted from Education Endowment Foundation's Implementation guide (2019)

5. Studying the features of the project

Three questions underpinned the project and were studied across the school cohorts:

- What do we understand by pupils being 'disadvantaged' or having vulnerabilities that affect their science learning?
- What practices take place across the KS2-3 transition to support pupils' progression in learning science?
- In what ways can science teachers improve the inclusivity and progression in learning within their classrooms?

a. Pupil 'disadvantage' within science learning

What was the issue?

Understanding what teachers and senior leaders understood by the term 'educational disadvantage' was one of the first areas of study within the project. As well as speaking with teachers, we used published material such as government educational policies and academic literature to clarify what was understood by this term. In particular, we sought to identify the characteristics or features that affected a learner's experience of science.

What intervention/activity was undertaken?

The project team collaborated with science teachers to undertake a one-day review (known as a SEERIH Transition Deep Dive) of science teaching and learning in each school. This involved teachers who taught classes in upper primary and lower secondary school engaging in professional conversations about data (that which enables children with specific vulnerabilities to be identified, science attainment data, attendance etc.), science lesson observations, pupil voice activities with groups of pupils and looking at learning in pupils' science books. The purpose of the monitoring day was to better understand the science learning of pupils at upper primary and lower secondary school, with a particular interest on the engagement of pupils identified as 'disadvantaged' according to government metrics (notably those identified as Pupil Premium and working below the expected standard in science attainment).

As a result...

Across all schools, teachers explained that the commonly used Pupil Premium 'measure' of 'disadvantage' was 'crude' and did not reflect the specific learning needs and characteristics of pupils who they would consider to be most vulnerable. The Deep Dives revealed that, on a day-to-day basis, teachers took a more holistic and broader view of what influenced a pupil's learning, describing disadvantage through a wider range of factors. Table 2 (page 15) indicates the range of features identified by teachers and characteristics identified in national documentation e.g. the National Foundation for Educational Research's guidance on Vulnerable Groups.

What is evident from Table 2 are the range of features that extend outside the Pupil Premium definition that influence pupils' readiness and engagement in science learning.

So what?

At the start of the project, it was considered that Pupil Premium at Year 5 (9-10 yr olds) and those pupils not on track to be at the national 'expected' attainment standard at the end of Key Stage 2 (7-11 yr olds) and Key Stage 3 (11-14 yr olds) would be the means by which to identify this group of pupils.

Features of pupils who are considered 'disadvantaged'	DFE Pupil Premium Indicator	Features considered by the school to be relevant	NFER Vulnerable groups
International New Arrivals (INA) With at least two countries prior to attendance at the school, and with particular reference to the Greater Manchester regional migration list		✓	✓
Special Educational Needs or Disabilities (SEND)	✓	✓	✓
Looked after Children (LAC)	✓	✓	✓
Pupils with a parent serving in the Forces	✓	✓	
English as a second language		✓	
Within year transient, Gypsy, Roma and Traveller pupils		✓	✓
Poor attendance, excluded or at risk of exclusion		✓	✓
Living in poverty			✓
Poor behaviour			✓
Young carers			✓
Young offenders			✓
Mental and medical health needs			✓
Teenage parents			✓

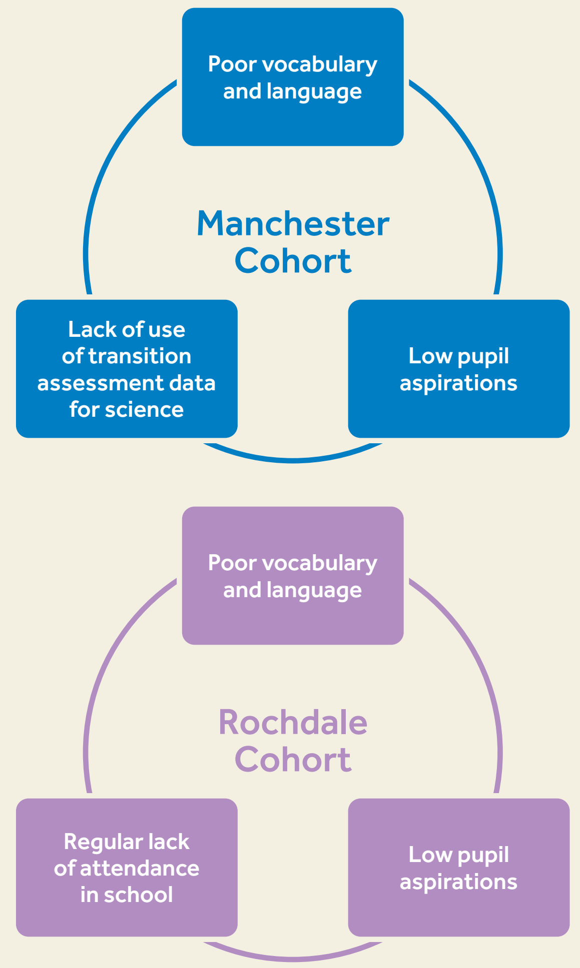
Table 2: Features of primary and secondary disadvantaged learners.

Teachers revealed that in practice the term 'disadvantage' had a wider range of interpretations. Teachers described the way in which they used multiple 'tags' to more holistically recognise the challenges a pupil brought to the classroom.

> *'It is challenging to identify disadvantaged pupils from a particular cohort. Going into this project I thought Pupil Premium/Free School Meal status was the key identifier for disadvantage, however it is a very broad term which we needed to unpick and decide on what is most relevant within our school context.'*
> **Secondary Science Head of Department**

Of course, 'tagging' could be considered a form of 'labelling' and is open to scrutiny. In being cautious with this term, what was clear was that teachers were aware of a set of wider issues that had relevance to the way pupils engaged with science learning. The explicit identification of these, and the shared understanding across the primary and secondary schools, was found to be valuable by teachers and senior leaders as it gave transparency to the shared challenges that pupils experienced when learning. The benefit in science teachers being engaged in this discussion was different to the norm, which most commonly would fall within the responsibility of transition coordinators or pastoral teaching staff.

The school cohorts identified the three most impactful features of disadvantage to be:



As the project was undertaken over the period of the CV19 pandemic, teachers described the impact of the limitation of normal schooling to be an added factor when considering disadvantage. They explained how new features of disadvantage had emerged during lockdowns, in particular that of digital poverty. This has been reflected nationally and also impacted on a wider range of pupils than those classified by standardised metrics of Pupil Premium (DfE 2021). Some schools in the project explained how their vulnerable pupils could not access online science learning in homes with large families, shared devices and lack of suitable spaces to work. In addition, they explained that there was an emphasis on sending work home that prioritised English and Maths for remote learning, and science, particularly in primary, was given less emphasis.

b. Practices of science transition from Key Stage 2 to 3

What was the issue?

The SHINE Trust are focused in their attention on pupils' experiences across the primary and secondary school transition. They are committed to bridging the gap between learning and experiences so that pupils maximise their progress at a critical time in their learning career. Ofsted's report 'Key Stage 3 – the wasted years' (2015), Scottish Government (2019) and other reports such as Evangelou et al (2008) draw attention to the challenges pupils face when transitioning and the disparities in practice between primary and secondary schools.

> ***'For children, parents and schools the factors that identify a successful transition can be summarised as social adjustment, institutional adjustment and curriculum interest and continuity.'***
> **Evangelou et al, 2008, p6**

This mirrors other authors who acknowledge the pastoral, pedagogic and curriculum 'bridges' that need to be considered at this point in a pupil's learning career. Concerns are raised across the literature related to (Evangelou et al, 2008, pg ii-5):

- Secondary schools not appearing to 'trust' the data on children provided by primary schools
- Pupils experiencing a drop in progress after transition
- Pupils experiencing insufficient challenge in Year 7
- Transition being more difficult for pupils who speak a language other than English at home
- Pupils from minority ethnic backgrounds being more unlikely than white pupils to feel they 'fitted in'
- Gender differences impacting on there being a tendency to 'teach the boys' because they need more help or make more demands

What intervention/activity was undertaken?

The Transition Deep Dives revealed a range of activities that schools undertook that are typical of school recruitment activities. These were organised by transition coordinators (mainly in the secondary school) resulting in secondary science departments offering visits to the science laboratory as part of a transition day, pastoral teams sharing information/data about pupils with specific needs, and occasions where the secondary science teachers would teach primary pupils in Year 5. The activities focused mainly on supporting pupils to better understand what secondary school would be like, with little opportunity for science teachers from primary and secondary school to discuss pupils' experiences or attainment, or the curriculum or pedagogical approaches used during the junior years.

As a result...

The transition focus for the project was directed towards curriculum and pedagogy. Through a collaborative lesson study approach, teachers were supported to talk openly about their science teaching and to work in the school cohorts to deconstruct their practice. The aim of this was to provide opportunity for science teachers to understand each other's approaches, and to listen and ask questions in order to consider the implications on a pupil's experience of science learning when moving from primary to secondary school.

The use of 'Collaborative Lesson Research' (CLR) (an adapted Lesson Study approach) was drawn upon to offer teachers structures for focused study of their practice and review of the way they taught science, including the teaching and learning approaches they selected. Important in this approach is the intent to 'learn' rather than 'change' practice in the first instance. This is in contrast to other forms of teacher collaborative research, such as Action Research, which would see teachers adopting a new intervention or practice and seeing how that influenced classroom practice. In this project, we placed value on 'learning together' and better understanding how science was taught in primary and secondary school, to examine the similarities and differences. This was not so that teachers would need to adopt or take on each other's practices, but that they were aware of the experiences the pupils had prior to or after they left their care.

The key components of CLR were adapted from Takahashi and McDougall (2016)

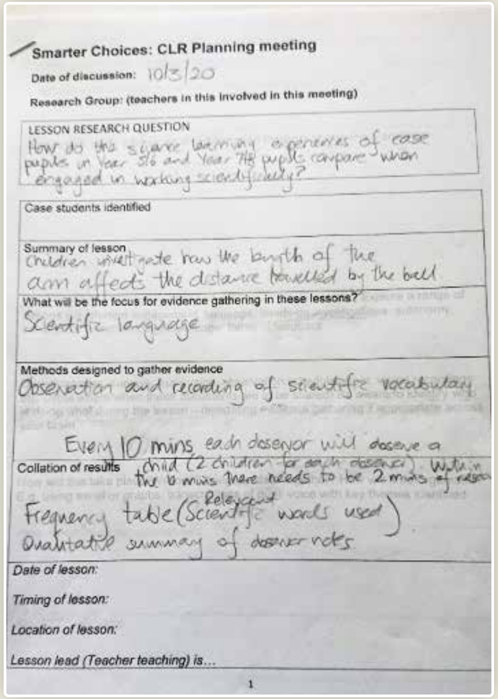
1. Identifying a clear research purpose, jointly within the cohort – *so that the focus of study was shared.*
2. **Kyouzai kenkyuu:** the study of curriculum materials, professional reading/learning to gain knowledge and insight into the topic area and student thinking – *so that teachers had some background information/ insight to enter into the study with.*
3. A collaborative written research proposal – *so that they had a shared understanding of what they were looking for in the lesson(s) they observed, and how they would gather insights/evidence from the experience.*
4. Live research lesson experiences and mentored reflective discussion – *so that they were able to see in practice the pupils' experience of science and to professionally discuss it.*
5. Knowledgeable others – *so as to be supported by someone with a depth of knowledge or understanding of the focus area, e.g. science education, assessment etc., to provide additional support to the professional dialogue.*

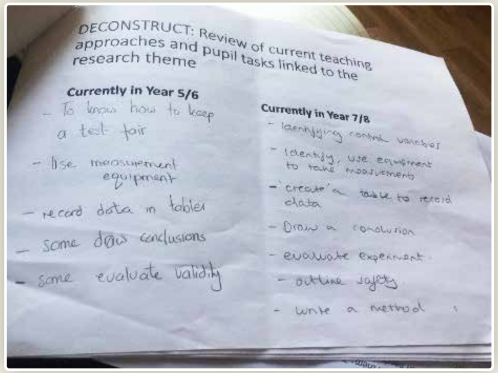
So what?

The school cohorts entered into the planning of the CLR just prior to the CV19 pandemic lockdown taking place. As such the teachers were unable to undertake more than the early discussions and virtual, facilitated interactions. In-school lesson observation was restricted and did not take place.

However, through open professional dialogue and consideration of practice, some early findings reinforced the issue of scientific vocabulary and language being an important factor in pupil's science learning experience.

Images showing how teachers deconstructed their lessons as part of the initial study.





Teachers identified that they were scientific terms that were inconsistent across the transition. In particular terms that were taught and reinforced in science lessons in primary, e.g. Fair Tests as a form of enquiry, were marked 'incorrect' in secondary school. It was explained that examination boards at secondary would not accept such terminology, therefore KS3 teachers did not value this.

> *'Relationships with the high school colleagues are essential in ensuring good transition in respect of improved information sharing including data, relationship building with children, shared resources to ensure continuity e.g. use of names for variables and use of 5 types of enquiry posters etc.'*
> **Primary Science Subject Leader**

Other practices, e.g., the use of enquiry-based learning were different across primary and secondary school, with less enquiry seemingly being undertaken in the KS3 classrooms. This contrasted to the primary approach, where enquiry and working scientifically as a means of learning subject knowledge was an endorsed national way of working. Science teachers valued the opportunity to share practice in this way.

> *'Communication between primary feeder schools and secondary is so useful in bridging gaps and understand pupils' prior knowledge and where gaps may lie in their knowledge. Pupils seem to be able to have access to a better science capital and literacy guidance in science at primary that drifts more at secondary due to the nature of science at secondary, only having hour lessons (time) and not knowing the pupils as well. [As a result we will be] improving the communication between us and the primary schools in terms of data, and making sure as a whole department that we understand where the pupils have come from and what they should already know.'*
> **Secondary Science teacher**

c. Vocabulary development in science lessons

What was the issue?

At a national level increased focus has been paid over the past decade to the links between a pupil's literacy, reading comprehension and vocabulary and their attainment and future prospects. Reports highlight the challenges that pupils face when learning science due to the range of language and vocabulary used in this specialist subject.

> *"...learning science involves learning a whole new language and it is important that you develop pupils' fluency in that language."*
> **Education Endowment Fund, 2018**

The significance of literacy and attainment in particular for disadvantaged learners is further highlighted within the Education Endowment Fund's Review of SES and Science Learning in Formal Educational Settings (2017) and in publications by educators such as Quigley (2020).

> *'In correlational studies of science learning, the strongest and most consistent predictor of pupils' scientific attainment has undoubtedly been how literate they are. Some of the possible reasons that have been given for this connection are the importance of reading scientific texts and preparing written scientific reports; the effects of reading on pupils' scientific vocabulary; the usefulness of understanding the morphemic structure of words in learning scientific terms. There is a strong relationship between pupils' socio-economic status (SES) and their literacy.'*
> **Nunes et al, 2017 P10**

What is apparent is that science learning demands the understanding of a large number of new words, many of which are technical terms that teachers use to instruct children. EEF note there is an obvious opportunity for longitudinal, correlational research to explore the impact of measures of pupils' vocabulary and their success in science learning later on. This would build on research into children's perception of the importance of vocabulary in science learning (Brown & Concannon, 2016).

During the project Transition Deep Dives, pupils spoke of the dominance of scientific vocabulary recall within their lessons, and how this was sometimes daunting and off putting.

They explained the things they found difficult to be:

- Memorising words in science
- Linking keywords and definitions
- Remembering lots of stuff
- Learning things over and over again

Undoubtedly the school demographics impacted on the pupils' proficiency with language, with all schools having an average of 85% of pupils with English as a second language. Pupils who were International New Arrival, having transitioned from multiple countries to achieve refugee status were also proficient linguists in Italian, Portuguese etc. Such transitions happened over a long period of time, with many pupils having significant disruption to their learning career, resulting in disrupted and missed learning sequences. The impact of the study raised science teacher awareness of the need to provide explicitly and regularly focus attention on keywords and language development. There was a raised profile of the need to proactively plan for language development and progression in science lessons, in order to enhance access and inclusion for all pupils. Even where some schools had dedicated language approaches and strategies, these were mainly used in intervention or literacy lessons. On occasion, word lists were identified at the start of a lesson yet little was done to explore and understand their origins or roots to support improved understanding.

Review of pupils work in books led to primary and secondary teacher reflections on vocabulary:

> ***'The class books also showed that generally disadvantaged pupils struggled with the language used by the teacher and were not able to portray their understanding of the scientific terminology used in class which in turn could potentially result in poor achievements in assessments.'***
> **Secondary Science teacher**

> ***'The first learning point [I have] is that disadvantaged learners are at an immediate disadvantage compared to their peers because they have not got a wide enough vocabulary to access the learning. Their experience of science is also limited and they have a paucity of experience to draw upon. The second point is that the scientific language used in UKS2 is not replicated in Year 7.'***
> **Primary Science teacher**

What intervention /activity was undertaken?

Two knowledgeable others (leading teachers and authorities) provided professional development for the project teachers. This was in the form of in-person training, book club group meetings and on-line webinars. Recordings were saved for post-event re-watching and review. In these sessions common messages about the need to consider different types of vocabulary in science was noted and explored. Teachers were supported to discriminate between different types of science vocabulary as follows:

Tier 1: words that most children use in everyday speech, e.g. book, pen, sad, run, dog, and orange

Tier 2: high frequency words that occur across a variety of domains, e.g. observe, measure, chart, evaluate, structure, distance, speed

Tier 3: specialised, academic language – key words e.g. dissolve, condensation, habitat, deciduous, metamorphic, omnivore

As a result...

Teachers used a CLR approach to consider how they would incorporate vocabulary development approaches into science lessons to support children to explore and understand Tier 3 and 2 language over the course of an academic year. It is acknowledged that school settings were highly disrupted at this time due to the CV19 pandemic, and as such teachers took opportunities where they could to implement these approaches.

Methods they used included:

a) Exploring the **etymology of words** – giving pupils an understanding of the origins of words and their morphology (roots, prefixes and suffixes). For example, What does -ology, bio- and ex- mean? Support for this type of knowledge is available via websites such as 'Collins CoBuild Dictionary'.

b) Looking at the **morphology of keywords** in science, e.g. exploring the prefix 'cent' in centimetre, centipede and century to recognise the concept of 'one hundred'. Pupils are encouraged to use these words in sentences and to find other words that use the same prefix or suffix.

c) Select, Explain, Explore and Consolidate (SEEC). This approach enables pupils to develop a deeper understanding of key words.

Using SEEC to introduce a scientist to pupils

Dr Ben Parslew,
Senior Lecturer in Aerospace Engineering,
The University of Manchester

Profile video

The pupils were introduced to their link scientist. They were given a short video to watch and a written profile describing Ben's journey to his current role.

They then used **SEEC** to find out more using this lesson plan:

Ask the pupils read Ben's profile in full

Then read again together identifying any broad themes or comments

Use the SEEC model to develop understanding of key words, and to encourage the pupils to develop questions to ask Ben about his career journey to becoming a STEM professional.

1/ Select

Ben describes himself as an **Aerospace Engineer** – let's unpick this word carefully.

The key words are likely to affect the pupil's understanding and engagement with Ben's profile. The terms may not be part of the prior knowledge.

Focus on unpicking these words carefully.

2/ Explain

- **Say** – Tell the pupils to repeat the words carefully pronouncing all the syllables.
- **Write** – Ask the pupils to write the words checking their spelling is correct.
- **Definition** – tell the pupils that it is an area of technology and industry concerned with both aviation and space flight. Aerospace Engineering is an area of engineering that is concerned with engineering of both aircraft and spacecraft.
- **Ask** – Invite the pupils to give examples of using these words which will support them to clarify meanings and allow you to identify any misconceptions or misunderstandings.

3/ Explore

Etymology is finding out about where the word comes from. In this part of the task, pupils explore the etymology of the keywords.

Aerospace is a compound word.

Aero – *(Noun)* from the root word air and used when forming compound words such as aerospace and aeroplane.

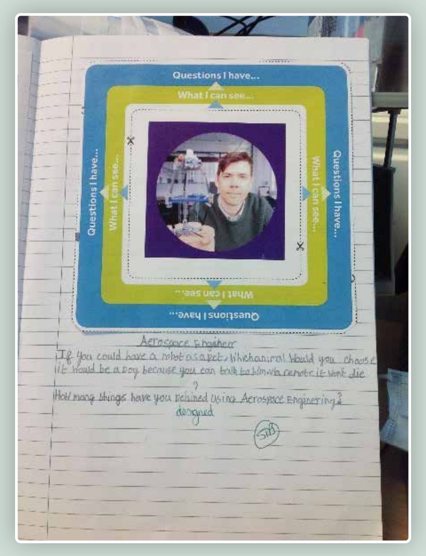
Space – *(Noun)* A continuous area or expanse which is free, available or unoccupied. In everyday language we commonly use it to refer to the physical place beyond the Earth's atmosphere. E.g. the astronaut went in to space. *(Verb)* It can also be a period of time e.g. she needed space to think. and the 3D extent to which events and object have relative time and direction. E.g. the cones were spaced equally.

4/ Consolidate

- Test and learn – revisit the keywords at regular intervals until you are sure there is a depth of understanding. Use some of the ideas already tried in other sections of the SEEC model as a quick quiz or reminder.
- Research and record – find out more about these words – what else can you find out or is connected to the word aerospace.
- Watch Ben's profile video once more.

- Ask the pupils to explain in their own words what Ben does. Ask them to explain what they understand about by the meaning of the keyword – aerospace?
- Using the keyword in the world – ask the pupils to use the word aerospace to produce questions for Ben.

Use the Question Maker to support this task.

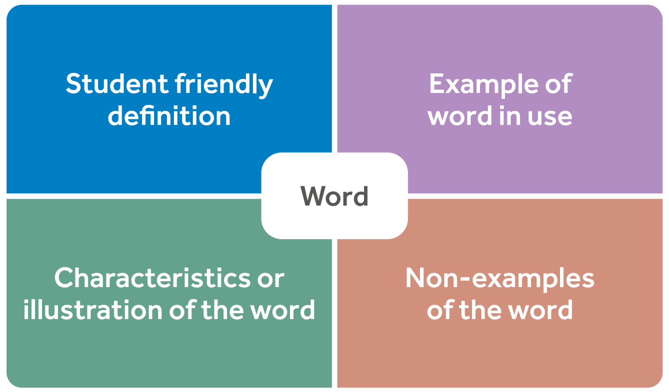


The pupils used a Question Frame which supports the development of questions, encouraging them to look closely at an object or image.

Examples of the questions the pupils asked			
Zaynal	Male	10	What has been your hardest project yet, as an Aerospace Engineer?
Jerin	Male	11	What was your first project as an Aerospace Engineer?
Zaynah	Female	11	If you are an Aerospace Engineer, are you creative with making things?
Husnain	Male	11	How many things have you designed using aerospace engineering?
Millie-Jay	Female	10	Is there something you would like to invent in the future?

Watch Ben's response to the children's questions

d) The Frayer Model which can be used to lead children to a deeper understanding of a keyword.



This quote provides insight into the benefits of this approach.

> *'An overall focus on drip-feeding Tier 2 vocabulary bridges gaps between different topics children are learning in science. For instance we've been able to make links between previous science learning about e.g. adaptations of animals in biology and apply it to adaptations of a circuit in electricity. We have also linked science to other subjects. A focus on vocabulary is especially useful when getting children to understand the working scientifically aspects of the National Curriculum.'*
> Primary Science Leader

Other strategies also emerged during the study. Further insight can be gained into text such as *Closing the Vocabulary Gap* (Quigley, 2018).

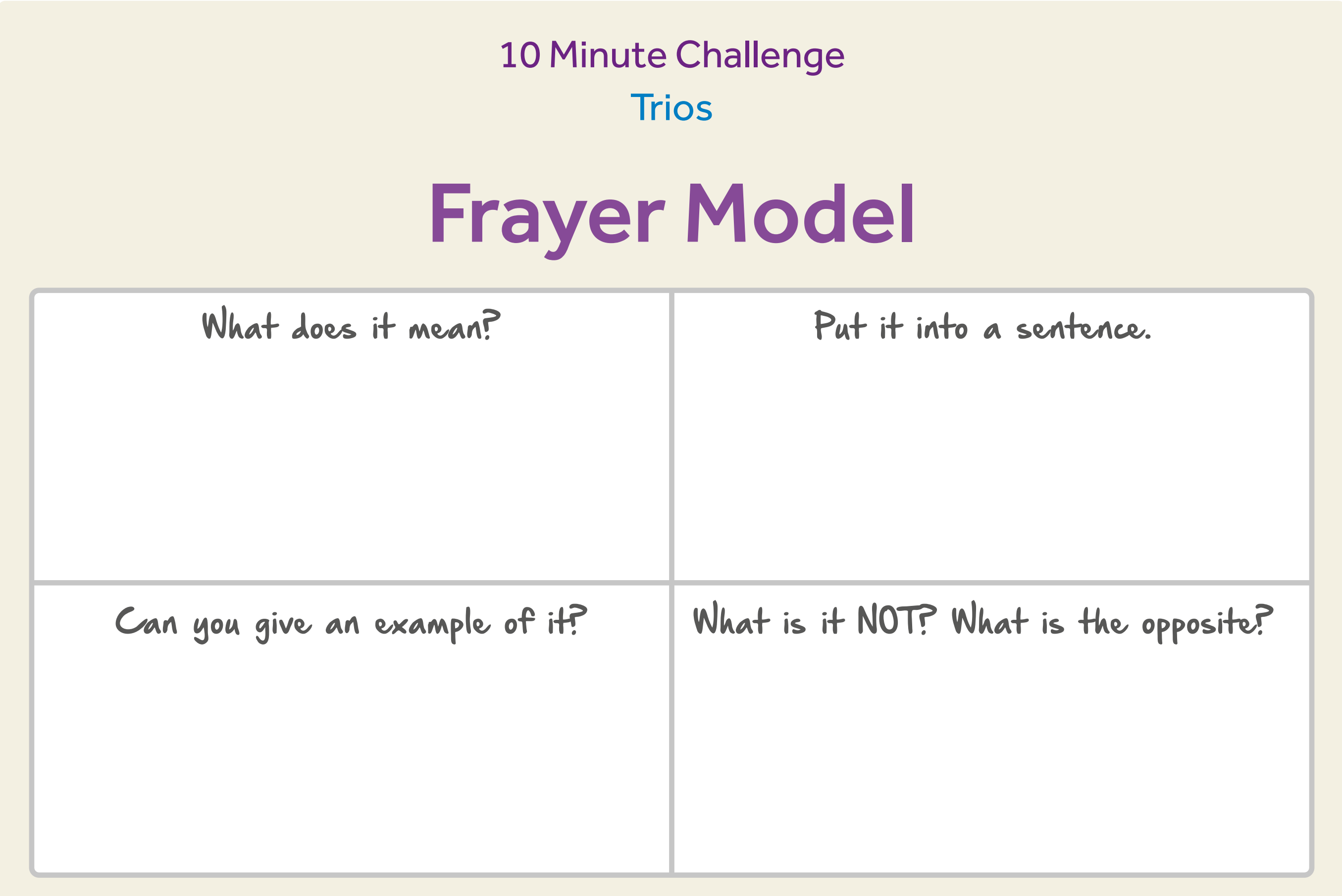


Image showing an example of the Frayer model used as part of the project.

So what?

All teachers across the two cohorts were able to integrate opportunities for developing scientific vocabulary into their lessons. These approaches were used with all the pupils, as opposed to selecting groups of 'disadvantaged' pupils for intervention. The reasoning behind this was to encourage an inclusive pedagogical approach, in which the whole class would benefit, whilst the teachers were able to use their skills in supporting and differentiating further input and support for children with specific needs.

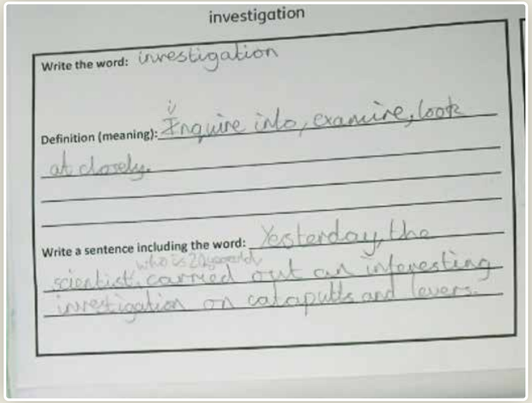
The shift towards 'inclusion' rather than 'intervention' was a subtle but significant shift in mind-set. It moved the project away from thinking of groups of pupils with additional needs, to all pupils working within an inclusive and supportive learning environment. They innovated with approaches to support vocabulary development in classrooms, e.g.

> *'Use of mats to refer to in lessons. Refer to vocabulary in a range of familiar contexts to embed it. Give time for discussion to introduce vocabulary. Look at Latin suffixes and prefixes in scientific words and relate to similar words. Use colourful semantic frame to investigate words.'*
> Primary teacher
>
> *'The use of symbols to describe not only scientific vocabulary, but Tier 2 vocabulary has also helped the children.'*
> Primary teacher

Teachers noted that these approaches took more time from 'doing science', and this posed some concern at times as the demands to 'cover' the curriculum were prevalent.

> *'The extra time needed to include the vocabulary elements of the lesson (impact on the rest of the curriculum in terms of time spent)'*
> Primary teacher (Cycle 2 lesson 2 reflection)
>
> *'Children engaged really well with the lesson since they understood what was going on in the investigation (in terms of understanding the vocabulary)'*
> ibid
>
> *'As a minimum, a discussion of the vocabulary (picture, word and definition) used in the science lessons is really important for children (disadvantaged and other!) to get a fuller understanding of the science concepts covered in the lesson. Some science lessons may need more time dedicated to discussion of vocabulary, whereas some lessons may need less depending on the amount of vocabulary and complexity of the vocabulary in the particular unit.'*
> ibid

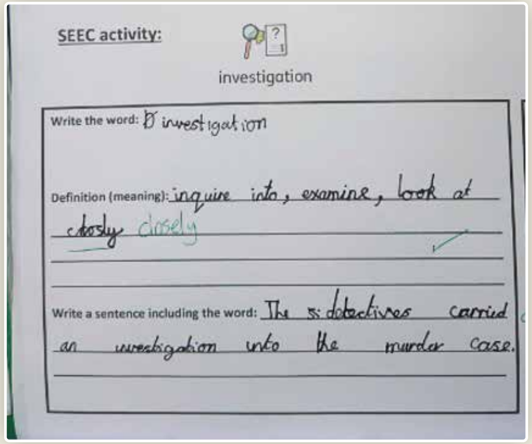
Images showing use SEEC activity related to the keyword 'investigation'


investigation

Write the word: investigation

Definition (meaning): Enquire into, examine, look at closely

Write a sentence including the word: Yesterday, the scientist carried out an interesting investigation on catapults and levers.


SEEC activity:

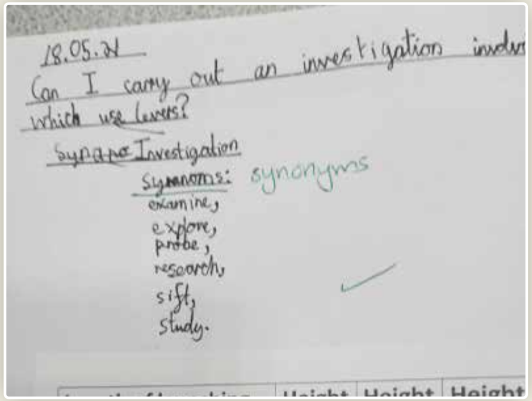
investigation

Write the word: investigation

Definition (meaning): inquire into, examine, look at closely

Write a sentence including the word: The detectives carried an investigation into the murder case.

Image showing follow on lesson from SEEC activity – showing further exploration of the term 'investigation' using synonyms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Can I carry out an investigation involving which use levers?

Synonyms Investigation

Synonyms: synonyms

examine,

explore,

probe,

research,

sift,

study.

However, as the project progressed teachers increasingly noted the impact of the invested time.

'Pupils are more confident in using key language and have better retention of information. They are able to recall key word definitions in subsequent lessons and apply them to new situations.'
Secondary teacher

'More pupils have been able to access the learning on offer in science lessons because they have had the time to learn and understand the scientific and Tier 2 vocabulary used in lessons. Engagement has been higher too.'
Primary teacher

'The pupils have improved their confidence in using Vocabulary – not just in their writing but in their answering of questions in class – they're thinking more deeply about the processes involved and are starting to explain these in their assessments. We are starting to notice some pupils are paying more attention to Tier 2 vocabulary but this will need to continue to be developed next year.'
Secondary teacher

In the third year of the project, teachers disseminated these approaches across the primary school and the secondary science departments. They led staff meetings to explain and share insights of their CLR activity with staff, and action planned ways in which the strategies could be systematically used to benefit more pupils.

6. Progression and Inclusion

Language and scientific vocabulary acquisition has emerged as the most significant challenge for children learning science within this project.

It was the factor that was of most relevance to giving all pupils greater opportunity to achieve success in science lessons and the factor that most impacted on disadvantaged learners' engagement with science learning. Professional dialogue with teachers revealed that across the transition, scientific terms and language became a benchmark for the level of expectation set for pupils, in both their disciplinary and substantive learning in science.

In hindsight, it may not be so surprising to find that at the route of all learning is the basic way we communicate knowledge. This study has shown that integral relationship between inclusivity and progression, drawing on curriculum and pedagogies to attune teaching approaches in a way that brings pupils further into the learning process and being alert to recognising and overcoming any explicit or perceived barriers. To ensure this science teachers must be supported and encouraged to dedicate time to reflect on pupils' practice, to be able to easily access data about their prior learning progress and curriculum coverage, as well as having a strong sense of the known national and local factors that impact on learners' achievement and success. Science teachers must be given autonomy and responsibility to see it as an integral part of their role to induct and transition pupils into and from their classes, with systematic process to involve teachers from previous year groups and those to come.

What has been evident is the way that primary teachers are able to use the whole curriculum to support children when learning science. The fact that they teach all subjects meant they had greater knowledge of language development strategies used in Literacy lessons. Secondary teachers however demonstrated interest and ease at integrating language strategies into lessons, and although at first were concerned over the time taken, found that established routines, e.g. focusing on keywords, resulted in improved engagement and quality of work.

Very early into the study there was a sense of parochialism within the primary and secondary groups. This was created by a sense of role and identity which led to teachers recognising they had common ambitions to enhance children's learning, but that they were different in nature due to the distinctiveness of the age ranges they taught. At first this was a challenge as having an ambition to create a common approach to science teaching and learning was not considered valuable. The goals of the two age phases were identified as different, with secondary teachers influenced heavily by examination outcomes and pressure.

The intention in effective transition and progression is not to standardise teaching approaches, or to make the terms or language the same across settings. What is purposeful for some age groups may or may not be as appropriate for others. However, this study has shown the importance of consistency and transparency. Children need to be able to see and understand how their science learning evolves and teachers need to be astute to the changes and implications of curriculum and the subtle yet significant changes inherent within it, especially that related to language.

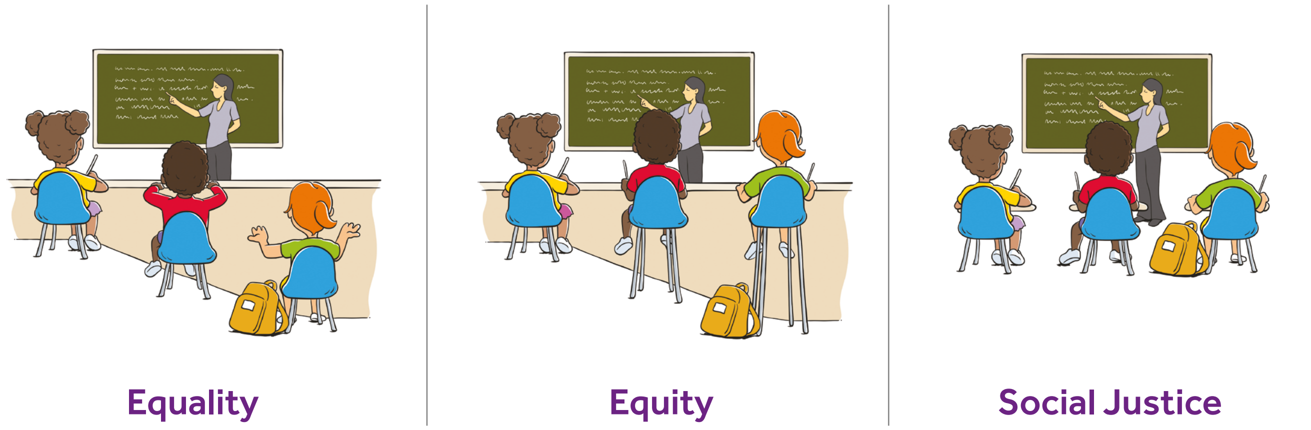


Figure from the Primary Science Capital Teaching Approach (Nag Chowdhuri 2021, pp10)

Being consistent is being aware of progression and having shared understandings between primary and secondary partners alike. This shouldn't be left to chance or a policy document to convey. It should be a brokered through regular professional conversations that are prioritised as highly as the assessment processes that report on pupil outcomes. It isn't appropriate that pupils risk falling off curriculum or language-bridge at age 11 years. Each deserve honed consistency and shared expectations delivered across a cohesive science teaching community. As science teachers, we cannot allow ourselves to disconnect with the process of transition, deferring it to the role of a coordinator. There is a tendency for transition to be mainly about recruitment and socialisation of primary pupils into a new secondary environment which has its place and need. This study has shone a light on the pedagogical and curriculum focus of transition that challenge us to see ourselves to focus on progression and consistency. It seeks to enable and encourage every teacher of science to take on their responsibility to sequence learning so that the learner experience is at the core. When learners are vulnerable and require adapted approaches, then this should be done coherently with collegiate awareness from those staff that have taught the pupils before and those that will teach after.

From the perspective of inclusion, the shift in teacher practice within this study reinforced the unease that the project group collectively felt with 'labelling' differences. The focus on educational disadvantage resulted in discussions which would often lead to pupils' needs being deficits and areas for 'fixing' or improving. Rarely did discussions take place where the differences pupils brought to the classroom were identified and valued as assets. The work of Blandford (2017) and the Youth Equity and STEM project reminds us that children from disadvantaged backgrounds have a wealth of cultural knowledge and skills that equip them for life and learning. Both promote a shift towards how embedding equity can be achieved through shifting focus from a deficit-based approach to an asset-based approach. The Equity Compass project encourages teacher reflection towards adopting a social justice mind set, through asking questions of their practice such as:

How are the interests, knowledge, identities and resources of underserved young people and communities being recognised and valued (an 'assets-based' approach)? Are (some) participants treated in deficit terms (as 'lacking' information, aspiration, interest and somehow being 'out of place')? To what extent are all participants valued and recognised for who they are, rather than who they are not?
YESTEM 2021

The disconnect between these assets and the formalised curriculum means, however, that few opportunities allow teachers to flex lessons in order to capitalise more fully on the cultural capital that pupils bring to science lessons. The key focus on vocabulary and language became a key to unlock learning, with many pupils describing the added challenge scientific terminology added to the learning process. Many identified science as a hard subject requiring large amounts of retrieval and recall of information, using technical language that had little relationship with their lives.

By shifting emphasis towards inclusive pedagogies for science, teachers used whole-class approaches to language development, enriching the learning experience for all. More communication with students over vocabulary and understanding meaning, definitions and origins of words enabled greater access as misconceptions or double meanings were addressed early in the learning sequence – e.g. the word 'iron' as a metal was thought by the pupils to be a laundry iron, the word 'conductor' was understood by pupils to be a musical conductor or bus conductor. By giving the opportunity to talk about conceptions early, pupils were given greater awareness of the multiplicity of meanings and the scientific terms that then allowed them to participate more fully in the lesson.

In improving teacher appreciation for enhancing access and attainment by focusing on progression and inclusion, this study has shown how necessary it is for ongoing professional dialogue and challenge between teachers. In particular, for this to happen across age phases means that there is a commitment to children's learning that has direct impact on the teaching they receive on a day-to-day basis. Blandford (2019) reminds us that, 'if all children and young people facing economic disadvantage received high-quality early education the gap in achievement could be closed by between 20-50%.' Although we appreciate that this study has only been able to explore these issues over a short time, and at a time of significant school disruption, it has led us to acknowledge how vital it is that we are consciously aware of the children in our care and what we are seeking to achieve long-term for them through science and other subjects. Blandford's perspective on mutuality is a helpful way to round off this section of this report.

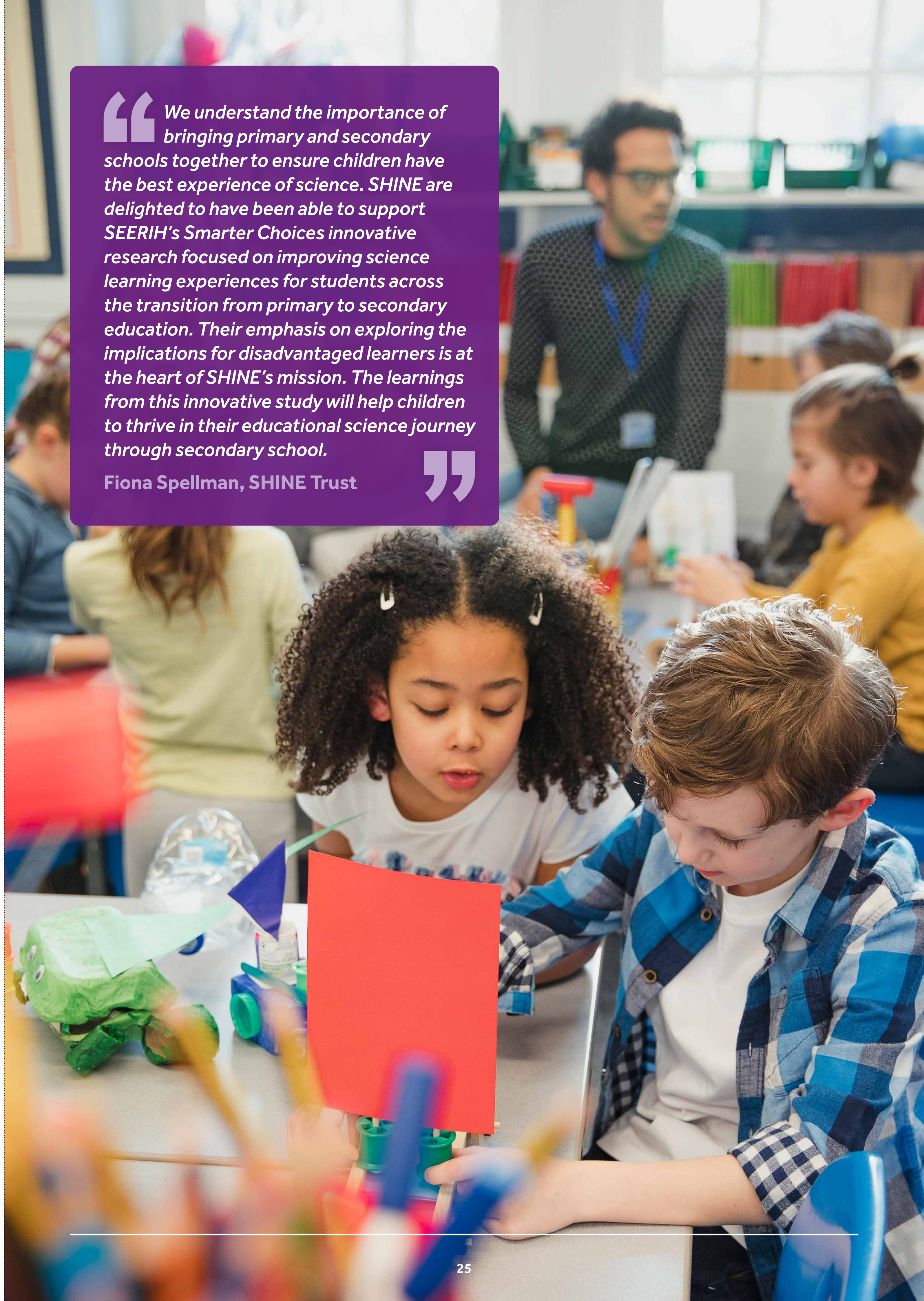
> *'Mutuality is about schools and a curriculum that is relevant to [children's] lives and which engages with them, so they can engage with larger society... Mutuality is not middle class professional people dipping their toe into a life of disadvantage and then going away feeling they understand enough to call the shots... Mutuality isn't about rescuing people. It's about valuing them and allowing them to develop in their own way, where they are now, or where they want to be. Mutuality is, I believe, social justice and the key to social mobility.'*
> Blandford (2017)

By broadening out the conceptions of educational disadvantage and acknowledging a range of 'under-recognised' factors that influence science learning we seek to stimulate reflection on classroom practice. We accept that big strategic national identifiers, such as Pupil Premium, open up funding streams and provide large-scale national awareness of need. However, these systemic indentifiers are too broad to influence science teaching and learning on a day-to-day basis. We have shown in this study the importance of drilling down beyond the factors that are required by school or external moderating bodies to uncover the influences that affect children and teachers striving to provide access and success in learning. These factors, e.g. vocabulary, identity etc. relate to teaching approaches, to teacher practice, to pedagogy. They relate to what children hear and see each day at the micro level of classrooms, to the essence of a keyword that can unlock learning or hold it back. Too often primary and secondary science teachers have been expected to accommodate for these factors in ad hoc and intuitive ways. Here we call for a more explicit and planned for approach, where progression and inclusion work hand in hand across the primary and secondary phases.

The shift in practice is suggested as follows:

	FROM DISADVANTAGE	TO INCLUSION
What is it?	Pupil Premium	Multiple tags/flags (greater awareness of our children's needs)
	Specific to some pupils	Relevant to all, all pupils can achieve their best
	Specific interventions	Inclusive pedagogies
Who does it?	SENCO	All teachers, in partnership with parents
Why do we do it?	Get specific pupils over the finish line	Enhancing the learning experience and outcomes for all
	Racing to the bottom (minimum expectations)	Removing glass ceilings – raising expectations for all
	Meeting aspirations	Raising aspiration

	FROM TRANSITION	TO PROGRESSION
What is it?	A day for Y5 or Y6 to visit the local secondary school. Summer camps, regular visits to science labs.	Seamless change from one learning environment to another where expectations are connected, and teachers talk the same 'language'
Who does it?	Y6 teachers, HOY 7, senior leaders	All staff and departments are valued in the process, and it includes young people
Why do we do it?	Recruitment only	Clarity of what is *Recruitment* and what is *Progression*



> *We understand the importance of bringing primary and secondary schools together to ensure children have the best experience of science. SHINE are delighted to have been able to support SEERIH's Smarter Choices innovative research focused on improving science learning experiences for students across the transition from primary to secondary education. Their emphasis on exploring the implications for disadvantaged learners is at the heart of SHINE's mission. The learnings from this innovative study will help children to thrive in their educational science journey through secondary school.*
> **Fiona Spellman, SHINE Trust**

7. Teacher ‘take-aways’: developing professional understanding of inclusion and progression in science classrooms

The following ‘take-aways’ are professional activities that can be undertaken by science teachers and leaders in order to consider the issues raised in this report within their own schools. They are designed to encourage active reflective practice and can be used as part of staff development or meetings.

A. Developing a shared understanding of the features that impact on your learners’ experience of science.

‘Disadvantage’ or vulnerabilities are present in all science classrooms in all schools. How much do you acknowledge and discuss these with your colleagues within school and across schools?

Step by Step guide: Identifying the 3 most critical features of educational disadvantage in your school

1. Arrange a whole staff or departmental discussion about what measures the school are currently using to identify pupils who are vulnerable or have educational disadvantages in some way. This could be broadly from a whole school perspective, and then brought down to a science specific perspective.

   Consider the questions:
   Do these measures capture the real story of pupils’ needs in your school?
   Does this represent all pupils, or could there be other issues that see some pupils fall ‘through the gaps’?
   This could be anonymously though online tools, shared documents/surveys or in person around a large sheet of paper.

2. Once these key features are identified, rank them so that you have prioritised the top 3.

3. Review your science teaching and learning for the next lesson, topic or term. Identify where and how pupils with these features can be increasingly catered for, through refinement or adaptation of teaching approaches. Remember your inclusive practices will influence all learners in your class, and most importantly, will not leave any learners more vulnerable than another.

B. Sharing collaborative study of science teaching and learning – a cross-department and cross-partnership approach to school improvement for science

Sustained relationships between science teachers in primary and secondary schools will never be easy. However, if CV19 has taught us anything, it has shown that digital engagement can create a bridge for regular sharing of professional discussion, training and pupil work. No longer need we be reliant on retaining masses of children’s books at transfer – there are digital platforms that can support us to share insights about teaching and learning on an ongoing basis by routine. For schools with large numbers of partnership primary schools a digital transition opportunity may support their dialogue.

Step by Step guide: Shared thematic portfolios

Create a shared space to collate information and insights between teacher groups.

1. Collaboratively select a science lesson or topic that will be taught across upper primary and lower secondary. You may like to select from the Teaching Assessment in Primary Science Transition materials www.pstt.org.uk/resources/curriculum-materials/assessment which are specifically designed to suit these year groups.

2. Encourage teachers to discuss what the anticipated learning outcomes for pupils will be for their age phases. Include discussions about:

   a. How do you expect the teacher to conduct the lesson?

   b. How do you expect the pupils to react, and the activities they’ll be involved in?

   c. What learning outcomes and ‘standard’ would be expected from the different ages of pupil?

   d. What adaptations are you planning on making for your class / school / year group?

   e. How will you record happenings in the lesson and what do you all agree to share after the lesson, e.g. pupil work, videos, photos of the lesson, etc.?

   f. What evidence will you share with each other post-lesson?

3. Teach the lesson in both age settings. If appropriate, teachers could observe the lesson, looking at how pupils engage.

4. Undertake a short review post-lesson, to reflect on if the lesson went as planned.

5. Share and discuss the evidence from the lesson in a planned meeting. Have a chair, or Knowledgeable other, support this reflective dialogue. Focus on whether the lesson achieved what you intended it to? Focus on what the pupils learnt and consider how the lesson could be further refined to further improve attainment of the learning objectives.

C. Closing the vocabulary gap in science to improve inclusion and access to learning

Step by Step guide: adapted from Quigley (2018).

1. **SEEC** – Select, Explain, Explore and Consolidate. This explicit approach to individual word learning is vital to help children develop the necessary understanding of important words.

   a. **Select** – whilst planning the lesson and reading around the topic, it is important that we identity the right words for explicit teaching. Subjects like science generate a lot of complex vocabulary that can alienate some learners if we don’t get it right. You might consider: difficulty, prior knowledge, interrelated words or ones which appear in other subject areas.

   b. **Explain** – once selected, it’s time to teach them. Say the word; write the word; provide a definition; give multiple examples; ask for their examples and clarify misconceptions.

   c. **Explore** – further exploration may be beneficial and this might include: word etymology and word parts, word families, synonyms or antonyms, peer think-pair-share to understand the word, related images, strategies to remember the word (such as mnemonics).

   d. **Consolidate** – allows deep understanding of the word and makes it more likely that it will stick and be used as part of the child’s lexicon in the future. Approaches to consolidate might include: test and learn, using the word within the world and ‘research and record’ in a child’s own vocabulary book.

2. **The Frayer Model** – was first developed by Dorothy Frayer and her colleagues at the University of Wisconsin in 1969 as they wanted to learn vocabulary more efficiently. This graphic organiser helps users focus differently on a particular word. Like the SEEC model, careful word selection is required and ones most aligned with the objectives of the lesson are critical to its success.

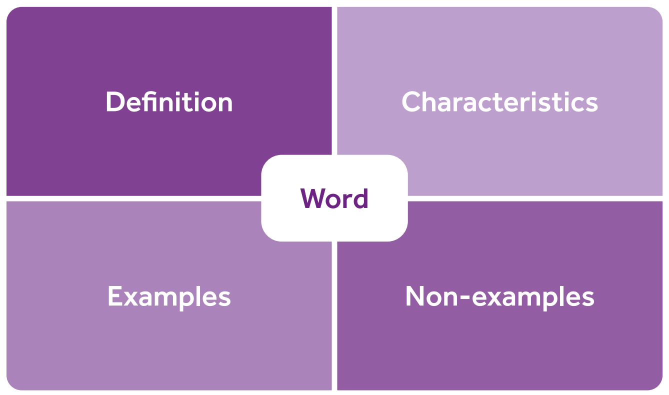
Tier 2 vocabulary can be explored easily here:

a. Select the word to put in the centre

b. Create a student friendly definition to share

c. Collate lots of examples of the word in use

d. Finally, add any non-examples. Often the hardest one to do but crucial especially when the word is used in different contexts in other subjects (Tier 2).



3. **Tier 2 and 3 Keyword lists**
   a. Start by identifying the keywords used in your latest science topic.
   b. Group them into Tier 2 and 3 keywords.
   c. Use the Tier 2 words to consider what are the most important to unlock learning in the topic. e.g. in the topic of light, children need to have a good understanding of the word 'straight' before they can appreciate that light travels in straight lines.
   d. Identify one word per lesson and build explicit teaching approaches to allow children to experience the meaning in practice, e.g. explore 'straight' by lining up, underlining titles and drawing a graph.

Year 1	Year 2	Year 3
Animals including humans Head, body, eyes, ears, mouth, teeth, leg, tail, wing, claw, fin, scales, feathers, fur, beak, paws, hooves, touch, see, smell, taste, hear, fingers (skin), eyes, nose, ear and tongue, fish, reptiles, mammals, birds, amphibians, herbivore, omnivore, carnivore, arm, elbow, back	**Animals including humans** Survival, water, air, food, adult, baby, offspring, kitten, calf, puppy, exercise, hygiene, reproduction, growth, child, heartbeat, breathing, germs, disease, meat, fish, vegetables, bread, rice, pasta	**Animals including humans** Nutrition, nutrients, carbohydrates, sugars, protein, vitamins, minerals, fibre, fat, water, skeleton, bones, muscles, support, protect, move, skull, ribs, spine, muscles, joints

Year 4	Topic: Animals, including Humans
Tier 2 Vocabulary	functions, basic parts, identify, construct, interpret, variety
Tier 3 Vocabulary	digestive system, food chains, producer, predator, prey, mouth, teeth, tongue, saliva, oesophagus, stomach, small intestine, large intestine, carnivore, herbivore, omnivore

Examples of keyword breakdowns as defined by the project schools.

Closing reflections

Bridging the primary and secondary transition by tackling educational disadvantage in the science classroom has proven to be complex. Not solely complicated by a very tough couple of disrupted school years, but in the way that the needs of pupils are diverse.

Teachers in primary and secondary schools are custodians of the curriculum they offer on a day-to-day basis, which is why it is invaluable to have the funded support of organisations such as the SHINE Trust and Comino Foundation, to take the necessary time to stop and reflect together.

The primary to secondary transition presents a range of social and educational opportunities for pupils. The science curriculum changes radically. Although always aligned to the National Curriculum, it is evident that secondary science teachers quickly feel the pressure of exam board regulations. This report has shone a light on 'disadvantage' and 'transition' – terms that hold multiple variables that require a place-based approach to scratch beyond surface-level understandings.

Head teachers, senior leaders and teachers collaborated with the University specialist science education team to arrive at strategies and approaches that have begun to make a difference in classrooms. Most crucially, they have developed professional alliances that will continue to focus on enhancing inclusion in science classrooms. The reframing of the language within this project has been significant. Refocusing on 'progression' in curriculum drew all our attention to the daily needs of our pupils in science lessons. Transition focused on how learning could build more concertedly on prior experiences, preconceptions and understandings. Tackling disadvantage focused on learning more about the vulnerabilities our pupils bring to the classrooms, beyond the strategic national identifiers such as Pupil Premium.

In essence, the light we have shone has been one that has refocused the way we look at our science classrooms, and the way we look at our responsibilities as teachers in different phases of a child's science learning career.

It has been inspirational to work with the teachers in this project. The head teachers' vision for their schools has been admirable, and the resilience of all to sustain effort throughout the pandemic has been second to none. The story is far from over and as a project group all acknowledge our ongoing responsibility to each and every pupil to keep the light shining on how we further enhance inclusion for educationally disadvantaged learners in our science classrooms.

We welcome interest and support to continue this vital work.

Dr Lynne Bianchi
SEERIH Director
The University of Manchester

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9. Acknowledgements

Schools

Abraham Moss Community School
Crab Lane Primary School
Crumpsall Lane Primary School
Heybrook Primary School
Falinge Park High School
Spotland Primary School

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About SEERIH

The Science and Engineering Education Research and Innovation Hub (SEERIH) is a nationally recognised centre of science and engineering education. We develop and engage teachers in innovative, research-informed continuous professional development programmes to ensure high-quality learning outcomes for young people.

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About SHINE Trust

SHINE is an education charity that works with teachers, schools, and other organisations, helping socio-economic disadvantaged children in the North of England to fulfil their true potential. SHINE feels passionately that every child deserves the best start in life – regardless of background or where they live. Since its creation in 1999, SHINE has invested over £30 million to more than 300 education projects supporting 1.3 million children across 20,000 schools.

www.shinetrust.org.uk

About the Comino Foundation

The Comino Foundation is a registered UK charity, founded in 1971 by the engineer, inventor and industrialist Dimitri Comino OBE and his daughter Anna. The Foundation is an Educational Trust whose work is currently based in England, though it has links with work in other parts of the United Kingdom. Its aim is to support the achievements of groups and individuals within a prosperous and responsible society.

www.cominofoundation.org.uk

Appendices

Appendix 1: Programme Structure

Activity	Engagement	Purpose
Full-group meetings (upto 4 half days)	Teachers, Senior Leaders, Specialist consultants, SEERIH Coaches, Research Associate	To build systems, processes, expectations and new understandings between phases and of the programme. Receive specific training on the use of Action Learning Sets. Data gathering, review and interpretation.
Regular, coached cohort specific group meetings (at least one per term)	Teachers with identified SEERIH Coach	Within action learning cycle discussions to identify the needs and interests of groups – create and trial interventions and review the impact on learning.
School-to-school cluster development and trialling (regular via range of communication types)	Teachers with virtual SEERIH Coach	Planning and reflection on in-class trials. Reflective discussions related to impact on learning.
Research Engagements (face-to-face or online)	Teachers and Research Associate	Academic research processes (including interviews and surveys) to track the impact of the project on teachers.
Specialist Leadership Advice	SEERIH project leaders, Head teachers and SLT, Research Associate	To critically review data (baseline and progress measures).

Appendix 2: School demographics and data

School name	% Minority Ethnic pupils	WP Rating	Banding compared to all schools based on the proportion of pupils who are disadvantage*.	Academic Performance compared to all schools.
School A	97.6%	2A	Top 40%	Bottom 20%
School B	41.8%	1D	Top 20%	Top 40%
School C	97.7%	2B	Top 40%	Bottom 40%
School D	83.8%	1B	Top 20%	Bottom 40%
School E	97.7%	1A	Top 20%	Bottom 20%
School F	93.3%	1A	Top 20%	Bottom 20%

* Measure of Disadvantage = The proportion of pupils who were eligible for free school meals at any point during the previous 6 years, plus those who have been in local authority care for more than 1 day, plus those who have been adopted from local authority care.

Appendix 3: Teacher representation

Rochdale Cohort	Purpose
High School	Head teacher
	Head of Science
	Teacher of Science
	Teacher of Science
Primary School	Head teacher
	Science Leader and specialist cross-school science teacher
	Specialist cross-school science teacher
	Teacher, joined the project September 2021
Primary School	Head teacher
	Science Leader and class teacher
	Year 6 teacher
	Assistant Head teacher, joined the project September 2021
	Year 6 teacher joined the project September 2021
Manchester Cohort	
High School	Head teacher
	Head of science/Strategic Lead
	Teacher of science, RQT at the start of the project
	Teacher of science, RQT at the start of the project
	Teacher of science, RQT at the start of the project
	Teacher of science, joined the project from September 2020
	Teacher of science, joined the project from September 2020
Primary	Deputy headteacher of the school/ Head of primary
	Year 6 teacher
	Year 1 teacher, science subject leader
Primary	Acting executive headteacher
	Head of School
	Year 1 teacher and leader of science
	Year 5 teacher
Primary	Acting executive headteacher
	Year 3 teacher and science leader
	Year 4 teacher
	Year 6 teacher, deputy headteacher and phase leader (from September 2020)

Get in touch

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