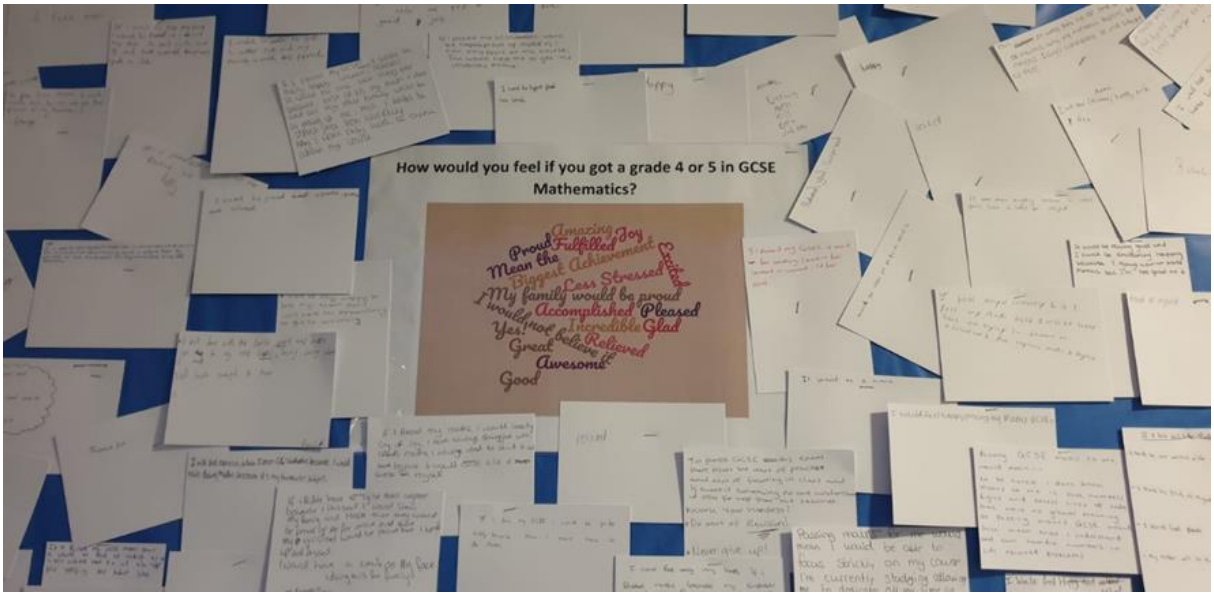
FE - Increasing progression beyond level 2 qualifications, by focusing on improving outcomes in Maths for STEM

Final report for ERA Foundation
STEM Learning
July 2023

“Thank you for being our STEM GCSE Maths Consultant. This is one of the engagement strategies you recommended; student reflecting on what it means to them to get that grade 4 or 5 in GCSE Maths. We have done this with our GCSE retake students this year.



Getting a grade 4 or 5 in Maths is truly a gateway for them of more opportunities for their future.”

Feedback from a mathematics lead at a participating college

Table of Contents

Introduction

There is a problem with the provision of post-16 GCSE mathematics in England. Students not achieving a grade 4 are required to continue their mathematics study. Mathematics is not always viewed positively; students often regard the fact that they are required to retake their mathematics GCSE as a punishment, resulting in the average pass rate for post-16 GCSE mathematics being less than 25%. The ERA funded a STEM Learning programme intended to explore methods to help make the study of mathematics GCSE post 16 a more positive experience for students and teachers alike.

The main objective of the ERA maths in FE Colleges pilot is to build an evidence base, focused on demonstrating what works to improve outcomes in GCSE maths for young people in FE colleges. While this pilot was initially intended to run in one phase with 50 colleges, this was not possible. Some colleges who expressed an interest in the project were unable to take up the training due to the COVID 19 pandemic, resulting in staffing difficulties, colleges not accepting outside visitors and teachers working from home delivering lessons remotely. The programme has therefore been run in two phases.

In phase one, 31 colleges engaged with STEM Learning support from summer 2021 to June 2022. Phase two saw 19 colleges engage with the support between summer 2022 and June 2023. 12 colleges completed all training and gave feedback. In total, the project has worked with 50 colleges, with 42 engaging with all training and support offered.

The current situation

Students in England take GCSE (level 2) examinations at the age of 16. The government states:

“Achieving a level 2 qualification, and in particular a GCSE grade 9 to 4 or A* to C, in both maths and English helps students to progress to further study, training and skilled employment[1].” Colleges of further education have an obligation to support students to retake their GCSE mathematics if they have not achieved a grade 4 or better in their GCSEs. This results in a significant number of students studying vocational courses at colleges also retaking their GCSE mathematics qualification. Students often have little motivation in continuing their mathematics study, having already been labelled a ‘failure’ in the subject.

[1] https://www.gov.uk/guidance/16-to-19-funding-maths-and-english-condition-of-funding

Experience tells us that teachers of mathematics in further education are an eclectic mix, with diverse backgrounds, variable experience and differing levels of expertise in teaching mathematics. The result of the above factors is that pass rates of students retaking their GCSE mathematics are very low; less than 25%.

The project is designed to help colleges to deliver their retake maths course in such a way that students develop a more positive attitude to learning mathematics and see that:

- The mathematics they are learning is relevant to their other learning, and to their life more generally.
- They are able to progress their mathematics ability.
- Learning mathematics post 16 is different from what they have experienced before, not just 'more of the same'.
- There is more to GCSE mathematics than just achieving a grade 4.

This will be achieved in part by helping colleges to evaluate their post-16 mathematics offering.

The project and support offered.

The support consisted of three parts. In part one a consultant engaged with the whole mathematics department in a college. Part two focused on support for mathematics leads to lead change within their department, and part three was implementation in which the consultant supported colleges to help enact their action plan.

Part One

Three half-day sessions concentrated upon Diagnostics, Skills, and Application. This was delivered by a trained consultant to the whole of a college mathematics department across three half-day sessions. Sessions were developed from several sources, including the Standards Unit: Improving learning in mathematics resources[2]. The sessions saw colleges evaluate their current mathematics teaching and explore how to develop mathematical reasoning, and problem-solving skills.

Part Two

Subject leaders attended a two-day residential summer school at the National STEM Learning Centre in York. The summer school covered how to support

[2] https://www.stem.org.uk/elibrary/collection/2933

curriculum planning and implementation. Subject leads developed an action plan during the summer school to be implemented in the following academic year.

Part Three

Consultants provided individual support to colleges to help implement their action plan. This took the form of lesson observation, feedback, lesson planning and any other support to meet the needs of the individual college.

For a timeline of activity, please refer to Appendix One

Methodology

To evaluate the effectiveness of this support, colleges completed a series of induction surveys at the onset of the programme. The first of these surveys was completed by the mathematics lead at the college and served three purposes:

- To give STEM Learning an understanding of historic performance of the college in both GCSE mathematics and English resits
- To provide an understanding of the current staffing of the mathematics department
- To understand the main intended outcomes of signing up for this support, from the perspective of the colleges

Mathematics leads were also asked to share two other surveys with their staff and students. The teacher survey was intended to understand what skills teachers consider most important for achieving a grade 4 in GCSE mathematics and to enquire about their attitudes towards teaching GCSE mathematics. Teachers were also asked to indicate how confident they were that a typical GCSE retake student would be able to answer three examination-style questions. The student survey was intended to understand student expectations of their resit lessons and to gauge attitudes towards mathematics lessons generally. Colleges were surveyed again at the conclusion of the project.

Colleges were also asked to provide updates on progress against their action plan at specified points throughout the year. Extracts from these progress journals are included in Appendix Two.

Initial Survey Findings

GCSE results

As part of this evaluation, GCSE performance by colleges in previous years was to be compared with performance in the academic year in which they took part in this trial, however on 23rd March 2020 the first national lockdown was announced to address the spread of COVID-19. Schools and colleges were closed to the majority of students, and remote teaching became the norm for many. Teaching and learning suffered significant disruption over the following 18 months. As a result, GCSE and A level examinations in the summers of 2020 and 2021 did not take place. Formal assessment was replaced by teacher assessed grades.

As the Department for Education does not wish for schools to be held to account on the basis of teacher assessed grades, data for individual institutions has not been released for these academic years. However, the proportion of students achieving a grade 4 in all subjects nationally, including mathematics, increased as borderline cases were given the 'benefit of the doubt.' For students resitting their mathematics GCSE in the academic year 2021/22, the implementation year of phase one of the project, they were doing so as their teacher assessed grade was below a grade 4. In summer 2022, GCSE and A level examinations did take place, however there were several key differences compared to exams in 2019 and prior years. In mathematics, these changes included providing students with more comprehensive formulae sheets in their GCSE exams. GCSE results of students in phase two of the project were not available at the time of writing this report.

Attitudes of staff

Mathematics leads were asked what they hoped their college would gain from taking part in this project. The most commonly selected intended outcomes were increased quality of teaching (96%), improved student resilience when faced with unfamiliar problems (88%), increased teacher pedagogical knowledge and improved student attendance (both 84%).

143 teachers in total completed the teacher survey. An encouraging finding is that three quarters of teachers surveyed have been in the profession for more than five years, however less than half (48%) of those surveyed hold either a mathematics degree or degree in a subject with a high proportion of

mathematics-based content. This indicates that over half of those surveyed do not hold a higher-level mathematics qualification.

The mathematics GCSE examines basic mathematics skills, students' ability to reason, and their ability to problem solve. Teachers were asked which skills they believe are essential to achieving a grade 4. The three most commonly chosen skills were fluency in basic mathematical skills, the ability to make connections between different mathematical topics, and appropriate literacy skills to interpret the questions. All three of these options were chosen by at least 83% of respondents. It was noticeable that problem solving skills were not considered to be an important skill which students require to achieve grade 4 by as many teachers. Only 56% said it was important. This is even though, at foundation level, 50% of the marks are allocated to using and applying standard techniques (AO1), 25% of the marks are allocated to reasoning, interpreting, and communicating mathematically (AO2) and the remaining 25% of the marks are for solving problems within mathematics and other contexts (AO3),[3] i.e. half of the marks are for reasoning and problem solving.

Teachers involved in the project report they are confident in their own abilities. 98% agreed they were confident in teaching the required subject knowledge for GCSE Maths. A similar proportion said they understood how the different topics which constitute a mathematics GCSE are connected to one another. 71% also agreed that they were capable of embedding employability skills into their GCSE maths teaching.

Teachers disagreed that their students are enthusiastic about learning in GCSE mathematics (80%) and most teachers also disagreed that their students could adapt what they learn to overcome challenging questions or unfamiliar contexts (75%). Over three quarters disagreed that their students are not resilient when faced with challenging or unfamiliar content.

The last section of the survey asked teachers to consider whether a typical student in a GCSE resit class could correctly answer three example questions. These were:

1. Saj wants to go to all 19 home games at a football club. For each game, a ticket costs £28 A season ticket costs £379 and gives entry to all 19 home games. In total, how much does Saj save by buying a season ticket?

69% of teachers were very or quite confident a typical student would be able to answer this question.

[3] GCSE Mathematics_final (publishing.service.gov.uk)

2. The rule for generating a sequence is. After the first two terms, each term is half the sum of the previous two term Here is a sequence that follows this rule. 2, 10, 6, ……. , ……. , ……. Show that the 6th term is the first one that is not a whole number.

Only 28% of teachers were confident that a typical student could answer this question, with 13% saying they were not confident at all

3. Jim has six banknotes. The value of each note is £5 or £10 or £20 He can make £20 with three notes. He can make £55 with four notes. He cannot make £25 with three notes. He cannot make £25 with four notes. List the six notes.

Only 19% of respondents said they were confident that a typical resit student could answer this correctly. 25% were not at all confident

These results suggest that the development of problem-solving skills in particular is an area in need of support. To a lesser extent, this also applies to mathematical reasoning skills.

Attitudes of students

The student survey was completed by 113 students. The majority of students said the main subject they are studying is a BTEC level 2 or level 3 qualification (55%). Over half (57%) achieved a grade 3 at the end of year 11

The majority of students appreciated the importance of GCSE mathematics. 92% agreed that GCSE mathematics classes help them improve skills they need to be successful in work, such as teamwork and problem solving. The same proportion said what they learned would be useful in everyday life, and 94% said they were willing to persevere when presented with an unfamiliar question in class. Less positively, only 63% said they enjoyed these classes. Confidence in whether they would achieve a grade 4 varied significantly; 60% said they were confident they would pass, however 35% were “not very confident” and 5% were not confident at all. This shows that students appreciate the importance of maths but do not enjoy studying it regardless.

Post project feedback

As the ERA foundation support came to a close, colleges were sent three separate surveys, aimed at maths leads, maths teachers and students respectively. Due to the pressures faces by colleges, the response rate to these was low, however feedback was positive. The three training sessions (What

makes good teaching, Mathematical and proportional reasoning, and Problem solving) were all considered to be beneficial by all those who attended, and the vast majority indicated that the changes to their teaching had led to an increase in student participation in lessons.

The student survey was completed by 81 students as they approached their GCSE resits. 90% agreed that their GCSE resit lessons had helped them to improve skills they would need in the workplace, and 78% agreed that what they had learned was important for their everyday life. The majority (78%) also said they had enjoyed their resit lessons and felt more confident `having a go` when presented with an unfamiliar or difficult question (84%). Almost a third said their resit lessons at college were very different from school. Most positively of all, 78% said they were confident that they would achieve a grade 4 in their upcoming exams.

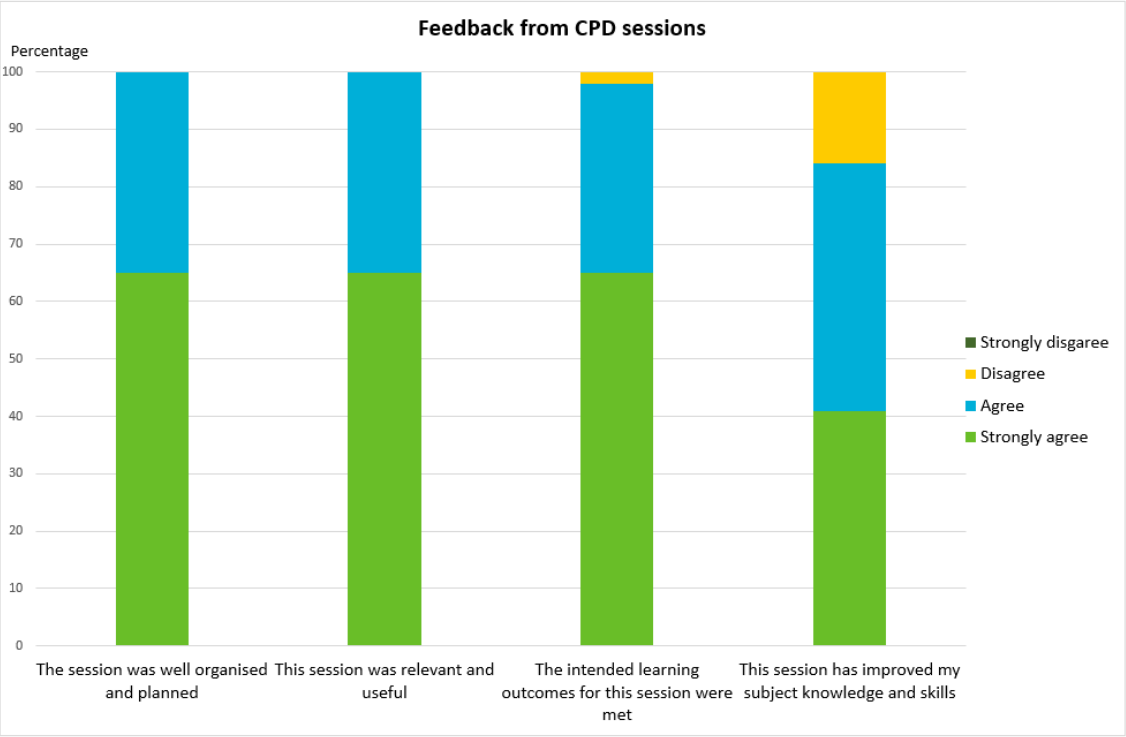
Students were given an opportunity to provide how they had used what they learned in their GCSE resit lessons elsewhere. Examples include:

- Working out Body Mass in sports coaching.
- To work out the length of a pipe so that it would fit into a frame.
- Unit conversions in carpentry lessons.
- In health and social care to calculate medication dosages.
- In hairdressing, to ensure a dye is mixed correctly.
- In sports lessons to measure performance, health and wellbeing.
- When I was doing construction.
- I had to use maths in my plumbing lesson, to work out the length of a pipe so that it would fit into my cooper frame.
- In bricklaying to gauge my work I need to know the 75 time table to properly get the bed right.
- I have used maths in health and social care to measure amount of medication to give to patients.

Feedback from the CPD sessions delivered by consultants.

Feedback indicated that teachers valued the sessions, the content was relevant and would have an impact upon their teaching and therefore the learning of their students. It was pleasing that the feedback indicated that the aims of the three sessions; to consider what makes good mathematics teaching, how to promote and develop mathematical reasoning and how to develop problem solving skills were met.

"A massive thank you for the inspirational and thought provoking training that you have provided to the Maths Department here at [college]. The three sessions have been engaging and upbeat. As an experienced team, my team is very hard to impress and they are all now buzzing."



A full breakdown of the feedback can be seen in appendix 3.

Staff who attended the summer school at the National STEM Learning Centre provided feedback via STEM Learning's Impact Toolkit (ITK). The ITK sent all participants an evaluation form immediately after the summer school concluded. Further to this, participants are sent short-and-long-term impact forms as a means of measuring the degree to which their action plans have been implemented and the impact that the summer school had.

23 of the 28 teachers who attended the summer school completed the post-course evaluation forms. 96% of attendees rated the summer school as good or very good, with the remaining attendees rating it as satisfactory. The responses to a series of follow-up questions on this theme were also equally positive, with attendees unanimously agreeing that the summer school was well organised and planned (75% strongly agreed), that the content was relevant and useful (67% strongly agreed) and that the learning outcomes were met (62% strongly agreed). Further to this, they also unanimously agreed that the conference will impact their own future practice (67% strongly agreed) and the students they teach (50% strongly agreed). Also they all plan to share their learning with colleagues in their college.

Those participants who completed the short-and-long term impact forms appear to have responded about the impact of the entire package of support. When asked to highlight specific impacts of the CPD on themselves-half said that it had improved their own subject and pedagogical understanding, and six of the ten said it had improved their confidence, motivation and enthusiasm for teaching STEM subjects. In the case of the former, this was not an element of the summer school but was something covered by the consultants as part of the phase 1 support. In terms of impacts on students, eight said that they had seen improvements in student motivation and engagement and four said they had already seen improvements in student progress and attainment. More widely, half said they had seen improvements in the quality of teaching across their departments and the same number said there had been an increase in progress and attainment of students taught by colleagues.

Of the respondents who did not respond more positively to these questions, they highlighted that no teaching of GCSE mathematics had taken place when the short-term impact forms were sent out. The Impact Toolkit automatically sends out impact forms 6-8 weeks post-course so as the summer schools took place in June, this is understandable if they completed the form as soon as it was received.

"Following the STEM training, for practicing problem solving in class, after exposition by the tutor we made sure there is discussions between the tutor and the students also students themselves. Specially discussion regarding different approach to solve a same problem.

We aimed to make sure there are opportunities in lessons for students to develop and show mathematical reasoning and lots of memorable discussions.

We have ongoing weekly meetings regarding STEM project to make sure the students are enjoying their experience with us and focusing on learning on each session rather than being worried about the final exams."

Post Project Findings

Changes in student behaviour

"We have seen that students are now attempting those last third questions on exam papers which historically were left blank. Therefore, we have seen a lot of improvement in students' resilience for these types of questions.

Colleges have reported a change to the format of delivery of retake mathematics classes over the last few years due to the COVID-19 pandemic. Lessons initially took place online during college closures. Many colleges then employed hybrid delivery models to limit student numbers in colleges. Reporting on differences in attendance rates is therefore problematic.

Since returning to the classroom, there is some emerging evidence that student behaviour has changed as a result of the different approach teachers are taking in the style of their lessons. Evidence suggests that students are more engaged in lessons.

"I have noticed clear changes in the way that students have worked using some of the alternative methods and materials. I have no empirical information at this stage though have noticed far greater involvement from all students"

"I say with confidence that student participation has increased, collaboration is markedly increased and sustainability and interest in achieving solutions is improved. There is definitely greater confidence to 'have a go' and get something on paper."

A college concentrated upon collaborative learning techniques. In addition to help improve student maths skills a positive effect on behaviour was noted.

1. Collaborative activities used in lessons include the following:
   a) Card games
   b) Tarsias
   c) Matching card activities

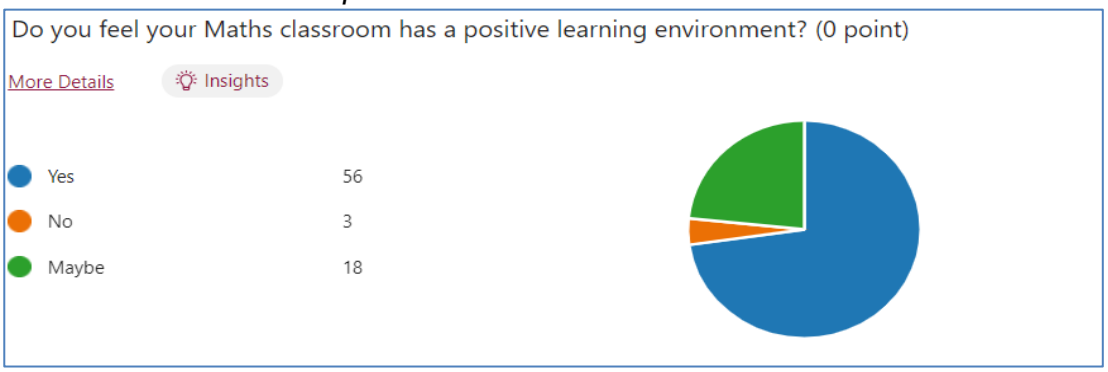
Apply Open Questioning technique through out the teaching.

   a) This was very effective for understanding of the learner and finally encouraging them to solve independently with little or no help Using realia such as the maths cubes
   b) Christmas relay activity
   c) Bar modelling
   d) Bingo games
   e) Kahoot games
   f) Use of Whiteboards

These have given learners the opportunity to develop maths skills and also to a certain extent helped with students who have challenging behaviour.

Another college reported:

"Engagement and resilience data was collated through the end of year survey, attendance data and exam attendance data. Students felt significantly more confident in their ability to undertake tasks in Maths in comparison to the start of the year, with learners reporting a 1.69 average score increase. 72.7% of learners indicated that they felt their classroom maintained a positive learning environment, with only 3% of learners stating that they did not find their classroom environment positive."



"Data from the final exam clearly demonstrates a strong attendance rate with all three exams above 92%. This is in contrast to the attendance class data, with a difference of 23%.

High exam attendance clearly indicates heighten resilience and a belief in an individual's own ability to achieve their desired grade."

Evidence of Impact on Teachers

Despite the challenges of the last couple of years and the demands of taking teaching online, there is evidence emerging that there have been teachers who, as a result of taking part in the project, have changed their attitude to the purpose of the mathematics retake class resulting in a change to their teaching.

One college reported:

"During our three GCSE Maths meetings, a significant focus was placed on reviewing and implementing the training sessions provided by STEM. These sessions, delivered by [Consultant on behalf of STEM Learning], highlighted three main purposes: problem-solving, creating discussions, and fostering an interactive learning environment.

We dedicated time in our meetings to thoroughly explore these training objectives and discuss how to effectively incorporate them into our teaching practices. By sharing our experiences and insights, we aimed to enhance our understanding of the training content and identify practical ways to apply it in the classroom.

Specifically, we delved into the approach to problem-solving and the strategies for creating meaningful discussions among students. We shared our experiences, lessons learned, and success stories related to implementing these techniques. This collaborative exchange allowed us to gain new perspectives, refine our practices, and ensure continuous improvement.

The GCSE Maths meetings served as a platform for teachers to reflect on the training sessions, exchange ideas, and collectively work towards putting the acquired knowledge into action. By leveraging the expertise and experiences of the group, we aimed to enhance the quality of our teaching and create a supportive environment for students' mathematical growth.

Through these meetings, we reaffirmed our commitment to implementing the strategies and techniques acquired through the STEM training. By actively sharing and reflecting on our experiences, we strive to continuously improve our teaching practices and provide an engaging and effective learning experience for our students."

Further feedback from colleges

"My own philosophy has changed dramatically, and I no longer panic about complete syllabus coverage for all students, having identified important themes, I have spent less time on teaching the AO1 as within the groups it is noticed that someone will know the fact, the formula and share this with the others in their group. The practice has been much more driven by breaking the problem into meaningful stages."

"I can say that I have implemented quite dramatic changes in my own practice during this term following the discussion and materials experienced on the course in July."

"Apply Open Questioning technique throughout the teaching.

This was very effective for understanding of the learner and finally encouraging them to solve independently with little or no help."

"The goal free problems took a lot of time and the discussion raised by the students was beneficial but didn't allow consistent model and repetition for student support. If I were to use these again, I would need to develop the questions as the depth of the question varied too much."

"Variation theory questions have continued to be excellent AFL resources. They allow me to check for understanding after an activity and to check for retention 1 lesson, 1 week or 1 term after a topic is taught."

"Staff collaboration and CPD:

The majority of staff have used a significant portion of their subject updating days. With an increase of formal requests from previous years. This shows a clear positive correlation with the STEM project actions. "

"Use proportional methods in as many topics as possible.

Attempt to apply Proportional methods across various topics were partially achieved.
For example, we used it for percentage topic.
More could have been done for topics like Probability and Statistics."

Evidence of impact on student learning

In the post project survey, in response to the question: “What has been the impact of these changes?”, teachers responded:

- “Students have more tools to answer questions - getting them to think before asking to help.”
- “Good pass rate at GCSE, above average, and would have been higher if the pass mark wasn't 135.”
- “Students were engaged and performed better in their Feb Mock than last year's.”

In the post project survey, in response to the question “Have there been any other impacts on your students as a result of you participating in this programme?”, teachers report:

- “Some [students] have had a deeper understanding of problem solving question and a willing to break them down.”
- “Definitely. though in my case, the scope was limited, but as per college data students' performance in maths improved nearly 13% than that of last year.”
- “Better fluency and therefore a development of the vocab, which is always a barrier. Different ways to approach and tackle problem solving.”
- “Bar modelling helped a lower ability learner to solve mathematical problems.”
- “They [students] have a better understanding of technical terms in mathematics.”

Evidence from college reports:

"Grade 1 and 2 students have fed back and 92% of them found the bar model lessons beneficial. 85% said they had a lasting impact and when we retested (4 weeks after the final lesson) using the same questions, all grades were higher than before the intervention and 50% of the students got full marks."

"We noticed that certain learners were facing difficulty in understanding topics like percentage increase. To address this issue, we decided to incorporate the use of bar modelling to illustrate concepts such as percentage increase and decrease. Additionally, we expanded the application of bar modelling to include comparing ratios and solving linear equations. It was also utilized during the process of solving simultaneous equations.

The implementation of bar modelling proved particularly effective when introducing simultaneous equations. Learners were able to visualize the process of eliminating one variable, leading to a deeper understanding of the topic. Subsequently, we transitioned to the algebraic solution of simultaneous equations. This strategy benefited numerous students, and their positive feedback emphasized the value of bar modelling in this context.

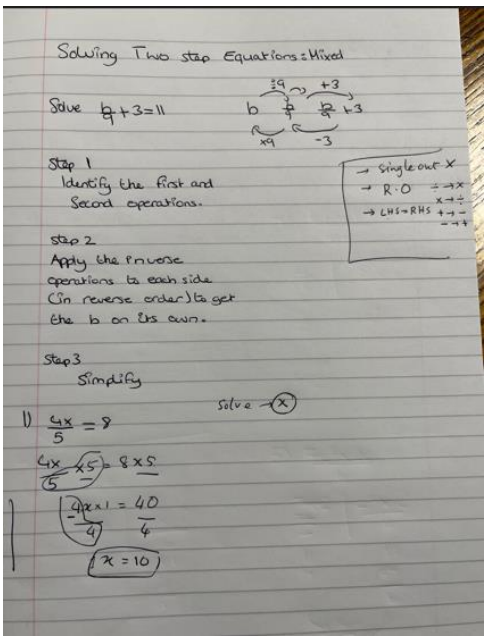
It is worth noting that strong learners displayed some initial reluctance towards using bar modelling, while lower ability learners expressed keen interest in utilizing this approach."

One college concentrated upon 'scaffolding' techniques to help develop students' problem-solving skills.

"For **Open Questioning and scaffolding**, we used a set of 4 Qs, for any given problem:

What do you **see**? (collect data/info)
What do you **know**? (prior knowledge)
How can you **solve**? (skill)
Can you **extend** the Qs? (mastery)

Most of the students responded well, said, it really gave them a track to follow for handling problem solving Qs. They reported to my line manager on his visit that they enjoy our session."



Conclusion

The project took place during one of the most difficult times for colleges in living memory. Despite the challenges posed by the COVID-19 pandemic, teachers in FE colleges have engaged well with the support offered and have implemented changes based upon the training. Evidence suggests these changes have resulted in positive changes in student learning.

The use of specialist consultants was successful; the content of the training was well received by teachers, who appreciated the training was specifically targeted at teachers in FE colleges. There is evidence that individual teachers and, in some cases, whole departments, have changed their approach to teaching mathematics as a result of participating in the project. There is evidence that the project has had an impact upon students, with teachers reporting students participating more readily in discussions about their mathematics, are more engaged with their learning, and more willing to 'have a go' at unfamiliar problems. Evidence of impact of increased attendance of maths lessons is mixed, some colleges reporting poor student attendance still being a concern. This is a general concern, not specific to mathematics lessons.

While the overall picture is positive, not every college who initially signed up as part of the programme gained the full benefit of the support offered. After initial interest in the project, some colleges withdrew for a variety of reasons. These included being unable to arrange the training due to COVID restrictions, staff shortages due to illness and, in one case, as the whole of the mathematics department would be leaving over the summer. Phase 2 showed good engagement as colleges continue to return to normality following relaxation of rules implemented to stop the spread of COVID-19, however, staff changes, often at short notice, continue provide a challenge for engagement.

From college report:
"In summary, there was limited evidence to indicate that learner's problem-solving ability was significantly affected by the STEM project training and the implementation of the action plan. This is not a reflection of the training or teacher implementation, but more the limited evidence available. "

"There are strong indications that increased resilience has been a direct result of the STEM programme. "

"A significant increase in the uptake of internal and external CPD demonstrates a greater engagement from the wider Maths team."

.

Appendix One: Timeline of activity

September 2020 to December 2020 Recruitment and training of consultants: between September 2020 and December 2020 25 potential consultants were interviewed, with 15 being recruited and trained.

September 2020 to December 2020 Recruitment of colleges: By December 2020 thirty three colleges had been accepted onto the pilot. A number of other colleges expressed an interest but were not in a position to proceed, mainly due to uncertainties over staffing, and restrictions imposed due to the COVID 19 pandemic. These thirty three colleges formed phase one of the pilot.

January 2021 to May 2021 Phase one colleges receive training from consultants. Due to covid restrictions many colleges were not accepting external visitors. In addition, many teachers were working from home delivering lessons remotely. The result was that training was mainly delivered in the period June 2021 to August 2021. Thirty one colleges received three sessions of training. Two colleges withdrew as training was unable to be arranged due to staffing difficulties.

July 2021 Summer Conference Mathematics leads attend two day conference with contributions from Further Education specialist from Mathematics in Education and Industry (MEI), the maths hub programme, Realistic Mathematics Education (Manchester Metropolitan University) and STEM Ambassadors.

September 2021 to June 2022 Phase one colleges implement their action plan and report on their findings.

January 2022 Recruitment of phase two colleges

June 2022 to August 2022 Training of phase two colleges

September 2022 to June 2023 Implementation of action plans by phase two colleges

Appendix Two: Extracts from the progress journals

The following extracts are from progress journals relating how methods experienced in the training were used successfully in the classroom.

“In relation to the groups I teach I have moved to an online model for the slides, posting them on each GCSE classes TEAMS channel. Two of my three GCSE groups have engaged very well, commenting, and discussing the slides with myself and each other.”

“The triangle area question was great as this was a question that some struggled with in mock 1 question 5, they forgot to half the area with it being a triangle. This addressed the misconception really well.”

“I asked them how many marks they thought this would get which was effective as they started talking in steps and predicted accurate method marks for showing the working out-even though their counting could have been mental maths, they clearly showed methods in working out to get there. This is valuable as we always reinforce how showing the calculation could gain those extra all important marks.”

“Collection and collation of resources that can be used in the shorter term to achieve greater students' confidence in ‘having a go,’ greater student interaction and discussion about maths, improved quality of delivery of Post 16 maths GCSE and FS. Departmental meeting prior to the end of Christmas term.”

Impact on teaching and learning

- “The training had a good impact on a personal level...there is more small, collaborative group work being done with some good feeling of how students are raising their own confidence with more of this way of working. You feel that it helps with quieter more timid students and there is more confidence in students having a go.
- Classroom environments have been enhanced with use of materials at eye level for students, to help them with problem solving processes.
- Much more emphasis on AO2 and AO3. This information shared and understood by many more students about how the examinations are structured.
- Clear messages about how marks are awarded, what evidence is required to achieve these marks.
- Greater collaborative discussion between students is evident. It has been a pleasure to wander around the classroom listening to students

discussing maths, problem solving, sharing ideas and being prepared to trial ideas."

"I can say that I have implemented quite dramatic changes in my own practice during this term following the discussion and materials experienced on the course in July."

"I have noticed clear changes in the way that students have worked using some of the alternative methods and materials. I have no empirical information at this stage though have noticed far greater involvement from all students."

"I have rarely used exercise books, merely for starters and as working jotters. Textbooks have been used productively for reference, not as banks of questions and much more discussion is taking place in the classes, student-student as well as teacher-student."

"My questioning techniques have improved allowing for far greater student explanation of their processes, methods, challenges, or solutions with discussion following these, engaging many more students."

"Has this led to improved progress? I am uncertain how to judge this at present as the cohorts this year, having experienced so much 'no schooling' is making comparisons difficult. I say with confidence that student participation has increased, collaboration is markedly increased and sustainability and interest in achieving solutions is improved. There is definitely greater confidence to 'have a go' and get something on paper."

"My own philosophy has changed dramatically, and I no longer panic about complete syllabus coverage for all students, having identified important themes, I have spent less time on teaching the AO1 as within the groups it is noticed that someone will know the fact, the formula and share this with the others in their group. The practice has been much more driven by breaking the problem into meaningful stages."

"I spend time talking through what is AO1 question, and the same with AO2 and AO3. They regularly must identify how many marks a problem may offer and where these will be given. These practices are making them understand how to secure marks that they may have missed in the past."

"I shall endeavour to arrange team meetings in the new year to get a level of feedback about changes to delivery and the problems or positive experiences to date."

Appendix Three: Feedback from the CPD sessions

Question	Strongly Agree	Agree	Disagree
The session was well organised and planned	65%	35%	0%
This session was relevant and useful	65%	35%	0%
The intended learning outcomes for this session were met	65%	33%	0%
This session has improved my subject knowledge and skills	41%	43%	16%

What part(s) of the session did you find most useful and why?

The responses to this question were many and varied. Two themes emerged: the opportunity to discuss and reflect on their teaching and how students learn and strategies to promote mathematical reasoning.

Many participants valued the opportunity to discuss and reflect upon teaching methods and strategies.

- Discussion about open and closed questions. Discussing students' processes for solutions.
- Interesting discussions around the needs to be flexible and ready to adapt - not quite so linear as maybe we are.
- Discussions around the links between reasoning and problem solving, allowing us to actually plan for reasoning in the lesson.
- The opportunity to work on problems with my colleagues.
- Time to reflect on my current practice and why has it developed the way it has.
- 8 underlying principles for improving learning in maths ..... Provided a platform to focus my thoughts on how to address students learning needs and reflect this in my lesson.
- The experience of been put in students’ shoes when asked to attempt a question was powerful.

There are several positive comments relating to mathematical reasoning.

- Incorporating questions that prompt reasoning. I have used these in lessons and found them effective.
- to revisit hands on tasks encouraging student discussions to support reasoning.
- Overall, I got a whole lot from this session, enabling me to consider how I approach reasoning skills with students.
- Discussions around the links between reasoning and problem solving, allowing us to actually plan for reasoning in the lesson.
- I enjoyed exploring strategies to promote effective reasoning skills with students.

What part(s) of the session did you find least useful and why?

Many participants left this blank, gave a response of ‘none’ or ‘N/A’ or wrote a positive comment such as ‘none really there was something to take from each part of today’s agenda’. Where comments were made, they identified a specific element of the training with which they were already familiar or thought to be not relevant in their particular situations.

Elaborate on one aspect of the session you will attempt to develop in your own teaching.

It was pleasing to see that all respondents replied to this prompt. There was a rich and varied number of responses showing that the intentions of the sessions had been met. Particularly pleasing responses were:

- Use thought provoking activities to get students to think and engage more during lessons.
- I am going to consider /apply the 8 underlying principles to improve learning in maths to my planning / practice and underpin my lesson reflection.
- Implementing more rich tasks within the SOW and in day-to-day teaching.
- I will endeavour to improve on ways that provoke reasoning & participation in my students.
- to encourage / provide more opportunities for students to verbalise their thinking in class.
- try and provide more opportunities to initially focus on process rather than final answer.