EDUCATION & TRAINING FOUNDATION

CENTRES FOR EXCELLENCE IN MATHS

CHANGING THE EXPERIENCE OF FE MATHS

CFEM INTERIM REPORT
SYNTHESIS OF ACTION RESEARCH REPORTS 2020/21

About CfEM

Centres for Excellence in Maths (CfEM) is a five-year national improvement programme aimed at delivering sustained improvements in maths outcomes for learners aged 16 to 19 up to Level 2, in general further education (FE) colleges and sixth form colleges in England.

The action research strand of the CfEM programme is exploring what works for teachers and learners. Other aspects focus more directly on embedding related CPD and good practice and building networks of maths professionals in colleges. CfEM is funded by the Department for Education (DfE) and delivered by the Education and Training Foundation (ETF) and partners.

Find out more about the CfEM programme online:
etfoundation.co.uk/maths/cfem/

View the CfEM action research reports:
etfoundation.co.uk/cfem-action-research

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Centres for Excellence in Maths (CfEM): Synthesis of Action Research Projects 2020/21

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1. Introduction: CfEM and FE resit grade attainment

The main aim of the Centres for Excellence in Mathematics (CfEM) programme is to raise attainment in Level 2 maths resits so that more learners achieve GCSE grade 4 or above or Level 2 Functional Skills. These are the widely recognised minimum qualifications accepted by employers and therefore required in government policy.

In recent years, approximately 140,000 learners aged 16 to 18 attending Further Education (FE) colleges have been entered for maths GCSE, annually. In 2018, 18% of FE college learners aged 16 to 18 who were entered for GCSE maths achieved grade 4 or better. In 2019, it was 17%. Other learners will, of course, have made progress towards a grade 4 (for example, from a grade 2 to a grade 3). Nevertheless, the vast majority of learners see themselves as having "failed" again.

In 2020, owing to cancellation of examinations because of the Covid-19 pandemic, GCSE learners received Centre Assessed Grades (or calculated grades). The consequent improvement in the headline statistic (40%) reflects 'the changed method for awarding grades rather than demonstrating a step change improvement in standards' (DfE, 2020). In 2020, an all-age total of 734,301 learners were entered for GCSE maths, of whom 66.6% achieved a grade 4 or higher.

FE colleges, including those involved in CfEM, enrol most of the remaining one third (33.4%) of these learners. They comprise those transferring from schools to do their first resit and those on their third or more attempt, all yet to achieve the required grade 4+.

A recent history of national FE maths resit attainment concerns and solutions

1999 Moser Report
Brought attention to low level of numeracy among adults

2004 Inquiry into Post-14 Mathematics Education
Highlighted teacher shortage and lack of relevant and effective CPD

2011 Wolf Review
Publicised that less than half 16 to 19 year olds held both English and maths, and only 4% achieved them during the 16 to 19 phase

2014 Condition of Funding
It became a condition of college funding that students aged 16 to19 without a grade 4 must study maths

2016 Sainsbury Review and 2017 Industrial Strategy
Compelling case for improving FE maths attainment for employers and prosperity

2017 Smith Review of Post-16 Maths
Advocated the importance of FE maths to policy makers

2018-2023 Centres for Excellence in Maths

1.1 About this report

Between 2018 and 2023, the DfE is investing unprecedented sums – approximately £30 million – into raising maths resit attainment, via CfEM. This research and development programme aims to upskill and put resit maths teachers at the heart of innovations. This report is a synthesis of action research reports produced from the action research strand of the CfEM programme in the Covid-affected academic year of 2020/21. It highlights key themes, is necessarily selective, and aims to inspire more action research by FE maths teachers.

As the research took place during the 2020/21 Covid-19 pandemic, most research plans had to be scaled down and adapted. In particular, fewer teachers were able to participate than originally planned, especially from network partners. Also, mental health of learners and staff took highest priority.

Brief summaries of all CfEM 2020/21 action research reports and full versions are available are available online at: etfoundation.co.uk/cfem-action-research

2. Action research for professional development: a model

One of the distinctive approaches that CfEM has taken to address low pass rates in maths resits is to support groups of maths staff to undertake their own enquiries.

Guided by theory and experience of doing action research, the aim was to:

- foster collaboration and sharing
- be highly contextualised and true to resit teachers and learners, colleges and the FE system
- be informed by evidence
- generate new knowledge for those directly involved
- be a model for professional development that leads to incremental change and a habit of continuous improvement.

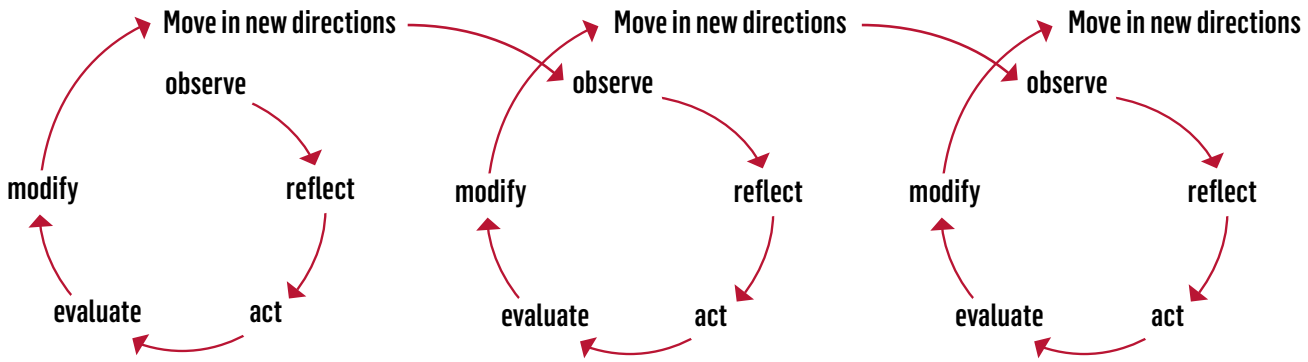
Traditional research techniques were covered in training sessions and used in all projects, for example, establishing a research focus, reviewing literature, data collection, data analysis and report writing. At this point, it is worth outlining **how *action* research differs from traditional research**. Action research can be thought of as a model for professional development and therefore highly relevant to transforming the experiences of resit maths teachers and learners. It allows for multiple lower-stakes iterations, thereby supporting incremental improvements.

It also closes the distance between the researcher and practitioner – the teacher is designing what and how to research and therefore the content is relevant and immediate. Action research becomes more than the results or findings; it becomes about the process or 'journey' – which is a benefit in its own right.

By taking a **collaborative approach** to action research, the views of CfEM participants were heard, valued and respected, fresh thinking was stimulated, and teachers genuinely enjoyed working together. Action research puts practitioners in control of research decisions. It recognises and draws on their specialist expertise in working with FE maths resits, an extremely challenging area within the education system. By contrast, traditional research is done 'to' others, by an outsider without lived experience of the detail and contexts of practice.

The **model of action** research recommended is based on McNiff and Whitehead. They see action research as a collaborative, empowering and iterative model highly suitable for professional development, based on the "power of sharing ideas to generate new ones."
(McNiff and Whitehead, 2007)

For many taking part in CfEM, an 'action research cycles' model represented as a diagram proved useful, with explanation, as follows:



The Action Research Cycles (based on McNiff and Whitehead 2006)

1. Making conscious **observations** about your own teaching in real time.

2. **Reflecting** further on your current practice. This is usually captured in journals, on log sheets or in meeting notes. Around the same time, agreeing what needs researching, pooling ideas and reviewing relevant literature to help inform what might work well.

3. **Acting** on this information, that is trying out a new approach or resource with learners.

4. Collecting evidence to **evaluate** what worked or did not, then sharing and analysing this data.

5. Agreeing how to ***modify*** practice (and agree what to research next, that is return to point 1. above).

3. Doing action research

This section examines ways in which doing action research as part of a CfEM made an impact on professional development. The aim is to inspire other FE maths resit teachers.

Here, it is worth noting the lack of relevant research that CfEMs found, for example, "Little research has been published utilising resit students in a 16 to 19 further education environment" (Nelson and Colne College Group).

3.1 Choosing research topics that matter

Topic selection is a major part of the work. This was guided by University of Nottingham's selection of topics that previous research had indicated were likely to make most difference to attainment in FE resits. All action research participants were asked to focus on one or a combination of topics from four broad areas:

- motivation and engagement
- effective use of technology
- approaches to mastery
- maths and contextualisation.

Topic selection for individual projects was guided by reflections on learners, community, college priorities and national attainment data. This is summarised in the background or introductory sections of each research report, giving the context and rationale for what was researched.

Then, teacher-researchers, sometimes collaboratively, narrowed it down to what would be a likely productive and pragmatic focus to investigate in any one action research cycle. Below is a summary of the research foci selected by FE maths teachers, which represent priority areas for development in FE maths resits. Motivation and engagement were by far the most popular and urgent areas for the FE maths resit teachers to address, followed by effective use of technology. The latter was added to many projects because of enforced periods of learning from home during Covid-19 lockdowns.

Themes and topics that were chosen to research are summarised below.

Broad theme	Topics selected for research by colleges
Motivation and engagement of maths resit learners	■ Coaching and mentoring one-to-one and small groups: – student engagement coaches – maths-specialist tutors as mentors – coaching to improve mindset and reduce anxiety – maths labs and clinics – coaching to identify gaps and build confidence. ■ Positive learning environments via: – maths motivation toolkit – non-traditional learning environments (including outdoors). ■ Learner motivation using: – online platforms – motivational online delivery strategies – growth mindset – resilience using blended learning. ■ Mindset interventions ■ Social media ■ Strategies for independent learning
Effective technology	■ Flipped learning online ■ Positive learning environments and student-teacher relationships online ■ Using tech for variation and fluency teaching ■ Motivational blended learning approaches ■ Blended learning model ■ Digital software for key maths concepts
Mastery approaches to teaching maths resits	■ Diagnostic teaching to identify starting points and address gaps ■ Conceptual understanding using Concrete, Pictorial, Abstract (CPA) representations delivered online ■ Feedback in digital maths provision ■ Curriculum coherence and connections for increased fluency ■ Maths language for ESOL and non-ESOL learners ■ Collaboratively planning for professional development

3.2 Examples of how action research led to positive outcomes

Below is a selection of diverse positive experiences of doing action research. Collaboration stood out as the main beneficial process: teachers enjoyed and grew as professionals from opportunities to share and discuss ideas, resources, planning and evidence about effective practice with colleagues. It also gave them licence (and time) to try out new ways of delivering maths, which empowered them to adapt their own practices.

This didn't previously happen, or not to the same extent. From these quotes, readers can see how the model of action research cycles has been used effectively, for example:

– reflective practice
– collaboratively re-designing aspects of provision
– trialling new techniques, resources or strategies
– using evidence to inform future practice.

> We conducted three cycles of **collaborative planning, teaching, gathering evidence and reflection**, based on our research. We practised and made sure we had mastered the techniques before teaching the lessons to our classes. During face to face lessons we took photos of students' work. After delivering the lesson we **reflected** on the lesson informally in the shared workroom and formally in writing and discussion. As part of this process we discussed **how the lesson could be improved for next teaching**.
>
> WESTON COLLEGE

> The **collaborative nature of the sessions worked well, with most people making contributions about elements to improve**.
>
> WARWICKSHIRE COLLEGE

> Lecturer-researchers wanted to continue... Action Research **to upskill and develop staff as navigators of online learning**.
>
> LEEDS CITY COLLEGE

> Lecturers involved have felt more **comfortable to think** innovatively and in a less constrained manner when creating and planning maths lessons.
>
> CITY COLLEGE PLYMOUTH

> We sourced mentors that were undergraduate maths students from a local university which we had built a **collaborative relationship** with through the CfEM programme.
>
> CHRIST THE KING SIXTH FORUM COLLEGE

> The research design stage was **very much a collaborative process** between the teachers and coaches involved in the action research, particularly in relation to the development of coaching strategies. Due to the disruption of Covid-19, it became paramount **that different strategies were trialled and improved throughout the year** so that they would meet the ongoing needs of our students. Using an **iterative cycle approach was invaluable in trialling interventions, reviewing as a group to modify and trial again**.
>
> CAMBRIDGE REGIONAL COLLEGE

Teachers agreed **that the intervention led to improved use of vocabulary as well as wider benefits of positive changes** in student understanding and outcomes and increased amounts of discussion taking place in classes ... Some teachers also noticed improvements in students' approaches to problem solving, and in behaviour for learning. Most teachers have indicated change in behaviour to include vocabulary as part of the lesson focus. **All teachers agree they will use this intervention in the future.**

NEWHAM COLLEGE

Teachers' reflections throughout the year looked at the experience from a teacher's growth perspective, and **the ability to embrace a new and different approach to teaching** proportionality. From our experience, we recommend **creating spaces to enable teachers** to reflect with other teachers.

WESTON COLLEGE

This action research has provided some **clarity and certainty** around the impact mentoring can have on resit GCSE Maths learners, particularly on their attitude and mindset. For example, the overwhelming evidence that growing and improving academic self-concept had a big role to play in how students felt or perceived their 'mathematical ability'.

CHRIST THE KING COLLEGE

Learner view capture was central to our research approach. The group collaboratively designed a learner survey ... to find out attitudes, behaviours and beliefs towards **what the current maths resit teaching model is like for a learner** and how they felt about it.

NEWCASTLE AND STAFFORD COLLEGE GROUP

The research has ... supported and encouraged lecturers to **strive forward in their teaching practice** ... with more **practical maths activities outside the traditional classroom environment** now included across the College.

CITY COLLEGE PLYMOUTH

Tutors submitted short reports after the final intervention, outlining their findings and feedback [which] provided ... **rich insight into those teachers' lived experience** of online mathematics teaching during a global pandemic. Systematic thematic analysis led to four key themes emerging from the data.

LAKES COLLEGE

4. Effective action research – case studies

This section features 11 case studies, supported by over 20 further action research projects. Each one celebrates and shares insights into what was tried out and evidence of effectiveness (or not).

The hope is to inspire interested FE maths teachers to adopt action research as a way to improve aspects of their own practice. The first four cases are examples of **mastery approaches to deepen learner and staff understandings**, the next four are on ways of **developing resilience and engagement**, and the final three on **effective uses of technology for maths learning**. The knowledge created was new and relevant to the staff participating in each piece of research. Findings are not being generalised to the wider FE sector because they were context-specific, as is the nature of action research.

4.1 Mastery approaches

Theme: identifying gaps in learning

Case 1 – Wilberforce Sixth Form College

Topic: different forms of assessment feedback
From early in the project, the wide-ranging sources of literature that the team at Wilberforce read gave them a consistent message: learners respond differently to different styles of feedback and some approaches to feedback can motivate and improve performance (for example, van der Kleij, 2019, Kyaruzi et al, 2019, Brown & Kirschfield, 2007).

The teacher-researchers were inspired by what they had read and discussed to try both chunking-up assessments into a series of micro-assessments and facilitating learners to identify which question types or topics they wanted help on after taking macro-assessments. Cleverly, a student survey after each assessment negated potentially negative impacts of doing a test by asking learners for their views and experiences to inform future teaching.

In this study, 51 learners completed five assessments in the 2020/21 academic year. All learners benefited from regular formative assessment to ensure knowledge gaps are identified and potentially bridged.

Standout findings:

- Learner motivation improved over the academic year, which was likely owing to staff finding out increasingly effective strategies, including the use towards the end of the project of wholly positive feedback.
- One hundred percent of learners who enjoyed maths and 70% of those who did not said that they wanted feedback.
- Eighty-eight percent of those who enjoyed maths found micro-assessments helpful, as did 61% of those who did not enjoy maths.

- Learners giving their teachers feedback on where they wanted further help after doing macro-assessments improved on average from grade 2.8 to around 3.5 out of 5. Motor Vehicle and Engineering learners improved 'massively' by 50-60%.
- Self-marking had greatest effect on student motivation, peer marking least. However, approximately half the teaching team had previously believed self-marking most effective for learning. Note that feeder schools tend to use student self-marking for student involvement.
- The most popular feedback media are attainment scores and teacher comment. The vast majority of learners prefer their teacher to provide feedback rather than their peers. On balance, although feedback including written (and unmediated) attainment grades of less than a 4 had a negative impact on confidence, Wilberforce College teachers still feel it is "important that students know which grade they are working at". Effort grades were considered too arbitrary to be considered meaningful and formative.

"Meaning-focused feedback is paramount to establish a professional teacher-student relationship as a catalyst for the improvement of learners' motivation."
(Rakoczy et al, 2008)

Reflections from other projects on this theme

East Kent College

An alternative approach to identifying gaps in maths skills was tried out by East Kent College. The ambition was for more learners to take their Functional Skills assessment when ready. The college trialled an **intensive support programme for a manageably small number of learners identified as nearly ready to sit their Level 2 Functional Skills exam, using a Question Level Analysis diagnostic approach**. Learners received back a checklist of gaps and teachers did additional small-group group sessions to fill those gaps identified in knowledge and skills, as required. Surveys of leaders, teachers and learners suggested that this diagnostic teaching approach can be a very successful strategy and have a positive effect on Functional Skills outcomes. The research team concluded that, "where implemented effectively, leaders, teachers and students embrace diagnostic teaching and it is an informative and invaluable tool" and data analysis showed it "correlates with higher achievement".

Gateshead College

At Gateshead College, learners who spent time **addressing gaps and misconceptions at Key Stage 1-3** achieved better than the college-average assessment results, which would translate to half a grade increase in an exam. What was originally planned as **short starter activities were expanded** over the duration of the project, in response to student feedback. In this study, Sport learners received 10 minutes doing questions then 30 minutes in teacher-led discussion. Art and Design learners received 10 minutes of questions and 10 minutes of teacher discussion. The former achieved significantly better on assessments. These researchers recommend that anyone implementing this approach should do so consistently throughout the year, make learners aware of the reasons and process behind it, and make links across maths topics obvious and routine.

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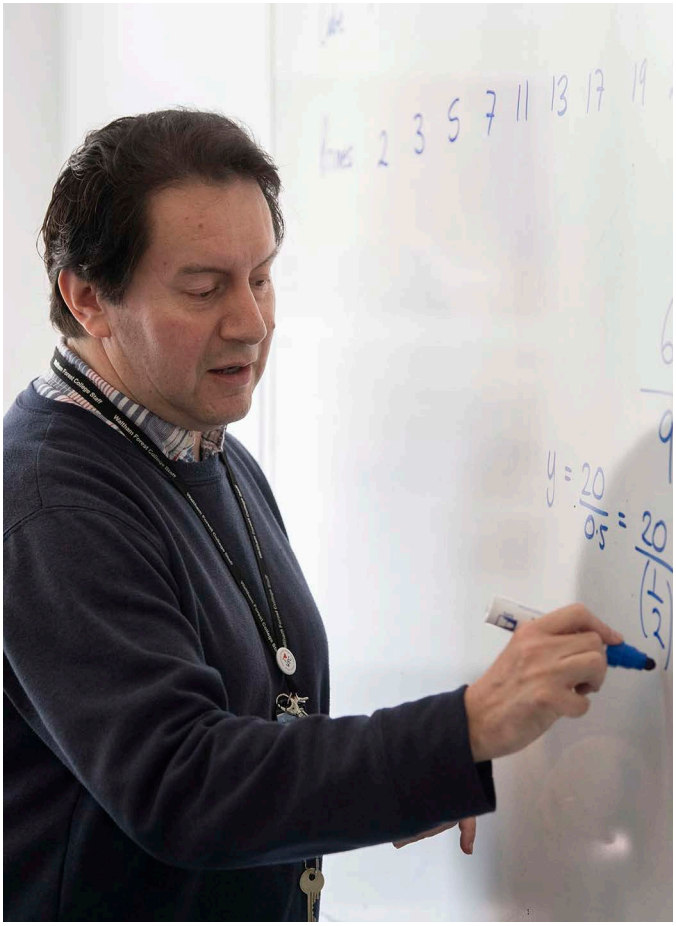
You can read the detailed reports from these projects by visiting the links below:

Different forms of assessment feedback at Wilberforce College: bit.ly/3r8KODb

Question Level Analysis to pinpoint students for intensive pre-exam support at East Kent College: bit.ly/3r9ILyO

Addressing Key Stage 1-3 gaps and misconceptions at Gateshead College: bit.ly/3nbfJxC



Theme: addressing gaps in learning

Case 2 – Newham College

Topic: teaching meanings of mathematic key words and phrases

Being able to solve mathematical word problems is a fundamental skill that promotes creative thinking and enables the learners to think in a logical manner, as well as attain a grade 4 or better in Level 2 examinations. All learners have to draw on their knowledge of the construction, content and meaning of words, phrases and questions they are given.

Maths department staff at Newham College hypothesised that their many learners without English as a first language may need additional support in mathematical word meanings and usage. Literature backed up this thinking. It also confirmed their own experiences that: some words have technical meanings in maths that are different to their common everyday use, while some learners struggle to distinguish between pairs of words with similar meanings (for example, multiple and factors, estimate and calculate), and some learners struggle to make sense of word problems.

In this study, 30 mathematical words with alternative everyday meanings were carefully selected. They were later reduced because of lockdown to 10 taught in depth: Expression, Expand, Estimation, Roots, Base, Reflection, Proportion, Translate, Compound and Similar.

Pre-diagnostic assessment allowed teachers to determine learners' individual strengths and weaknesses and therefore acted as an initial point for intervention. Data was collected in the form of:

- a language survey and pre- and post-diagnostic test with a little over 100 learners each
- a post-intervention survey by 95 learners
- reflections from the five participating teachers.

Standout findings:

- Contrary to expectations, learners on English for Speakers of Other Languages (ESOL) courses did better than non-ESOL learners in understanding the meanings of ambiguous words in both the pre- and post-diagnostic assessment.
- On average, learners could accurately recall 10% more maths and English definitions/meanings after the intervention. Most notable increases were for the words: Compound, Reflection and Translate. Root and Base were clarified in English. Note that just over half of learners could still not define at least some of the 10 words after the intervention. Nevertheless, the increases were statistically significant and therefore the intervention was considered very worthwhile.
- Most learners said that learning maths definitions/ meanings helped them with their GCSE exam questions and wanted their teachers to continue using the intervention in the future. Teachers were also enthusiastic, reporting increases in learners' understandings of maths and a notable improvement in behaviour because of greater comprehension in lessons.
- Pre-teaching of the words and then learners completing an adapted Frayer-model-style template (see full report) had a particularly positive impact on both test scores and in-class demonstrations of understandings of definitions/ meanings.
- There was a statistically significant association between the words that learners were struggling to define and answering maths questions that included those words. Most notable of all were the words Similar, Compound and Proportion.
- Most teachers have already changed behaviour to include teaching vocabulary in lessons. All say they will continue it in future. Further, 70% of learners wanted to carry on learning vocabulary, though 16% did not. The large majority (69%) wanted to continue with the adapted Frayer word template, only a few (5%) did not. In addition, 77% said it helped them understand exam questions, while 19% said it did not.

"Mathematics education begins in language, it advances and stumbles because of language, and its outcomes are often assessed in language." (Durkin and Shire, 1991)

Reflections from other projects on this theme

Leicester College

Understanding the meaning of maths vocabulary is essential for solving worded problems in exams and real life. A quarter of the GCSE maths specification at the Foundation Tier is on problem solving (A03) and a further quarter on the related areas of reasoning, interpreting and communicating maths (A02). This rises to 60% at the Higher Tier and three-quarters of Functional Skills.

One of Leicester College's projects focused on **improving learners' worded problem-solving skills** and, like some other projects, focused on number (AO2/3 in the GCSE syllabus) and used gap analysis. The researchers compared assessment data from three different strategies undertaken with a total sample of 65 self-selecting learners against the overall college average of 34% in an assessment. They found that teaching problem solving plus doing gap analysis led to a much-improved assessment percentage (54%). Fifteen learners gave their feedback. Confidence to attempt worded questions, mathematical knowledge and willingness to improve their problem solving all went up when participating learners watched video clips tailored to their gaps.

You can read the detailed reports from these projects by visiting the links below:

Teaching meanings of mathematical key words and phrases at Newham College: bit.ly/3HWD6Tp

Improving learners' worded problem-solving skills at Leicester College: bit.ly/3HTZehn

Theme: addressing gaps in understanding

Case 3 – Leyton Sixth Form College

Topic: double number lines and bar modelling

Leyton Sixth Form College investigated representations including double number lines (DNL) and bar modelling for lower-level learners. Multiplication skills are required by many exam questions, but teachers knew it was an area of weakness for many learners. The team at Leyton agreed that learners would benefit from strengthening their understanding of multiplicative reasoning. After sharing relevant literature, they decided it would be worth investing time in developing learners' skills in using DNLs and bar models.

Examples of easily relatable lessons and their success:

- **'Best buys'**
  The cost-per-unit was found easy once it was taught using double number lines. Analysis of learners' work indicates a range of correct and incorrect or incomplete steps that different learners took, which could be referred to in future.
- **'Enough food for everyone'**
  Most successful was scaling up the given weight of each recipe ingredient by multiplying (in this case by 2.5), represented by working along a line (93% of a class). The unit strategy (working out the amount for one then multiplying by 40) was less popular and less successful.
- **'Life-size and scale models'**
  When scaling up a toy car, learners who did a pictorial representation had a much better success rate than those who did not.
- **'Fastest animals'**
  Here, DNLs were found especially helpful as the question involved more proportional reasoning than simple substitution. Teachers found they should in future do starter activities on calculating distance and time, including converting hours to minutes.

Standout findings:

- Learners who did not have a method or who struggled with traditional methods were more likely to attempt to solve a problem if they have learned how to picture the information on a diagram.
- Learners needed support to draw the diagram well enough for it to be useful. Especially, how to take information from questions and put into diagrams correctly. They could do the maths when given the bars but struggled to draw for themselves.
- A quarter of learners surveyed towards the end of the year could not remember whether they had been taught DNLs (which they had), so reminders are essential to prompt 'working memory'.
- Regarding DNLs, success working along lines was significantly greater than working across (that is, between) lines. Learners who had an alternative method before being taught DNLs and bar models were more reluctant to try these diagrams, and some found it confusing. It was important to connect diagrams to other methods for them to see how they can be applied over various mathematical topics.
- Regarding bar models, a little over half of learners had either forgotten or had not been taught how to share in a ratio. Once the bar models were taught, the learners who did not understand ratio previously found the bar models easier to adapt to. Of 50 learners formally assessed, 12 chose to use bar model for a subsequent ratio question, of whom almost all (11) got some or all marks. Of 19 who did not use a bar model, just over half (10) got some or all marks. Nineteen learners did not attempt the question. The main problem was that the learners were not able to identify the type of ratio question it was, and others stuck with what they already knew or felt.

Pedagogy points for teachers: be absolutely committed to the DNL/bar model to get learners to engage with it. Use mini whiteboard formative assessment sessions, essential for raising skills and confidence. Show balance method alongside the bar modelling to support learners making connections between methods and progress towards a fully abstract method. Learners need time to learn and practise using representations.

> "Echoing the experience of Leyton College, Weston College found several months of persistence and continual informal practice was needed."

Reflections from other projects on this theme

Weston College

Other CfEMs also investigated using representations for the first time in their lessons. Weston College focused on ratio tables to deepen understandings of proportionate reasoning. Both Leyton and Weston Colleges found it worked well when applied to real-life and vocational contexts. Weston College found learners better able to identify with abstract concepts after using pictorial models to illustrate proportionality. Here, **ratio tables worked particularly well for proportional reasoning** when using life/vocational contexts such as pancakes. Most of the eight teachers noticed greater engagement when maths was contextualized. Echoing the experience of Leyton College, Weston College found several months of persistence and ongoing informal practice was needed with ratio tables, otherwise teachers felt under-confident, and learners would go back to old and incorrect ways of working. As at Leyton, the real-life context of food was popular and easily relatable. Learners seemed better able to engage with the context and relate it to their experiences of food, which enabled a rich classroom discourse and a sense of ownership. Half of the eight teachers involved struggled to fit the first iterations of teaching ratio tables into their schemes of work, so the group decided that for their final action research cycle of the year they would focus on shorter, snappier use of ratio tables as starters in lessons.

Christ the King Sixth Form College

Here they decided to explore high quality manipulatives, which have traditionally been 'concrete' physical resources used prior to introduction of pictorial and abstract representations. These are commonly used in primary schools. Owing to remote learning during lockdown and staff interests in technologies that help deepen conceptual understandings, **virtual manipulatives** were investigated which would appeal to young adults. Studying the characteristics and benefits of existing virtual manipulative apps was found to develop fluency more than conceptual understanding. Evaluating existing apps led to "essential professional collaborative learning experience on what tech works for this purpose". After much development work, five teachers and 60 learners trialled a new mobile virtual manipulative app for three weeks. It needed time to build up familiarity and learners needed time to 'play'. A comparison of 25 pre- and post-intervention learner questionnaires indicated a split on whether the app helped learning. More conclusively, on assessments, the lowest performing learners improved a lot. Teachers found that learners' success with the app was contingent on more support, not less as had perhaps been thought.

Gateshead College

At Gateshead, they examined **virtual manipulatives**, this time in the context of the pandemic necessitating the transference to online teaching of what had been successful in-class mastery approaches using physical manipulatives. The maths topic being taught was ratio, and virtual manipulatives were used as **part of a sequential teaching model Concrete-Virtual-Pictorial-Abstract**. The study was inspired in part by Lee's (2014) case study of virtual manipulatives that had resulted in narrowing cognitive gaps, the significant improvement of learner engagement, and the increased efficiency of lesson planning (also see Hunt, Nipper and Nash, 2011). The research led teachers to look at new ways of doing things. The team concluded that:

- training for learners and staff with software and hardware is vital
- explaining to learners in advance what you are trying to achieve and how their views are important
- learners will understand and admire teachers more for trying something new if you involve them in the process
- most of all, remember to have fun.

You can read the detailed reports from these projects by visiting the links below:

Double number lines and bar modelling at Leyton Sixth Form College: bit.ly/3qM9fHG

Ratio tables to deepen understandings of proportionate reasoning at Weston College: bit.ly/3tGqtlu

Virtual manipulatives to engage learners at Christ the King Sixth Form College: bit.ly/3r659t5

Virtual manipulatives to teach ratio at Gateshead College: bit.ly/3fM9aNP

Theme: staff development

Case 4 – Cambridge Regional College

Topic: professional learning model

Teaching becomes a significant challenge when many resit learners have negative attitudes towards maths, which exhibits itself as lack of engagement and poor behaviour in class. Dalby and Noyes (2018) highlight the need for FE maths teachers to address these issues by using pedagogies that are responsive to learners' needs, allowing them to build confidence and resilience. At the same time, maths teachers at Cambridge Regional College (CRC) had been distributed throughout vocational subject areas to improve college-wide maths provision as part of a recent restructuring. Though done for good reason, maths teachers felt isolated and lacking in support.

The top priority for this action research was for maths teachers to collaborate and share. The group decided to develop a **sustained programme of professional development with collaborative planning at its heart.** The professional learning model that was worked out over the duration of the project improved the engagement and resilience of staff and was beginning to impact on learners as well:

- Meeting dates could not be the same afternoon each week owing to teaching timetables.
- A core group met regularly, and a wider group joined other professional development events.
- A padlet was used to share resources among maths teachers.
- Most of the meeting time was spent doing collaborative lesson planning and talking about how lessons planned together went and could be improved.
- A feedback questionnaire found teachers also needed guidance on the use of shared resources, so that was added to the CPD model.

Teachers collaboratively developed their vision and pedagogy for teaching and learning. For example, teachers welcomed shifting from directly instructing learners to supporting them on short tasks which promoted student talk. Also, assessment content, pacing and frequency were investigated and now better understood, as were formative assessment strategies.

This work led to the empowerment of teachers to take risks and try new approaches without fear of judgement by others. In turn, these classroom experiences and opportunities to share different insights have caused teachers to change their perceptions of potential learner engagement and capability.

Reflections from other projects on this theme

Other CfEM projects concentrating on maths teachers' professional development included Greater Brighton Metropolitan College's investigation of bite-sized videos on assessment for learning, which looked to train or remind staff of key principles and pedagogy. Warwickshire College also found teacher engagement in initiatives aiming to change practice whilst in a pandemic extremely challenging, yet still managed to deliver CPD sessions on learner resilience. All these projects confirmed that teachers do not change practice after a single CPD session – they need sustained support and time to practise.

You can read the detailed reports from these projects by visiting the links below:

Collaborative planning for teacher development at Cambridge Regional College: bit.ly/3rw9Zje

Bitesize training videos on Assessment for Learning at Greater Brighton Metropolitan College: bit.ly/3KuTnkC

4.2 Developing engagement and resilience

Theme: promoting self-efficacy

Case 5 – Leeds City College

Topic: an engaging new set curriculum

Leeds City College, as with several other CfEMs, found the US psychologist Albert Bandura's concept of 'self-efficacy' particularly relevant to the FE resit learners. Self-efficacy can be defined as an individual learner's belief in their capability to influence their level of performance. It determines how people feel and think, and the amount of effort they're willing to put in.

"There is a clear correlation between student performances and self-efficacy, with a general agreement amongst researchers that when students do not see themselves as competent their achievement is lower (Kirby et al, 2015; Nguyen, 2015; Leaper, Farkas, & Brown, 2012), which is in accordance with the claim that students with high self-efficacy are more likely to persevere with a given task and continue to work on problems until they are solved or correct (Pajares & Miller, 1994)."
(Extract from literature review, Leeds City College)

A new scheme of work based on Mathsbox Focus 4 was being introduced across Leeds City College campuses with teacher-researchers: how could this be done in a way that promoted self-efficacy? Learners were provided with new Mathsbox Focus 4 resources, which coincided with Covid-19 lockdowns. Literature had already alerted teachers to online learning building some learners' self-confidence while de-motivating others, and how the role of the teacher was key. Therefore, the research intervention evolved to using a mixture of modes of delivery – synchronous and asynchronous. Greater variety was introduced in terms of task and information delivery (such as verbal explanation, visual presentation, multimedia, online resources, models and simulations, using calculators and other equipment) to potentially appeal to different learners.

Eighty-eight learners completed both pre- and post-intervention questionnaires and the results could be compared. Nine teachers took part in the research and were interviewed towards the end of the project.

> "Overall, it is evident that both raising a learner's self-efficacy and the impact of the teacher are the principal factors for increasing engagement, however the field would benefit from more research into how to do this efficiently."
>
> LEEDS CITY COLLEGE

Standout findings:

- Teachers found Mathsbox Focus 4 resources suitable for learners who had previously attained a grade 3 at GCSE, with lower-level learners finding them too difficult. Five of the nine teachers said contextualisation built in to Mathsbox Focus 4 resources helped learners realise why maths as a subject is important and helps combat the rhetoric of "why do I need to know this?" All nine teachers said that they wanted to carry on with Mathsbox Focus 4 the following year, mainly because it was flexible and possible to differentiate and personalise.
- Learners were observed responding well to the retrieval style of the resources, which boosted perceptions of their own progress when able to correctly answer questions from a range of topics.
- Of the 88 learners surveyed, 63% reported increases in motivation to learn maths. The main reasons cited were Mathsbox Focus 4 being good for revision/recapping and the range of topics. Approximately half of the learners surveyed said that they found maths interesting. The large majority had enjoyed Mathsbox Focus 4 (72%) and found it helpful for their learning (81%). This data was considered outstanding in the context of Covid-19. Confidence on maths questions ranged from 81% positive on statistics down to 47% positive on angles, with the average across all maths topics being 62%.

The team was inspired to provide:

- Effort feedback – as other researchers had found it particularly valuable for enhancing learner engagement (Heshmati, Johnston-Wilder and Sinclair, 2018). For example, statements such as "you got it correct because you worked hard and didn't give up" can be highly effective as they place emphasis on the importance of effort and growth mindset.
- Open-ended questions – easily created by working backwards from a given answer or modifying an existing question (Small, 2009; Sullivan and Lilburn, 2004) or posing an additional challenge. They tend to have many solutions and several methods for finding solutions, thereby opening opportunities for success, giving learners more control, developing problem-solving skills, focusing on process and reducing anxiety (for example, Bobis et al, 2018).
- Goal setting – promoting interim subgoals allows learners with low self-efficacy to have more immediate insight to gauge their abilities (for example, Oldham, 2018).

Reflections from other projects on this theme

Nelson and Colne College Group (NCCG)

NCCG was inspired by the **VESPA (Vision, Effort, Systems, Practice and Attitude) mindset model** and wanted to investigate its impact on learners. High VESPA scores have been shown in extensive research to correlate with exam success. At NCCG, maths resit learners stood to gain from developing a VESPA mindset as they had little or no confidence in their own ability and tended not to associate success with the lack of effort they were putting in.

Just over 100 learners received the VESPA mindset teaching and there were 60 learners in a control group. Average scores of those receiving VESPA increased in three out of the five aspects. Only Attitude improved in the control group and other aspects significantly declined in this very challenging Covid-19 affected year. Learners reported improved confidence levels, higher resilience and greater levels of feeling in control. This thinking spilled outside maths – learners said they *wanted* to be more confident and less anxious and wanted more ideas on how to revise. The majority (61%) said they'd noticed a lot of change in their mindset in maths and the same outside of maths. Teachers appeared less convinced of the impact of VESPA, partly because so many other factors were at play.

Greater Brighton Metropolitan College (GMBC)

Last year, a group of maths teachers at GMBC had identified a need for and had undertaken staff development in mindfulness. This year, the intention was **for learners to do a mindfulness course in class** and researchers to evaluate its impact. There is little research into the impact of mindfulness on maths attainment but one project with higher education students in the USA was found. This had achieved reduction in maths anxiety and an increase in maths self-efficacy (Samuel and Warner, 2019). Over half of the GMBC learners surveyed felt mindfulness was a good use of class time (57%), and anxiety levels were significantly lower after mindfulness sessions.

Tameside College

Here they were seeking a mastery model of maths teaching and learning that would also **foster positive mindsets**. Learners at Tameside College said they had lost focus in maths at school because of others' distracting behaviour, it was too hard, or they found it boring. Maths anxiety and low confidence were found to be common. Further, learners coming into the college were increasingly aware of the value of a GCSE in maths and its importance to employers, but often could not see how they could bridge that gap between where their maths was now and where it needed to be to gain advantage and traction in today's job market. Tutors knew that most learners were unlikely to do enough work to pass maths GCSE unless these issues were addressed. At the same time, they felt that the FE system was not set up for the in-depth teaching required for these learners.

> "Most students are unlikely to do enough work to pass maths GCSE."

The following quote from Swan struck a chord: "Traditionally maths teachers in FE teaching the resit course face the cognitive dissonance between covering the maths content and taking the time to develop understanding" (Swan, 2006).

The CfEM programme allowed for small group and one-to-one interventions. These focused on breaking down questions and developing confidence, fostering positive attitudes to mistakes, and creating a safe environment for getting answers wrong. Learners who received these interventions were also asked to practise their new skills on an online platform. Evidence from 400 resit learners, 25 maths teachers and 30 vocational staff suggested that the intervention could be credited with significant grade improvement. Many intervention learners' performances improved significantly, as shown in assessment data. There was less but still notable impact on learners' self-reported attitudes. By the end of the action research project, approximately a third to one half of intervention learners indicated improved attitudes towards maths. For example, 44% felt they benefited from question breakdowns received, 32% believed they could improve at maths.

You can read the detailed reports from these projects by visiting the links below:

An engaging new set curriculum at Leeds City College: bit.ly/3qfQUTl

The VESPA mindset model at Nelson and Colne College Group: bit.ly/3r67tQP

Mindfulness courses at Greater Brighton Metropolitan College: bit.ly/3HUM7wk

A mastery model of maths that fosters positive mindsets at Tameside College: bit.ly/3tfaWz2

Theme: lessons outside classrooms

Case 6 – City College Plymouth

Topic: alternative learning environment

The overriding aim of this research was to have a positive impact on learners' maths learning by fundamentally changing the experience for learners, creating new and innovative ways to support them to overcome maths anxiety and using practical activities to support them with underpinning maths mastery concepts.

The team had read literature that suggested that lecturers first needed to feel empowered to embrace new ways of working. Fears associated with change would need acknowledging, so CPD was provided, which covered not only alternative learning environments (ALE) but also learner motivation, maths anxiety and student/staff trust relationships. This CPD gave teachers a strong principled practice and theory that underpinned and helped sustain their ALE work.

Maths lecturers, supported by a teaching assistant and Learning Support Assistants, took classes of learners out of the classroom and into college grounds to do practical maths activities, with each lesson having a different theme – murder mystery, running speeds, campus orienteering and making perfect squash and smoothies.

A total of 67 learners from two college sites took part in three ALE lessons and then responded to a learner survey. The evidence from this survey, together with staff reflections, indicated that the action research on ALEs had led to changes that felt radical and then developments in on-site maths teaching and learning. Very notably, it had improved engagement and behaviour of learners whose behaviour had been the most challenging when inside classrooms. Lecturers reported that more effective lecturer/student relationships were formed by taking learners outside.

Standout findings:

- Learners became more engaged with learning and their maths skills progressed outside the classroom in ways that had not happened in classrooms. Positive effects on learner autonomy and resilience were observed and reported by staff. The vast majority (89%) reported increased motivation, and 93% enjoyed maths lessons in ALEs. According to the four teachers engaged in the collaborative action research and their assistants, engagement was higher *because* of being outside traditional classroom settings, behaviour was better (the very best effect was with the previously most disruptive), learners took ownership over their own learning, they more readily overcame barriers.
- Maths lecturers have "reignited passion and confidence to develop their teaching practice through the freedom to create and explore".
- For the whole college, the research team worked hard to brief senior leaders and all College staff, which was integral to overall awareness, appreciation of impact and success.

"We are beginning to see the pattern that practical, outside the traditional classroom environment sessions support maths learning to become more of a 'level playing field', encouraging students that may lack confidence in a classroom environment normally to engage and take part more."

ALEs differentiate maths at City College Plymouth from secondary school experiences, "with an aim to treat the student in a more adult manner and allow them to practically experience and have ownership of their maths learning".

A recent Ofsted visit confirmed positive findings of this action research: **"Mathematics teachers have also experimented with taking learners out of the classroom. … These memorable practical activities help learners to grasp important mathematical concepts."**
(City College Plymouth OFSTED report, 2020).

You can read the detailed reports from these projects by visiting the links below:

Alternative learning environments at City College Plymouth: bit.ly/33pritV

Theme: one-to-one and small group work outside the classroom

Case 7 – Cambridge Regional College (CRC)

Topic: student engagement coaches

A group of particularly disengaged learners was making little progress in maths. Published literature identifies a range of barriers to engagement. Hume et al's (2018) list resonated particularly strongly with the team at CRC: perceiving maths as not relevant to future lives, fixed mindsets, being afraid of looking stupid in class in front of peers and tutors, lacking social support for learning.

To address these concerns, student engagement coaches were introduced, characterised by one-to-one conversations outside of class time and in-class support by the same coach. The common aim was to reframe perceptions as a strategy for anxiety management. It was a 'solution-based' coaching approach, focusing on positives.

Inspired by Warwick (2008), emphasis was put on three types of engagement – behavioural, cognitive and motivational – which could be improved by working on self-efficacy. The three coaches and one lead teacher had their confidence raised and were further informed by the 'Coaching for Mathematical Resilience' course run by Sue Johnston-Wilder.

Both the literature reviewed and their own experience led the team to think that learners needed to be helped to put effort in and realise that effort reaps rewards, that is, to recommend work on learners' effort beliefs.

Thirty-five learners from a range of vocational areas, referred by five different teachers, were supported by three student engagement coaches. Thematic analysis was carried out on qualitative data taken from teacher referral forms, meeting minutes, coaches' reflective journals and learner post-intervention questionnaires. Quantitative data was sourced from learner attendance to maths lessons pre- and post-intervention.

Standout findings:

- Initially, teachers' reflective journals identified disengagement, lack of focus, avoidance techniques, lack of online response.
- Teacher referral forms were vital for informing intervention planning and work.
- Positive feedback was found to be crucial to balance negative feedback which was remembered more.
- The end-of-project student survey found a massive 65% increase in attendance in class and more confidence in attending one-to-one meetings. Compared to their pre-intervention scores, 81% of learners self-reported moving from feeling stressed to hopeful/excited. Further, 94% said having their coach in class made them more confident. Crucially, 88% said it helped them realise that, when they make a greater effort, they were better at some maths topics than they had initially thought.
- Some learners continued to use avoidance techniques throughout the year – checking phones frequently, avoiding eye contact, using clothing to create a physical barrier, attempting to distract the teacher.
- Learners responded well to academic support as a coaching strategy. This took place during one-to-one meetings, online during lessons, and in face-to-face classes. Coaches focused predominantly on breaking down tasks into smaller chunks and asking open-ended questions to remind learners of their existing knowledge and close any topical gaps – cognitive engagement.
- However, it was only at one-to-one coaching sessions where learners opened up and really talked in enough detail to be useful for reducing motivational engagement barriers to maths learning. A safe environment.

"Research indicates learner mindset can have a huge effect on student engagement and subsequent attainment."
(Dweck, 2012)

"Coaching strategies learned and subsequently practiced included, but were not limited to, pastoral support, academic support, coach and teacher collaboration, one-to-one conversations about maths experience, in-class support, reframing and anxiety management."
(Cambridge Regional College)

Reflections from other projects on this theme

Several other CfEMs also developed and trialled various models of one-to-one and small group support outside classrooms. Selected insights are below:

Christ the King Sixth Form College

For their project on **specialist maths mentors**, Christ the King Sixth Form College drew upon published literature to inform their own implementation of mentoring. Here, a series of classroom observations identified mentors giving verbal feedback, verbal encouragement, asking/answering questions, and giving explanations in almost equivalent amounts.

"It is important to identify verbal encouragement distinct from verbal feedback, in which the former focuses on growth mind-set and motivational language and the latter to academic feedback."
(Christ the King Sixth Form College)

Harlow and Northampton Colleges

Coaches based in a **Maths Lab** and **Maths Clinics** were introduced at Harlow and Northampton Colleges. Through teacher referrals and coaches' reflective feedback, staff learned that students were less neurotypical than had previously been thought, with implications for improving recall. When asked for their input, learners expressed boredom, disengagement, wanting more practical activities and fun in lessons. A notable minority of learners said that they found processing mathematical information given during the 90-minute to two-hour lessons very difficult.

These invaluable insights into learners' perceptions informed the coaching models at Harlow and Northampton. For example, at Harlow, back in the classroom, additional teaching was done to fill skills gaps that had been identified by coaches, teachers took more time to go through topics, and learners began to talk more freely and without fear of peer reaction or failure because coaches had worked on resilience and self-esteem.

> "Students feel able to speak more, are able to work on areas struggled with, feel there's a chance of passing."

City College Plymouth

City College Plymouth's **coaching model was all about 'mindset, memory and maths**'. Learners did a maths mindset-based self-assessment and opted in to six 30-minute coaching sessions, each one covering maths skills and wider confidence and resilience. Maths teacher-coaches were trained in fundamental coaching skills (following Starr, 2008). The full research report outlines the procedure used for developing coaching skills in maths teachers. Prior to receiving coaching,127 learners averaged 5.07 out of 10 in self-confidence in studying for a maths qualification and 3.73 on confidence explaining a maths formula. Key themes were identified by nine learners and four teachers who took part in reflective post-session research:

- maths is getting easier
- learners feel able to speak more
- learners can work on areas struggled with
- learners feel that there's a chance of passing
- learners are proactive with asynchronous learning.

Overall, this coaching model was deemed beneficial enough to continue the following year, extended to 45-minute sessions to fit in goal setting, mindset coaching, maths activities and evaluation.

Fareham College

At Fareham College and five partner colleges, the **coaching model aimed to help learners think positively about maths**. This started by increasing learners' willingness to attend maths classes by addressing what initially appeared to be maths anxiety but was then more accurately defined using learner feedback questionnaires as more general forms of anxiety. Learners enjoyed the coaching. Confidence in their own maths ability, feelings about maths overall, feelings about maths assessments/exams and engagement/ participation in maths classes, as well as independent problem solving, all rose significantly. Aspects of the coaching model that worked well for Fareham and partner colleges were as follows:

- teachers contacting coaches immediately when first spotting signs of anxiety
- having a permanent, well-known room
- longevity of coaching to build trusted relationships.

You can read the detailed reports from these projects by visiting the links below:

Student engagement coaches at Cambridge Regional College bit.ly/3JTF4WJ

Specialist maths mentors at Christ the King Sixth Form College: bit.ly/33ktpPO

Maths labs and maths clinics at Harlow and Northampton Colleges: bit.ly/3fdBOHC

Coaching for 'mindset, memory and maths' at City College Plymouth: bit.ly/3GhCwPU

Coaching for positivity about maths at Fareham College: bit.ly/3Gj1Apw

4.3 Effective use of technology

Theme: motivational online delivery model

Case 8 – Tameside College

Topic: experiences of online learning

At Tameside, the aim was to develop an **effective technology-based delivery model**. Crucially for FE maths resit learners, it would have to be a model that added value to learning and supported learners to develop a growth mindset to enable them to gain insights into mathematical concepts.

"The research focus needed to carefully marry staff and students' concerns whilst working closely and collaboratively with our network partners through the Covid-19 uncertainty and the associated impact of digital poverty, to produce some rich data."

Like other research teams, staff at Tameside brought together an authoritative body of published literature on motivation and engagement, as this is essential for FE maths resit learners. An extract is below:

"As many FE students have poor grades, little intrinsic motivation and a fixed mindset about maths, it is vital that planned interventions must be mastery orientated as opposed to performance orientated (Maehr & Midgley, 1991; Meece, et al, 2006). In this way, importance is placed on improvement and the learning process irrespective of the current level of the student (Meece et al, 2006) so that the student's self-efficacy grows as they move from thinking about their ability in terms of what they have done previously to thinking about 'am I capable of doing this?' (Bandura, 1986; Skaalvik, 1997; Zimmerman and Cleary, 2006). As the students refine their ideas and understand that their ability is malleable, so their mindset changes from fixed to growth (Dweck, 2006)."
(Extract from Tameside literature review)

In moving from better, shared understandings of the issues and considerations outlined in the quote above towards practical solutions, Tameside found Kazakoff and Mitchell's (2017) paper worthy of further investigation through action research. These authors propose that: some of the learning should allow learners to take risks, set their own pace and monitor their own progress; continuous feedback should be given relating to effort; material should challenge and engage learners; provide opportunities for repeated practice with teacher support; foster supportive environments.

The Tameside team's reflective and collaborative thinking, together with the data they collected, led to significant insights to inform future practice:

- Of the 150 learners surveyed, 14% were unable to access work online (during and after Covid-19 lockdowns) and a further 20% only had a phone, so material had to be compatible and visible on small screens.
- Learners were very mixed as to whether they liked online learning or not – two fifths liked it, a quarter did not, the remainder were neutral.
- Unless feedback was given alongside computer generated answers then learners would not always know what was wrong and this could reinforce a negative mindset.

Reflections from other projects on this theme

Other colleges also identified the proportions of learners not accessing online delivery and were therefore able to put measures in place to address these. Across CfEMs, three fundamental barriers were commonly found in significant minorities of learners:

- access to hardware, internet and suitable home learning environments
- generic IT skills, and familiarity with technical aspects of specific software
- using technology for learning.

Disruption in any one of these could often lead to learners missing several lessons, thus causing them to be behind on content, less confident … and so on, in a negative downwards spiral. Learners with low levels of digital aptitude were found to regularly experience "obstacles, failures, and the resultant negative emotions such as anxiety, confusion, and frustration" (Lehman et al, 2012).

Regarding technology for learning, several CfEMs found Adedoyin and Soykan's (2020) paper pertinent. These authors emphasise how **learners need to bring many skills to the table to access online learning**: "The group of skills, knowledge and attitudes needed when using ICT and digital devices to perform responsibilities, such as problem solving, information management, collaboration with respect to effectiveness, efficiency and ethics…"
(Adedoyin and Soykan, 2020).

> "Familiarity with a resource is intrinsically linked to the levels of engagement with it."

> "Learners need to bring many skills to the table to access online learning."

Leeds City College

Having noticed, shared and reflected upon a pattern of very mixed willingness of learners to engage in online maths learning, a team of teacher-researchers at Leeds City College decided to investigate this issue further. They concluded from their own evidence from 100 learners and five teachers and previous literature that **familiarity with a resource is intrinsically linked to the levels of engagement with it.**

By the end of the year, the newly-blended curriculum produced an increase in engagement and more positive attitudes towards online resources. As with other CfEM studies, learners preferred live over pre-recorded lessons because they could ask teachers questions and they felt more interactive. Key to this was familiarity with a platform caused by regular exposure, which seemed to lead to repeated future engagement. Also, two thirds of learners preferred online to paper-based resources because "online is more fun". The presence of a teacher or facilitator mitigated concerns highlighted in literature about some learners feeling isolated, unable to navigate the technology or feeling overwhelmed. Learners cannot be assumed to be digital natives. The role of the teacher is evidently an essential one, whether in terms of motivating and engaging learners or facilitating the multi-media aspects of online learning.

Newham College

The team of fourteen teachers at Newham College, working in collaboration with three other London colleges and a total of 138 learners, initially found out that around half of online lessons during lockdown were negatively impacted by issues with hardware and connectivity. Also, only half of the teachers rated themselves as confident teaching with technology. The aim became to **introduce a new technology** successfully **in ways that would facilitate maths master**y (for staff and learners). Despite literature indicating that teachers needed plenty of time to plan and for CPD to be provided before introducing new tech, the team still underestimated how much time was needed for familiarisation, lesson planning and synchronous learning.

Newham and partners chose to trial mainly Desmos, after trying several software options, focusing on fluency and variation. They struggled to find previous research which assessed how digital tools can support the teaching of fluency and variation when you are not able to have the class physically in a room together. Data was triangulated from multiple sources including teachers' reflective logs, lesson observations and learner and teacher questionnaire surveys. Key features of Desmos that teachers found useful for teaching fluency and variation across different settings were:

- live learner response/teaching
- live engagement tracking
- individual and immediate feedback
- independent paces
- the snapshot feature.

Note Desmos did not have virtual maths equipment (such as a protractor) integrated. After the intervention, teacher confidence had improved, teaching was more efficient, lessons were rarely negatively affected by technology. The team celebrated Desmos' 'instantaneous nature'. They concluded that Desmos could work well for variation and conceptual understanding, and it supported small group work. A 'gamechanger' for teachers was when they could see in real time what learners were doing.

"To have a digital and mastery classroom is a transformation."

You can read the detailed reports from these projects by visiting the links below:

An effective technology-based delivery model for maths resits at Tameside College: bit.ly/3JZ6U3E

Improving learner engagement with online maths resources at Leeds City College: bit.ly/3zZB7eF

Introducing new technology to improve maths fluency at Newham College: bit.ly/3na792f

Theme: introducing new ways of using tech

Case 9 – Lakes College

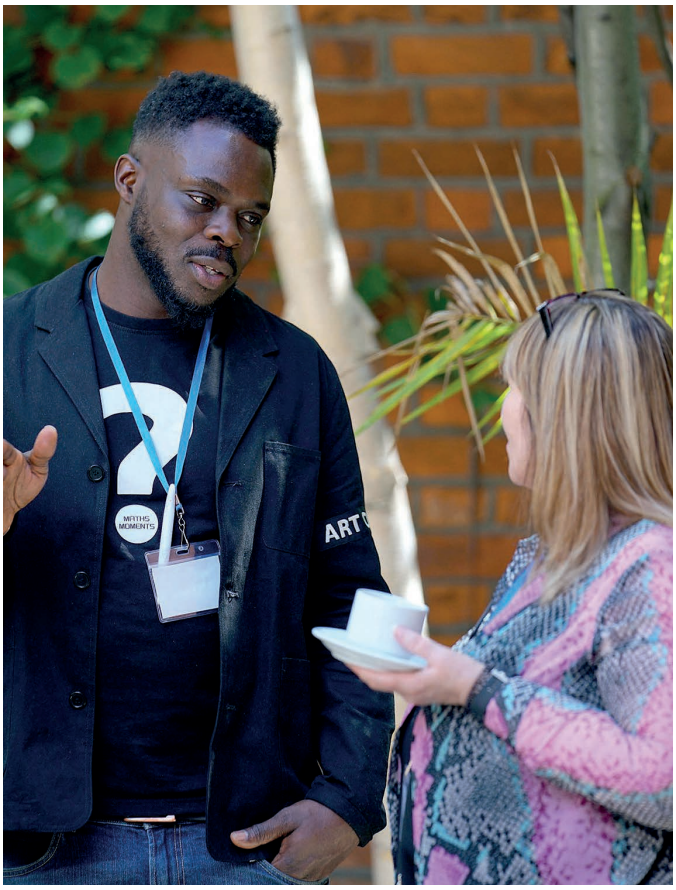
Topic: building confidence in digital delivery

Owing to the Covid-19 pandemic and lockdowns, like the rest of the education system, maths tutors from Lakes College and their partners had to switch to an online delivery model. The ambition was to introduce new ways of using technology that would enable learners to experience maths in new ways, supporting mastery skills and learner independence. Ultimately, this meant attempting to co-design and effectively use digital pedagogical approaches in maths teaching. A preliminary step was to explore the digital and pedagogical barriers faced by both teachers and learners and find practical steps towards the end goal.

A total of 12 teachers from five FE colleges and approximately 450 learners took part in the main part of the action research, with a further two colleges responding to an end-of-project survey.

Standout findings:

- In the early days of lockdown, teaching using PowerPoint presentations was common, nationally. Staff at Lakes and partner colleges found these led to feelings of isolation, which suggested to the research group that interaction was important for positive mindsets. So, different colleges investigated different interactive online functions and pooled their findings, though at this stage their usage largely replicated offline pedagogies:
  - Multi-user whiteboards promoted peer support and interaction, although there were technical problems if used on a phone.
  - Quizzes with a competitive element engaged many learners, but there was a need to be aware of the potentially negative impact on the confidence of others.
  - Polls were an effective tool to develop skills and timing for multiple choice question skills.
  - Videos with tutor explanations and additional support proved popular at one college.
  - Break-out rooms on Teams or Zoom gave learners time to think and share ideas (and enabled tutors to differentiate activities), though staff were needed to facilitate each room.
  - Public chat allowed for tutors to receive feedback from learners and for learner collaboration. Higher level learners could also use it to give/receive peer-to-peer support, which helped dispel feelings of isolation.



- The experience of collaboratively reflecting on the effectiveness of CPD confirmed previously published literature and led the team to believe that:
  - CPD aimed at introducing new technologies takes considerable time
  - CPD focusing on confidence of teachers in digital learning is as important as technical skills
  - providing CPD inputs outside of classrooms is no guarantee of their application inside them.
- Maths teachers needed to develop their own online maths pedagogy. For example, teachers being able to make conscious choices about how they selected which technology to support different parts of the job. By the end of the year, several tutors had altered their concepts, for example:

  "It is interesting to see how the role of the teacher in an online setting slightly shifted to become an IT facilitator in addition to a maths teacher." (Tutor)

  "The teacher's role is as a facilitator, to locate or direct to the most efficacious resources, to be ready to respond to queries and encourage questions in a timely manner." (Tutor)

Reflections from other projects on this theme

Several other CfEMs also investigated how to use interactive software effectively.

Harlow College

A group of maths teachers at Harlow College were very interested in **ways of using interactive software that engages learners and supports their learning progress**. They tried using Teams in remote class lessons and Blutick, Desmos and Nearpod for additional learning in and outside of lesson time. Early on, these teacher-researchers identified barriers to using new software or using it in new ways: staff confidence, staff buy-in, technical issues and student motivation to give it a try until they were familiar with the software.

All learners who completed at least 250 questions on Blutick achieved the desired grade 4 standard, though it was only a minority of learners who did this. The large majority did 75 questions or fewer, and none were assessed as grade 4. Learners said that they liked Blutick for consolidation, revision and for homework after lessons, but not for learning topics that felt new to them, so teachers decided not to implement flipped learning. In practice, learners were reluctant to complete homework, that is asynchronous work. However, they found learning synchronously with their teachers effective. Nearpod was used synchronously. Teachers could see learners' answers live to see who was struggling and give instant feedback, which was found to improve engagement in future lessons. Nearpod was motivational and promoted learning for students because it checked understanding and skills in different parts of a question by breaking them up into steps/tasks. It also showed their workings to teachers who followed along with them. This finding is backed up by Kehrer et al's (2013) robust review of 69 research papers, which concluded that when feedback was given immediately, students learned more than when receiving the same feedback later. This is equally if not more possible using technological platforms than it is in face-to-face delivery.

Stamford College

This project gives numerous insights into using **interactive online learning platforms for effective learning and their impact on perceptions of GCSE maths**. Four different software products for maths were used across the six participating colleges – GCSE Pod, Moodle, MathsWatch and Century Tech. Five colleges took part in this study. In total, approximately 350 learners fed back their views in surveys in October 2020 and March 2021. Reflections from 11 tutors were gathered monthly and student data was analysed. With more delivery and focus on online learning platforms owing to Covid-19 lockdown, confidence in using computers for maths learning and confidence in maths more generally, increased between October and March, regardless of the software used. Maths topics that learners found challenging were also common across colleges and software, which led teachers to consider additional support specifically for fractions, ratio and algebra.

Learners appreciated consistency in online platform choice and that their specific needs were being addressed (owing to teachers' use of automated reporting functionality). Unlike some other CfEM learners, these learners felt that software helped them learn but, as elsewhere, they were polarised as to whether they liked online learning or not.

The Stamford study confirmed previously existing literature which strongly points to **teachers seeing the potential for technology but, unless conditions are right, development is limited** by lack of time in FE, existing skills, support to tackle technical problems, and so on. Consistent on-hand technical support and development of staff confidence is key to take-up of new technologies by teachers. Reflection is essential to identifying strengths as a team and where there could be training opportunities. As the team developed their knowledge of the software and identified strengths and areas for development, they could support their learners more effectively. Learners judged the effectiveness of the software to have increased between the timeframes of October 2020 and March 2021. Increases were between .02 and .35 for each college, on a five-point scale.

Weston College

Weston College explored the possibility and likely effectiveness of using **social media** to engage learners in maths. After gathering feedback from staff and learners, social media was found not to be compliant with college policies and to be unpopular with learners, who disliked intrusion into their private social worlds. The college therefore turned attention to developing a number of **GIF (Graphic Interchange Format)** files, distributed using familiar college platforms, and found some learners were willing to watch them and felt more engaged in maths, though they had to be designed carefully and were not useful to everyone.

You can read the detailed reports from these projects by visiting the links below:

Building confidence in digital delivery at Lakes College: bit.ly/3neoCGQ

Impacts of interactive software on learner engagement at Harlow College: bit.ly/3qdOynD

Interactive online learning platforms at Stamford College: bit.ly/3GhDsDU

GIFs to engage learners at Weston College: bit.ly/3neXWWo

Theme: blended learning

Case 10 – Newcastle and Stafford College Group (NSCG)

Topic: aspects of online delivery that motivate

Online learning was thrust upon learners and staff at NSCG so abruptly. Like many colleges around the country, they had to strive hard to make the effective transition to remote delivery owing to the many challenges that come with blended learning. Together with partner colleges, they jointly identified patterns of student learning and then each investigated aspects of their online delivery of relevance to their own learners.

Two surveys were conducted during the winter 2020/21 lockdown. There were 428 learners and 36 maths teachers, which represents a substantial sample from across seven general FE colleges in the NSCG-led partnership. Out of the 428 learners, the majority (57%) experienced blended learning, a combination of live online and face-to-face learning.

Standout findings:

- In general, learners felt empowered when teachers asked them their views and experiences of learning maths.
- Caution is needed when assuming all learners are fully comfortable using different technology and software.
- During lockdown, the majority of learners experienced issues with access to IT for online learning, with just over one in 10 affected enough to impact their grade.
- Staff mental health decreased. Four fifths said it was the hardest year of their teaching career.
- Overall, learners said they found face-to-face teaching most effective (62%). However, for a notable minority of 16%, remote online learning was more effective, mainly because of the ability to work without distractions and freedom to choose their location for learning (synchronous and asynchronous combined). Approximately one in ten indicated anxiety issues about being in a classroom (thought to be associated with fears of looking stupid in front of peers and tutors).

The specific issue of **asking for help during online lessons was** investigated in a survey of 189 learners at Reaseheath College. This revealed that 27% of learners could not recall ever asking their teacher for help during an online lesson, and 16% would not consider asking even if they were struggling. Half felt uncomfortable asking for help, mainly because they would look silly and did not like being seen to ask in front of peers. Typically, they preferred private contact with their teacher away from the online group lesson, with learners' suggestions including follow-up after lessons, breakout groups and private messaging.

Learner perceptions of 'cameras off' during online lessons was the focus at Telford College. Half of those surveyed preferred cameras off owing to poor connectivity, social anxiety and their home environment. However, almost all thought learning would be better quality if cameras were on. These findings led teachers to reflect on how more private, small-scale spaces could be implemented and managed to ensure engagement and progression of all learners, while simulating the classroom dynamic (which everyone missed) in an informal digital space. More specifically, the idea of doing streamed, small, instant messaging groups, facilitated in ways that would foster peer-to-peer support and tutor oversight.

Why a few learners attended online when they had not face-to-face was City of Wolverhampton College's chosen focus for research. They found that for resistant learners, online independent study could provide an alternative way to engage. Eighteen non- and low attenders were identified, of whom four appeared to have maths anxiety and a further seven found maths overwhelming on top of their main programme. Ten of these 19 learners attended online lessons, mainly because they enjoyed the teacher's teaching, felt anonymous and did not have to be in a classroom. The others cited poor IT and/or not knowing how to engage.

The studies summarised above, together with others from the NSCG partnership, resulted in tutor-researchers having an increased appetite for further investigations into how a considered blended learning approach can increase learners' motivation and engagement in GCSE resit maths.

Reflections from other projects on this theme

Leyton Sixth Form College

At Leyton Sixth Form College, a learner survey identified the great extent of challenging home learning environments that students were trying to study in. Lessons were learned from literature on blended learning, but most published research was done with higher education rather than further education learners. Teachers went on to trial software that was compatible with available devices used at home, including phones, and that allowed learners to be right and wrong in various ways, which is a mastery maths approach to strengthening conceptual understandings. The software included Desmos, Jamboard and Whiteboard.fi. Teachers' real-time view of answers and progress through Desmos pages was found to be strongly beneficial to teaching. Used synchronously, teachers could tell a lot from learners' responses, pinpoint misconceptions, and give feedback to individuals or the whole group. One-to-one interviews with learners confirmed Desmos was engaging for them.

Similar to several other CfEM projects, learners at Leyton Sixth Form College had quite **different experiences with online learning**. On the positive side some learners enjoyed greater independence with their learning, liked not having to come into college, or the ability for more private feedback with the teacher. Others, however, struggled with having suitable technology, with up to a half completing lessons on their smartphones, as well as having connection issues. The lack of face-to-face teacher support and interaction with peers was also raised by many. One third of learners reported that their ability to focus was improved by working remotely, while a slightly higher proportion (40%) said working remotely hindered their ability to focus. The remaining approximately 25% responded neutrally or did not know. However, there was more consensus with learners' self-reporting of their learning progress, with online remote learning seeming far more challenging than face-to-face learning: 85% of learners felt they made progress in most or every face-to-face lesson compared to 45% for online lessons, and 7% felt they never made progress when they were supposed to be learning online.

East Kent College

Here they wanted to ensure that the **interactive software used in their blended learning model was implemented in ways that promoted effort and growth mindset**. They found that learners who were more motivated to start with in the classroom were more likely to participate in and complete more learning when it moved online owing to Covid-19 lockdowns. Also, there was little correlation found between learners doing Hegarty maths activities and subsequent results on assessments (see Macclesfield College, below). In the first lockdown, Hegarty, Century, Microsoft Forms, Class Notebook on Teams and other software were used by different teachers.

On one of the participating college sites, by March 2021, after the second lockdown, the picture was different. Teachers were engaging their learners more and were also encouraging them to use microphones and cameras in live lessons more than previously, but these lessons had become less interactive and more teacher led, with PowerPoints taking over the lessons.

On a second college site, attendance improved after the seminar/webinar teaching model was replaced with a Single Tutor Model where a tutor had a decreased class size online, freeing up their assistant to address non-attendance. This included phoning parents of non-attenders during lessons, assisting with learners' IT issues and tackling timetable overlaps. Also, tracking learner progress and providing individualised feedback. Frequency of logging on to Hegarty maths had greater impact on assessment results than total time spent, a finding which led these teacher-researchers to recommend setting tasks weekly rather than what looked like big chunks of online work termly.

In general, teachers felt upskilled since the beginning of the first lockdown in terms of using technology effectively and began selecting different technologies for specific purposes. For example, teachers on one college site introduced visualisers to model answers during synchronous lessons for the first time, as well as Mathswatch, a web-based platform for asynchronous delivery. This approach paid off as their learners fed back that they preferred online lessons to face-to-face delivery by the end of the year.

You can read the detailed reports from these projects by visiting the links below:

Investigating online learning behaviours at Newcastle and Stafford College Group: bit.ly/3tgBjVe

Improving learners' experience of learning maths at home at Leyton Sixth Form College: bit.ly/3tfUpe5

Interactive software to promote effort and growth mindset at East Kent College: bit.ly/33vXc8R

Theme: flipped learning

Case 11 – Nelson and Colne College Group

Topic: flipped learning

The GCSE resit is taught within very limiting time constraints and development of out of class work is essential.

Teachers have been turning to a flipped classroom approach to accommodate more targeted in-class teaching (Muir, 2019). Flipped provides space for active learning strategies and time for learners to engage in higher levels of Bloom's taxonomy (Krathwohl, 2002); for example, application, analysis, and synthesis (Nouri, 2016). These more sophisticated levels are essential for all reasoning and problem-solving questions and require learners to understand topics more thoroughly. It can give more time for independent and student-led learning, more time for applying knowledge and skills, and freeing up the teacher to provide individualised support (Straw et al, 2015). This free time can be used to target gaps in knowledge and enable more one-to-one time in the classroom.

Literature was found where flipped learning had led to improved engagement, much-improved quiz scores, higher learner confidence, and improved engagement where teachers are fully committed to the flipped approach. However, no literature was found saying exam attainment or mini-assessments in lessons were assisted by flipped learning (for example, Sahin, Cavlazoglu and Zeytuncu, 2014) – indeed there is little research done in FE settings on flipped learning.

Before one lesson each week for nine weeks in the study period, learners were asked to watch 10-12-minute videos and complete questions set by teachers.

Data presented here is based on 348 maths GCSE resit learners tracked across two campuses throughout a nine-week period in 2021, mid-way snapshot surveys of 57 learners and eight teachers, and three student and one teacher focus group at the end of the tracking period.

Standout findings:

- Just over half (55%) of learners did the flipped learning at least three times in the nine-week study window, 25% did flipped learning less often, 25% did not do any. Note, completion of flipped learning activities dipped significantly after a learning break (half term), suggesting recent reminders are important for engagement.
- Learners found it hard to motivate themselves to complete flipped activities. Asking learners why they did/didn't do the flipped learning tasks they had been given, two thirds said they already understood the subject, which led teachers to believe they needed to better explain the purpose and clarify what learners were to do and make expectations really clear from the start. If teachers recapped knowledge covered by flipped videos and questions, as was needed to ensure a fair starting point for all learners in the lesson, some learners who had done the flipped learning realised they would experience less repetition if they did not do the flipped first.
- Learners rated their confidence higher if they had engaged with flipped learning prior to a lesson, and in focus groups, participants said they felt more comfortable in lesson if they had done the flipped learning.
- Teachers commented that learners who had completed the flipped learning tasks demonstrated a higher level of 'base knowledge' in lessons. Teachers could also gain some insight from seeing learners' incorrect as well as correct attempts at answering quiz questions.

Reflections from other projects on this theme

Leicester College

Here they investigated **how flipped learning could improve independent learning**. Learners were given homework in preparation for their next lesson, mainly selected from Hegarty maths. Three assessments done in December, April and May found no significant change in the average marks of learners overall. However, higher level students achieved a grade 4 standard in their assessments if they had done 10 hours or more of Hegarty maths independently beforehand. Other students disliked online learning, struggled to engage with the concept of flipped learning or found it difficult accessing it on a phone. The teacher-researchers concluded from all their data that there was not only a digital and pedagogical divide between different learners, but also vocational and cultural ones.

Macclesfield College

A partner of part of the NSCG partnership, Macclesfield also investigated **how flipped learning activities could improve independent learning**. They were inspired by The Flipped Learning Network's definition of 'flipped learning' as "a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter" (Flipped Learning Network, 2014). Macclesfield College found that 17 out of 37 learners who were surveyed had engaged with the independent flipped learning tasks. In general, learners found activities on Desmos easy to access, and their overall experience was "very positive". Using the computational layer code in Desmos, learners received quick feedback on whether their answer was correct, making them aware of their progress immediately as opposed to progressing using the wrong technique and finding out towards the end of the work. Those who did not do the independent flipped activities gave reasons why: jobs and assignment commitments in the main, forgetting or lack of awareness. The team concluded that working on engaging all learners is important for success, so that content does not have to be repeated in class. Learners suggested regular reminders and timetabling flipped sessions at home.

You can read the detailed reports from these projects by visiting the links below:

Developing a flipped learning model at Nelson and Colne College Group: bit.ly/3teVyCN

Flipped learning to improve independent learning at Leicester College: bit.ly/3r796xx

Flipped learning to improve independent learning at Macclesfield College in NSCG's report on using a blended learning model: bit.ly/3Fi8kCV

5. Interim conclusions

This interim report has raised several key issues that have arisen consistently across a number of colleges and have led to the identification of four priority questions:

1 How can mastery (and related) teaching approaches be used to develop learners' deeper understanding of maths concepts and their ability to use maths to reason and solve problems? How does this relate to learners' progress in maths and attainment?

2 How can we organise and deliver the maths curriculum to address the gaps in individual learners' maths skills and understanding? How does this relate to learners' progress in maths and attainment?

3 How can we develop learners' engagement and resilience in maths learning, and overcome negative attitudes, anxiety and fixed mindsets? How does this relate to learners' progress in maths and attainment?

4 How can technology be used effectively to address any combination of questions 1-3 (that is, develop learners' engagement and resilience, address gaps in learners' skills and understanding, facilitate mastery teaching to develop deeper understanding). How does this relate to learners' progress in maths and attainment?

These four questions have helped to inform the foci for investigations in 2021/22. If they remain high priority and solvable via action research, they warrant being a strong focus of Continuing Professional Development support for which the ETF is responsible.

- Overall, the action research projects done as part of CfEM in 2020/21 strongly suggest that **enabling teachers to understand and apply motivational psychology is both a major challenge solvable through high quality training and a topmost priority** for the FE maths sector. Without being engaged in the subject, learners are unable to make progress towards grade improvement. Unfortunately, prior experiences and examination failure mean negative thinking is prevalent. However, action research designed to develop positive or growth mindsets for learning maths have had positive effects, even in the extremely challenging context of Covid-19.
- **Particularly effective for learning progress were one-to-one/small group, out-of-classroom, personalised sessions.** They were **informed by diagnostic assessments** and used for a **mixture of filling skills and conceptual gaps in maths topics/exam questions and wider motivational support**.
- Similar to educators globally, FE maths staff appear to have made great strides during the pandemic in using technology for teaching, learning and assessment. The systematic approach taken by CfEM action researchers should enable them to evaluate **which technologies to continue using for what purpose**.

This report will be revised and updated in Autumn 2022 after the completion of 2021/22 action research projects.

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