How do workshops, designed using a Maths Mastery approach, delivered in weekly small group sessions in addition to discrete classes, impact learners on a post -16 GCSE maths resit course?

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OUR PARTNERS

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About CfEM

Centres for Excellence in Maths (CfEM) is a five-year national improvement programme aimed at delivering sustained improvements in maths outcomes for 16–19-year-olds, up to Level 2, in post-16 settings.

Funded by the Department for Education and delivered by the Education and Training Foundation, the programme is exploring what works for teachers and learners, embedding related CPD (Continuous Professional Development) and good practice, and building networks of maths professionals in colleges.

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Summary

During the academic year 2021-2022, mastery themed bespoke workshops were implemented as an addition to the GCSE mathematics resit offer. The workshops were designed to enable learners to have a deeper understanding of four main topics. Eighty-eight learners across two campuses with prior attainment of a grade 2 at GCSE or Level 1 Functional Skills maths were invited to attend the weekly workshops over five half terms. A mid cycle snapshot of both learners and teachers was carried out together with three learner focus groups, and a teacher focus group. At the end of the workshops a learner snapshot was conducted, and teacher reflections recorded. Results showed that learner confidence improved. Recommendations as a result of this research are that workshop structure is key in ensuring student engagement and knowledge retention. This is further enhanced by adopting a Concrete-Pictorial-Abstract (CPA) approach in a relatable manner.

Background

Introduction

This piece of Action Research was conducted within Nelson and Colne College Group (NCCG). NCCG consists of two colleges, Nelson and Colne College and Accrington and Rossendale College. It also encompasses Lancashire Adult Learning provision. All three sites are located in East Lancashire in the North West of England. The college had approximately 2,265 young leaners on role in 21/22. The college group offers a range of provisions with flexible entry requirements to ensure that we provide the best possible experience for every learner, and support them to reach their potential. There is an ethos of inclusivity and focus on positive destinations and not qualifications for learners. The GCSE maths resit team always strive to improve and learn with the aim of enriching the learners experience, improving progression, and ensuring learners can take their next step in their educational journey.

The college was number one nationally for maths resit pass rates in 2019, with a pass rate of 65% compared to the national mean of 22.3% for the same period. The figures for the years 2020 and 2021 were unreported due to the Covid pandemic. The college has recently been rated as outstanding by OFSTED (Ofsted, 2022). The academic year 21/22 had a GCSE maths resit cohort of approximately 600; 400 at Nelson and 200 at Accrington. The majority of these learners are on vocational courses. The college is proud to be a 'big fat maths, English and digital' college which means the ethos holds these subjects within its core values and puts them at the forefront of everything they do. The college is one of 21 further education settings delivering the Centres for Excellence in Maths programme.

The Area and The Learner

The communities that both the colleges serve suffer high levels of deprivation with trends worsening since 2015 (Lancashire Country Council, 2019). Using the Index of Multiple Deprivation (IMD) ranking system, which is a relative measure of deprivation, Hyndburn is positioned in the most deprived 10% of local authorities and is the 18th most deprived authority of 317 in England. Pendle is in the most deprived 20% of the local authority areas and is 36th nationally. ACORN, the tool used to categorise the national population into demographic types, identifies local households in eight wards out of sixteen across Hyndburn with 'Young Hardship' as a dominant profile. The statistics from the UK Census in 2019 represent the highest level of education obtained by residents of the area. The data shows Hyndburn is below the national average for qualifications with a high proportion of residents with no

qualifications. The statistics for Pendle also show a substantial percentage with no qualification compared to the national average (Lancashire County Council, 2021a).

QUALIFICATION	HYNDBURN (Accrington Site)	PENDLE (Nelson Site)	LANCASHIRE	ENGLAND
No Qualifications	28%	28.2%	23.6%	22.5%
Level 1	13.8%	13.3%	13%	13.3%
Level 2	16.2%	15.1%	15.8%	15.2%
Apprenticeship	5.5%	4.8%	4.5%	3.6%
Level 3	12.5%	12.5%	13.6%	12.4%
Level 4	18.9%	20.2%	25%	27.4%
Other	4.9%	5.8%	4.5%	5.7%

Figure 1 - Table showing the percentage of people in Pendle (Nelson) with specific levels of qualification, in comparison to the wider Lancashire area, and then England.

GCSE Maths Resit Learners

Changes to the national and regional job market in England have highlighted the need to close the skills gap. The number of low skilled workers outstrips the number of low skilled jobs available in the area, and this predicament is projected to worsen. Forecasts show that in 2022 the country will have an underqualified workforce unable to fit the demands of available jobs (Lancashire Country Council, 2021a). At the other end of the scale there is a demand for high skilled workers that isn't being met. It is imperative now that the Further Education (FE) sector provides the skills needed to ensure our learners do not enter the job market at a disadvantage, and GCSE maths is key to their employability.

In 2014 the government responded to this crisis by intervening to make it a condition of funding for all learners aged 16 continuing to FE who did not achieve a Grade 4 or above in their Maths GCSE to study and retake their GCSE or a more suitable maths qualification for up to three years. Nationally, the proportion of re-sit learners achieving a Grade 4 is increasing. The percentage went up from 39.5% in 2020 to 42.3% in 2021. However, due to Covid 19 teacher assessed grades were used making the data less reliable. In 2019, the last year the summer exams went ahead, the pass rate was only 31.9%. When broken down further less than a quarter of 17 plus learners achieved a Grade 4 in 2019 which translates to the fact that on every attempt at the exam the chance of passing is reduced (Skills and Education Group, 2021).

The COVID-19 pandemic forced teaching to move online for learners up and down the country. However, young people in the Northwest were arguably disproportionately impacted compared to other regions. Learners in the North spent 54.6% of their time in one of the two highest restricted tiers, compared to the rest of the country who spent on average 46.3% of their time under highly restricted lockdown rule (NHSA, 2021). Therefore, learners within this research context spent a higher proportion of their course managing online learning and the social impact of lockdown than their southern counterparts, which leads to questions about the fairness and equality of the previous academic year and the impact this had on the cohort re-siting GCSE maths in 2021-2022. Many struggled to access lessons in the first UK lockdown due to lack of skills or available devices, with many unable to find a suitable space to study in their homes (Gov.UK, 2021a). The GCSE teaching team at the colleges anecdotally reported an increased knowledge gap, stating that the loss of learning due to the pandemic was visible in the skill set learners assigned to a grade two or a grade three had when entering the year, in comparison to previous years. It was apparent from enrolment that extra support to bridge the learning gap was needed as a result of the COVID pandemic preceding the 2021-2022 academic year.

The cohort of learners assigned to re-sit their GCSE maths qualification are unique in a number of ways. Critically, unlike the majority of all other courses at Post-16, they have not chosen to embark on their GCSE maths qualification, they have been entered through compulsory terms linked to their condition of funding (Education and Skills Funding Agency, 2021). Often resit learner experience of GCSE maths in secondary school has been negative. When they arrive in an FE resit class, a negative history with the subject, engrained self-doubt, and questions about the relevance of maths is difficult to unpick (Curtis, 2017).

At NCCG both GCSE maths and Functional Skills are taught to resit learners. However, in the academic year 2020-2021 the decision was taken to enter both grade two and three learners for GCSE, whereas in the past, only grade three learners would resit GCSE, and grade two learners would enrol on Functional Skills. The year 2020-2021 was not what the education sector would coin a ‘normal year’; and upon entering 2021-2022 the team felt a specially designed programme of workshops working alongside the GCSE Scheme of Work [SoW (Scheme of Work)] was needed to bridge the skills gap both between grade two and three learners, and that of lost learning as a result of the pandemic.

Research Aim

The research is designed to give learners the best chance of gaining a meaningful and deep understanding of mathematical concepts. This will give them the best chance of achieving a Grade 4 or above and therefore increase job prospects. However, GCSE achievement is not the only measure of success. This research also aims to look at the impact on learner confidence, resilience and engagement with the subject. It is important that as country, college and research group we do everything we can to improve the life chances of our learners which is directly linked to the pass rate. However, it needs to be acknowledged that by breaking down the barriers to learning and re engaging learners this increases potential for success in the long term, particularly considering the lasting impact from COVID-19. If as a result of this research project learners have more self-belief and are happier in their study and application of maths it has been a successful step for both them and the wider society.

Literature Review

What is meant by mastery?

"*A mathematical concept or skill has been mastered when, through exploration, clarification, practice and application over time, a person can represent it in multiple ways, has the mathematical language to be able to communicate related ideas, and can think mathematically with the concept so that they can independently apply it to a totally new problem in an unfamiliar situation."* (Drury, 2014, p. 9)

The concept of a Maths Mastery approach was born in the late 1960s by American Educational Psychologist Benjamin Bloom. Bloom developed this concept from previous work undertaken by former theorists (TES, 2021a). One of Bloom's most notable findings when developing his approach to Maths Mastery was an increase in motivation for learning (Bloom, 1968). For resit tutors across the country this is one of the hardest hurdles to overcome; motivation to continue to learn and engage.

Teaching for maths mastery was further developed in East Asia in the 1980s, the movement is more commonly known as Singapore Maths. Following the countries poor performance in maths a new programme was developed which continues to inspire and influence teaching in over forty countries worldwide. The approach enables learners to develop mathematical fluency without resorting to rote learning and encourages them to solve non-routine maths problems without memorising procedures (Maths No Problem, 2021a; 2021b).

The Mathematics Teacher Exchange report (Boylan et al. 2019) evaluates the differing ways mathematics is taught in both China and England. South-East Asian approaches to Mastery embed the following features:

I. Teachers reinforce the idea that all learners are capable of achieving in maths.
II. Learners progress through content at the same pace, with differentiation through deeper understanding.
III. Curriculum is methodical.
IV. Teachers use regular questioning to assess pupils and identify intervention needs.

(Boylan et al. 2019)

Additionally, the report explores the cultural difference between Shanghai & England which impact how maths is learned. Key differences include overall higher expectations and core beliefs projected by learners and professionals in Shanghai; along with a supportive extended

family network as a result of the one-child policy that was legislated in China up until 2016. Researchers argue that due to the very different cultural, political, religious and racial composition of East Asia it is difficult, if at all possible, to emulate their approach in other countries (Boyd & Ash, 2018). Yet, the benefits are clear for all in the mathematics teaching world, and therefore, it is research such as this that will help the sector better understand how we can adapt the Maths Mastery approach for British learners, and more specifically the resit learner. Work does not need to emulate the Singapore Maths approach like for like, but adapt and grow a version which fits the context in which it is used.

The National Centre for Excellence in the Teaching of Mathematics present five concepts which underpin the teaching for Maths Mastery approach; Coherence, Representation & Structure, Mathematical Thinking, Fluency and Variation (National Centre for Excellence in the Teaching of Mathematics, 2021).

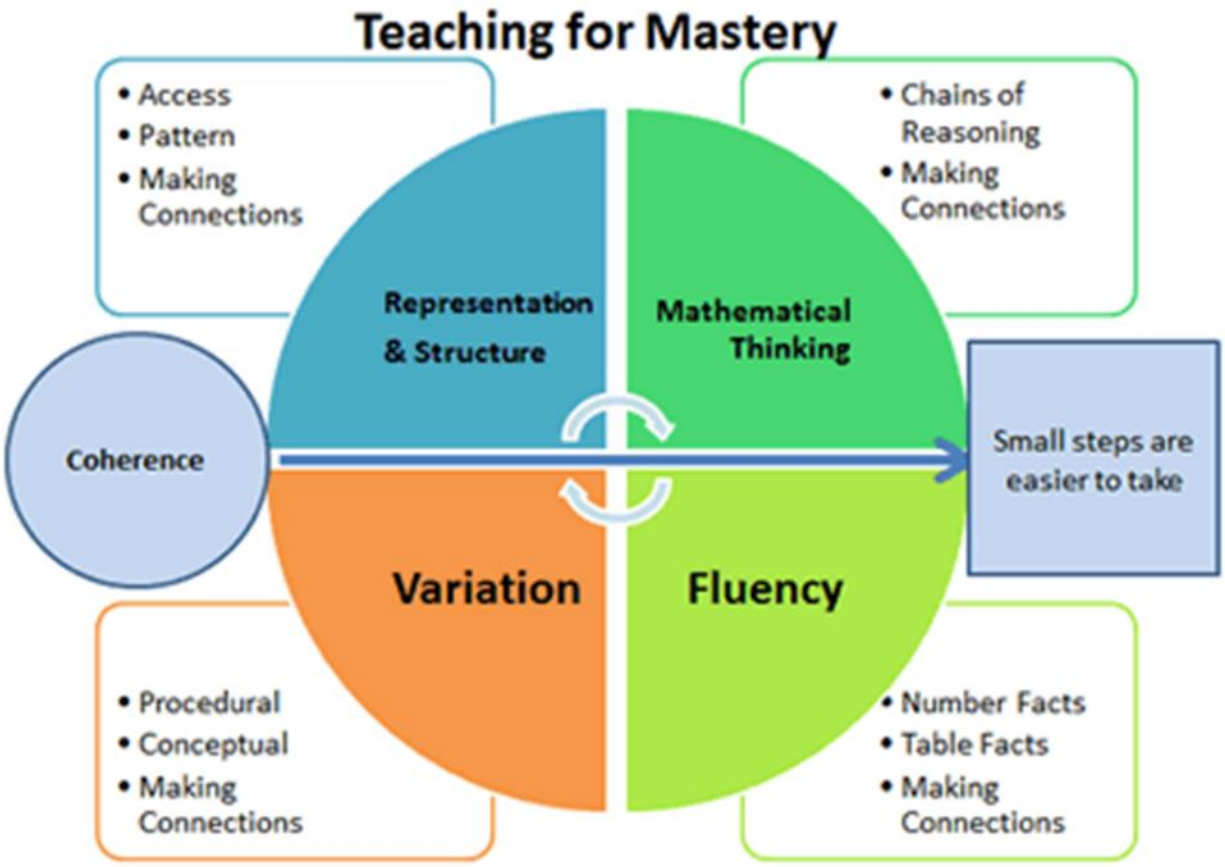

Figure 2 – The five concepts which underpin the teaching for Maths Mastery (National Centre for Excellence in the Teaching of Mathematics, 2021).

How can Mastery Work in the Resit Classroom?

Research from Professor Nuthall (Research ED, 2019) suggests that learners can remember topics and concepts after encountering the core information three times; learners need the space and time to explore content to then be able to master it. Often the GCSE maths resit SoW is high paced and packed with content, seldom do teachers allow time for exploration and mastering of topics. This style of teaching and learning within the resit sphere is both understandable and necessary because the content requirement does not change from secondary GCSE to FE GCSE examinations, but the time in which teachers must cover the content is halved, even cut by two thirds in some settings.

It is widely acknowledged that an 'appropriate curriculum' is needed which reflects the needs of the resit learner to further progress in their chosen career but is also academically rigorous to provide an equivalent to the GCSE qualification (Davies et al. 2020, p9). Some may argue that this is the Functional Skills Level Two qualification, however, this has its own challenges and flaws. Until the correct qualification is available, GCSE maths resit tutors must address the challenge of teaching a two-year curriculum in nine months and design the content to support the learners in the best way possible. To achieve this, NCCG GCSE maths team commenced this research into teaching for Maths Mastery in FE.

Concrete – Pictorial – Abstract [CPA]

Fundamental to Singapore Maths is the Concrete-Pictorial-Abstract [CPA] approach. Learners work in pairs or small groups using physical resources and manipulatives to investigate mathematical concepts and ideas, before moving on to pictorial representations and then finally numbers and symbols: the abstract in which they must be able to apply their learning to in turn succeed in the GCSE maths exams (Oxford Educational Blog, 2017).

A Description of Concrete-Pictorial-Abstract [CPA] Methodology (TES, 2021b)

Concrete – With the help of manipulatives and concrete objects, learners are able to understand and explain what they are doing.

Pictorial – Building on the concrete approach, learners are able to use pictorial representations to assist and solve mathematical problems.

Abstract – Once these techniques have been mastered, learner should now have the confidence to be able to apply key concepts using number. Learners should be able to identify and apply the different concepts to solve mathematical problems.

By following this approach, all learners will benefit from a deepened conceptual understanding of mathematics as opposed to memorising key facts and procedures, which can lead to a superficial understanding that can easily be forgotten (TES, 2021b). The emphasis needs to be on keeping up rather than catching up, with learners given time to fully understand, explore and apply ideas. It is important that learners work through a concept together and therefore high-attaining learners should be challenged though depth, rather than moving onto a new concept (TES, 2021b).

The CPA design has a breadth of support, especially within secondary school mathematics teaching. For example, Sharma and Connor (2018) utilised this approach when teaching directed numbers. They found that learners who engaged with the approach scored significantly higher marks in a post-assessment than those who did not. Although this was a small-scale piece of research, it was quality driven and supports, in particular, the use of manipulatives for teaching for maths mastery.

The use of manipulatives for teaching mathematics has a long history. Dienes (1960) cites many examples of using concrete objects as the first steps to developing an understanding of the use of symbols and the abstract concepts used in mathematics. Dienes writes at great length about using square and strips to teach factorisation. This method has a great likeness to the algebra tiles that are frequently used in teaching this topic today.

Akhtar (2019) talks about using manipulatives within her classroom and the benefits to learners deeper understanding and reasoning skills. She discusses how the use of manipulatives allows learners to explore connections and engage in mathematical conversation, which directly supports their engagement with the concrete stage of a CPA

curriculum design. The research team discussed the use of manipulatives within workshops, and decided an investment with these would be key for initial engagement. One concern is that some learners may find the manipulatives not age appropriate or childish, which raises concerns about their engagement. However, Akhtar (2019) discusses how she found that physical resources can also challenge those learners who believe that they have grasped the concept as it forces a deeper understanding through problem solving. It was key that the research team considered the types of manipulatives used with resit learners to ensure the benefits of this approach were felt.

Teach Less, Learn Better – The Essential 8

The Essential 8 Framework was developed by John Cooper (Cooper, 2021) following an extensive investigation into mathematical components that interlink, and whether focusing on them, in-depth, enables learners to master them. The framework instils a focus on "teach less, learn better" as opposed to existing theories of teach more, faster (Cooper, J. 2021, p253). The Essential 8 topics were sequenced through extensive trawling of previous exam papers, noting mark weightings and frequency of topics, leading Cooper's team to conclude the core concepts in which they believed, if learners mastered, they would find success in their GCSE maths examinations (Cooper & Nixon, 2020).

Cooper (2021) established that for a learner to be successful in their GCSE maths exam, they need to focus on eight core topics. The skills acquired from mastering these topics give learners the confidence and ability to be able to apply this knowledge to all questions posed in the GCSE maths resit exam. Cooper found that repetition and assessment of these core concepts was fundamental in learner success. Learners were assessed on these topics on a weekly basis, and followed the same order each time (Cooper, 2021):

- Transformations
- Area and Perimeter
- Probability
- Angles
- Simple percentages and fractions
- Ratio
- Algebra
- Straight line graphs

Harriet Griffey (2019) tested Cooper's theory in her own research conducted in a Further Education College. Using the Essential 8 Framework as a base, learners were given questions on each topic for a period of ten weeks and their progress was tracked weekly. One of the unexpected outcomes from this research was that learners thrived from the tracking element. They were motivated by being able to see their progress, which in turn highlighted areas for improvement. Maths teachers also liked that they were able to focus on fewer topics, but in more depth. The tracking element is key to learners recognising their progress, and developing independent learning skills. This is something the research team were keen to embed in the workshop design.

"*Learners could all be working on the same topic regardless of level, but still have an appropriate level of challenge…Having learners starting on the same thing every lesson means that learners know the immediate expectations*" (Griffey, 2019, p11)

The Essential 8 Framework supports learners to access heavily weighted topics within the GCSE maths examinations. Key to this research is to ensure that learners deepen their knowledge of mathematical concepts, and build learner self-confidence within the maths classroom; yet the unavoidable reality is that they must sit an examination in the summer months. Ofqual (2017) regulate the topic weightings across all exam boards with a 3% tolerance for each.

Domain Area	**Weighting of Marks per Assessment Series**	
	Foundation Tier	*Higher Tier*
Number	25%	15%
Algebra	20%	30%
Ratio, Proportion and Rates of Change	25%	20%
Geometry	15%	20%
Probability and Statistics	15%	15%

Figure 3 – Table to show the mark weightings for each topic area within the GCSE maths examinations – regulated by Ofqual across all exam boards (Ofqual, 2017, p 18).

It's clear from figure 3 (Ofqual, 2017) that the most heavily weighted topics within the exam are Number; Algebra; Ratio, Proportion and Rates of Change.

Weighing up the Essential 8 Framework research, learner Initial Assessments and Ofqual (2017) mark weightings, the research team concluded a variation of the Essential 8 framework would form the building blocks of the Maths Mastery approach in FE sessions.

Working in Small Group and Intervention Workshops

For several years research evidence has suggested that small groups are effective in allowing learners time and space to master concepts when learning. For example, Bloom et al. (1968) found that regular small additional group study meetings, of around two or three learners, allowing repetition of difficult points were effective. The Centres for Excellence in Maths programme also showcased some great research into small group workshop and coaching approaches that all yielded positive results (Gunduz et al. 2021; Fremlin et al. 2021).

In Gunduz et al (2021) one-to-one or small group mentoring was offered, and this saw a significant improvement in the learner's self-confidence. Fremlin et al (2021) showed that additional maths coaching sessions supported an increase in learner confidence. This provides evidence that small group intervention can work effectively within the FE sector.

Given the body of research surrounding small group tuition, and past successes in the Centre's for Excellence Programme, the team explored this as a design in more depth. Small group tuition, or workshop can be defined as a teacher working in a separate space to the usual classroom with a group of two to five learners. It's usually used with lower attaining learners, or those defined as falling behind (Education Endowment Foundation, 2021). There is not a wide breadth of research on the most effective sized groups when designing small group tuition outside the classroom, but it is generally advisable not to have groups of more than seven (Education Endowment Foundation, 2021), as it becomes difficult as a teacher to provide directed support. Workshops, in addition to discrete classes was the most effective way of embedding a teaching for Mastery approach within the successful curriculum already in place within the college – the team saw it as a way to ensure grade two learners can access a grade three and four SoW rather than bringing the lessons in line with grade two skills as the GCSE team would then loose the challenge for learners striving for a grade five in their lessons.

Ethics Statement

All the work conducted with learners at Nelson and Colne College Group was done so following the BERA (British Educational Research Association) Ethical Guidelines (2018). Learners were made aware of the parameters of the research, their participation in the work and assured of anonymity for any feedback given. They were given the right to withdraw their information at any time.

Methodology

Rationale

Considering the research discussed above, the context of NCCG, and expectation of GCSE maths resit learners in summer exams, an intervention programme was designed.

Learners who were enrolled on a GCSE maths qualification in September 2021, with a previous grade of two at GCSE or Level One Functional Skills maths were invited to an intervention workshop in addition to their discreet classes. The workshops were timetabled as groups of three to seven due to a number of factors; previous research, timetabling issues, main course commitments and the business needs. The curriculum design was based on a CPA approach, with learners looking at one topic per block in depth, whilst also interleaving the concepts. The following order and topic decision were highly influenced by Cooper's (2021) Essential 8 Framework, learners low achieving topics in initial assessments and Ofqual (2017) topic weightings:

- Percentages
- Fractions
- Ratio
- Algebra

Research Question and Objectives

The Research Process

This project was designed and executed by four staff. The workshops were delivered by the three teachers who were part of the dedicated action research team. The research was carried out across two campuses and involved 88 learners. The participants were selected based on prior attainment. In previous years, the Functional Skills qualifications from Entry to Level Two played a key role in our curriculum design, with only grade three learners sitting the GCSE maths resit. In 2020-2021, and 2021-2022, learners with a grade two or Functional Skills level one were also enrolled on a GCSE qualification. Therefore, a new design which embedded a Maths Mastery approach to upskill learners, to in turn access the already successful SoW was needed. Hence this intervention was aimed at learners who had achieved either a Grade 2 or Functional Skills Level 1.

The research was carried out over two distinct cycles. The intervention was delivered in weekly workshops. Group sizes were kept to between four and six and the sessions were one hour long. The year was split into four blocks of workshops with each block covering a different area of maths. The first started at the beginning of the second half term and each block lasted the duration of one-half term. Each research cycle was the duration of two blocks.

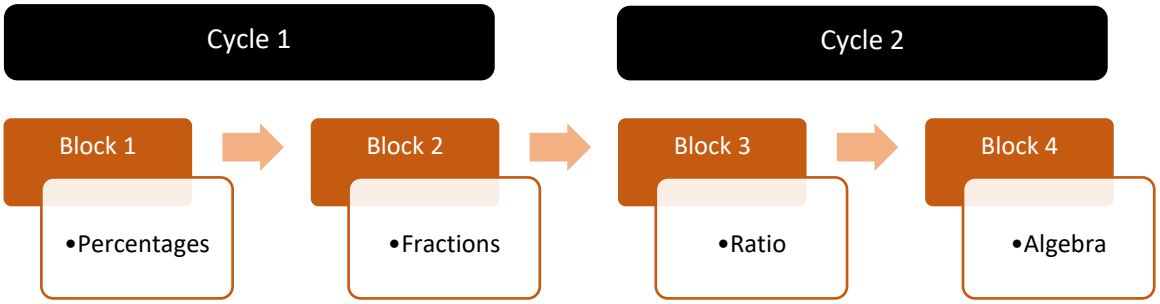

Figure 4 – Table to show the block topics and order

The structure of the sessions was based on a Mastery approach. Each area was broken into small steps that started with the basics. The philosophy was to ensure the learners developed a deep understanding of the work covered and had a solid foundation of knowledge. Learners worked at their own pace, each moving onto the next step when they had mastered the one before. A CPA framework was followed and manipulatives were used where relevant.

"achieving mastery means acquiring a solid enough understanding of the maths that's been taught to enable pupils to move on to more advanced material."
(National Centre for Excellence in the Teaching of Mathematics, 2021).

Data Collection Design

A combination of both quantitative and qualitative data was collected over the course of the project. Initially the workshops were designed based on the research in the literature review and staff experience. The data collection and analysis informed and facilitated implementing strategies into the second cycle. Some of the blocks were impacted by Covid-19 due to both staff and learner absences. This affected the data and limited the analysis we could complete for some of the blocks. The data collection methods for each cycle listed below.

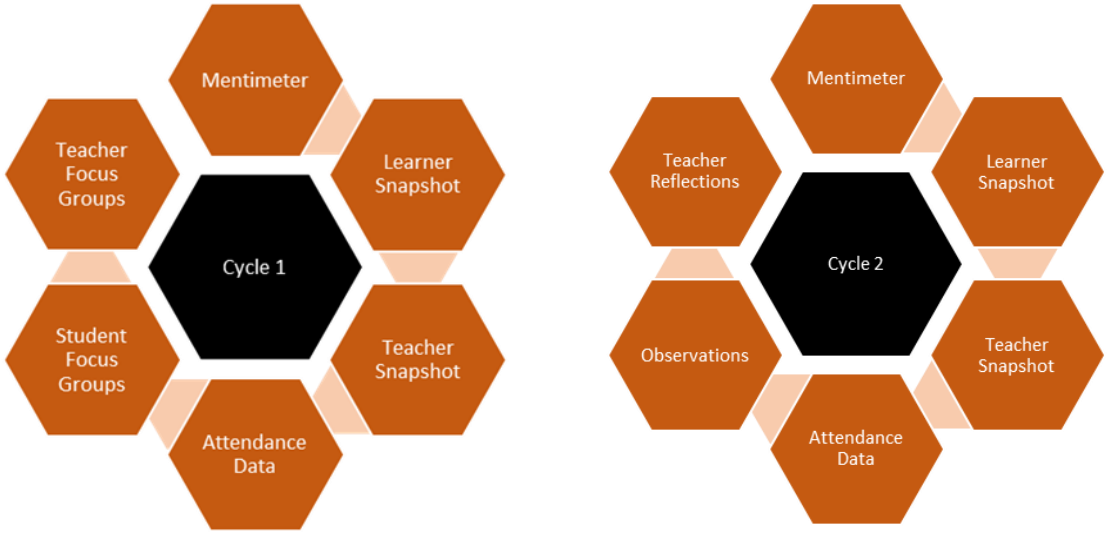

Figure 5 – Data collection methods used in cycle 1 and cycle 2

Quantitative Data

Initially a Mentimeter was used at the end of block 1 to record how the learner felt about the topic. However, after analysing the data a Mentimeter was used at the start and end of each subsequent block in order to compare. This was done to quickly gage the learners' current feelings. A learner snapshot was also completed at the end of each block to assess the learners' attitudes and confidence. The first four questions were repeated in each snapshot and the final two questions were adapted to specifically ask about the topics covered in previous blocks. These questions were done on a Likert scale. It was designed to be quick and easy to follow to get honest response from learners. The relevant maths teacher completed a snapshot to evaluate whether the learner's attitude to maths had altered over the course of the block. Again, this was done on a Likert scale with follow up questions. At the end of each half term learners completed a short assessment based on the work covered in that block. We used the data from the November resit exam and compared it against the assessment data and the March mock exam data. A record of attendance was kept and compared against learner attitude and results.

Qualitative Data

Learner focus groups were arranged to collect qualitative data. A focus group gives the opportunity to delve into the reasoning behind learner responses and the chance to get

clarification if needed. The focus group created a safe space where the learners could speak openly about the impact of the project; the teachers of the workshops were not present in the focus groups as this could lead to the learners giving responses they believed their teacher wanted to hear. Another potential issue is that one of the learners could control the narrative and others could keep quiet or agree with the most outspoken learner. The questions for the focus groups were carefully designed to minimize any potentially misleading data and the interviewer was experienced at dealing with dominant personalities. The participants of the group were chosen based on the practicality of timetables. A workshop teacher focus group was also conducted to gather more in-depth opinion of the impact of the workshop and potential improvements for the second cycle. The sessions were recorded and transcribed to ensure all feedback and opinions were included.

A Mentimeter was also used to collect qualitative from learners at the start and end of each block. They were asked to describe how they felt about the specific maths topic in three words. The later snapshots also included follow up questions where learners were expected to give qualitative reasons for their answers. Observations of the workshops were carried out to get a first-hand experience that informs and reinforces the data. Teaching staff also kept a reflective log to record anything significant during the workshops.

Our Study

The purpose of the action research was to explore the following question:

How do workshops, designed using a Maths Mastery approach, delivered in weekly small group sessions in addition to discrete classes, impact learners on a post -16 GCSE maths resit course?

Sub questions were set out to focus the research without limiting it:

1. Do the workshops impact learner resilience?
2. Do the workshops impact learner self-confidence?
3. Does attendance at workshop impact learner attitudes towards learning?
4. How does the use of a Mastery approach impact the retention of knowledge?
5. How does the use of a Mastery approach impact the pace of learning?
6. How do the workshop of learner progressions?

Results and Discussion

Improved Confidence

The workshops have significantly increased learner confidence, evidenced in numerous ways.

One of the fundamental findings from the intervention is that through attending the workshops learners have become more confident and curious. This confidence has been highlighted in numerous ways, primarily through their communications and their resilience.

It is widely acknowledged that resit learners have not had the best GCSE maths experience prior to attending college, with these learners having low confidence in their abilities. The workshops appear to have gone some way in helping increase their self-esteem and performance.

The intervention has increased learner self-confidence in the subject of maths. At various checkpoints throughout the year, learners have been asked how confident they feel about maths. When asked in December 2021, only 8% of learners felt VERY confident. When asked this question again in February, half way through the intervention, 20% of learners felt VERY confident. Whilst the learners reported increased confidence the impact of this filtering through to maths lessons is yet to be observed.

"*I feel more confident in my maths than I usually would*. "

(Cycle 1 - Nelson FG 2 - Learner B - 3:46)

The increased learner confidence is further supported when analysing each topic in more detail. At the start and end of each topic block, learners were asked to rate how confident they felt (figure 6). Each topic has shown an increase in confidence of the learners.

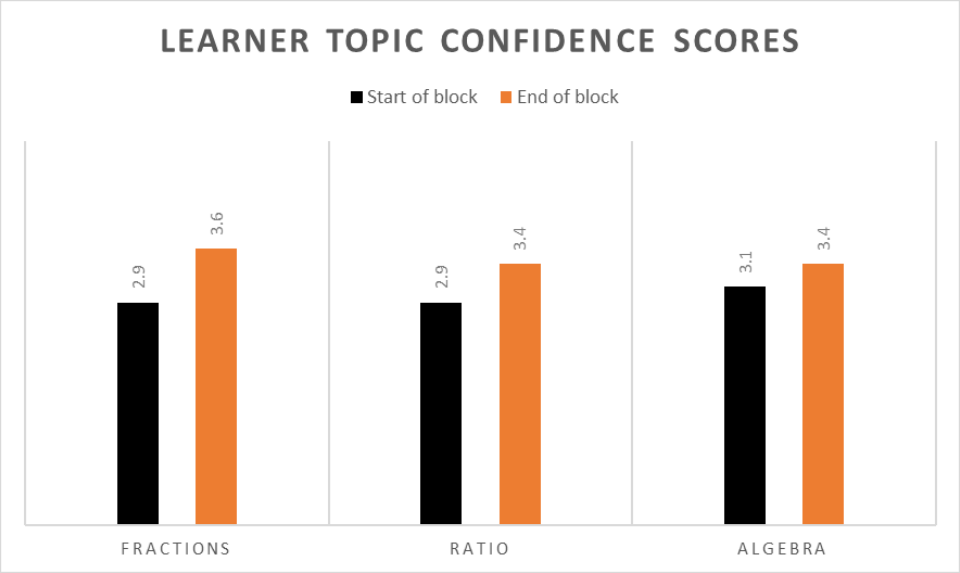

Figure 6 - Graph to show learner confidence at the start and end of each topic block

They were also asked to describe how they felt at the start and end of each topic. Interestingly learners became more confident as the intervention progressed, resulting in a higher starting confidence score for the final block. The word clouds (figure 7) give a clear representation of how learners are feeling. The immediate impression is that there is not much difference between the start and the end of the topic, however when looking in more detail there is more positive language used at the end of each topic. This data collection was anonymous.

	Fractions	Ratio
Start of block		
End of block		

Figure 7 – Illustration of learner feelings towards each topic at the start and end of the fractions & ratio blocks

Although learners recognised an increased confidence, it was difficult for the subject teacher to identify any direct improvements in the topic areas as a result of the workshop due to the misalignment of the scheme of learning. Ideally learners would have been able to practice and apply the skills learnt in the workshop during their lessons. This was made explicit in one of the learner focus groups, whereby a learner explained that skills learnt in one of the blocks (percentages) linked in with what was being taught in class and given as homework. This really helped to reinforce the workshop skills for this learner, which increased their confidence even further. However due to the necessity of the fast-paced delivery of GCSE maths resit course synchronisation of topics is not always possible.

Confidence can be split into two main categories –

- Communication; improvement between peer on task communications and improved teacher / learner relationships
- Resilience; having the confidence to 'have a go' and 'keep trying'

Increased learner confidence has resulted in improved communication with teachers.

One of the significant observations from the research has been the improved communications between learners and teachers. In addition to maths confidence and ability, learners feel the workshops have given them an increased confidence in the way they communicate with their teachers.

"*it helps us improve our ability to communicate with teachers and ask for help*"
(Cycle 1 - Accrington FG - Learner C – 6:21)

When learners feel confident in asking for help, this is a fundamental step in breaking the maths confidence barrier. Asking the teacher for help is a great example of a behaviour that describes what confidence is to these learners. This is a behaviour change due to the workshops and is something that should be harnessed and developed into discrete maths classes.

This is further substantiated by a discussion observed in the teacher focus group, whereby teachers noticed that learners appear to feel valued in the workshops. The workshop pace is driven by the learners, and they appreciate the opportunity to steer the content to some extent.

For example, one teacher *(Teacher C – Teacher FG - 12:03*) noted that the learners seem to "*like the fact that you're reacting to them in the workshops".* All teachers agreed, and one added *"doing something again, means that you've listened to them and what they need, so they feel a bit more valued in that way"*. When reflecting on the Further Education landscape and the fact that GCSE resit learners have low confidence in their abilities, these learners need to increase their self-esteem to perform well and the workshops have helped them with this.

"*It is a pleasure to watch the students learning and engaging in mathematical conversations. Their curiosity has been piqued and many have started asking to ask questions beyond what they are being asked to do. This makes me feel particularly proud of how far they have developed*" *(Teacher A – Teacher Reflective Log's*)

It is apparent that through attending the workshops learners are becoming more confident and curious in their workshop environment. However, it is not clear whether this confidence has filtered through into their maths lessons. All teachers felt that these learners are more open and honest in the workshop environment as opposed to their GCSE maths class; asking more questions and speaking more. Almost all learners clearly felt more confident in workshops, and moments of clarity reinforce this.

"*They speak more, they ask more questions. They're very open, aren't they? They'll tell you how they feel. They'll tell you 'I get it now. I've never got this, I get it now!*' "
(Cycle 1 - Teacher FG - Teacher A – 16:39)

One learner recognised this confidence in themselves, proclaiming *"I feel like I'm shouting out [well not shouting out] more than I usually would* " (Cycle 1 - Nelson FG 2 - Learner B - 4:15). Many learners regularly use the term 'confidence' when discussing workshops. This increased confidence makes them feel that they will be more successful in their exams.

"*I think they're really good as it helps us, like build our confidence with maths and explore different things that we probably didn't like know*" (Cycle 1 - Accrington FG - Learner C – 1:02)

Whilst observing the workshops it was evident that all learners appeared capable although most waited to be asked a question rather than openly offering answers. Whilst working in pairs learners demonstrated peer support, discussing and problem solving, but held back sharing answers with the wider group until asked.

Some learners lacked confidence to attend the workshops in the first instance. One workshop teacher recognised that "*some didn't turn up to start because they were anxious about the fact that it was to do more maths*" (Cycle 1 - Teacher FG - Teacher B – 7:38), and sought to

eradicate these barriers by reaching out to individual learners and engage them with the sessions. Being an unfamiliar teacher to these learners, Teacher B made introductions outside the workshop environment. This improved learner confidence to attend unfamiliar workshops. All staff felt it was important that the intervention wasn't seen as a punishment for those learners who don't like maths.

Increased confidence has also enabled learners to become more resilient in application.

Learners appear more resilient in their workshops. They have the confidence to try new things and 'have a go' in workshops. This behaviour change was noticed as one workshop teacher commented:

"*I've not put a worksheet in front of any of them and they've point blank refused, even if they don't get it, they've asked, which I think is a change in behaviour pattern compared to the lessons. Whereas in lesson, they just sit and talk, or sit on the phone, or say that I'm not doing it. So the fact that they're either willing to ask or try it and they are not point blank refusing to do it, to me means they're more confident*" (Cycle 1 - Teacher FG - Teacher B – 17:07).

Previously these learners did not fully engage in maths and were reluctant to partake in something they were unsure of. However, the workshops gave the learners the confidence and encouragement to apply their newly acquired knowledge in their maths lessons, with one learner saying "*if you've learned something, you can use what you've learned in your workshop and then bring it into your maths lesson*." (Cycle 1 - Nelson FG 1 - Learner D - 1:30)

As their resilience is in early stages of development, it has not yet transferred into their maths lessons. As discussed previously, development in workshop didn't feed into the classroom learning, and vice versa, due to the misalignment of the topics. This meant learners didn't have many opportunities to use their newly learned skills and strengthen their resilience.

As a learner cohort, due to COVID restrictions, these learners have had limited experience in a formal exam setting. Learners recognise this and have openly asked to "*do more examples to help us know like what you're actually going to feel like in the exam*" (Cycle 1 - Nelson FG 1 - Learner A – 8.44). These learners have a double setback of struggling with maths in the first instance and limited exam experience to manage expectations.

The consensus across all the learner focus groups is that students believe they have a better chance of passing their exams as a result of merely attending the workshops. Their rationale for attending and engaging is often simply “so we (can) pass the exam”. This is often said in such a way that it feels like a phrase they are just repeating, rather than understanding the wider concept. The learners need to understand that workshop attendance will not automatically grant a pass, but providing they put the effort in, it will give them the tools to succeed.

"*I think I'll be able to pass my maths now that I've participated in the workshops, I have more chance than I would usually I think because she works out how we work, and then puts it into practice*" (Cycle 1 - Nelson FG 2 - Learner B – 4:47)

Learner exam confidence continued to increase as the year progressed. As part of the learner snapshot survey, they were asked how confident they felt their maths grade would improve this year. When asked in December 2021, 10% of learners felt VERY confident they would improve their grade. When asked this question again in February 2022, 24% of learners feel VERY confident they will improve their grade.

However, there is some uncertainty when it comes to the ‘big mark’ problem solving questions. Learners still don’t feel confident enough to attempt these and asked to focus more on these types of questions. Learners also feel that even when they can apply their skills in maths lesson, when it comes to applying that knowledge outside the classroom they struggle. This correlates with the teacher focus group, whereby there was a lengthy discussion around application and spiralling. Learners felt that recapping would help their retention. " *Get the teacher to like, go over it every week so then that you don't forget it and then move on to what they want to do. Like recap it, as such*" (Cycle 1 - Nelson FG 1 - Learner D – 4:17). Some learners were clear that they did not want to recap in lesson and stated that they could do this in their own time at their own pace. They suggested information booklets to work through independently, trialling the skills learnt. It is clear that application and regular recapping is important but the underpinning knowledge and solid foundations are crucial to access the ‘big mark’ problems and use maths outside the classroom. This suggestion informed a change in cycle 2 whereby revision booklets were introduced.

When discussing alternative methods that may help they didn’t seem keen on online applications and preferred the idea of handouts and workbooks. They preferred something tangible to make notes on and refer back to. This comment was repeated throughout the learner focus groups.

"*Just because you can write your working out on the paper for instead of online I just think it's easier*" (Cycle 1 - Nelson FG 2 - Learner B – 2:25)

Other learner suggestions included quizzes as a way of improving and retaining knowledge. Quizzes are an example of how they can learn better and retain more information in a fun and memorable environment. This 'fun' element has emerged in all the learner focus groups as a factor for helping them retain information, and the reason why they enjoy and attend the workshops. Learners were keen to practice exam style questions to help prepare them. This feedback led us to create recap and application booklets. These were trialled in cycle 2 of the intervention as part of a series of subtle changes to refine the intervention.

"*The learners responded well to the booklets of exam questions where they could apply their knowledge and solve problems. It is a pleasure to watch the learners learning and engaging in mathematical conversations. Their curiosity has been piqued and many have started asking questions beyond what they are being asked to do. This makes me feel particularly proud of how far they have developed.* " (Block 3 teacher reflection)

Figure 8 below, illustrates how confident learners felt in the GCSE exam after completing the workshop intervention. Learners were asked to rate from 1 to 5, with 1 being not very confident and 5 being very confident. When asked to expand on their score, learners were in agreement with the statement that they "*believed that the workshops helped massively*" (learner X - End of intervention student snapshot survey) in their understanding of maths.

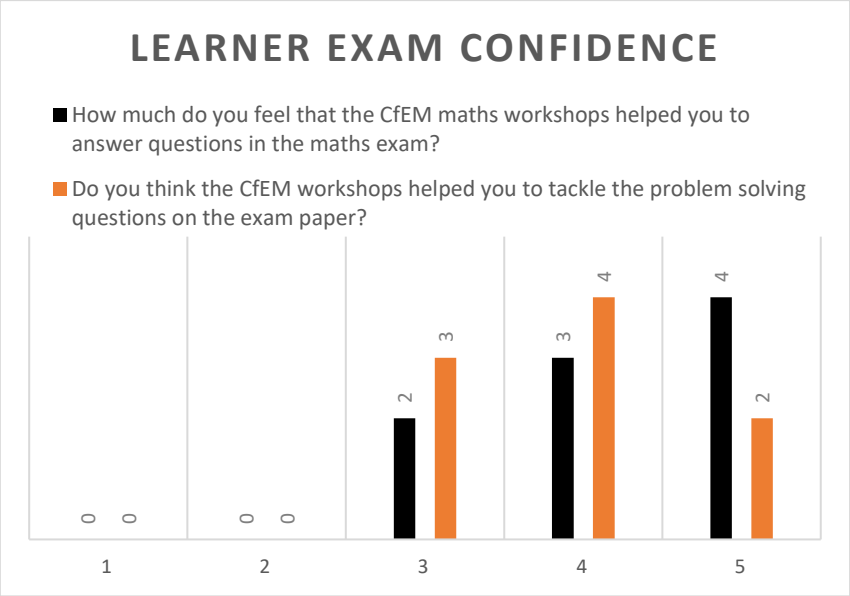

Figure 8 – Graph to show learner exam confidence

"I feel that I didn't understand a lot of maths topics because I didn't know why they should be answered in the way they are, and the workshop has helped me understand why we do

some certain equations or methods for certain topics" (learner Y - End of intervention student snapshot survey)

"Problem solving was hard for me at first but when going extra maths has made me confident and revising hard has helped me " (learner Z - - End of intervention student snapshot survey)

Resilience and Manipulatives

The use of manipulatives helped learner understanding and improved resilience, particularly as they illustrate how to break things down. Learners enjoyed using the manipulatives and felt having a physical representation helped their maths understanding and application.

"*when there's a physical representation of a question, some are easier to answer*"

(Cycle 1 - Accrington FG - Learner A – 2:39)

Workshop teachers also noted an improvement in retention, albeit slowly but it was noted that learners became reliant upon manipulatives as a prompt. When learners are unsure, the manipulatives can serve as a prompt and they immediately remember how it was used and are able to answer questions independently. The next stage is for learners to recall which tool to use without teacher prompts.

" *just that little prompt, no maths input, it's come back to them*"

(Cycle 1 - Teacher FG - Teacher A – 13:56)

Data shows that 70% of learners have scored at least 60% in the end of block assessments meaning that the majority of learners are retaining knowledge and skills from the workshops. (figure 9)

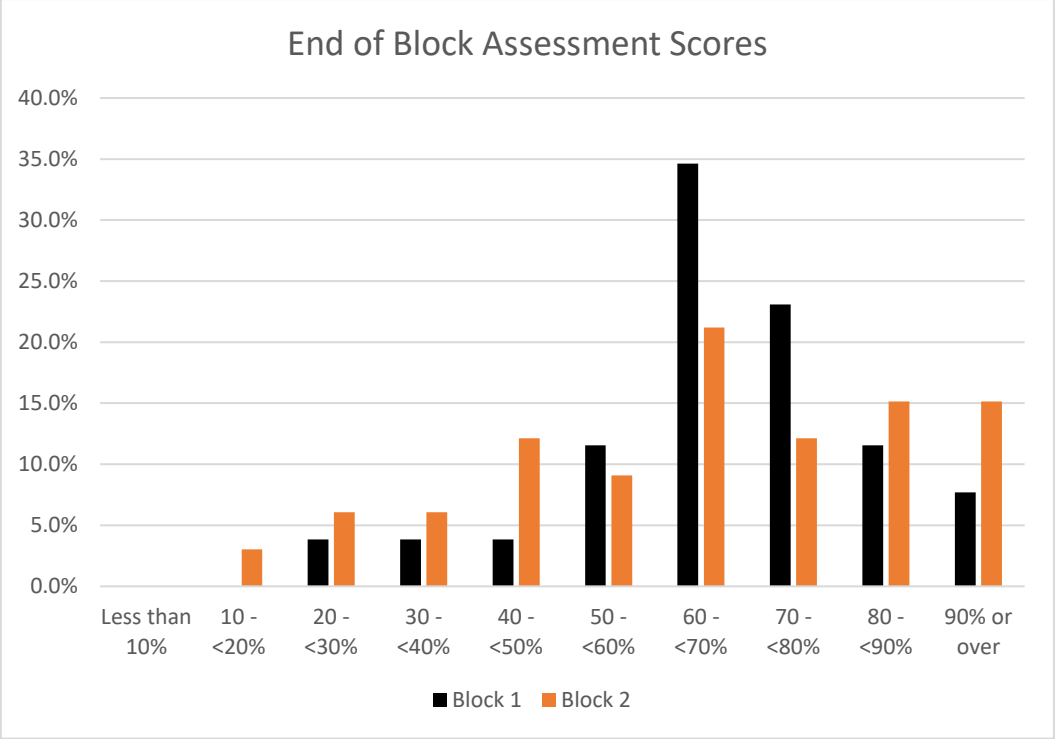

Figure 9 – graph to show end of block scores, illustrating knowledge retention

Fun, Relatable, Different

Enjoyment is key to retention. By enjoying the workshops and being able to influence the steps, learners are remembering key skills and concepts.

Learners refer to the workshops as being fun and the 'fun' element is repeated across all the workshops. This was witnessed first-hand by the research team whilst observing a 'ratio' workshop whereby learners were using centimetre cube blocks to illustrate ratio in a 'fun' way.

Observations suggest that learners need different approaches depending on what individuals find relatable. One learner in particular enjoyed building the blocks. The teacher adapted the task with this learner, so that the blocks could be built up, like a tower, rather than in a straight line on the table. The learner was then instantly keen and involved, exclaiming 'It still makes sense!'. This learner then went on to explain what he had learnt (using the towers) to a struggling peer. Lots of smiles and positive body language were noted from both learners, after finally 'getting it'. This highlighted that when the manipulatives were used in a way that the learner could relate to, they found this engaging and this led to a deeper understanding of the concept being taught. It is not a 'one size fits all', however, the nature of these workshops allows for bespoke teaching.

The use of manipulatives helped learners to underpin key concepts. Although one learner did find the use of manipulatives childish and used this as a reason to stop attending. This was an isolated case as all the other learners found the use of manipulatives helped their concrete understanding.

The manipulatives provide a 'fun' element to the workshops, with learners finding the workshops more engaging and memorable than normal maths lessons. This setting allows for a more relaxed environment where the learner is at ease and this tailored approach seems to be what makes the workshops stand apart from lessons. Learners feel at ease in the sessions. All this helps retention of knowledge. As one learner explained in the focus group "*they make it a bit more fun and engaging, helping us remember the skills a lot more*." (Cycle 1 - Accrington FG - Learner A – 3:20)

Learners understood the concept of the workshops, and said they prefer the workshops to their normal lessons. Workshop teachers have said how learners openly tell them how they enjoy the workshops, more so than their normal maths lessons.

"*I asked two of my learners, what do you think about the workshops? And they said they said that they're very different to lesson, why can't lesson be like this*."

(Cycle 1 - Teacher FG - Teacher B - 10:21)

Teachers also believe that there is a positive relationship between attendance and enjoyment, with learners admitting that they don't want to miss sessions as then they get behind. One workshop teacher recognised that "*the more they come, the more they like them*" (Cycle 1 - Teacher FG - Teacher A – 9:12).

The enjoyment theme also resonates with workshop teachers. Despite some of the barriers that have been faced, all teachers are enjoying delivering the workshops and can see a clear benefit to the learners. Teachers have enjoyed seeing learners have their 'light bulb moments'.

"*It's nice, because we know they're the sort of learners who often don't want to engage, we can see them engaging, and we can see them having their moments of understanding*."

(Cycle 1 - Teacher FG - Teacher A – 23:48)

Using the manipulatives in a relatable way encourages a memorable experience for students, fostering positive teacher relationships and increasing overall maths confidence.

Right Length, Right Pace, Right Size

The success of the workshops is all down to their structure. Learners attended a one hour workshop per week, concentrating on one topic block per half term.

When asked, the majority of learners felt that one hour per week was sufficient. One learner explained that "*I think one session a week is enough for me at least. Because it allows me to focus on the information of the rest of the week and I can practise it more*" (Cycle 1 - Accrington FG - Learner A - 8:25) This supports using independent learning for these learners would be better than a second weekly workshop, to allow them to reflect on what they have learnt and practice in their own time. However, there were still some learners who would welcome more workshops, particularly those who are not motivated enough to complete independent study. "*I think it'd be better to have more of them, because it helps boost our confidence with it*. " (Cycle 1 - Accrington FG - Learner C - 7:52).

There are a lot of considerations when planning the workshops. For many learners they were difficult to schedule due to vocational course demands, extra-curricular, placements and external commitments. Timetabling longer or more frequent workshops is not always feasible.

A concern amongst teachers is there isn't enough time to work through the many small steps of each topic block, with one teacher stating "*one of the problems I do find with it is for a year course we aren't getting through much content* " (Cycle 1 – Teacher FG – Teacher A – 1:55). The consensus among teachers is that this intervention needs to commence at the start of the year. This will not only help to get through the content but will also raise learner expectations to attend.

"*I would have preferred it to have been, from the start of the year, in hindsight, because I think we could have got through more content, and we probably wouldn't have had as many attendance issues*" (Cycle 1 – Teacher FG – Teacher B – 0:36)

Teachers felt that increased content should be through an extension of the block as a whole, rather than longer workshops. One teacher felt that extending the blocks would benefit learners by getting them " .. *to a point where it'll help them answer a GCSE question. Because I just feel that we're not getting there. Because we're still concentrating on the underpinning skills that they need to be able to get there*." (Cycle 1 – Teacher FG – Teacher C – 2:39). Learners openly admit that they would switch off if the sessions were longer, with one learner admitting "*An hour is good. Sometimes if it's too long, it just drags and you can't be bothered*

doing it" (Cycle 1 – Nelson FG1 – Learner C - 9:00) Keeping the workshops shorter in length supports learner and teacher feedback.

This was further evidenced through the workshop observations. Towards the end learners became distracted, using phones, chatting, off task, rather than moving on to the next task. The session reached a natural end, and it was clear that these learners would not have remained engaged any longer.

Another distinctive feature of the workshops is the slower pace. Topics are broken down into small steps, and the next concept is not introduced until all have understood. This approach fosters a slower pace with a focus on deeper understanding. This learner cohort struggles with the fast nature of the GCSE maths lessons and all felt that the pace of these workshops was right. This allows for students to acquire the foundations required for the fast paced GCSE SoL.

"*I think it's the right pace. Because like, if we're going a lot faster, then you won't understand it. And once you get an exam put in front of you, you're like well, how do I work this out because everything's rushed. Whereas, if you go in at a slower pace, it's easier to understand and remember it – how to do the question and work it out*."

(Cycle 1 – Nelson FG1 – Learner D – 10:08)

By moving at the pace of the learner and removing usual time pressures enjoyment creeps in. Learners can sometimes find they are picking up pace without realising.

"*it's very different, not having to work to that that time pressure. [of usual SOW] And getting to give them all the time they need to get the head round something. I do think it's really rewarding because you can see it happening. And quite often you can feel yourself moving on before you want to in the classroom*."

(Cycle 1 – Teacher FG - Teacher A – 23:26)

Initially some learners felt agitated when waiting for others to catch up as one stated "*I think it's an ok pace for when you are struggling, but not for when you're understanding it. I want to move on*." (Cycle 1 – Nelson FG 2 – Learner x - 8:36). However, it didn't take long once they had become used to the Mastery approach, for them to appreciate the pace which gave them the time and space to deepen their understanding.

"*I think it's like the right pace to be honest because in like normal math lessons, you like go a bit too fast*"

(Cycle 1 – Accrington FG – Learner C – 8:54)

Workshops groups were kept small. With added attendance issues, each workshop had on average four learners. Learners reaped the benefits from the smaller groups, as they felt they were bespoke and similar to a 1-2-1. When asked what they enjoyed about the workshops, one learner stated "*It's like a one to one, which is better for us"* (Cycle 1 - Nelson FG 1 - Learner A - 0:18). The smaller groups gave learners the confidence to practice and apply their skills that they would not normally have the confidence to trial in their larger maths class.

Most learners, 21 out of 24 who responded to a learner snapshot survey, felt that the workshops made a difference. Due to the nature of the workshops, being smaller and more targeted, learners felt supported and as a result more confident in their maths.

All teachers felt the intervention worked well and learners were benefitting from the workshop length, slower pace, and the smaller group size. There have been several noticeable lightbulb moments where learners have 'got' the concept, with all teachers in agreement that "*you can see it clicking like they've understood, because they're doing it slowly or because they've done it using manipulatives*." (Cycle 1 – Teacher FG – Teacher C – 1:14).

"*they're quite vocal about liking that the pace has slowed down,*
I think they find the pace really fast in class."
(Cycle 1 - Teacher FG - Teacher A – 1:21)

Attendance

Attendance has been the biggest barrier to workshop success. Once learners experienced their first workshop and realised the benefits, they were more likely to continue attending. This is an example of change in mindset. Teachers agree that "*when they turn up to a couple, and they realise what it's about, I think they're really starting to engage*" (Cycle 1 - Teacher FG - Teacher B – 0:36)

"*First time I just couldn't be bothered. And then I was okay, you know what,*
I'm actually going to go to them"
(Cycle 1 - Nelson FG 1 - Learner C - 0:54)

Attendance was also impacted by the workshops not being scheduled until November, which meant many learners didn't see them as important. The delayed start was due to timetabling intricacies and identifying the learner cohort eligible for the targeted workshops. Teachers felt if the workshops had been timetabled from the start of the year, learners would have been

more willing to attend. One teacher stated "*if it's on from September, it's just part of the timetable. And then if they don't need it, you can take it off and taking it off is better than trying to put it on*" (Cycle 1 - Teacher FG - Teacher B – 7:01) However staff remained determined throughout the intervention and adapted plans to try and engage learners.

COVID has continued to cause disruption this academic year and was particularly prevalent in block two for both learners and teachers. The difficult decision to cancel one set of workshops for two sessions had to be made due to staffing issues. When those workshops resumed, it felt like some of the learners had regressed.

"[*Covid impacted] Massively for me, because a few workshops were cancelled. So when it came to the assessment, they weren't ready for it. And it was like almost going back to square one, they didn't want to do it. 'Putting the shutters up. Can't do maths.' So yeah, missing a lot of lessons*." (Cycle 1 - Teacher FG - Teacher A – 20:55)

The graph below (figure 10) illustrates workshop attendance throughout the intervention, and highlights the dip in attendance at the start of the year primarily due to COVID, followed by a steep rise in the run up to the mock exams (Block 3).

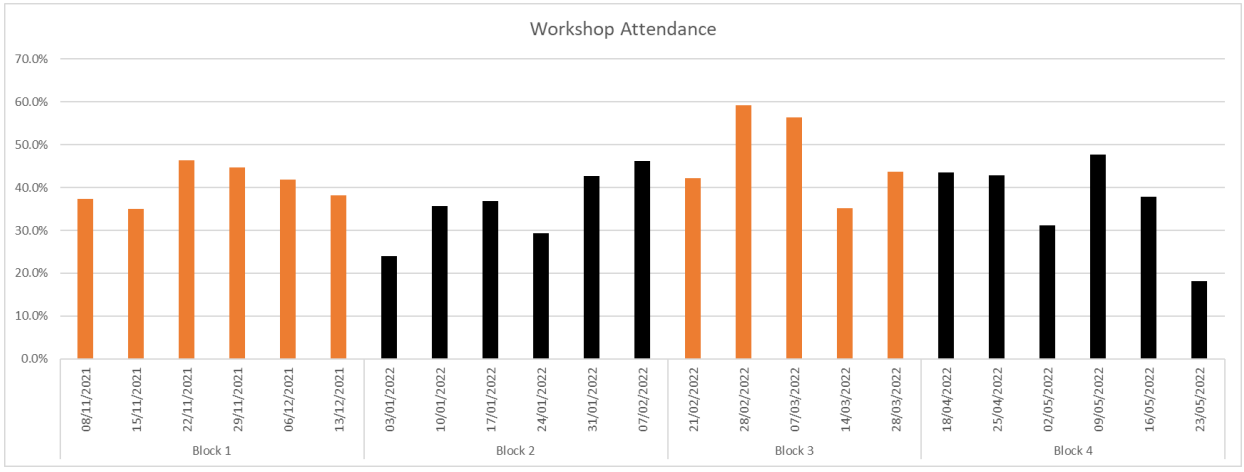

Figure 10 - Graph to show workshop attendance levels throughout the intervention. at start of year when COVID cases were at their highest

Once students realise the workshop benefits their attendance increases. This realisation and expectation needs to be instilled at the start of the academic year.

Conclusion and Recommendations

Summer 2022 results

The November resit exam was conducted prior to the intervention and was used as a grade benchmark. Over two thirds of students who attended 50% or more of the workshops improved their GCSE grade in the Summer of 2022, in comparison to low attenders where the majority either stayed the same or dropped a grade.

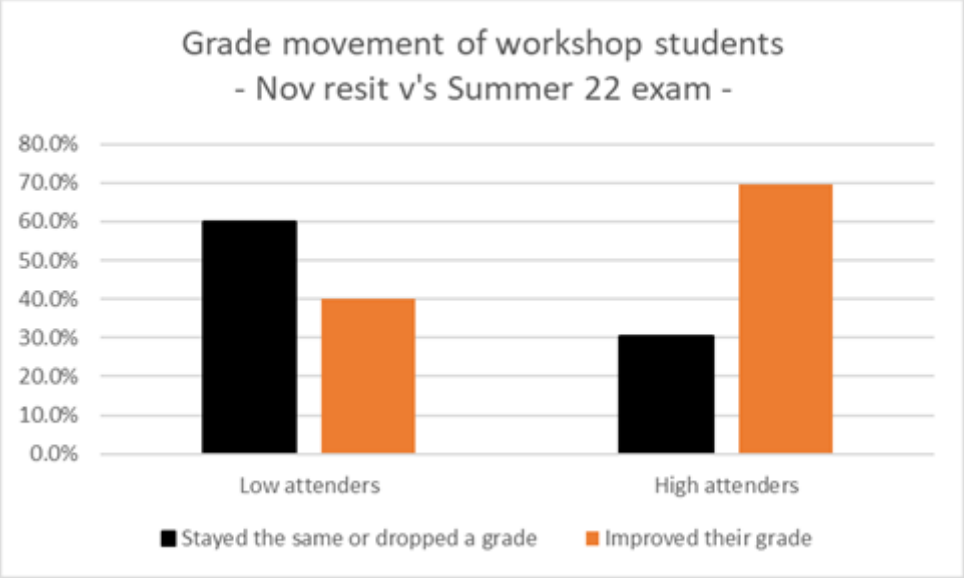

Figure 11 – Graph to illustrate attendance of workshops has enabled students to improve their GCSE Maths grade

Conclusion

It is clear that resit learners lack confidence in maths. They have fundamental skills gaps and this has been exacerbated by the pandemic. These were reflected in both the student and teacher focus groups. The project went some way to address these issues. It was not without its difficulties, but overall the data shows that workshops attended once a week by small groups of learners had a positive impact. As a result of the research, the GCSE maths team plan to implement many of the strategies used. These will further build on the successes of this action research and ultimately improve confidence and engagement which will positively impact learner future progression and prospects for generations to come.

Recommendations

- Relatability was the biggest factor for success. The CPA approach was ideal in facilitating this. It supports memory and further application, and manipulatives was one of the main concrete features used that successfully kept the learner engaged.

- The workshops need to be timetabled from the beginning of the academic year. The expectations need to be clear from the start. This will help with attendance and change the perception of the workshops from being additional and less important to simply a part of the learning journey.

- The workshop structure is key. The sessions need to be kept to no more than one hour to maintain engagement and optimise retention.

- The topic steps need to be carefully planned and delivered at the appropriate pace, to engage the learners and give them the time and space to ensure a solid foundation of skills.

- The groups need to be kept small to guarantee individual attention from the teacher, enabling each learner to develop confidence and resilience without the fear of failure in a large group.

- The resources need to apply the Mastery approach to ensure the focus is on depth of understanding rather than the speed of study.

- Ensure there are application questions available so learners can realise the progress they have made. Through the use of application, they can self-identify that they have fully mastered the skill. This boosts motivation and investment from an intrinsic value point.

- All tasks must be accessible to SEND (Special Educational Needs and Disabilities) learners.

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Appendices

Appendix One - Flipped Learning Student Focus Group Schedule

Thank you for coming today. I must make you aware at this point, this focus group will be recorded so we can analyse it. It will not be shared with anyone outside of the research team and it will be stored securely. Is that OK?

The aim of today's meeting is to gather your thoughts and opinions of the Maths Mastery Workshops you have attended this academic year as part of the Maths Centres for Excellence project. We are particularly keen to understand what you thought of the workshops, whether you found them useful and what we can do to improve them. There are only a few basic rules to keep in mind while participating today:

a) Everyone is encouraged to be an active participant.

b) There are no "right" or "wrong" answers.

c) Speak freely but remember not to interrupt others while they are talking.

d) Note taking is for reporting purposes only and will be used for analysis. Names are not attached to the notes.

e) We are conducting numerous sessions. All information gathered will be analysed to determine trends and make recommendations to the project.

f) All feedback today will remain anonymous. In order to maintain anonymity, I just ask that anything that is said during our session is not repeated outside of our session.

1. Tell me about the workshops you've been attending?
    a. Do you enjoy them?
    b. Do you find them useful?
    c. Do you understand the purpose of them?

2. Do you regularly attend the workshops?
    a. Why?

b. Why did you think it was important?
c. Why not?
d. What prevented you from attending?
e. Did this change over time?

3. How do you feel about the manipulatives that are used in the workshops?
    a. Do you enjoy using them?
    b. Do they help you understand maths more?
    c. Have they helped you understand fractions and/or percentages more?
    d. Please explain why.. (negative or positive)
    e. Do you prefer other methods to help you understand Maths, such as online platforms?

4. Thinking back to the first workshop block – percentages – can you still remember the skills and techniques that were covered?
    a. Tell me about a time you've used the things you've learned in the workshops in your lessons or homework.
    b. For example, if there was 20% off in a shop would you feel confident calculating the discount?
    c. If not, why do you think this is?
    d. Is there anything else we could have changed to help you remember this information?

5. Has attending the workshops changed how you feel during your maths lesson?
    a. Did you feel more confident?
    b. Did it change how you felt about answering questions?
    c. In particular fractions and/or percentage questions?
    d. Please explain why.. (negative or positive)

6. Have the workshops helped you in answering the 'big mark' problem solving questions in class?
    a. Do they help? How/why?
    b. Can you tell me about a specific task you thought they helped with?
    c. Do you feel more confident?
    d. Have the workshops helped you in retaining maths knowledge?

7. Do you think that participation in the workshops will have an impact on your achievement in maths this year?
    a. What is the impact?
    b. What makes you think that?
    c. Do you think you will be better prepared for exam questions? Particularly big mark problem solving questions?
    d. Have they given you the confidence and skills required to be able to answer percentages and/or fraction based questions?

8. Is there anything else that you would like to add with regards to your experience of the Maths Mastery Workshops?
    a. What would make the workshops better?
    b. Is there anything you didn't like about the workshops?
    c. What would you like to have done differently?
    d. Do you feel the timings/frequency (1hr per week) are the right amount?
    e. Do you feel that the pace of each workshop is the right amount?
    f. We have already covered fractions and percentages, what other topics do you feel you would like to cover?

Thank you for your participation today, we really appreciate your comments and time.

Appendix Two - Flipped Learning Teacher Focus Group Schedule

Thank you for coming today. I must make you aware at this point, this focus group will be recorded so we can analyse it. It will not be shared with anyone outside of the research team and it will be stored securely. Is that OK?

The aim of today's meeting is to gather your thoughts and opinions of the Maths Mastery Workshops that have been implemented this academic year as part of the Maths Centres for Excellence project. We are particularly keen to understand changes in student behaviours. There are only a few basic rules to keep in mind while participating today:

a) Everyone is encouraged to be an active participant.

b) There are no "right" or "wrong" answers.

c) Speak freely but remember not to interrupt others while they are talking.

d) Note taking is for reporting purposes only and will be used for analysis. Names are not attached to the notes.

e) We are conducting numerous sessions. All information gathered will be analysed to determine trends and make recommendations to the project.

f) All feedback today will remain anonymous. In order to maintain anonymity, I just ask that anything that is said during our session is not repeated outside of our session.

1) Now you have completed two blocks of the Mastery workshops, what are your general thoughts on the workshops as a concept?
    a. What are the benefits?
    b. What are the disadvantages?
    c. Have your opinions changed since the start of the first block?
    d. Why?
    e. What makes you think that?
    f. Can you explain in a bit more detail?

2) In this next question I would like you to focus on your personal experience. Tell me about any barriers you've faced whilst conducting the workshops.

a. How?
b. How did the (*said barrier*) create a barrier?
c. What adaptions did you make to accommodate (*said barrier*)?
d. How did you overcome this?
e. How would you change it?

3) Now I would like you to focus on your student's experience. In your opinion, how do your students feel about the workshops?
    a. What makes you say this?
    b. How do you know?
    c. Student feedback?
    d. Negative or positive?
    e. Do they understand the purpose and benefits of the workshops?
    f. Do they understand the term Maths Mastery?

4) In your opinion, how did students feel about the use of manipulatives?
    a. What makes you say this?
    b. How do you know?
    c. Student feedback?
    d. Negative or positive?

5) Have you noticed improved knowledge retention of the block topics?
    a. What makes you say this?
    b. How do you know?
    c. Student feedback?
    d. Negative or positive?
    e. Have you noticed an increase in application of knowledge?
    f. Have you noticed an impact their Maths confidence?

6) Have you noticed a difference in student behaviour so far over the course of the year of those who have attended the workshops?
    a. How?
    b. Why?

c. Please expand
d. Have you noticed an impact their Maths confidence?

7) Have you noticed a difference in student mindset so far over the course of the year of those who have attended the workshops?
    a. How?
    b. Why?
    c. Please expand

8) I'd like to discuss the effects of COVID in a bit more detail, both positive and negative. How has the current COVID situation impacted the workshops?
    a. How?
    b. What are the negative impacts?
    c. Were there any positive impacts?
    d. Would this research have been better or worse without COVID?

9) Is there anything else that hasn't been covered in today's session that you would like to share with us with regards to your thoughts and opinions of the mastery workshops?
    a. Personal experiences you would like to share and are relevant to the research
    b. Changes you would like us to consider for future iterations

Thank you for your participation today, we really appreciate your comments and time.

Appendix Three – Example of Workshop Step Plan – Block 2 Fractions

Step	Title	Objectives	Vocab	Questions	Delivery/Content	CPA	Spec Link	Tools
1	What does a fraction represent?	Recognise that the denominator shows how many equal parts the whole is split into. Recognise that the numerator shows how many parts we are using.	Parts of a Whole Numerator Denominator	If the denominator is 5 how many parts is the whole splt in to? What does the word numerator mean? What does the word denominator mean?	Look at different representations of a fraction Use Frayer model to describe the following terms - denominator, numerator, unit fraction (numerator 1)	CP	FR4	Frayer model Cuisenaire rods Card Sort Activity Multi-link Cubes Step 1 Worksheet Step 1 True or False Frayer Model handout
2	Simplify Fractions	Understand that 1/2 is equal to 2/4. Recognise the relationship between 1/2 and 2/4. Recognise that simplifying a fraction requires dividing both numerator and denominator by the same amount.	Parts of a Whole Numerator Denominator Dividing Multiple Factor	Why would you divide the numerator by 6 if you divide the denominator by 6? Is 2/3 equivalent to 2/6?	Physically show fractions that are equal in quantity i.e. 1/2 = 3/6. Recognise relationships. Understand that simplifying uses division. Revise simplifying questions.	CPA	FR4 FR5 FR7	Strip diagrams Multi-link Cubes Fraction Walls Step 2&3 Worksheet Step 2 True or False
3	Equivalent Fractions	Find more than one equivalent fraction on a fraction wall. Identify relationships between the numerator and the denominator of equivalent fractions. Recognise how to find equivalent fractions using multiplication and division.	Parts of a Whole Numerator Denominator Dividing Multiply Equivalent Multiple Factor	What relationship can you see between the numerators and the denominators?	Comparing two fractions. Discussion about simplifying. Recognise that you can divide by an amount to simplify, but also multiply to make equivalents.	CPA	FR4 FR5 FR7	Fraction wall Squared paper Strips of paper to fold into different amounts Step 2&3 Worksheet Step 3 True or False
4	Compare Fractions to Percentages	Recognise that a percentage is a part out of 100. Convert a fraction into a percentage.	Parts of a Whole Numerator Denominator Dividing Multiply Percentage	What does the word percent mean? How would you turn 23/50 into a percentage?	Turn fractions into percentages by making the denominator 100. Consider how to make a fraction a percentage on a calculator. Convert a percentage into a fraction icluding - 60%, 12.5%.	CPA	FR4 FR5 FR10	Fraction and percenatge wall comparison Step 4 Worksheet Step 4 True or False
5	Fractions greater than 1: Improper fractions	Define an imprper fraction. Recognise what an improper fraction is.	Parts of a Whole Greater than a Whole Numerator Denominator Improper	How many equal parts make a whole? Describe how you know a fraction is improer.	Use manipulatives and diagrams to show that a fraction can be split into wholes and parts.	PA	FR4 FR7 FN2 FN3	Multilink cubes Pizza and Apple Diagrams Step 5 True or False Step 5&6 Worksheet
6	Improper Fractions to Mixed Number	Recognise the difference between an improper fraction and a mixed number. Convert from an improper fraction to a mixed number. Convert from a mixed number into an improper fraction.	Parts of a Whole Greater than a Whole Numerator Denominator Improper Mixed	Describe how you know a fraction is improper. Describe a mixed number. How do you know 2 and 3/4 = 11/4?	From prior knowledge of improper fractions explain how many wholes are made. Convert an improper fraction into a mixed number and explain why. Reverse knowledge and convert mixed number into an improper fraction.	PA	FR4 FR7 FN2 FN3	Multilink cubes Pizza and Apple Diagrams Step 6 True or False Step 5&6 Worksheet
7	Compare and Order (less than 1): denominators are multiples of the same number	Comparing fractions less than 1 where the denominators are multiples of the same number. Correctly order fractions less than 1 in both ascending and descending order.	Parts of a Whole Less than a Whole Numerator Denominator Ascending Descending	How many parts are there in a whole? What happens to the mixed number when the denominator increases and the numerator remains the same? What happens when the numerator is a multiple of the denominator?	Represent this process visually using multilink cubes. Compare fractions pictorially where denominator is the same and numerator is different. Write fractions in acsending order. Write fractions n descending rder.	PA	FR4 FR7 FN1 FN2 FN5	Multilink cubes Pizza and Apple Diagrams Fraction Wall Step 7&8 Worksheet Step 7 True or False
8	Compare and Order (less than 1): denominators are not multiples of the same number	Comparing fractions less than 1 where the denominators are not the same. Correctly order fractions less than 1 in both ascending and descending order.	Parts of a Whole Less than a Whole Numerator Denominator Ascending Descending	How many parts are there in a whole? What happens to the mixed number when the denominator increases and the numerator remains the same? What happens when the numerator is a multiple of the denominator?	Represent this process visually using multilink cubes. Compare fractions pictorially where denominator are different and numerator is different. Write fractions in acsending order. Write fractions n descending rder.	PA	FR4 FR7 FN1 FN2 FN5	Multilink cubes Pizza and Apple Diagrams Fraction Wall Step 7&8 Worksheet Step 8 True or False
9	Compare and Order (more than 1)	Compare both improper fractions and mixed number fractions. Convert improper fractions and mixed number fractions to correctly order both ascending and descending.	Parts of a Whole Less than a Whole Numerator Denominator Ascending Descending	How many parts are there in a whole? Decribe an improper fraction. Describe how an improper fraction and a mixed number can be equivalent.	Successfully covert fractions from improper to mixed numebrs. Recognise when improper fractions need to be simplified to allow success ordering using the denominator. Describe why a particular order has been choosen.	PA	FR4 FR7 FN1 FN2 FN5	Multilink cubes Pizza and Apple Diagrams Fraction Wall Step 9 Worksheet Step 9 True or False

10	Compare and Order (denominator same)	Compare and order fraction with the same denominator - in ascending and descending orders. Convert fractions so they share the same denominator, where appropriate, to order them in ascending or descending order.	Parts of a Whole Less than a Whole Numerator Denominator Ascending Descending	Which is bigger 1/4 or 1/8? WHY? Which is greater 4/8 or 6/8? WHY? Describe how an improper fraction and mixed number can be equivalent.	Successfully covert fractions from improper to mixed numebrs. Recognise when improper fractions need to be simplified to allow success ordering using the denominator. Describe why a particular order has been choosen.	PA	FR4 FR7 FN1 FN2 FN5	Multilink cubes Pizza and Apple Diagrams Fraction Wall Cuisenaire rods Step 10 Worksheet Step 10 True or False
11	Compare and Order (numerator same) ASSESSMENT CHECKPOINT	Compare and order fraction with the same numerator - in ascending and descending orders. Convert fractions so they share the same numerator, where appropriate, to order them in ascending or descending order.	Parts of a Whole Less than a Whole Numerator Denominator Ascending Descending	Which is bigger 1/4 or 1/8? WHY? Which is greater 4/8 or 6/8? WHY? Describe how an improper fraction and mixed number can be equivalent.	Successfully covert fractions from improper to mixed numebrs. Recognise when improper fractions need to be simplified to allow success ordering using the numerator. Describe why a particular order has been choosen.	PA	FR4 FR7 FN1 FN2 FN5	Multilink cubes Pizza and Apple Diagrams Fraction Wall Cuisenaire rods Step 11 Worksheet Step 11 True or False
12	Add and Subtract Fractions (same denominator)	Add fractions with the same denominator. Subtract fractions with the same denominator.	Parts of a Whole Denominator Add Subtract	Why would you add the numerator but not the denominator? Why, when the denominator is the same, do you only subtract the numerator?	Recognise that the denominator signifies what your whole is split into. Pictorially recognsie what is happening when you add and subtract fractions with the same denominator. Rehearse adding and subtracting fractions with the same denominator.	CPA	FN1 FR4	Multilink cubes Fraction Wall Cuisenaire rods Step 12 Worksheet Step 12 True or False
13	Add and Subtract Fractions (when denominators are multiples)	Add fractions when the denominators are multiples one one another. Subtract fractions when the denominators are multiples one one another.	Parts of a Whole Denominator Add Subtract Multiple Factor	Why do you need to convert the fractions to an equivalent whereby the denominator is the same in both fractions?	Review equivalent fractions, and recognise their similarities. Rehearse converting equivalent fractions to then add and subtract.	PA	FN1 FN4 FR4	Multilink cubes (if needed) Fraction Wall Cuisenaire rods Step 13&14 Worksheet Step 13 True or False
14	Add and Subtract Farctions (when denominators are not multiples)	Add fractions when the denominators are not multiples one one another. Subtract fractions when the denominators are not multiples one one another.	Parts of a Whole Denominator Add Subtract Multiple Factor	What do you multiple the denominator and numerator by the same number whn simplifying/find equivalences?	Review the terms multiples and factors. Review equivalent fractions, and recognise their similarities. Rehearse converting equivalent fractions to then add and subtract.	PA	FN1 FN4 FR4	Multilink cubes (if needed) Fraction Wall Cuisenaire rods Step 13&14 Worksheet Step 14 True or False
15	Add and Subtract Mixed Number Fractions	Add mixed number fractions. Subtract mixed number fractions. Rehearse how to convert fractions from mixed numbers into improper fractions and reverse.	Parts of a Whole Denominator Add Subtract Mixed Number Improper Fraction	Why would you convert a mixed number into an improper fraction to add or subtract it? Why can't you simply add the whole numbers in a mixed number?	Review equivalent fractions, and recognise their similarities. Rehearse converting equivalent fractions to then add and subtract. Where possible - convert improper fractions back into mixed numbers to answer the question.	PA	FN1 FR4	Multilink cubes (if needed) Fraction Wall Cuisenaire rods Step 15 Worksheet Step 15 True or False
16	Find a Fraction of a Given Amount	Demonstrate how to find a fraction of an amount. Apply 'fraction of an amount' methodology to exam/worded questions.	Parts of a Whole Denominator Numerator Divide	How do you know what to divide by? Why do you multiply by the numerator in a fraction?	Recognise why a number is divided by the denominator - relating the denominator to 'parts of a whole'. Recognise why a number is multiplied by the numerator. Regearse the process of 'finding a fraction of an amount'. Successfully recognise the 'amount' in a worded question.	CPA	FN1 FN4 FN8 FR4	Multilink cubes Fraction Wall Cuisenaire rods Step 16 Worksheet Step 16 True or False
17	Fraction of an Amount - find the whole ASSESSMENT CHECKPOINT	Recognise that knowing a fraction can enable you to work out the original/whole amount. Find the orginal/whole amount when given a fractional worth.	Parts of a Whole Denominator Numerator Divide	If you have 5/8 how many 1/8's do you need to make a whole? If 6/7 is representitive of £60, what is 1/7 worth?	Review the idea of 'parts of a whole' - understanding that if you find 5/8's then the remainder is equal to 3/8's. Establish that if you know what the fraction is worth then it is equal to the interger value of the numerator. Rehearse reversing the process to find the orginal/whole amount.	CPA	FN1 FN4 FN8 FR4	Multilink cubes Fraction Wall Cuisenaire rods Step 17 Worksheet Step 17 True or False
18	Multiply by Integer	Recognise that a whole interger = x/1. Multiple a fraction less than 1 by a whole interger.	Interger Denominator Numerator Multiply	Explain why an interger can be written x/1. Why do we multiply the numerator by the 'interger'?	Recognise why an interger is x/1. Explain why we multiply the numerator by the 'interger' through diagrams or concrete objects. Rehearse multiplying fractions by whole intergers.	CPS	FN1 FN4 FR4	Multilink cubes Fraction Wall Cuisenaire rods Step 18 Worksheet Step 18 True or False
19	Multiply by a Fraction Less than 1	Explain why, when two fractions less than 1 are multiplied, we multiply the numerators and denominators by one another using the grid method.	Interger Denominator Numerator Multiply	Describe how you know 1/2 x 1/3 = 1/6.	Use the grid method to pictorially show why we multiply numerators and denominators together. Rehearse multiplying two fractions, less than one, together.	PA	FN1 FN4 FR4	Multilink cubes Fraction Wall Cuisenaire rods Step 19 Worksheet Step 19 True or False
20	Divide by Integer	Recognise that the denominator does not change when dividing a fraction by an interger. Divide a fraction less than 1 by a whole interger.	Interger Denominator Numerator Divide	Explain why an interger can be written x/1. Why do we divide the numerator by the 'interger'?	Pictorially show what happens when dividing 2/3 by 2, 4/5 by 2, 10/12 by 6 etc. Rehearse dividing fractions by whole intergers.	PA	FN1 FN4 FR4	Multilink cubes Fraction Wall Cuisenaire rods Step 20 Worksheet Step 20 True or False
21	Divide by a Fraction Less than 1 ASSESSMENT CHECKPOINT	Recognise patterns and methods to divide a fraction by another unit fraction.	Interger Denominator Numerator Divide	Describe how you know that 5/8 divided by 1/8 = 5.	Pictorially show what happens when dividing fractions - White Rose PP slides are good for this. Rehearse dividing a fraction by another unit fraction.	PA	FN1 FN4 FR4	Multilink cubes Fraction Wall Cuisenaire rods Step 21 Worksheet Step 21 True or False

Appendix Four – Example of Teacher Classroom Checklist – Block 2 Fractions

Step	Title						
1	What does a fraction represent?						
2	Simplify Fractions						
3	Equivalent Fractions						
4	Compare Fractions to Percentages						
5	Fractions greater than 1: Improper fractions						
6	Improper Fractions to Mixed Number						
7	Compare and Order (less than 1): denominators are multiples of the same number						
8	Compare and Order (less than 1): denominators are not multiples of the same number						
9	Compare and Order (more than 1)						
10	Compare and Order (denominator same)						
11	Compare and Order (numerator same)						
	ASSESSMENT CHECKPOINT						
12	Add and Subtract Fractions (same denominator)						
13	Add and Subtract Fractions (when denominators are multiples)						
14	Add and Subtract Farctions (when denominators are not multiples)						
15	Add and Subtract Mixed Number Fractions						
16	Find a Fraction of a Given Amount						
17	Fraction of an Amount - find the whole						
	ASSESSMENT CHECKPOINT						
18	Multiply by Integer						
19	Multiply by a Fraction Less than 1						
20	Divide by Integer						
21	Divide by a Fraction Less than 1						
	ASSESSMENT CHECKPOINT						