

***MA Education
(Teach First)
Programme***

Independent Study

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Abstract

Based on the studies of Mavarech and Kramarski (1997; 2003), this report finds that their *IMPROVE* method for developing metacognitive skills in mathematics classrooms is an effective way to narrow the attainment gap between a group of Year 7 pupils who are eligible for Free School Meals (e-FSM) and their more advantaged peers. It is argued that this is because the intervention develops the perseverance, self-efficacy and resourcefulness of the participants, which together improve their levels of resilience. This study corroborates with a theoretical approach towards educational disadvantage which values both the functionalist and socially critical perspectives (Joseph Rowntree Foundation, 2007) and argues that the effects of adverse environmental risk factors on educational achievement can be minimised by developing the resilience of more disadvantaged pupils in this way. The report notes that the quality least substantially improved by this intervention was self-efficacy, and therefore recommends pairing it with an intervention with proven successes in this area in order that the full effect of improved resilience might be realised.

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Introduction

Research suggests that disadvantaged pupils are likely to benefit from teaching approaches that support metacognitive and self-regulatory skills (Callan, G. L., Marchant, G. J., Finch, W. H. and German, R. L., 2016; Pappas S., Ginsburg H. P. and Jiang M., 2003; EEF, 2018). The purpose of this research is to investigate this hypothesis through the use of the *IMPROVE* method of teaching mathematics which includes the explicit teaching of metacognitive strategies alongside peer interaction and feedback-corrective-enrichment components (Kramarski, B and Mevarech, Z. R., 1997). The report begins by outlining a theoretical framework regarding why metacognition may have a positive effect on the educational achievement of disadvantaged learners, and by further exploring the *IMPROVE* method as researched by Kramarski and Mevarech. The setting, design and ethics of the investigation are then considered, and the results presented with discussion. This research activity aims to add to the field of inquiry by investigating whether or not the *IMPROVE* method shows large gains in the mathematical achievement of more disadvantaged learners, an area in which no published research currently exists.

Literature Review

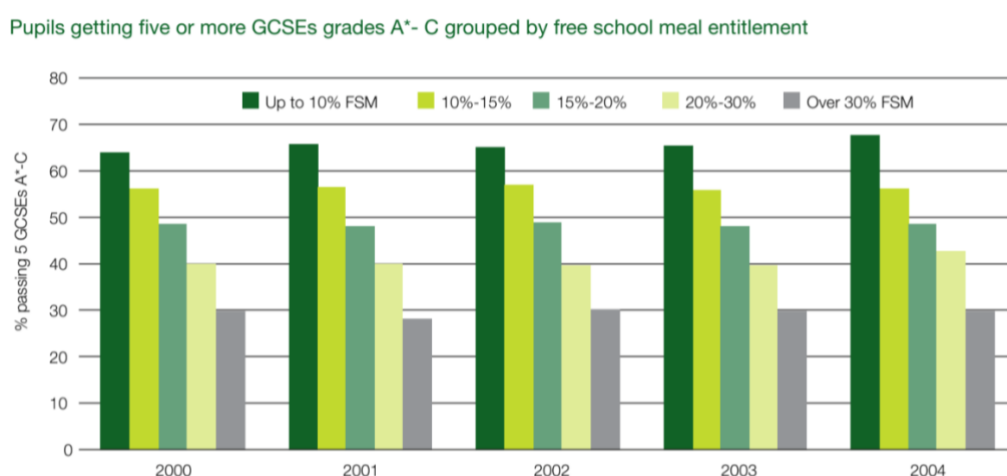
The term ‘educational disadvantage’ is wide-ranging, referring generally to the trends that become apparent when the different facets of learners’ demographics are examined in relation to their educational performance or post-16 pathways. Factors including gender, ethnicity and geographical location have all been shown to have an effect on educational outcomes (WG, 2008; WG, 2017c), however in Wales and England an income-based measure – eligibility for Free School Meals (e-FSM) – is the widely-used

proxy for disadvantage, specifically socio-economic. Despite e-FSM children not necessarily living in the lowest-income households due to the eligibility criteria being restricted to parents or children in receipt of certain benefits (Taylor, 2018), eligibility for Free School Meals has been shown to frequently encompass a number of circumstances that may present situational barriers to educational achievement: e-FSM children are more likely than their non-Free School Meal (n-FSM) counterparts to live in single-parent households, have more siblings, have a parent/carer who is long-term unemployed, live in rented accommodation, and have parents or carers who are relatively less qualified (Halse and Ledger, 2007). This fact, alongside the advantage of e-FSM eligibility criteria having remained relatively similar over time, makes it a meaningful indicator by which to examine and discuss the effects of socio-economic disadvantage on educational outcomes.

The fact that socio-economic disadvantage has a negative effect on educational achievement is a widely recognised phenomenon with a global presence (BERA, 2010; Ainscow, M. et al., 2012; Jerrim, J. and Shure, N., 2016). In Wales, not only is there a strong link between eligibility for Free School Meals and academic performance (see Figure 1), but this eligibility can be seen to have a growing impact from the Foundation Phase through to Key Stage 4: in 2012 the gap between e-FSM and n-FSM pupils achieving the expected levels in English or Welsh, mathematics and science at Key Stage 2 was 20% (Hughes, 2013: 5) whilst in 2017 the gap between the same cohort of pupils leaving school with five GCSEs at A*-C including English or Welsh and mathematics (Level 2 inclusive, or Level 2+) was 32.4% (Dauncey, 2018: 7). The learning barriers that create this gap for disadvantaged pupils are multifarious and different for every learner, but in general it can be said that, when compared with their more advantaged peers,

disadvantaged pupils are more likely to: have significant difficulties in basic literacy and numeracy (WG, 2015; WCEE, 2014); have poor attendance records (Estyn, 2012; WCEE, 2014); experience frequent behavioural difficulties (WG, 2015); be permanently excluded (WCEE, 2014); be allocated to low-ability groups (WCEE, 2014); experience a poorer quality of teaching (WCEE, 2014); believe that they have no control over events that affect them (WG, 2015); have parents who have a negative perception of school (Estyn, 2012), and; have parents who are uninvolved in their education (WG, 2015).

Figure 1: The effect of disadvantage as demonstrated between secondary schools in Wales (Egan, 2007: 4)



Because the sets of situational and learning barriers facing e-FSM pupils are so diverse, there are differing opinions in the academic and policy literature as to the fundamental causes of, and thus solutions to, educational inequality of this kind. The Joseph Rowntree Foundation (JRF) has distinguished between two broad positions: functionalist and socially critical (2007). For functionalists, solving educational inequality means supporting parents, pupils and schools to change in such a way that

disadvantaged pupils are better positioned to access the education on offer (BERA, 2010; Ainscow, M., 2012; WCEE, 2014; Estyn, 2011; Estyn, 2012; Estyn, 2013). For the socially critical, solving educational inequality means deconstructing education in its current form – which is seen to reflect and reproduce unequal distributions of power – and reimagining it in a way which works to overcome these societal problems by empowering marginalised groups (Dorling, 2014; Reay, 2017; Siraj et al., 2014; Ball, 2010; Fielding, 2001; Khan, 2011; Crehan, 2016). Though these two positions are not mutually exclusive – and the JRF (2007) has argued persuasively for the necessity of a combination of both positions in the work of schools and policy-makers – they find that the vast majority of policy- and school-based initiatives are largely functionalist in their approach with very few taking a socially critical position, not least because a large number of socially critical recommendations require large-scale changes to be made (JRF, 2007: xii). However current evidence calls into question whether purely functionalist interventions are having the necessary impact on educational inequality in Wales (Burn, 2018: 14), suggesting that schools might benefit from finding ways to embed some changes with a socially critical component in both their leadership and pedagogy.

There are some recently-published studies that integrate the functionalist and socially critical positions, most frequently starting from a developmental psychological viewpoint and exploring how various environmental risk factors in childhood affect how young people will engage with education; by developing intervention strategies that promote resilience in young people, it is argued, the effect of adverse environmental risk factors on educational achievement can be minimised (JRF, 2007: 25-33; Public Health Wales, 2015: 20). However, whilst there is strong pedagogical literature engaged with the development of pupils' resilience from a pastoral point of delivery (C4EO, 2010; *ibid.*,

2011), there is relatively little that focuses on ways to support pupils' resilience in a way that is embedded in 'standard' classroom teaching. According to the Welsh Government, the term 'resilience' describes several related elements including 'belief in one's own effectiveness' (self-efficacy), 'being able to cope well with change' (perseverance) and having 'repertoires of approaches to solving social and other problems in which they find themselves' (resourcefulness) (WG, 2010b: 15). In this way, although it is possible to argue that the work of Dr Carol Dweck on 'Growth Mindset' is a method of developing resilience in the classroom, this intervention actually appears only to address the self-efficacy aspect of this more nuanced definition (Dweck, 2000).

An approach that more fully encompasses all aspects of the Welsh Government's definition of resilience is what the Sutton Trust-Education Endowment Foundation [EEF]'s *Teaching and Learning Toolkit* – which summarises international evidence about education - terms 'metacognition and self-regulation'. This is made up of three components: cognitive skills, such as using different methods to solve equations in mathematics; metacognitive strategies, such as evaluating and selecting the most appropriate cognitive skill to use, and; motivational strategies, such as engaging in repeated practice in order that one might master a skill (EEF, 2018: 9). These components develop resilience by increasing the tools at pupils' disposal with which they can both solve new problems and monitor and improve their own rate of progress. Indeed for the EEF there is 'some evidence to suggest that disadvantaged pupils are less likely to use such strategies and are, therefore, most likely to benefit from the whole range of approaches to supporting metacognitive and self-regulatory skills' (EEF, 2018: 12), and the organisation rates the intervention as a high impact, low cost approach to improving

the attainment of disadvantaged learners, based on extensive evidence (Higgins et al., 2014; EEF, 2018).

The EEF offers broad guidance as to the teaching of metacognition and self-regulated learning in mathematics lessons, such as using teacher modelling, guided practice, feedback and encouraging pupil self-explanation, but emphasises the importance of using the strategies repeatedly across many mathematics lessons as '[i]t is likely that the time required to develop metacognition is much greater than for other skills and knowledge' (EEF, 2017a: 21). Similarly, Schneider and Artelt's recent meta-analysis of metacognition and mathematics education (2010) argues that the impact of metacognition and mathematics performance is substantial, but that the most promising interventions evaluated were those which integrated metacognitive instruction into existing mathematics curriculums. An example of this approach in practice is the instructional method developed by Mavarech and Kramarski called *IMPROVE* (1997), a modified teaching model based on the incorporation of three elements: metacognitive training, cooperative learning, and the systematic provision of feedback-corrective-enrichment. This method is particularly noteworthy due to the rigorousness and longevity of the studies published about its implementation (Schneider and Artelt, 2010: 9-10; Lovell, 2015) and the nature of its impact: significant improvements were seen at all achievement levels (Mavarech and Kramarski, 1997: 381-385). It is also the only intervention selected by Schneider and Artelt which is designed for secondary school pupils without the necessity to purchase additional computer software. As Mavarech and Kramarski prove, in one publication, that the method is most effective when all three elements were included, this will be the format in which *IMPROVE* is henceforth discussed (Mavarech and Kramarski, 2003).

Mavrech and Kramarski argue that *IMPROVE* was successful in that it: made it necessary for the pupils to use formal mathematical language accurately; made the pupils aware that problems can be solved multiple ways; encouraged the pupils to see different aspects of the problems, and; gave high-attaining pupils the opportunity to articulate and further develop their thinking processes at the same time as letting lower-achieving pupils see these thinking processes modelled (1997: 388; Lovell, 2015). In this way *IMPROVE* is likely to develop resilience in pupils as it provides them with an increased number of cognitive strategies with which to approach a problem (resourcefulness), a developed language with which to discuss different cognitive strategies, and the experience of overcoming a cognitive block with the combined effort of a small group (perseverance). To position the intervention as part-functionalist and part-socially critical, it is possible to hypothesise that using *IMPROVE* in a classroom setting might serve to narrow the e-FSM/n-FSM attainment gap by developing the metacognitive skills and thus resilience of the more socioeconomically disadvantaged pupils and hence facilitating these pupils to progress at a faster rate than their more advantaged classmates (whose skills in this area may be more developed). This research enquiry therefore aims to add to the field of inquiry by investigating the following research question: Does improve have a larger positive effect on the attainment of e-FSM pupils than their n-FSM peers?

Methodology

In accordance with BERA guidelines (2011), both the school in which the research took place and the names of the participants will remain anonymous.

Setting

The research took place in School X, an English medium, 11-18 mixed comprehensive school in the South Wales valleys. School X is medium in size with approximately 700 pupils on roll, one third of whom live in the 20% most deprived areas of Wales and a quarter of whom are e-FSM (compared to a national average of 17%). The school was rated 'adequate' in its most recent Estyn report (2014) with Key Stage 4 (KS4) e-FSM pupils noted as not achieving as well at Level 2+ as those in the family of similar schools. Recent results indicate that this assessment is still valid, as School X's e-FSM to n-FSM attainment gaps are currently broader for Level 2+ than for Key Stage 3 core subjects or for KS4 Level 2 (five GCSEs at A*-C), indicating that e-FSM pupils are less likely to achieve Level 2 English and mathematics than their n-FSM peers (Burn, 2018).

Participants

The class chosen for the study was a mid-to-low ability Year 7 (aged 11-12) class already taught by the teacher-researcher. The ratio of girls to boys was 5:4 in the e-FSM group and 3:5 in the n-FSM group, and each group contained two pupils with an Additional Learning Need. Prior to the beginning of the academic year, 14 of the 17 pupils were assessed to be achieving a Level 4, two n-FSM pupils at a Level 3 and one e-FSM and English as an Additional Language (EAL) pupil at a Level 2.

Design

As the research was conducted by a teacher-researcher in the context of their normal teaching practice, it was necessary for certain professional constraints to inform the design of the study, including the precise implementation of the *IMPROVE* method, the measurements used, and the extent to which variables could be controlled.

The *IMPROVE* method was used to deliver a statistics topic, as specified in the school's scheme of work, over eight teaching hours. The metacognitive training element of *IMPROVE* comprised introducing three new questions to the mathematics classroom: a comprehension question ("what is the problem/task about?"); a connection question ("how is this problem or task different from what you have already solved?"), and; a strategic question ("which approach is best for solving the problem or task?"). Each lesson began with the teacher-researcher introducing new material to the class before asking them to work through a booklet of five GCSE questions, each with accompanying metacognitive questions printed alongside, in their groups of one high-, two middle-, and one low-achieving pupil (Brown and Palincsar, 1989). At the end of the session the teacher reviewed the main ideas of the lesson with the entire class and provided additional explanations for common difficulties. Finally, at the end of the unit, the pupils took a formative test to check their comprehension of the unit's main ideas. In the subsequent corrective-enrichment lesson, pupils who did not attain mastery (80% correct) on this test were given corrective activities and then a parallel form of the formative test to complete to ensure that mastery had been attained, whilst those who did attain mastery in the initial test were given enrichment activities. See Appendix 1 for the accompanying short- and medium-term planning documents and Appendix 2 for the accompanying assessment materials.

It was out of the practical remit of this study to compare the effect of the intervention on a group of e-FSM and n-FSM pupils of the same age, ability level and mix of demographics through the use of a control group as mathematics classes in the school were setted in every year group and therefore no parallel class existed without approaching another school, and the short time-span of the study meant that results from one year group could not be comprehensively compared to those of a previous or subsequent year group (EEF, 2017b). Instead, the impact of the intervention is indicated by the relative progress made between the pre-test and post-test (before the corrective-enrichment lesson) by e-FSM and n-FSM pupils of the same class when all pupils receive the intervention. In this way, eligibility for Free School Meals was the independent variable and the survey and assessment results were the dependent variables. Only the data of pupils who were present for both tests are included in the results.

Ethical considerations

The research was conducted in accordance with school guidelines for parental consent, within BERA guidelines (2011) and within the boundaries of normal classroom practice, though particular considerations were made in specific matters. Firstly the risk of potential coercion through pupils giving their consent in order to please the teacher was mitigated by pupils being told that they could express their wish to withdraw at any point to another member of school staff (see Appendix 3). Secondly, the assignation of pupils to groups according to their ability or eligibility for Free School Meals was completed in a confidential manner, and associating data with particular pupils only occurred in analysis. Finally, all assessments used were a normal part of assessment schedules or planned classroom activities, and no pupil was asked to complete any

differing tasks on account of their eligibility for Free School Meals. Indeed the lack of a traditional control group in this study meant that the ethical issues related to providing and withholding interventions from certain pupils (EEF, 2017b: 9) were avoided, although it is also worth noting that the ethics of continuing to use this intervention without it being tested more thoroughly with a control group in the UK context may therefore be deemed questionable. Approval to conduct the research was granted by the Ethics Committee at the University of Wales Trinity Saint David.

Findings

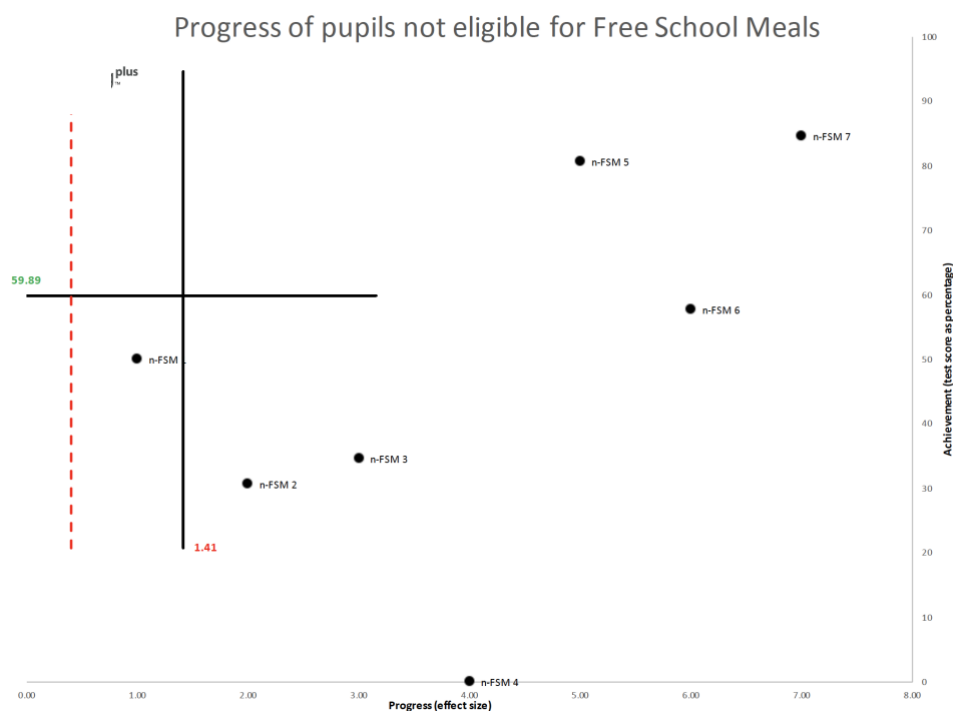
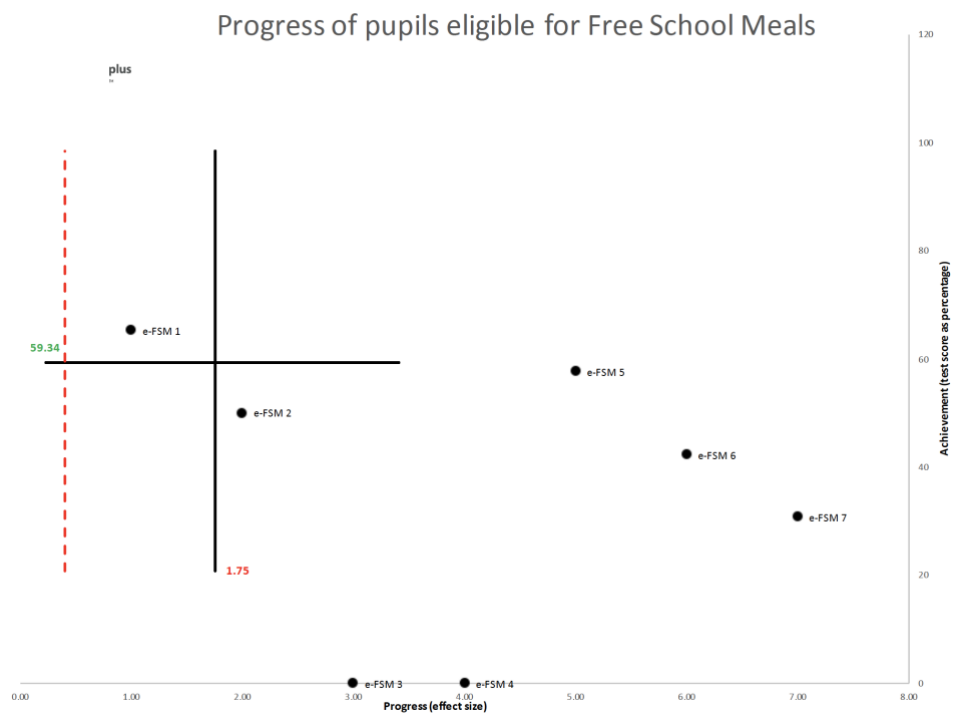
Assessment Results

To assess the effectiveness of the intervention on the mathematical skills of e-FSM and n-FSM pupils, their scores on a pre- and post-assessment were recorded. This assessment was identical in both cases, with the pupils receiving no feedback or access to the paper between sittings. Appendix 4 shows the raw data from these tests, Figure 2 is a table showing a summary of the analysed results, and Figure 3 includes graphs displaying the effect sizes of each group.

Figure 2: Table showing the effect of the intervention using the mean scores from each group. The e-FSM pupils improved by 29.67 percentage points on average whilst the figure for n-FSM pupils was 25.82 percentage points.

Group	Pre-test mean	Post-test mean	Difference	Percentage increase
<i>e-FSM</i>	29.67%	59.34%	+29.67%	100%
<i>n-FSM</i>	34.07%	59.89%	+25.82%	75.79%

Figure 3: Graphs showing the effect sizes of the intervention: 1.75 for e-FSM pupils and 1.41 for n-FSM pupils. The horizontal line represents the average achievement of the cohort, the vertical line represents the cohort effect size, and the red line represents an effect size of 0.4 which is what Hattie (2012) calculates to be the average effect we expect from a year's schooling. No score indicates that the pupil was not present for one of the tests and therefore their result is disqualified.



Survey Responses

In addition, the pupils' attitudes towards their mathematics lessons were recorded through a survey both before and after the intervention was implemented. Appendix 5 shows the raw data from these tests, and Figure 4 shows the results of three key question responses.

Figure 4: Table showing the survey responses to three key questions for e-FSM and n-FSM pupils. Each statement was followed by a Likert scale (1932) with the possible responses of 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree'.

Statement	Element of resilience (WG, 2010b: 15)	e-FSM responses either 'agree' or 'strongly agree'	n-FSM responses either 'agree' or 'strongly agree'
"I give up when I do not understand something."	Perseverance	57% -> 33% (decrease of 24%)	43% -> 14% (decrease of 29%)
"I am confident in my ability to learn what is being taught."	Self-efficacy	43% -> 56% (increase of 13%)	57% -> 86% (increase of 29%)
"I am encouraged to explore problems in different ways."	Resourcefulness	57% -> 67% (increase of 10%)	43% -> 29% (decrease of 14%)

Discussion

The data above indicates that the *IMPROVE* intervention had a larger effect on the attainment of the e-FSM pupils than the n-FSM pupils. However it is important to note here that an effect size above one seems unreasonable given that the amount of progress that Hattie (2012) expected pupils to make over a year was indicated by an effect size of

0.4. It is likely, therefore, that effect size is not a reliable indicator of the impact of this intervention as it contains what Lovell (2018) has termed a 'measurement design flaw' of effect sizes in which the use of a teacher-made assessment has resulted in far larger effect sizes than those expected of broad, standardized tests. What it does indicate to us, however, is that the progress made is more consistent for e-FSM pupils than n-FSM pupils, which is indeed confirmed by the data in Appendix 4 in which the average standard deviation of the e-FSM pupils is lower than those who are n-FSM. A more nuanced picture of the impact of the intervention in this instance is created by triangulating this information with the summarised data in Figure 3 which indicates that the e-FSM pupils made more progress than the n-FSM pupils both in terms of mean percentage points gained and as a proportion to their original score, achieving a mean score just 0.55% behind the n-FSM pupils in the post-test and therefore closing the attainment gap by 3.85%.

The survey results, meanwhile, can be used to explore whether or not the hypothesis presented in this paper – that a metacognitive intervention will increase mathematics attainment for disadvantaged pupils by improving their resilience levels – is a likely explanation for these quantitative results. Firstly, the e-FSM pupils indicated in the pre-intervention survey that they were more likely to give up when they do not understand something, which is in accordance with the literature above. Both groups of pupils then responded that they gave up *less* in the post-intervention survey, suggesting that some effect on perseverance was had, but that this effect was no larger for the e-FSM pupils than for the n-FSM pupils. Self-efficacy levels (the second statement) were consistently lower for e-FSM pupils and also showed a lower increase in these pupils, suggesting that the intervention did not serve to make them more confident in their

abilities to learn. One explanation of this could be that the pupils had not experienced success through this intervention *enough* for it to change their mindset, although it also suggests that this intervention may benefit from being paired with Growth Mindset work (Dweck, 2000). Lastly, the e-FSM pupils indicated that they felt more encouraged to explore problems in different ways after the intervention, whilst the n-FSM pupils indicated the opposite. This suggests either that the e-FSM pupils gained an awareness of what resourcefulness looked like in practice or that their repertoire of different skills was expanded. Both would fit a definition of metacognitive progress, and both are reasons why Mavrech and Kramarski argue that *IMPROVE* is so successful, but it is particularly interesting that this difference occurred between pupils with different levels of disadvantage and suggests that this is the strongest element of resilience (as defined by the Welsh Government) improved by the intervention.

Conclusion

This report hypothesised that the e-FSM pupils in this class would have lower levels of resilience than the n-FSM pupils, and therefore that using *IMPROVE* in the mathematics classroom would narrow the attainment gap by improving the e-FSM pupils' resilience through an intervention which focused on their metacognitive skills. The term 'resilience' was understood to include 'belief in one's own effectiveness' (self-efficacy), 'being able to cope well with change' (perseverance) and having 'repertoires of approaches to solving social and other problems in which they find themselves' (resourcefulness) (WG, 2010b: 15). The fact that more e-FSM pupils than n-FSM pupils either agreed or strongly agreed with the statement "I give up when I do not understand

something” in the pre-test (Figure 4) supported the postulation that e-FSM pupils tend to have lower levels of perseverance, and the decrease of this measure for both groups of pupils in the post-test – as well as the increases in agreement to the statement “I am confident in my ability to learn what is being taught” – indicates that the implementation of the metacognitive intervention *IMPROVE* had a positive effect on their levels of perseverance and self-efficacy. The pre- and post-test results, meanwhile, show that the e-FSM pupils made greater and more consistent progress over the intervention period than the n-FSM pupils, reducing the attainment gap from 4.4% to just 0.55% and therefore supporting the initial hypothesis of this report. As the changes in the two aforementioned survey questions were very similar for both groups, it is possible to conclude that the superior improvement of the e-FSM pupils came about as a result of their *increased* agreement with the final statement “I am encouraged to explore problems in different ways” in comparison to the n-FSM pupils’ *decreased* agreement; the e-FSM pupils gained resourcefulness through the intervention, by way of cognitive skills and metacognitive strategies, where the n-FSM pupils did not. Ultimately, this study indicates that the *IMPROVE* method is a useful intervention for secondary school mathematics teachers to use to narrow the attainment gap in their classrooms and equip their most deprived pupils with the skills needed in their future education and life. They may, however, consider pairing this intervention with the Growth Mindset work of Dr Carol Dweck (2000) so that the improvements of *IMPROVE* method on resourcefulness and perseverance can be supported by improvements in self-efficacy and thus resilience over-all.

Appendices

Appendix 1: Planning documents

1.1: Medium-term planning document for the sequence of eight lessons in which the *IMPROVE* intervention was implemented.

Lesson	Topic(s)	Notes	Homework?									
1	Tally charts & types of data (discrete/grouped/continuous), including inequality symbols	When getting pupils to do a task where they select the regular groupings for grouped data discuss the pros and cons to using larger groups i.e. less groups = loss in data accuracy but better overall awareness in general terms.	Yes									
2	Reading 2-way tables	<table border="1"><tr><td></td><td>Boys</td><td>Girls</td></tr><tr><td>Yr 7</td><td>64</td><td>57</td></tr><tr><td>Yr 8</td><td>71</td><td>76</td></tr></table>		Boys	Girls	Yr 7	64	57	Yr 8	71	76	
	Boys	Girls										
Yr 7	64	57										
Yr 8	71	76										
3	Bar charts (drawing/interpreting): traditional/multiple bar/stacked/horizontal/line	Mix up the idea of using a bar or a line within your exercises. Lower classes should take advantage of the Foundation Tier GCSE papers that have many tallies to bar chart questions available.										
4	Frequency polygons & trend	Ask the pupils if the lines connecting the points mean anything specific? Why doesn't it?	Yes									
5	Pictograms	Focus on the use of key and choice of picture.										
6	Pie charts (drawing and interpreting)	Only very simple Pie Charts where they are linked to $\frac{1}{4}$ or $\frac{1}{8}$ and other easy divisions of a circle.										
7	Re-test											
9	Feedback-corrective-enrichment	Grouped according to ability this time. Mastery mark is 80%.	Yes									

1.2: Short-term lesson plan model for an *IMPROVE* lesson.

Learning Objective: To be able to interpret and draw bar charts	Outcomes: All: To be able to collect data in tally charts (Level 4) Most: To be able to interpret and compare different bar charts (Level 5) Some: To be able to construct bar charts and interpret the results (Level 6)	Literacy/Numeracy Focus: Literacy: - written, wordy answers - oracy skills Numeracy: - timestables bell work - addition of frequencies
Bell work (15 mins): - Settle (3 mins) - Timestables grid (12 mins) Starter (1 min): - What big sporting event began yesterday? Does anybody know how many teams are involved? Do you know the different continents, and which do you think has the most teams entered? Example (4 mins): - Pupils complete the annotations to the worked example in the front of their booklets as the teacher goes through how to complete the question. Likely misconceptions/mistakes built in to the annotations. Plickers 1 (5 mins): - Pupils use their 'Plickers' cards to attempt five multiple-choice questions displayed on the board. Individuals and the teacher will know if they got the question right whilst the rest of the class will not. Can be treated as a 'baseline' for learning that occurs during the group discussions. Booklets (30 mins): - Groups work through the booklet of five (GCSE-style) questions together, talking through and agreeing their answers with one another. Each question is followed by three 'metacognitive' questions to help them to structure and reflect on their learning: 'What is the problem/task about?'; 'How is this problem or task different from what you have already solved?', and; 'Which approach is best for solving the problem or task?' Plenary & Plickers 2 (5 mins): - Pupils self-asses their answers to the booklet questions, with more explanation around common difficulties. - Pupils mark the front of their booklets with an indication of how they feel they met the success criteria. - As above, using similar but different questions. Hopefully their scores will be better if decent learning has occurred during the group discussions. Hand out homework as leaving.		Starting Points: - Students currently working between a level 4C and 5C. - Previous lessons have covered Pictograms and Two-Way Tables. - A baseline assessment indicated some substantial prior knowledge with relation to bar charts, but generally more success with interpreting than drawing. Deepening Thinking: - Example: Pupils will be required to understand not only how the answer was produced but how to avoid common errors in similar questions. - Booklets: Critical thinking is essential to complete all. Breadth of questions requires deep understanding. Role Modelling: - Example: Worked solution provided, role modelling a good answer to the questions as well as good metacognitive skills to use when considering new questions. - Booklets: Pupils will role-model certain behaviours and ways of thinking of other pupils in their group. Impact: - Bell-work: continued improvement on timestables knowledge indicated by time scores on the front of the bell work booklets. - Starter: Relating maths to the real world - Learning tasks: Level 4-6 skills, group work, metacognitive skills, flexibility and resilience - Plenary: Metacognition and reflection on learning Challenge: - Bell work: Students compete with themselves each day - Example: Pupils can add further annotations if they wish, further developing metacognitive skills. Also potential to discuss when and when not to draw gaps between bars in bar charts. - Booklets: Level 4-6 questions. Extension work available. Engagement: - Mention of the World Cup! - Lack of teacher-talk, lots of group-talk Assessment and AFL: - Plickers: Assessment for Learning - Plenary: Self-assessment Use of Incidental Welsh: Register

Appendix 2: Assessment materials

2.1: Pre- and post-test assessment questions

Q1.

The number of pupils in Year 11 in each of four different schools is shown in the following table:

School	A	B	C	D
Number of pupils in Year 11	80	140	110	130

Draw a pictogram to represent the above information, using $\oplus$ to represent 40 pupils.

School A	$\oplus \oplus$
School B	$\oplus \oplus \oplus \oplus \oplus$
School C	$\oplus \oplus \oplus \oplus$
School D	$\oplus \oplus \oplus \oplus \oplus$

(4) 20 30 50

Q2. Below is a table showing the number of people that are male, female then whether they are French, British or German.

	French	British	German
Male	17	58	25
Female	43	52	5

A) How many females are there in TOTAL?
 $43 + 52 + 5 = 100$

B) How many MORE British men are there than French females?
 $58 - 43 = 15$

(2) (2)

The chart shows the number of millimetres of rainfall recorded in Wrexham and Swansea on five different days.

mm of rain $\square$ Wrexham $\blacksquare$ Swansea

(a) On which day did Wrexham and Swansea have the same amount of rainfall?
 Day 2

(b) On how many days did Wrexham have less than 4 mm of rainfall?
 3 days

(c) On how many days was there more rain in Swansea than in Wrexham?
 2 days

(d) Find the total number of mm of rain that fell on Wrexham over these 5 days.
 $3 + 3 + 4 + 3 + 5 = 18$

(1) (1) (1) (1)

Q4.

Each of 40 pupils writes down how many pets they have. When they have more than 3 pets they write down M. The following table shows their results.

(a) Complete the frequency table below:

Number of pets	Tally	Frequency
0		5
1		14
2		12
3		6
M		3

(b) Write down the mode:
 1

(c) Using the squared paper on the next page, show a suitable bar chart for the data given in the table.

(1) (1) (1) (1)

Q5.

How pupils in Year 7 travel to school

There are 120 pupils altogether.

How many of them walk to school?
 30 pupils

(2)

Q6.

Month	Jan	Mar	May	July	Sept	Nov
Temperature in Europe °C	9	15	20	28	25	14
Temperature in Australia °C	27	32	23	13	12	20

This graph shows the temperatures for Europe plotted against the months.

a) Plot the values for Australia on the SAME graph above.

b) Compare the two graphs. What do you notice about the temperatures in Europe compared with those in Australia?
 in January, march, may, november in australia is hotter and in July and September in europe is better.

(5)

2.2: Survey questions



PARTICIPANT QUESTIONNAIRE

Project Title: Investigating different approaches to teaching and learning in the classroom

1	I try my hardest in class (please circle one) Strongly agree Agree Undecided Disagree Strongly disagree
2	This class challenges my thinking (please circle one) Strongly agree Agree Undecided Disagree Strongly disagree
3	I give up when I do not understand something (please circle one) Strongly agree Agree Undecided Disagree Strongly disagree
4	It is helpful for me to work with other students (please circle one) Strongly agree Agree Undecided Disagree Strongly disagree
5	I am confident in my ability to learn what is being taught (please circle one) Strongly agree Agree Undecided Disagree Strongly disagree
6	I am encouraged to explore problems in different ways (please circle one) Strongly agree Agree Undecided Disagree Strongly disagree
7	I have personal targets for my learning in this class (please circle one) Strongly agree Agree Undecided Disagree Strongly disagree
8	I evaluate and improve my work on a regular basis (please circle one) Strongly agree Agree Undecided Disagree Strongly disagree
9	Do you feel you work best... (please circle one) Alone In pairs In small groups (3 or 4) In big groups (6-10)
10	How do you feel in maths lessons? (please circle all that apply) Happy Angry Sad Calm Bored Nervous Excited

Appendix 3: Documents for ethical protocol

3.1: Participant information sheet

DATE

Dear Parent/Guardian,

My name is X. I am your son/daughter's Mathematics teacher and I am also studying for a Master of Education qualification in the School of Education at the University of Wales Trinity Saint David.

I would like to invite your son/daughter to participate in my research project. This project will involve no extra input from them (apart from our normal maths lessons) and aims to investigate how different classroom activities help pupils to make good progress in lessons. I hope to ascertain whether any activities that we do in the classroom help pupils to learn more quickly, more thoroughly and/or more enjoyably.

All questionnaires/results will be anonymised and kept strictly confidential to the researcher involved, and at **NO** time will individual questionnaires/results be released to the general public. The results from this study, after careful analysis, will hopefully enhance my understanding of how students learn, and the outcomes will be fed back to tutors at the University. These findings will be stored on a secure memory stick and I will be happy to provide you with a copy at your request.

I will be asking the pupils to sign a consent form in class which confirms that they:

- Have understood the purpose of the study and have had any questions answered
- Understand that they may decline to participate in the study and are free to withdraw at any time, without giving any reason
- Understand that their name will not appear in any reports, articles or presentations
- Understand that their answers may anonymously be used in future studies carried out by the researchers
- Agree to take part in the study

Their participation in this study is completely voluntary so they can be withdrawn from the process at any stage by either speaking to myself or X (Deputy Head Teacher in charge of Teaching and Learning). Should you yourselves have any questions about the project or wish to **NOT CONSENT** to your son/daughter's participation, please contact the school and ask to speak to Ms Burn.

Yours sincerely,

X

3.2: Participant consent form



FFURFLEN GANIATÂD CYFRANOGIAD	PARTICIPATION CONSENT FORM
Project Title: Investigating different approaches to teaching and learning in the classroom	
Name of Researcher: X	

		Please initial box
1	I confirm that I have understood the information sheet for the above study (dated 7/6/18) and have had any questions answered.	
2	I understand that I may decline to participate in this study and am free to withdraw at any time, without giving any reason.	
3	I understand that any information given by me may be used in future studies carried out by the researcher(s).	
4	I understand that my name will not appear in any reports, articles or presentations.	
5	I agree to take part in the above study.	
Signature		

Appendix 4: Raw data of results

4.1: Pre- and post-test assessment data

e-FSM pupils

[illegible]

n-FSM pupils

Student	Pre-test	Post-test	Effect size
n-FSM 1	50	50	0.00
n-FSM 2	26.92	30.77	0.21
n-FSM 3	11.54	34.62	1.26
n-FSM 4			
n-FSM 5	23.08	80.77	3.15
n-FSM 6	46.15	57.69	0.63
n-FSM 7	42.31	84.62	2.31
n-FSM 8	38.46	80.77	2.31
Average	34.07	59.89	1.41
STDEV	13.94	22.63	
AV Stdev		18.29	

4.2: Pre- and post-intervention survey data

Pre-intervention: e-FSM pupils

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10						
Response	Response	Response	Response	Response	Response	Response	Response	Response	Happy	Angry	Sad	Calm	Bored	Nervous	Excited
Disagree	Agree	Agree	Agree	Undecided	Agree	Disagree	Disagree	In pairs					Bored		
Agree	Undecided	Strongly disagree	Agree	Agree	Agree	Strongly agree	Agree	In pairs				Calm	Bored		
Agree	Agree	Agree	Agree	Undecided	Undecided	Undecided	Disagree	Alone				Calm	Bored		
Disagree	Strongly agree	Strongly agree	Strongly disagree	Disagree	Disagree	Disagree	Disagree	In big groups (6-10)					Bored		
Undecided	Agree	Strongly agree	Agree	Undecided	Undecided	Disagree	Undecided	In small groups (3 or 4)		Angry			Bored		
Strongly agree	Agree	Disagree	Agree	Strongly agree	Agree	Agree	Agree	In pairs	Happy						
Agree	Undecided	Undecided	Agree	Agree	Agree	Undecided	Agree	In pairs						Nervous	

Pre-intervention: n-FSM pupils

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10							
Response	Response	Response	Response	Response	Response	Response	Response	Response	Happy	Angry	Sad	Calm	Bored	Nervous	Excited	
Strongly disagree	Undecided	Strongly agree	Strongly agree	Strongly disagree	Agree	Strongly agree	Strongly agree	In pairs					Bored			
Strongly disagree	Strongly disagree	Strongly agree	Strongly agree	Undecided	Disagree	Disagree	Disagree	In pairs					Bored			
Agree	Agree	Strongly disagree	Strongly agree	Agree	Agree	Agree	Agree	In pairs	Happy			Calm	Bored			
Agree	Disagree	Disagree	Agree	Agree	Undecided	Strongly agree	Agree	In pairs				Calm	Bored			
Agree	Agree	Undecided	Disagree	Agree	Agree	Undecided	Agree	In pairs					Bored			
Agree	Agree	Strongly disagree	Strongly agree	Agree	Undecided	Agree	Agree	In small groups (3 or 4)			Calm					
Undecided	Strongly agree	Strongly agree	Strongly agree	Disagree	Undecided	Disagree	Strongly agree	In pairs				Calm	Bored			

Post-intervention: e-FSM pupils

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10							
Response	Response	Response	Response	Response	Response	Response	Response	Response	Happy	Angry	Sad	Calm	Bored	Nervous	Excited	
Agree	Agree	Disagree	Strongly agree	Agree	Strongly agree	Undecided	Agree	In small groups (3 or 4)	Happy				Bored			
Undecided	Agree	Agree	Agree	Undecided	Agree	Undecided	Agree	Alone					Bored			
Agree	Undecided	Disagree	Agree	Undecided	Strongly agree	Disagree	Undecided	In small groups (3 or 4)	Happy			Calm		Nervous		
Disagree	Agree	Agree	Strongly agree	Agree	Undecided	Undecided	Undecided	In pairs					Bored			
Agree	Agree	Undecided	Strongly agree	Agree	Agree	Agree	Agree	In small groups (3 or 4)				Calm	Bored			
Strongly disagree	Strongly agree	Strongly agree	Strongly disagree	Strongly disagree	Undecided	Strongly disagree	Strongly disagree						Bored			
Undecided	Agree	Undecided	Disagree	Undecided	Undecided	Undecided	Undecided	In small groups (3 or 4)					Bored			
Strongly agree	Undecided	Strongly disagree	Strongly disagree	Agree	Agree	Undecided	Agree	In pairs					Bored			
Strongly agree	Undecided	Disagree	Strongly disagree	Agree	Agree	Undecided	Agree	In pairs					Bored			

Post-intervention: n-FSM pupils

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10							
Response	Response	Response	Response	Response	Response	Response	Response	Response	Happy	Angry	Sad	Calm	Bored	Nervous	Excited	
Undecided	Strongly agree	Agree	Strongly agree	Agree	Disagree	Agree	Strongly agree	In small groups (3 or 4)		Calm						
Strongly disagree	Strongly disagree	Strongly disagree	Strongly agree	Strongly disagree	Disagree	Strongly disagree	Undecided	In pairs					Bored			
Agree	Agree	Disagree	Agree	Agree	Undecided	Agree	Agree	In pairs	Happy			Calm				
Agree	Agree	Disagree	Strongly agree	Agree	Undecided	Agree	Undecided	In pairs	Happy			Calm				
Strongly agree	Agree	Disagree	Agree	Strongly agree	Agree	Disagree	Agree	In small groups (3 or 4)			Calm					
Agree	Undecided	Disagree	Strongly agree	Agree	Undecided	Agree	Undecided	In small groups (3 or 4)				Bored				
Strongly agree	Agree	Undecided	Strongly agree	Strongly agree	Agree	Undecided	Agree	In pairs					Bored			

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