

Education
Endowment
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Improving Level 2 English and maths outcomes for 16 to 18 year olds Literature review

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Contents

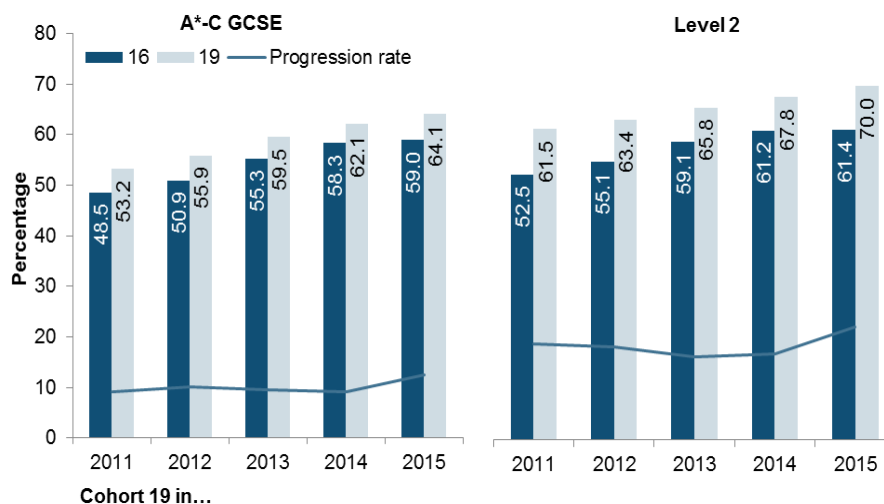
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1 Executive summary

1.1 Introduction

From 2014, students aged 16 to 18 without A* to C GCSEs in English and mathematics are mandated to continue to study towards achieving a GCSE in these subjects. This includes students in schools and further education (FE) colleges, as well as those on apprenticeships and traineeships. Current figures suggest that only a relatively small proportion of students who do not succeed at age 16 go on to succeed in their next two years of education. The progression rate¹ between 16 and 19 was 22.3% in 2015, an increase over previous years. The chart below shows attainment rates since 2011 for level 2 in English and maths by age 16, by age 19, and also the progression rate. Results are shown separately for A* to C GCSE and all level 2 qualifications.

Figure 1: GCSE A* to C and all level 2 English and maths attainment at age 16 and 19, and progression between 16 and 19—England, young people in state schools at academic age 15, cohorts 19 in 2011–2015



DfE, 2016, p. 6²

The Education Endowment Foundation (EEF) aims to improve the educational attainment of disadvantaged students aged 3 to 16 by funding and evaluating promising interventions, and building the evidence base on which interventions are most effective for improving outcomes. Students from disadvantaged backgrounds have worse educational attainment on average than their peers: only 41.1% of students in receipt of Free School Meals (FSM) attain GCSE English and mathematics by age 19 compared to 68% of the non-FSM group.

Compulsory education now continues to age 18, and students who do not attain A* to C GCSEs in English and mathematics in Year 11 are now required to continue to study towards achieving a GCSE in these subjects.

¹ The proportion of young people who failed to achieve a level 2 qualification in English and maths at age 16 who had achieved both by age 19.

² Department for Education (2016). Statistics: 16–19 attainment. [Available: <https://www.gov.uk/government/statistics/level-2-and-3-attainment-by-young-people-aged-19-in-2015>, April 2016]

These students are disproportionately from disadvantaged backgrounds and in particular need of high quality intervention to ensure that they have the opportunity to succeed in education and beyond.

The EEF has therefore commissioned this review to assess the evidence on specific interventions, or key features of interventions, which may be effective in improving English and mathematics outcomes for these students. Particularly in light of the new policy requirements, the EEF is interested in interventions that aim to help students succeed at GCSE, and also provisions that aim to improve mathematics and English attainment more generally, for example through improved functional skills outcomes.

As well as projects in schools and colleges, the EEF is interested in work-based routes to improving these outcomes—and how building these skills might also contribute to positive labour market outcomes and vice versa.

The review is based on a systematic literature search done by the National Foundation for Educational Research (NFER), with selection, summary, and synthesis of the evidence by AlphaPlus.

1.2 Key findings

1.2.1 English interventions

The English interventions that were reviewed fell into a number of different categories: those that were taught in the English classroom, those that were taught across the curriculum, those that involved withdrawing students from core lessons, and writing interventions.

Six of the 33 reviewed articles described interventions taught in the English classroom. The evidence demonstrates that there are a number of specific interventions that have been subject to robust evaluation and found to lead to significant improvements in outcomes. The following features of interventions were found to have a positive impact based on robust evidence from multiple studies:

- peer-mediated support, for example, peer tutoring (Wexler *et al.*);
- sustained support over time (Mostert and Glasswell, 2012); and
- an approach that includes a number of strategies including whole language approaches, linguistics and phonics, rather than relying on one approach.

Three interventions targeted literacy skills across the curriculum. The evidence from these was not robust and the findings were mixed (with some interventions showing no positive gains). However, in some cases it was found that there are improvements to outcomes when literacy interventions are embedded in other curriculum areas (Lai *et al.*, 2014; Williams *et al.*, 2010). The evidence from the interventions suggests that professional development for teachers in the content areas is crucial, and sustained input for the students is generally required.

One article included in the review provided evidence about the impact on reading outcomes of an intervention that involved withdrawing students from mainstream lessons. The report was based on robust evidence and did not find any evidence that withdrawing students from lessons had a positive impact on outcomes (Somers *et al.*, 2010).

Overall, the review found evidence that a number of specific interventions had a positive impact on reading outcomes, and in a number of cases this was based on robust evidence. Drawing out features that are likely to be effective from these interventions is not straightforward, as how they interact in the overall intervention, and how they are implemented, are likely to be important. However, for reading, we suggest that interventions may work when:

- they involve specific teaching of literacy skills;

- they adopt either within-English-class or cross-curricular approaches, rather than withdrawing students from mainstream lessons;
- significant time is given to them;
- they focus on fluency, comprehension, or vocabulary, or a combination of the three; and
- they adopt multiple approaches to developing skills.

Only one study in this review covered a writing intervention. It was based on robust evidence and found that explicit teaching of grammar can improve writing skills. However, it was found that the intervention was more likely to benefit those in the sample who were already the more able writers (Myhill *et al.*, 2012).

1.2.2 Mathematics interventions

The mathematics articles were also grouped into different approaches. These groupings are somewhat different to the English ones, for example, we did not find any interventions that teach mathematics across the curriculum as we did for literacy. The mathematics articles were grouped into those that (a) were mathematics interventions within mathematics lessons, (b) those that were some type of support intervention (such as teacher selection or training), (c) those that embedded mathematics into vocational studies in some way, and (d) those that involved interventions outside of the main teaching (tutoring interventions). We also included a number of articles that proposed general features of mathematics interventions that may have a positive impact on mathematics teaching.

We found three specific interventions that took place in the mathematics classroom: two were based on robust evidence, and one reasonably robust. All showed significant positive improvements on outcomes. The findings suggest that targeted increases in time allocated to study can have a positive impact for borderline students, and that using realistic contexts and classroom discussion can lead to improvements in outcomes.

Three interventions focused on different forms of supporting mathematics teaching. Two focused specifically on teacher training or recruitment, the first, aiming to train ‘maths counsellors’ who could address specific learning problems in mathematics (Jankvist and Niss, 2015), the second provided evidence from the Teaching Fellows Programme (What Works Clearing House, 2014). The evidence from these studies was inconclusive: the first was incomplete and showed some initial positive impact, the second was based on robust evidence and found no impact on outcomes. The third study reviewed in this section was on diagnostic testing. It was based on robust evidence and found a positive impact on mathematics outcomes.

Three articles provided evidence of the impact on outcomes of embedding mathematics learning in vocational areas. The evidence in each of these articles was limited—being from either small-scale or qualitative studies—however the three studies were unanimous in their positive findings. It was found that:

- integrated, contextualised functional mathematics is more accessible and engaging to vocational students who struggled with GCSE than a more traditional academic approach (Dalby and Noyes, 2015);
- high quality, contextual eLearning can lead to gains in vocational mathematics (Bakker *et al.*, 2012);
- supporting apprentices requires a broad approach considering a range of social and cultural factors (Leung and O’Donnell, 2006);
- personal relationships are crucial (Leung and O’Donnell, 2006); and
- early diagnosis (i.e. testing) is beneficial (Leung and O’Donnell, 2006).

There were two articles in the review on tutoring in mathematics. Although both studies were small-scale and do not provide robust evidence, both found positive impacts on outcomes, whether the tutors were professional (Chappell *et al.*, 2015), or non-professional (Karsenty, 2010). This may tie in with the finding that

personal relationships are important in improving mathematics outcomes. Both articles emphasised the importance of high quality training for tutors.

The final group of mathematics articles all presented lists of common features of mathematics interventions that they argued led to positive outcomes. The evidence reviewed in this section is of mixed quality—three studies adopt a robust approach and conclude that the evidence that they find is limited. The final review is based on a more qualitative approach. Generally, there is some consistency in the conclusions drawn in these reports. Key features appear to be:

- the use of technology to both motivate students and to develop skills more effectively (ETF, 2014);
- diagnostic assessment at the start of the programme (ETF, 2014);
- the use of real life contexts (ETF, 2014);
- teaching by vocational and mathematics specialist tutors (Ofsted, 2011);
- embedding of the content in vocational learning (Ofsted, 2011);
- building self-identity (ETF, 2014; Kyriacou and Goulding, 2006); and
- developing student motivation (Kyriacou and Goulding, 2006).

The six articles that provided evidence about both English and mathematics (and sometimes other subjects too) were mixed in their approaches and findings. The quality of evidence was also mixed: many found no positive impacts, but interventions that were found to have a positive benefit are summarised below.

One article of reasonable quality reviewed a tutoring intervention and found a positive impact on mathematics (supporting the finding above) but not on English (Buchanan *et al.*, 2015).

Walker *et al.* evaluated the ‘Gaining Ground’ initiative and found the intervention had a positive impact on GCSE results across the curriculum by adopting a range of approaches, but no significant difference to the control group. This is a study of reasonable quality.

A second article on a multi-strand intervention, of reasonable quality, found a range of factors that may lead to positive benefits including:

- appropriately skilled teachers;
- targeted and sustained teaching;
- relevant contexts;
- sustained participation;
- teaching of reading and writing;
- initial assessment; and
- the use of a range of approaches.

Many of these features replicate those found in the sections on English and mathematics interventions above.

One small-scale study found that withdrawing learners from lessons for extra ‘catch up study’ does not work (McGusky and Thaker, 2006).

One article focused on a non-subject-specific intervention. This robust study—investigating the use of financial incentives or rewarding them with event attendance with the aim of improving motivation and therefore outcomes—found no positive impact on GCSE attainment (Sibetia *et al.*, 2014).

A number of the features that have emerged from this review warrant a final comment.

Many of the articles we reviewed covered interventions aimed at significantly improving understanding and skills for students who have fallen behind in English and mathematics within mainstream schooling. These

interventions often find that significant and sustained input is required in order to achieve positive impacts. Such interventions are useful where the intention is to improve English and mathematics outcomes more generally over a two- to three-year period—one area of interest to the EEF. However, this is a different context from working towards the short-term goal of success in an examination resit—also of interest here—where less time is available. There may be strategies that work more effectively in this context which may not have long-term impacts on learning. A number of articles reviewed found that short-term interventions can lead to short-term gains and be appropriate for such a context.

The cohort of interest here may be different to the participants in some of the studies in mainstream schooling described above in that they have already failed in English and mathematics and may be, therefore, more disaffected. A number of the articles reviewed suggested that multiple approaches are required to achieve better outcomes for those falling behind, and this may apply even more in this case. The ETF's observation (2014) is relevant here: 'The reasons that learners disengage from learning are diverse, and therefore strategies to re-engage them with learning must be equally so' (p. 5). In this case, where a shorter period of time is available for the catch-up sessions, this may be reflected in a greater need for a personalised approach, rather than multiple approaches with each student. Again, the ETF authors comment: 'The review of international practices demonstrates that no one single approach is appropriate for learners; approaches must be combined and tailored according to the specific needs of the learners being taught' (p. 5).

The quality of the teaching may be of particular importance to this group of potentially disengaged or struggling students. Tailoring approaches to meet particular student needs, addressing misconceptions and weaknesses that have developed, providing useful feedback that can be used to narrow the achievement gap, all require high levels of content knowledge and pedagogical understanding. The studies on tutoring, and some of the other interventions reviewed, highlighted the importance of high quality professional development.

As this cohort of students has already failed in their GCSEs at least once and are being mandated to continue with English and mathematics, motivation and engagement are likely to be particularly crucial. In the articles reviewed, this is achieved in a range of ways, including making the subjects more relevant by using relevant contexts or by embedding the subjects in wider learning. The development of personal relationships, such as through tutoring in mathematics, may also be valuable in this context.

Initial assessment and/or ongoing diagnostic assessment is a recurring theme across a number of the interventions reviewed. This is a key element of formative feedback that has been generally proven to improve outcomes.³ However, where time is short, as it may be for some of the students resitting GCSE, it may be particularly important to focus on developing understanding in particular areas of weakness, rather than trying to cover all the content and understanding again. The ETF (2014) suggests that the testing may best be done at the start of the course rather than in advance:

'Some models of assessment include testing prior to the commencement of courses. Pre-course testing can, however, be off-putting to learners. The accuracy of such testing has also been called into question. Teachers and trainers would therefore require high levels of diagnostic skills' (p. 15).

Finally, the use of technology-based interventions came up a number of times in the review. While technology may have a positive impact on motivation in and of itself in the short term, it was noted that this can improve outcomes where it uses pedagogy that will improve understanding. Technology may be a means of delivering content in a more embedded or personalised way. It may also be a means of supporting the ongoing administration of assessments.

³ See for example the EEF Pupil Premium Toolkit.

1.3 Quality of evidence

Overall, the evidence about which interventions may work is limited.

Few studies gave detailed descriptions of the actual intervention in their reports. This makes it hard to evaluate how effective they would be in the post-16 English and mathematics context in England, or which features of them are essential for the interventions to be replicated with fidelity. Detailed summaries of interventions that look particularly valuable, and where detail is available, are shown in Appendix 1 of the main report.

Although we did exclude from the review articles that were based on research in single classrooms, much of the included evidence stems from studies that do not have a robust design (for example they lack a suitable control group), are from small-scale studies, or are based on qualitative evidence.

There are some individual interventions that have been subject to robust evaluation, and some of these show significant positive impacts on outcomes and some do not. There is no consistent pattern as to where the evidence exists or which type of intervention appears to have most benefit. Where studies are based on robust evidence, they tend not to have been replicated.

In some cases there are multiple studies in a single area each with limited evidence, for example tutoring in mathematics appears to have universally positive evidence from three studies, although none of these is based on fully robust evidence. There may still be a case, based on the existing evidence, for pursuing such interventions further to test them out in a robust way.

Experimental or quasi-experimental study designs, although ostensibly offering the most robust evidence, often included weaknesses. Common design flaws included the lack of a comparison group, use of multiple pre- or post-tests or inconsistent use of tests, and high levels of attrition in the samples.

We included a number of systematic reviews in our own review. These reviews often followed a robust approach but frequently concluded that the evidence they located was not robust. Such reviews support our finding that there is limited robust evidence available (see for example ETF, 2014).

Based on the current evidence levels it is best to say that the findings in this review are indicative: they give some suggestions as to areas of interest, but are not based on conclusive evidence. In addition, it is important to note that there are a number of areas in which we did not find any evidence of high quality, so it is difficult to draw conclusions about what may work. In particular:

- Interventions in vocational or adult education settings, or those involving employer-led provision, seem to be universally under-researched. The evidence is either small-scale, qualitative, or non-existent.
- We found only one article which provided evidence about reading interventions in which students are withdrawn from lessons, and only one article focused on writing skills.

1.4 Summary of the key findings

A summary of the key findings is provided on the following page.

	General features	Intervention grouping	Findings and key features	Quality of evidence
English interventions	<ul style="list-style-type: none"> specific teaching of literacy skills within-English-class or cross-curricular approaches, rather than withdrawing students from mainstream lessons significant time is given to them focus on fluency, comprehension or vocabulary, or a combination of the three multiple approaches used to develop skills 	English classroom	some positive findings for: <ul style="list-style-type: none"> peer mediated support sustained input multi-strand approaches 	variable some robust
		cross-curricular	mixed findings for: <ul style="list-style-type: none"> professional development for content area teachers sustained input 	weak
		withdrawal from mainstream teaching	one article <ul style="list-style-type: none"> no positive findings 	robust
Mathematics interventions	<ul style="list-style-type: none"> use of technology to motivate students and to develop skills more effectively diagnostic assessment at the start of the programme use of real life contexts teaching by vocational and mathematics specialist tutors embedding of the content in vocational learning building self-identity developing student motivation 	mathematics classroom	some positive findings for: <ul style="list-style-type: none"> targeted increases in time spent on maths realistic contexts classroom discussion 	variable some robust
		mathematics support	some positive findings for: <ul style="list-style-type: none"> teacher training and recruitment (mixed outcomes) diagnostic testing 	variable
		embedded in vocational studies	positive findings for: <ul style="list-style-type: none"> integrated and contextualised contextual eLearning multi-strand approach emphasis on personal relationships early diagnosis 	weak
		outside of mainstream teaching	positive findings for: <ul style="list-style-type: none"> tutoring 	weak
English and mathematics interventions		no grouping used	positive findings for: <ul style="list-style-type: none"> mathematics tutoring (not English) multi-strand approaches no positive impact for: <ul style="list-style-type: none"> withdrawing students from main stream classroom 	variable
Non-subject-specific interventions		no grouping used	single study, no positive findings <ul style="list-style-type: none"> financial or event incentives 	robust

2 Introduction

2.1 Background

This review is set in the context of a period of change in the education system in England: the education leaving age is incrementally being increased from 16 to 18, the national curriculum has been updated, and there are significant changes to the qualifications offered to 16–19-year-olds—both general and vocational. One of the changes currently being implemented is the requirement that 16–19 year-old students without an A* to C grade in GCSE English and mathematics continue to study these subjects. This will include students in schools and further education (FE) colleges, as well as apprentices and students on traineeships. Those students who currently hold a grade D at GCSE are expected to continue with GCSE. For other students, where appropriate, stepping-stone qualifications such as functional skills will be offered as an interim step.

The new national curriculum sets higher standards in terms of what students are expected to know and the skills they develop during their school career. Both GCSEs and A-levels are being redesigned to assess at the new higher standard. All GCSEs, including English and mathematics, will have a new assessment design. These changes aim to ensure that students working towards GCSE qualifications will develop the skills and knowledge needed for their further studies and/or for application in everyday life and the workplace. It is also intended that the new qualifications will provide greater assurance of English and mathematics content knowledge, and skills to educators and employers. Among other changes, the mathematics GCSE will include more problem-solving, including the use of mathematics in everyday contexts, and the new English language GCSE will place greater weight on accurate spelling, punctuation, and grammar.

The grading system for the new GCSEs is also being revised. Grades are currently awarded at A* to G, and these will be replaced with a scale from 1 to 9. In the current grading system, achieving a C grade is considered to be the crucial threshold, and in the new system the '4' will be set at the same standard. However, a '5' has been set as the target level, or a 'good pass', which is approximately the equivalent of two thirds of a grade higher than the C grade. Achievement of this key threshold in both English and mathematics GCSE is critical in enabling young people to progress in further studies and/or the world of work. GCSEs at this level are the gateway to many level 3 courses such as A-levels and Advanced Apprenticeships and are considered by many employers to be the baseline level of qualification to demonstrate the core skills of literacy and numeracy.

Changes to education policy in 2014 made it compulsory for those not succeeding in GCSE in English and mathematics at the target level to continue with those subjects until they do succeed at the appropriate level as a condition of funding.⁴ Current figures suggest that a relatively small proportion of students who do not succeed at age 16 go on to succeed in their next two years of education (DfE, 2016). The new GCSEs, which will be examined first in 2017 and set at a more demanding standard, will potentially compound this situation.

The new policy was introduced in 2014, so statistics from 2014 and 2015 will show the initial impact. The Department for Education published its Statistical First Release of GCSE results from 2015 (DfE, 2016) in April 2016, with the results showing some improved outcomes in the target group. The results show that 70% of students attained level 2 in English and mathematics by age 19 in 2015, increasing from 67.8% in 2014. This includes 64.1% of students achieving GCSE A* to C in 2015. The progression rate⁵ between 16 and 19 was 22.3% in 2015, up from 16.9% the previous year.

⁴ See: <https://www.gov.uk/guidance/16-to-19-funding-maths-and-english-condition-of-funding>

⁵ The proportion of young people who failed to achieve a level 2 qualification in English and maths at age 16 who had achieved both by age 19.

The Statistical First Release (*ibid.*) states that the increases in attainment have largely been driven by an increase in English progression rates—with rates increasing from 19.1% in 2014 to 28.7% in 2015 (8.2% to 14% for GCSE). For mathematics, progression has increased to 17.7% from 16.3%. For GCSE the progression rate for mathematics was 8.7% in 2015, up from 8.3% in 2014.

The Release also shows that there has been a reduction in the number of students achieving level 2 through vocational qualifications by the age of 16, as would be expected as more providers encourage the students to study for GCSEs. It is not clear whether the increase in progression rates is because students are staying in school longer or are doing better in their exams post Year 11 as the participation age is being increased at the same time as this policy for GCSE is being introduced.

The Education Endowment Foundation (EEF) aims to improve the educational attainment of disadvantaged students aged 3 to 16 by funding and evaluating promising interventions and building the evidence base on which interventions are most effective for improving outcomes. Students from disadvantaged backgrounds have worse educational attainment, on average, than their peers: only 41.1% of students in receipt of Free School Meals (FSM) attain GCSE English and mathematics by age 19 compared to 68% of the non-FSM group.

Compulsory education now continues to age 18, and students who don't attain A* to C GCSEs in English and mathematics in Year 11 are now required to continue to study towards achieving a GCSE in these subjects. These students are disproportionately from disadvantaged backgrounds, and in particular need of high quality intervention to ensure that they have the opportunity to succeed in education and beyond. They are therefore a group of particular interest to the the EEF.

The EEF have commissioned this review to assess the evidence on specific interventions, or key features of interventions, which may be effective in improving English and mathematics outcomes for these students. In line with the new policy requirements, the EEF are interested in interventions that aim to help students succeed at GCSE and also provision which aims to improve mathematics and English attainment more generally, for example through improved functional skills outcomes.

As well as projects in schools and colleges, the EEF are interested in work-based routes to improving these outcomes—and how building these skills might also contribute to positive labour market outcomes and vice versa. The EEF have commissioned AlphaPlus to conduct this literature review.

2.2 Key policy documents

Since the introduction of the policy mandating continuing study of English and mathematics post-16, a number of articles have been produced providing a discussion of the changes and suggesting key areas where changes could be introduced or where support may be required for the policy to be successful. The section below summarises some of the key articles.

2.2.1 Capacity of providers

Robey *et al.* (2014) produced a valuable report into the emerging policy context, under commission to BIS and the DfE. In total, 127 organisations contributed to the call for evidence, including FE colleges, independent training providers, community-learning providers, third-sector organisations, unions, employers, sector-representative organisations, and awarding organisations. The main conclusions presented in the report are, first and foremost, that the analysis demonstrates that the sector broadly supports the government's ambition to promote GCSEs as the national standard of English and mathematics. In addition, they conclude that the key themes in the comments are that:

- There is a need for flexibility in the implementation of the new GCSEs. Greater flexibility on the part of all stakeholders—including government, learning providers, and employers—will be important in supporting and motivating learners to engage with and achieve GCSEs in mathematics and English.
- Continuing Professional Development (CPD) of the teaching workforce will be essential for successful policy implementation.
- It will be essential to embed and contextualise the teaching and learning of English and mathematics within learners' 'vocational courses, work and wider lives'.
- It is important that appropriate and accessible stepping-stone qualifications and courses are available to help students progress to GCSE.
- The use of technology will be valuable in supporting the teaching of English and mathematics to this group of students.

The Association of Colleges (AoC) was commissioned by the DfE to conduct a survey with its members to gain a fuller understanding of the impact of government policy in this area, including 'the requirement for students with GCSE grade D to continue to study GCSE rather than a stepping stone qualification' (AoC, 2014, p. 1). Of the 125 respondents, 118 were from FE colleges and sixth form (SF) colleges and five were from Natspec (The Association of National Specialist Colleges) specialist colleges.

The AoC found that there were, on average, 675 students enrolled per college without GCSE A* to C in mathematics in 2014, and 681 without GCSE A* to C in English (of an average of 2,291 students per college). These numbers show an increase of 4.7% and 3.6% respectively over 2013. The numbers include 242 with a grade D in mathematics and 302 with a grade D in English. This is an increase of 5% for maths and 4% for English over 2013. The colleges stated that the biggest logistical challenges that these increases cause are timetabling and staffing for mathematics. Staffing for English is seen as less of a challenge. Their response to the challenges has been to recruit additional mathematics and English teachers and to upskill their existing staff. The majority of respondents to the survey (62%) say they have a specialist cross-college team with responsibility for the delivery of mathematics and English. Only 4% have given the responsibility to vocational tutors (34% use a mixture of specialist and vocational tutors). Most respondents to the survey are teaching both GCSE (90% for mathematics and 79% for English) and functional skills (85% for mathematics and 91% for English).

2.2.2 Mathematics teaching workforce

Hayward and Homer (2015) also conducted a survey with colleges (40 SF colleges and 65 FE colleges), supplemented by face-to-face interviews with teachers from a sample of colleges and an online survey of college teachers. Their focus was specifically on mathematics. They estimated that the teaching workforce in FE colleges in England is 830 full-time and 720 part-time mathematics teachers, and 920 full-time and 850 part-time numeracy teachers. In SF colleges they estimated the numbers to be 820 mathematics and 550 numeracy teachers working full and part time. In SF colleges the bulk of the teaching is for AL and Further Mathematics.

In terms of qualifications, 88% of FE college staff had qualifications that would confer qualified teacher status compared to 94% of those in SF colleges. Over half of the 82% of FE college mathematics teachers who hold a degree and teach numeracy and functional skills, hold an arts, humanities or social science degree. However, FE college teachers are significantly more likely to have relevant industrial experience (59%) compared to their SF college peers (39%). The authors estimate that the current policy developments necessitate the teaching of mathematics to approximately 50,000 additional learners each year in FE colleges, and about 1,800 more in SF colleges. These figures do not appear to take into account the increase in standards of the GCSEs, so the figure may be higher than this.

Hayward and Homer (2015) concluded that SF colleges tend to focus on teaching A-level mathematics, using full-time teachers with degrees in mathematics. FE colleges teach across a more diverse range of qualifications,

with a larger proportion of part-time staff who do not hold mathematics degrees. They often have mathematics qualifications no higher than GCSE grade A* to C: 'of those teaching GCSE and numeracy/functional skills without a mathematics degree, 43% do not have an A-level or equivalent in mathematics' (*ibid.*, p. 2). There is little spare capacity in FE colleges for teaching mathematics, and expansion may be met by their part-time workforce. However, 'considerable sustained investment in upskilling the current workforce' is required to enhance its mathematics knowledge. They suggest that there will be a need for an additional 6.5 mathematics teachers per FE college (1,500 across the sector in total) and about 0.5 full-time member of staff for each SF college.

Ofsted (2011) findings are in line with the Hayward and Homer findings in suggesting that 78% of the approximately 500 specialist numeracy tutors working in the post-16 settings that they visited had a generic teaching qualification, and only 28% had relevant qualifications at level 5 or equivalent. As with the Hayward and Homer study, Ofsted found that the CPD provision for numeracy tutors was limited: 'Tutors did not have sufficient opportunities to develop their specialist expertise in the teaching of numeracy or their own knowledge in mathematics above level 2' (Ofqual, 2011, p. 7).

2.2.3 Vocational learning

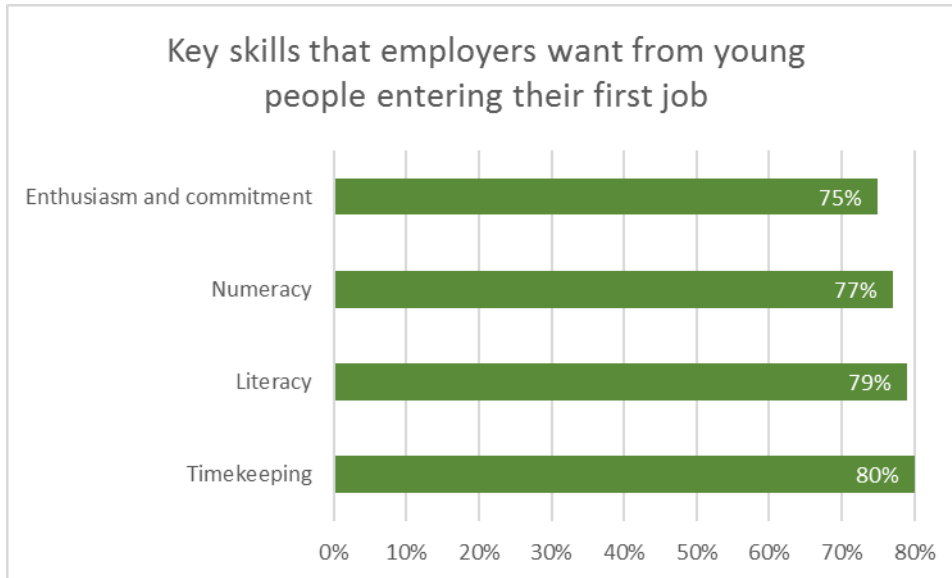
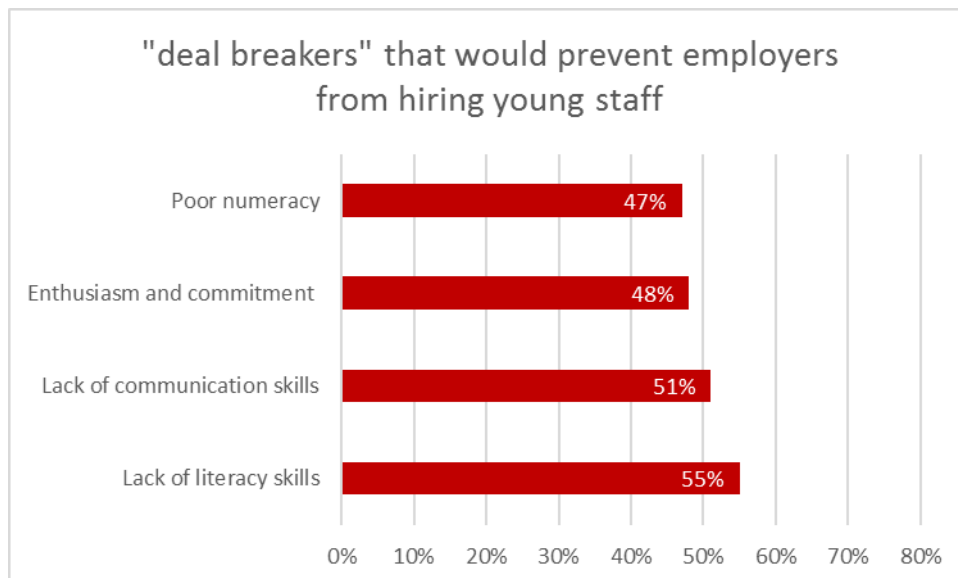
The Richard Review of Apprenticeships (2012) argues explicitly for level 2 qualifications in English and mathematics to be included in all apprenticeships. Although the author argues that functionality and applied knowledge is critical—

'All apprentices should have achieved Level 2 in English and mathematics before they can complete their apprenticeship. Mathematics and English taught within apprenticeships should be sufficiently functional in approach to be suitable for an apprenticeship context' (Richard, 2012, p. 18).

—it is also argued that a limited number of qualifications should be approved for inclusion. Although policy direction has changed since the introduction of the report it is likely that the new GCSEs in English and mathematics will be included.

2.2.4 Employer views

Findings from employers appear to support government policy. Mallows *et al.* (2016) conducted a literature review on the impact on employers of low literacy and numeracy skills in the workplace: citing a 2009 survey (Martin *et al.*) of more than 1,000 employers by the Learning and Skills Network, they report that the key skills that employers want from young people entering their first job are timekeeping (80%), literacy (79%), numeracy (77%), and enthusiasm and commitment (75%). The 2009 survey also asked employers about 'deal breakers' that would prevent them from hiring young staff, no matter how good their other skills: 55% of employers cited a lack of literacy skills, 51% a lack of communication skills, 48% focused on enthusiasm and commitment, and 47% said poor numeracy skills would prevent them from hiring young candidates.

Figure 2: Key skills that employers want from young people**Figure 3: 'Deal breakers' that would prevent employers from hiring young staff**

Mallows *et al.* also quote the CBI survey (2012), a major high-profile national survey that questioned employers about workplace basic skills gaps, among other related issues. In the last five surveys (2008–2012), the CBI received responses from senior executives across all employment sectors (735 employers in 2008, 581 in 2009, 694 in 2010, 566 in 2011, and 542 in 2012). Based on these surveys, the CBI argues that the majority of employers suffer because of the poor basic skills of their staff. Generally, the trend in percentages of employers expressing concern about skills in literacy and numeracy is upwards, with 56% expressing concerns about literacy levels in 2012, and 55% about numeracy levels. They add that: 'For employers expressing concern about literacy skills, the quality of written English was consistently the major concern. In numeracy, spotting errors and rogue numbers was the main shortcoming'.

Mallows *et al.* do caveat this by suggesting that there is a possibility that the CBI is overstating the severity of employees' literacy and numeracy skills gaps. They suggest that the CBI survey findings stand in marked contrast to those of the National Employer Skills Surveys (LSC, 2008, quoted in Mallows *et al.*) in which only a small percentage of employers expressed similar concerns.

2.3 Format of report

After describing the methodology used in this review (Section 3), this report presents our findings (Section 4) relating to the efficacy of interventions aiming to improve the outcomes for those students who fail to achieve the target level at age 16 and continue with English and mathematics post-16.

Summaries of specific interventions are provided at Appendix 1.

3 Methodology

3.1 Searches

The literature search was designed to identify the most robust UK and international research evidence on effective interventions and approaches for improving outcomes for disadvantaged 16- to 19-year-olds in English and mathematics (either in an education setting, or through employer-based or employer-led learning), as well as documentation which would provide an up-to-date picture of the current policy and practice context. As the requirement to resit GCSEs post-16 is a new policy, there is, as yet, no research evidence relating to interventions working in this new context. We therefore include articles for similar cohorts but without this mandatory requirement, for alternative post-16 provision, and for slightly younger age groups.

Information specialists from the National Foundation for Educational Research (NFER) searched a range of bibliographic databases (the Australian Education Index, the British Education Index, the Education Resources Information Center (ERIC), and the Idox Information Service) using an extensive combination of keywords relating to 'post-16', 'English and maths', and 'outcomes'. (The full search approach is provided in Appendix 2.)

In addition, the NFER 'hand searched' the tables of contents in volumes of the following journals published between January 2005 and March 2016:

- [Journal of Further and Higher Education](#)
- [Journal of Vocational Education and Training](#)

The NFER also browsed the publications/research/policy sections of the following websites:

Advisory Council on Mathematics Education (ACME)	Mathematics in Education and Industry
Association of Colleges (AoC)	MRDC
Association of Colleges in the Eastern Region (ACER)	NRDC National Association for Numeracy and
Association of Employment and Learning Providers (AELP)	Mathematics in Colleges
Best Evidence Encyclopaedia	National Centre for Excellence in the Teaching of
Best Evidence in Brief	Mathematics
Centre for Evaluation and Monitoring (Durham University)	NFER (including the 'On the Web' archive)
Centre for Post-14 Education and Work (IOE)	National Literacy Trust
Confederation of British Industry (CBI)	National Numeracy
Education and Training Foundation (ETF)	Nuffield Foundation
Excellence Gateway	OECD
Gatsby	RSA
GOV.UK (Department for Education (DfE),	Scottish Government
Department for Business, Innovation and Skills (BIS),	SRDC (Canada)
OFTSED and UKCES)	Sutton Trust
Learning and Work Institute	Welsh Government
	What Works Clearing House

NFER experts screened all search results (in excess of 7000 records from the database searches alone) against the parameters set out in the review protocol resulting in 170 records for the AlphaPlus research team to consider in detail.

3.2 Assessing the interventions

3.2.1 Coding

AlphaPlus team members then coded the literature using an agreed coding framework. The coding framework included the following questions:

- Does the article provide evidence about an intervention to support ‘catch up’ or resit learning?
- Does the article provide information about the key features of the intervention?
- Does the article provide other supporting evidence about the intervention, such as learning context or other contributory factors?
- Was the article published between 2005 and 2016?
- Is the article about English and/or mathematics?

The articles were also coded for quality of evidence using the following criteria:

- High (3): authoritative, independent study, research paper, systematic literature review, or review of reviews including some quantitative information or case studies covering a range of settings and stakeholders.
- Medium high (2): independent study, research paper or research/literature review (non-systematic), or official documentation, not covering as much quantitative information, and based on fewer case studies, settings and stakeholders, but based on sound theory.
- Medium low (1): study, research paper, research review (non-systematic), or official documentation authored by organisation or individual.
- Low (0): observation or opinion piece, based on one case study or views of one person.

The articles were coded using the published abstract.

The objective coding was used to inform a judgement about whether to include the article in the review, based on the EEF’s initial remit. This process resulted in 36 articles being selected. The coding spreadsheet was then shared with the EEF and the proposal about which articles to include was ratified by them.

3.2.2 Screening

Once agreed articles were located, they were summarised onto an agreed template. One article in the full review was found to not be of appropriate quality; one was found to be an early review for which there was a later and more detailed study also included; one was a policy article rather than being evidence-based; and it was not possible to locate one article. These articles were omitted from the review at this stage. One article sourced for the background section was found to include content relevant to the full review so this was included. This meant that we finally summarised 33 interventions. These articles were then synthesised to produce a standard literature review report, including summaries of the literature and discussion of the emerging themes.

3.2.3 Detailed summaries

Based on the summaries, 11 interventions were selected for further detailed investigation. These were selected where the reviewers believed the interventions to have real potential for improving progression rates for students in England who fail to achieve GCSEs in English and mathematics at the target level at 16, or for improving English and mathematics outcomes post-16 more generally. A detailed screening template was agreed with the EEF to summarise the key features of these promising interventions. There was a degree of

overlap in the important features of the English interventions, so rather than describing specific interventions, in a number of cases it was agreed to describe an overall model or approach based on the findings from a number of interventions. Four of the detailed summaries ultimately described models for effective reading interventions, pulling together evidence from a range of articles. The completed summaries are included in Appendix 1.

The means of summarising evidence on cost, effect size, and quality of evidence was agreed with the EEF. This involved:

- cost—an estimate based on available evidence with brief explanation;
- effect size—an estimate based on available evidence with brief explanation; and
- quality of evidence—coding against the rating system given above under the coding stage with a brief explanation.

4 Findings

As described above, 33 articles were selected for inclusion in this review. These are summarised below and key insights from each article have been pulled out. This review aims to collect evidence about interventions and specific features of them that may support learners who have failed their GCSE in English and/or mathematics and are required to continue with these qualifications until they reach the target level. The interventions reviewed have been split by subject: English, mathematics, interventions that apply to both subjects, and those that do not target any subject specifically. This section aims to provide detail of the interventions of interest, as well as to summarise key findings from a group of interventions. The synthesis may, in fact, be the least useful area of the evidence as the nuances about what works and what doesn't is lost when generalisations are made; some of the details about what works and what doesn't are very specific.

The following groupings have been used:

- reading interventions in the English classroom;
- reading interventions in other curriculum areas;
- reading interventions in which students are withdrawn from regular classes;
- writing interventions;
- mathematics interventions in the mathematics classroom;
- mathematics support interventions;
- mathematics embedded in vocational programmes of study;
- mathematics interventions outside of the classroom;
- generic features of mathematics learning that lead to improved outcomes;
- English and mathematics interventions; and
- non-subject-specific interventions.

4.1 Reading interventions in the English classroom

4.1.1 Striving Readers programme

Boulay *et al.* (2015) reported on a study of the effectiveness of interventions for struggling adolescent readers. They described the Striving Readers programme. The article summarises outcomes of ten reading interventions for struggling adolescent readers that used four specific reading programmes. The trials of the programmes were conducted as RCTs. Research took place in different states in the U.S. and different types of institution, and involved a sample size of 18,271 students across the ten interventions across different grades in approximately 220 schools. The research quality is reasonable although different instruments were used across the interventions leading to a lack of coherence in the data, and in some cases there was a lack of randomisation of the students in the research design.

Across the interventions, all participants were pre- and post-intervention tested using state reading instruments focusing on comprehension. This focus was selected as comprehension was considered to be the primary cause of reading problems among struggling adolescents. This is also viewed as an essential skill for mastering other content areas such as mathematics and sciences. The students were randomly assigned to one of four specific reading programmes: READ 180, Xtreme Reading, Learning Strategies Curriculum, and Voyager Passport Reading Journeys. Other groups were assigned to 'business as usual'. Detailed information on what

each reading programme comprised is included in the paper. All the students were studying for their USA qualifications.

It is not specifically stated in this report whether teachers were reading specialists, English specialists, or content/subject teachers, or if the students were withdrawn from English or subject classes. This would be useful to know for replication purposes.

Of the ten interventions, four had at least one result showing a positive effect on reading achievement (the remaining six had no discernible effects):

- For READ 180 there was evidence of positive effects on reading achievements that were statistically significant.
- For Xtreme Reading there was evidence of potentially positive effects on reading achievement. One study found a significant positive effect, and one did not.
- The Learning Strategies Curriculum potentially had a positive effect on reading achievement. One study found statistically positive effects.
- Voyager Reading Journeys had mixed effects on reading achievement. One study found positive significant effects and two found no difference.

Key insight: The study identified four examples of reading programmes with initial evidence of positive impact for struggling adolescent readers: READ 180, Xtreme Reading, The Learning Strategies Curriculum, and Voyager Reading. For some of the programmes there were negative as well as positive findings.

4.1.2 Re-engaging NEETs⁶

Smith and Wright (2015) reported on the literacy curriculum and engagement of 16- to 19-year-old NEETs (Not in Education, Employment or Training). This was a qualitative study of teacher perception of the effectiveness of the curriculum for low-achieving students. The data consisted of a mix of reflective journals and interview data. The research participants were teachers working in FE and community settings who were studying for their literacy specialist teaching qualification.

The authors found agreement among the teachers that there was a need for a curriculum that uses existing literacies as a foundation for re-engaging NEET students, but that contextual constraints often prevented the realisation of such a curriculum. They found that the picture is complex and concluded that the most successful learning occurred when students engaged in holistic, innovative curricula, personalised to the individual student, and considering their social needs. Conversely, the least successful learning occurred when students engaged in 'literacy through a technical approach that included a focus on grammar, word classes, and apostrophe use' and where funding constraints meant students were working towards national qualifications that might not be the most appropriate route for them.

The authors concluded that students who are already disengaged need good pastoral care to build confidence, and that a different approach to literacy is needed that engages the students rather than replicating experiences in school.

Key Insight: The perception of teachers in this study is that young people Not in Education, Employment or Training need an innovative, holistic and personalised approach to literacy, rather than a technical approach that teaches to the test.

⁶ A detailed summary of this intervention is included in Appendix 1.

4.1.3 Peer-mediated academic interventions⁷

Wexler *et al.* (2015) produced a synthesis of evidence on peer-mediated academic interventions for struggling students in secondary schools in the USA. The students were in grades 6–12 (ages 11–18). This is a robust synthesis of research on peer-mediated reading and mathematics interventions for students with academic difficulties and disabilities. Thirteen studies were included, meeting the minimum requirement of measuring the effect on at least one academic outcome.

Of the 13, there were ten studies that used an experimental or quasi-experimental design and three single-case studies (the latter are not included in the review here as they involved very small numbers of students). Four of the reading studies are focused on in more detail for this review—these met all of the quality criteria set by the authors (two were experimental and two quasi-experimental in design).

The studies included those with some formal teacher-led linguistic skills training (such as phonics) or modelling of comprehension strategies (for example, preview, click and clunk, gist, wrap-up) followed by students working in pairs or small groups for shared activities, sometimes using a computer-assisted programme, and partner reading. One of the four studies did not use a formal peer-mediation strategy.

The greatest impact was found where interventions had a peer-mediated feedback component (this worked except in one study where both students were operating at a low level—this study also had no formal peer-mediation strategy). Interventions using a formal peer-mediated strategy overall had the largest impact on comprehension and less on reading fluency (where measured)—effect sizes for comprehension ranged from 0.84 to 2.73. The intervention with no formal peer-mediated strategy had either a very low or negative impact on all measures.

There was a wide range of different time allocations (duration, frequency, length) for the treatment arm of the interventions.

Key insight: This study looked at a set of interventions for struggling readers aged 11–18. Those with a peer-mediated feedback component had the greatest impact. Effect sizes for improvements to comprehension ranged from 0.84 to 2.73.

4.1.4 Dreams to Reality⁸

Mostert and Glasswell (2012) reported on the Dreams to Reality programme, an intervention aimed at closing the reading achievement gap with a focus on fluency. The target students were 10- to 14-year-olds (Years 5 to 8) in Brisbane, Australia.

This was a three-year project looking at improving reading through a programme of instruction on fluency. It involved large numbers of students who were selected because their reading age was more than three years behind the expected level. In total, 3,149 students and 133 classroom teachers across 12 schools were included in a culturally diverse, low socio-economic area in Brisbane.

The authors found that reading was of little or no interest to the students. They focused on fluency instruction as this was seen as a key skill by the research team for helping students to comprehend texts. The intervention took the form of professional learning for teachers shaped around developing knowledge and skills in accuracy, speed, and prosody. The instruction focused on repeated oral reading through a number of activities including tape-assisted reading, poet's corner, reader theatre, and timed repeated reading.

Evidence was collected through pre- and post-reading assessments, and teacher and student reporting.

⁷ A detailed summary of this intervention is included in Appendix 1.

⁸ A detailed summary of this intervention is included in Appendix 1.

Student assessment results for 2011 showed that 89% of the cohort in these schools demonstrated a rate of improvement that was greater than the gain expected in a national sample. For 65% of the 2011 cohort, significant acceleration was evident. Students were found to be making between 1.5 and 4.0 times the expected rate of progress. In 10% of the cohorts, improvements were more than 4.5 times the expected rate.

The 2011 national test results (NAPLAN) supported this finding with improvements greater than the national cohort gain in 88% of project schools in reading and 77% of project schools in writing.

In the Year 7 cohort, 100% of project cohorts showed acceleration on NAPLAN reading and writing. The authors conclude that ‘this is a significant achievement for schools that have traditionally experienced a widening achievement gap in literacy and low levels of student and teacher confidence’ (p. 19).

In addition to the test result improvements, students were found to be more enthusiastic about reading, used the library more, and practised poems and plays out of class time.

Key Insights: This was an intervention designed to improve reading fluency of 10- to 14-year-olds. It concluded that 65% of the cohort were making between 1.5 and 4 times the expected progress, and 10% made 4.5 times expected progress. Although these results should be treated with some caution due to the lack of a control group in the study, the gains in outcomes were established against the results of the national cohort on the same tests.

4.1.5 Ramp-up Program⁹

Guskey *et al.* (2009) reported on a randomised controlled trial of an intervention designed to improve literacy outcomes for struggling readers in urban schools in Kentucky. The students involved were in the 10th grade (15- to 16-year-olds). The study was on an intervention, the Ramp-up Program, and aimed at improving and accelerating students’ literacy skills. Forty self-selected teachers took part from 18 schools. The program focus is on students becoming fluent readers, developing wider vocabularies and comprehending grade-level texts through a variety of instructional strategies over a two-year period. The evaluation focused on improvements to students’ scores on criterion-referenced reading assessments.

The Ramp-up Program includes independent reading, ‘read aloud/think loud/talk aloud’, whole- and small-group instruction, writing instruction, and cross-age tutoring. Teachers had access to regular training, and email and telephone support.

The findings concluded that:

- Gains by students on reading outcomes showed statistically significant differences between students in high versus low implementation classrooms and between the high implementation classroom and control group
- There was a percentage reduction in the number of students scoring at novice (lowest) level of reading over seven years, and the gap between black and white students narrowed.
- Participating teachers were ‘exceptionally satisfied’ with the professional development provided.
- There was a high level of satisfaction with the support offered (though some modifications are proposed for further interventions).
- Observation of teachers showed significant gain in quality of implementation over time.

Key Insights: This intervention aimed to improve reading fluency, vocabulary, and comprehension for 15- to 16-year-olds. The programme required sustained input from schools. Measures of reading outcomes showed

⁹ A detailed summary of this intervention is included in Appendix 1.

statistically significant differences between students in high-implementation classrooms compared to those in low-implementation classroom or a control group.

4.1.6 Learning to Read: Reading to Learn¹⁰

Rose and Acevedo (2006) report on a reading intervention designed to close the gap and accelerate learning in the middle years of schooling. They describe a whole-class approach to improve reading and writing across the curriculum. The students were aged 10 to 15 (in Years 5 to 9)—the middle years of schooling.

The programme, Learning to Read: Reading to Learn (LRRL), was implemented over three years with approximately 1,000 students. The project was run with the Catholic Education Office in Victoria, Australia, and was linked to The Victorian Quality Schools Project, a longitudinal study. The programme was set up in response to concerns about students making less progress in the middle years, the gap between top and bottom achievement increasing, and significant underachievement among boys. The transition from primary to secondary school was considered to be problematic for some students.

It is argued in the article that many schools have withdrawal programmes aimed at students at risk of poor literacy achievement, and that this focuses on deficit or remedial approaches resulting in a mismatch with the practices and pedagogies of the mainstream classroom.

The LRRL intervention is designed to improve outcomes for at-risk learners using an intensive approach to scaffolding student literacy. The approach can be used in the mainstream classroom or in withdrawal contexts and models language features in fiction and factual texts.

‘The distinctive features of this approach are that it uses high quality, challenging, age-appropriate texts, articulates strongly to mainstream curriculum and assessment practices and redesigns classroom teaching patterns to enable success for all learners’ (p. 35 of PDF).

The results show that the approach is capable of extending the learning of the most competent students in the class or group as well as those at risk. The authors argue that the intervention—

‘provides teachers with two sets of skills for accelerating learning and closing the “ability” gap in their classrooms. The first is a set of skills for interacting with students around written texts that supports all students in a class to read high level texts with critical comprehension, and to use what they have learnt from their reading to write successful texts. The second is a set of skills for selecting key texts in the curriculum to work with intensively, and to analyse the language patterns in these texts to plan their lessons’ (p. 36 of PDF).

Teachers prepare students by providing background information and knowledge about the text before it is read by students. This is followed by detailed reading, one sentence at a time, and then a third step which is preparing for writing. The fourth step is joint rewriting, in which the students write in groups, followed by step five, individual writing. The LRRL approach is designed to systematically tackle the complexity of written language by drawing on a similar approach to the text, sentence, and word approach. It adds in syllable and letter patterns.

As part of the project, all teachers in the study undertook off-site professional development, and participated in local area professional clusters and school-based professional action learning. A key element of the project was that teachers across the curriculum took part. Teachers had access to email and telephone support from Education Officers from the Catholic Education Office in Melbourne.

¹⁰ A detailed summary of this intervention is included in Appendix 1.

The paper reports significant improvement in literacy outcomes for those students targeted by the approach. Pre- and post-test scores showed that average literacy gains across all schools and classes, and among students from all backgrounds and ability ranges, was approximately double the expected rate of literacy development. Furthermore, 20% of students made gains of four times the expected rate of literacy development.

Key Insights: This reading intervention was designed to close the gap and accelerate learning for 10- to 15-year-old students. The paper reports significant improvement in literacy outcomes (double the expected rate) for those students targeted by the approach; 20% of students made gains of four times the expected rate. These results should be treated with caution due to the lack of a control group in the study.

Section Summary

Overall, the evidence demonstrates that there are a number of reading interventions that appear to have led to improvements in outcomes. Many of them have involved reasonable to high levels of research. There is a suggestion that greater success in improving English outcomes may come from an approach that includes a number of strategies including whole-language approach, linguistics and phonics, rather than relying on one approach. A number of the interventions require a sustained input over a period of time.

4.2 Reading interventions in other curriculum areas

4.2.1 Content area literacy¹¹

Lai *et al.* (2014) reported on the impact of a literacy project on reading comprehension and secondary school qualifications. The intervention took place with 13- to 16-year-olds in response to concern over progress in literacy skills among adolescents. The authors cite evidence that improvements at an earlier age (primary) are not sustained into adolescence. They suggest that this is due to the increasing complexity of texts and tasks associated with reading, and the transition from the primary classroom—where one teacher teaches all content—to the more challenging linguistic environment of subject-specific classrooms. The authors argue that the move to secondary school leads to more high-stakes exams, and therefore more transmission-type teaching.

The project involved a collaboration involving all schools with secondary-age students aged between 13 and 16 in a small rural town region. All English and mathematics teachers participated in content area literacy professional development (PD). The research involved collaboration between researchers and the schools, and iterative cycles of data collection to inform the instructional design.

The results show increases in reading comprehension in the first two years of secondary school and concurrent increase in attainment rates of national qualifications. The authors state that:

‘The evidence we have suggests that the workshops were used in schools, that there was some increase in teachers’ content literacy pedagogical content knowledge (albeit variable), and that students reported greater levels of explicit literacy teaching and vocabulary instruction. Successful implementation of the PD was also indicated by no noticeable increase in teacher turnover and no school dropout as in the early stages of school reform programs (Slavin & Madden, 2001)’.

However, they go on to state that more needs to be known about the relative importance of content area literacy professional development in improving achievement, particularly what teachers have learned and are able to transfer to their classrooms from both content area and generic literacy PD. They suggest that it would be useful to go on to investigate whether a blended model of generic and content area literacy PD is more

¹¹ A detailed summary of this intervention is included in Appendix 1.

effective than either on its own. They also suggest it would be useful to investigate the most effective sequence of introducing content and generic literacy components within a blended design.

Key Insights: The study describes a literacy intervention for 13- to 16-year-olds in which literacy skills are developed in another content area, in this case in mathematics. The results show increases in reading comprehension in the first two years of secondary school, and a concurrent increase in attainment rates of national qualifications. However, the relative importance of generic and content area literacy is not clear.

4.2.2 Content Literacy Continuum¹²

Corrin *et al.* (2012) reported on the evaluation of the Content Literacy Continuum (CLC)—an intervention designed to improve adolescent literacy across randomly selected schools in which there are significant numbers of low-income or low-achieving students. The study took place with grade 9 and 10 students (age 14–16). The quality of the evidence is high although the authors suggest that much of the reason behind the lack of impact of the intervention relates to the loss of fidelity in implementation. The CLC involved a combination of whole-school, cross-curricular approaches and structured specialist groups.

The CLC is a—

‘tiered, schoolwide intervention that aims to support core content teachers within secondary schools (that is, teachers in the content areas of English language arts, mathematics, science, and social studies) in the use of developer-specified instructional routines, and to share with students content-specific learning strategies (that is, strategies that allow them to access, understand, and retain course content)’ (p121).

In addition, the intervention sets up additional reading classes for students that are two to five years below grade level, in which students are provided with greater exposure to the specific learning strategies.

The research study was designed as an RCT across 33 schools. The intervention involved all grade 9 students in year 1 and all grade 9 and 10 students in year 2 of the two-year project. The intervention involved three levels:

- Level 1—enhanced content instruction across all core subjects by content teachers;
- Level 2—embedded strategy instruction aligned to specific demands of the content; and
- Level 3—intensive strategy instruction in supplemental classes.

Training was provided to subject content teachers for Levels 1 and 2. Specific training was provided for Level 3.

Full implementation of the intervention includes collaborative planning, CPD, and literacy leadership teams that make structural changes in schools. These measures create conditions in which instructional change can take place. This is onerous, and the key finding of the study was that there were no statistically significant differences in reading comprehension scores between CLC schools and non-CLC schools, and no statistically significant impact on students’ core credits in the second year. However, the lack of difference in achievement is not necessarily down to the CLC itself but rather its implementation. There was some evidence that the impact was compromised because of school dropout and changes of staff.

These results highlight the need for full implementation of the scheme in terms of:

- timing—three to five years rather than two;
- the structural components—these need to be fully implemented to enable teachers to engage in CPD and use the routines and instructions with students; and

¹² A detailed summary of this intervention is included in Appendix 1.

- all students needing to complete assessments.

It was also the case that non-CLC schools were not strictly implementing 'business as usual': as the development of literacy skills is a priority, all schools were intervening in some respects to help their students to improve.

Key Insights: The study describes a complex reading intervention designed to improve literacy skills of 14- to 16-year-olds across schools in which there are significant numbers of low-income or low-achieving students. The study found no statistically significant differences in reading comprehension scores between CLC schools and non-CLC schools. This finding may be due to the fidelity of implementation.

4.2.3 Review of five literacy strategies

Williams (2010) reviewed research in the USA aimed at literacy strategies that may help adolescents who struggle with reading. The review covers five studies, summarising each and offering evidence of both improvements in reading (if any) and a critique of the methodologies used.

The author offers a number of conclusions derived from the five studies:

- students require literacy interventions throughout high school;
- continued years of struggles with reading are a barrier to the continued motivation to keep reading;
- literacy interventions work best when they are taught within the core subjects;
- core content teachers do not teach literacy, but rather teach alternative modes of viewing core material; and
- subject teachers are not confident teaching literacy and need professional development to support them.

Key Insights: This is a study of five strategies to improve literacy skills. The quality of the evidence is reasonable. The conclusions support other research that finds that reading/literacy/English should be taught through other subjects, particularly as the content becomes more complex.

Section Summary

Overall, the findings, although mixed, suggest that reading interventions implemented across the curriculum may have a positive impact on reading outcomes, although professional development is crucial (for teachers in other subject areas) and sustained input is generally required. The quality of evidence in this section is 'reasonable' at best, and the studies do not clearly establish which elements are crucial.

4.3 Reading interventions in which students are withdrawn from regular classes

4.3.1 Reading Apprenticeship Academic Literacy and Xtreme Reading

Somers *et al.* (2010) reported on an RCT of a literacy intervention in the USA. The target group was ninth-grade students who are two or more grades below their expected reading level. Thirty-four schools were involved in ten districts. The schools implemented one of two reading interventions: Reading Apprenticeship Academic Literacy (RAAL) or Xtreme Reading. The intervention took place over two years with the intention of helping readers develop the strategies and routines used by proficient readers and thereby improving their overall performance.

Within each district, high schools were randomly assigned to use either the RAAL program or the Xtreme Reading program for two school years. Within each high school, students were randomly assigned to enrol in a reading programme group or to remain in a 'business as usual' group. Those involved in a reading programme were taught by English or social studies teachers in separate classes each week. The teachers were self-selecting.

The researchers found that most schools (76%) adhered fully to the programmes as observed by observers.

The reading programmes increased some readers' comprehension in the ninth grade, however 77% of students were still performing two or three years below grade level at the end of the year. Where there was improvement it did not continue once the support was taken away. The reading programmes increased performance in core subjects and added to students' credits, but again this improvement did not persist once the programmes had finished.

The reading programmes did not increase students' vocabulary scores, nor did they affect students' reading behaviours or their school behaviours.

Key Insights: This is a highly detailed study of two reading interventions used with 15-year-old students. It describes an approach to catch-up reading which involves students being withdrawn from other classes. The study did not find significantly positive impacts on outcomes. Note, however, that Boulay *et al.* (2015, see above) reported positive impacts of the Xtreme reading intervention.

4.4 Writing interventions

4.4.1 Embedded grammar teaching

Myhill *et al.* (2012) reported on an intervention of embedded grammar teaching and its impact on the writing and metalinguistic understanding of students. The study was conducted with Year 8 students in England and provides high quality evidence. While there is evidence of some attrition and lack of fidelity, this appears to have been covered in the process evaluation and the findings interpreted accordingly.

The research involves a mixed-methods approach including an RCT, text analysis, student and teacher interviews, and lesson observations. The aim of the study was to investigate whether contextualised teaching of grammar would improve student outcomes in writing and in metalinguistic understanding, and looked at the impact of teachers' previous linguistic subject knowledge (LSK) as a determining factor in learner success. The intervention comprised the provision of schemes of work to support embedded grammar where a meaningful connection could be made between grammar and writing—an example of this would be the use of grammar in persuasive texts.

The control and treatment groups worked towards the same written outcomes for each genre studied: the opening of a story, a written speech, and a portfolio of three specified types of poem. A medium-term plan was provided for all groups specifying time-frame, learning objectives, assessed outcomes, and a range of stimulus resources. The study involved 744 students from 31 schools. Classes were randomly allocated to control or intervention group after the sample had been matched for teacher LSK (this was tested prior to randomisation). There were 93 teacher interviews (three per teacher), 93 student interviews (three per focus student from each class), and 93 lesson observations.

Although analysis showed a statistically significant positive effect from the intervention, regression modelling indicated that the intervention was more likely to benefit those in the sample who were already the more able writers, and teachers' LSK was a significant mediating factor on the intervention being successful. The authors state that:

‘Further research would be necessary to establish whether using the same pedagogic strategy of embedded grammar teaching but addressing different aspects of writing more relevant to lower attaining writers’ needs would be more successful. It is also possible that able writers had higher levels of cognitive understanding of the concepts being taught, and that they were more effective in transferring the learning into their own writing’ (p. 152).

Teachers considered the most important factors of the interventions to be the explicit use of metalanguage, the discussion, and the emphasis on experimentation.

Some of the teachers had made changes to the materials to move away from the focus on grammar as they were unsure of their own understanding. This had implications for the study’s fidelity. Approximately half of the teachers expressed anxiety about how they would handle grammar explanations and student questions.

‘In terms of LSK (linguistic subject knowledge), those students in intervention classes with teachers with higher subject knowledge benefitted more than those with teachers who had lower subject knowledge. This is a less surprising finding, because of the very obvious pedagogical relationship between LSK and the nature of the intervention. The teaching materials provided some support for linguistic knowledge through the accompanying resources, but nevertheless required confident mastery of grammar, particularly in making meaningful connections for writers between a linguistic construction and a piece of writing, and in being able to cope with children’s questions’ (pp. 152–53).

Key Insights: This study describes an intervention in which there is explicit teaching of grammar with the intention of improving writing outcomes. The study involved 13-year-old students and was based on high quality evidence. Although analysis showed a statistically significant positive effect from the intervention, regression modelling indicated that the intervention was more likely to benefit those in the sample who were already the more able writers, and teachers’ LSK was a significant mediating factor.

4.5 Mathematics interventions in the mathematics classroom

4.5.1 Double-dose algebra

Cortes *et al.* (2013) reported on a study in which Chicago Public Schools (CPS) implemented a double-dose algebra policy whereby students scoring below the national median on an eighth-grade (age 13) mathematics test are subsequently assigned to two periods of ‘freshman algebra’ rather than the usual one period. This is a robust, large scale quantitative study. The paper presents the results of applying a regression model to assess student gains from the intervention.

The study uses longitudinal data that tracks students from eighth grade through to college enrolment. The sample size was more than 41,000 students (this includes the control group).

The authors focus on two primary sets of outcomes: variables measuring grades, coursework, and standardized test scores; and measures of high school graduation and college enrolment. The analysis shows positive and substantial long-term impacts of double-dose algebra on both sets of outcomes.

The intervention’s impact was highest among students with below average reading skills. The authors believe this may be because the intervention focused on verbal exposition of mathematical concepts. They postulate that this highlights the importance of targeting interventions towards appropriately-skilled students.

The study notes that ‘long-run impacts [on high school graduation and college enrolment] of double-dose algebra were substantially stronger for students near the threshold than those far from it’—in other words, students who were originally quite close to the national median score were more likely to gain sufficient benefit to enable them to graduate from high school and/or enrol in college than those who originally scored well below the national median. This is as you might expect, but does, as the authors say, ‘highlight the

importance of carefully targeting such interventions to students most likely to benefit from them'. They conclude that 'intensive math instruction was quite successful for students with average math skills but relatively low reading skills, and modestly successful in the long run for the average treated student' (p. 22). They go on to add that 'Also, like other recent studies, we find that the test score impacts of this policy dramatically understate its long-run benefits as measured by educational attainment' (p. 22).

Key Insight: This study reports on an intervention in which 13-year-old students are given twice as much algebra teaching than standard to improve their learning outcomes in this area. The evidence from the study was high quality and found positive and substantial impacts. Those students close to the passing threshold were most likely to benefit, that is their gains were more likely to help them over the threshold than those students who were further below it.

4.5.2 Realistic Mathematics Education¹³

Searle and Barmby (2012) reported on an evaluation of the Realistic Mathematics Education (RME) intervention. RME is an intervention in which students learn mathematics through engaging in solving problems in contexts that are meaningful to them. It originated from the Freudenthal Institute in the Netherlands in the 1970s and was subsequently taken up in the 1990s in the USA within a project called Mathematics in Context (MiC). Since that time, researchers from Manchester Metropolitan University (MMU) have used the materials in a number of projects in local schools. Projects have been at Key Stage 3 and Key Stage 4.

The aim of the intervention is to provide contexts and related activities that interest the students and so engage them in the mathematics learning. Students experience a range of activities, including practical work and discussion. Discussion takes place in pairs, in a group, or whole class and is an essential part of the RME approach.

The authors suggest that the RME approach is different to the approaches traditionally used in mathematics lessons in England in a number of respects, including:

- the use of realistic situations as a means of developing students' mathematics understanding, as opposed to using contexts as an introduction to mathematics or as an application of mathematics;
- less emphasis on algorithms and more on making sense of informal procedures;
- an emphasis on refining and systemising understanding; and
- less emphasis on linking single lessons to direct content acquisition and more on gradual development over a long period of time.

Qualitative and quantitative research into the existing data was conducted as part of an evaluation by Durham University. As part of the quantitative analysis, assessment data from Year 7 students from the 2004–2006 MiC project were reanalysed using Rasch modelling. This compared achievement and understanding of students who had experienced RME with a matched group of students who had not.

Quantitative results indicated that those students who had experienced RME were more likely to solve mathematical problems correctly, and also showed better understanding through their ability to explain their strategy.

Qualitative findings show positive support from teachers who argue that the students will have developed problem-solving skills and the ability to think around a problem, and will find it quite natural to get started on a new problem. There was some concern, though, about adequate preparation for the more abstract questions, with some saying they revert to traditional methods to prepare students to answer such questions. It was felt

¹³ A detailed summary of this intervention is included in Appendix 1.

that the impact was greatest on the foundation students, although higher-level students would still benefit by being able to apply the models they had acquired through RME.

Key Insights: This reports on a study of an intervention in which students learn mathematics through engaging in solving problems in contexts that are meaningful to them. The intervention has been used with students aged 11 to 16. This is high quality evidence and reports an effect size of 1.05 when comparing the intervention and the control group outcomes on problem-based test items. The authors note that some teachers report having to compromise their methods in Key Stage 4 to enhance their students' chances of success at GCSE. Note that the problem-based test items used in the study may not accurately reflect GCSE questions.

4.5.3 Classroom discussion¹⁴

Swan (2006) reported on a study to improve mathematics attainment through classroom discussion. The target group was post-16 GCSE resit students. The research is based on learning from a previous pilot study that involved four teachers over two years. This paper reports on findings from work with teachers and students from 44 FE colleges.

A teaching resource was developed to support the teaching of mathematics through discussion and reflection. Its focus was on algebra at GCSE. The resources included classroom materials, teaching guidelines, video clips of resources being used in classroom settings, questions for teacher reflection, and discussion. The resources were supplied on CD-ROM with an accompanying video. It included support for ten lessons (approximately 17–20 hours of class time). One participant from each college was invited to attend three workshops—a two-day introductory residential with two follow-up one-day workshops.

The author states that the—

'resources encourage and support the implementation of collaborative, discussion-based approaches to learning algebra. As these are used by teachers, even for the first time, there is evidence here to suggest that learning is enhanced, particularly when they are used in student-centred ways. In particular, this means that students' existing knowledge and misunderstandings are brought to the surface and discussed in the lessons' (p. 240).

Algebra was chosen because it is considered the language of generalization and describes 'underlying structures of mathematics' (p. 231).

The final sample of students was 334 from original sample of 834. This shows that there was a high level of attrition (the final reduced sample was from a range of colleges considered representative of the general student population retaking GCSEs). In total 312 students aged 16–21 took the algebra pre-intervention test, responded to a post-course questionnaire, and attended at least 60% of their mathematics classes.

The lessons take place in supportive social contexts and consist of rich and challenging tasks. Students are encouraged to learn from mistakes; emphasis is put on methods and reasons, not just answers; students make links between topics; the purpose of each lesson is made clear; and there is appropriate use of technology.

Results from algebra pre- and post-course tests show that the greater the number of discussion sessions used, and the more student-centred the teaching style, the greater the gains in algebra learning. Classes that had not used any discussion activities showed an overall decline in students' confidence and motivation and an increase in anxiety about algebra.

Key Insights: This is a study of a mathematics intervention that supports the teaching of algebra to post-16 GCSE resit students through classroom discussion. Results from algebra pre- and post-course tests show that

¹⁴ A detailed summary of this intervention is included in Appendix 1.

the greater the number of discussion sessions used, and the more student-centred the teaching style, the greater the gains in algebra learning. However, there were high levels of attrition in the study.

Section Summary

Overall, the three interventions included in this section show positive impacts on outcomes and are based on reasonable to high quality evidence. The findings suggest that targeted increases in time allocated to study can have a positive impact for borderline students, and that using realistic contexts and classroom discussion can lead to improvements in outcomes.

4.6 Mathematics support interventions

4.6.1 Mathematics counsellor programme

Jankvist and Niss (2015) present a framework for designing and implementing a ‘maths counsellor’ programme for experienced in-service upper-secondary-level mathematics teachers. The course is designed for upper-secondary mathematics teachers with master’s degrees in mathematics and related subjects. The aim of the course is to turn teachers into practising ‘maths counsellors’—practising mathematics teachers who have been trained to assist students and teacher colleagues to counteract genuine learning problems in mathematics. The target group of students are those who unsuccessfully try hard to learn mathematics and who are interested in getting help to overcome their difficulties.

The work uses the Danish KOM framework of mathematical competencies to identify and analyse students’ learning difficulties in mathematics. The KOM framework identifies the following eight competencies: mathematical thinking, problem handling competency, modelling, reasoning, representation, symbols and formalism, and communication. It also identifies the following six pedagogical competences for teachers: curriculum, teaching, revealing learning, assessment, cooperation, and professional development.

The programme was piloted in 2012 and has trained approximately 24 in-service teachers every year since. It is a substantial programme, running over three semesters and comprising upwards of 400 hours.

The aim is to effectively assist the kinds of upper-secondary students who try hard to learn mathematics but for whom nothing seems to really work. The approach taken was to design an in-service supplementary teacher education programme so as to educate a ‘task force’ of maths counsellors whose job is to assist such students and their teachers.

The paper concludes that it is ‘much too early to provide a comprehensive, in-depth answer’ to whether or not the intervention has been effective. Instead, the authors offer a number of observations, including:

- participants had to ‘unlearn’ being teachers and take on the role of a maths counsellor;
- participants often pointed to the side effects the course had had on their own teaching, and the authors commented that ‘Changing role to not being a teacher and letting the students explain themselves has provided surprising insights’ (p. 280); and
- in general, all participants had positive experiences to report from each semester about students who were perceived to have gained from received counselling.

The quality of the evidence is considered to be medium-high, providing credible qualitative evidence.

Key Insights: This study reports on an intervention designed to train experienced maths teachers as ‘maths counsellors’. It is particularly aimed at students with problems with mathematics learning. It is aimed at upper-secondary mathematics students and is based on reasonable quality evidence. No concrete findings are available as yet, however, there are some initial positive outcomes.

4.6.2 Teaching Fellows Program

A 2014 What Works Clearing House report provided evidence about the impact of the Teach for America and the Teaching Fellows Program on secondary mathematics attainment. These are both teacher training interventions in which the intervention group is classroom teachers. The Teaching Fellows Program recruits new college graduates and professionals changing career. The programme is very selective—only 13% of applicants are accepted for the programme. The application process includes a written application, an analysis and writing activity, an interview, a group discussion, and a five-minute sample lesson. The programme involves 25 hours of independent study, attendance at a summer institute (68 hours of instruction and 64 hours of fieldwork), and participation in a local certification programme. The comparison group was made up of teachers certified on a programme other than the Teaching Fellows Program.

In each participating school, researchers matched two or more mathematics classrooms so that at least one classroom would be taught by a Teaching Fellows teacher, and at least one classroom would be taught by a teacher who had not followed a programme such as Teaching Fellows or Teach for America. Students in grades 6–12 were randomly assigned to these classrooms, typically at the beginning of the school year.

The study was conducted in 44 schools located in eight states, with 118 classroom matches covering 69 intervention and 84 comparison teachers; 3,659 students were randomly assigned to a Teaching Fellows teacher, and 3,629 students were randomly assigned to a comparison teacher. The analytic sample included 2,127 students in the intervention group and 1,989 students in the comparison group.

The study found that Teaching Fellows teachers did not differ in effectiveness from comparison teachers on improving student mathematics achievement scores.

Key Insights: This study reports on the evidence of the impact of a teacher selection and training programme on secondary mathematics outcomes. It is based on robust evidence. The study found that this approach to recruiting and training teachers did not have a significant impact on mathematics outcomes.

4.6.3 California Mathematics Diagnostic Testing Project¹⁵

Betts *et al.* (2011) reported on a large-scale, high-quality study on the effectiveness of the California Mathematics Diagnostic Testing Project (MDTP) on students' mathematics achievement.

The MDTP consists of a set of 'readiness' tests designed to give students and teachers detailed feedback on a student's readiness to move on to a given course in the next academic year. For example, the Geometry Readiness Test evaluates a student's understanding of first-year algebra topics required to do well in a subsequent geometry course. Each test lasts 45 minutes and contains, depending on the subject matter, 40 to 50 multiple-choice questions.

This was a large-scale study using data from 2001–2007 (by 2006/2007 the MDTP was processing about 690,000 tests for more than 1,700 schools). Individual students' trends in maths achievement were modelled, and researchers looked for an improvement in the years after the student took an MDTP test. As MDTP tests were phased in differently across the state, researchers were able to compare years with and without mandated MDTP testing.

The study found that district-mandated diagnostic mathematics testing produced positive gains, enough to move a student originally at the 50th percentile to somewhere between the 54th and the 57th percentile in the subsequent year. Researchers used two statistical models to estimate gains, and obtained very similar results with each.

¹⁵ A detailed summary of this intervention is included in Appendix 1.

These results have to be interpreted with care as the nature of this test is to help stream learners for the subsequent year's learning—the authors found evidence that MDTP testing lowered variation in prior achievement within mathematics classrooms in the following year. However, this is only found to account for about 11% of the positive effect of MDTP. The remaining (majority) of the effect is not specifically evidenced, but the authors speculate that the MDTP provides teachers with the knowledge they need to identify and address specific student weaknesses in mathematics. It should be noted that the gains were only seen where MDTP testing was mandated, and therefore adopted across the whole school. The authors found that isolated MDTP testing may not be as helpful as repeated testing:

'In contrast to district-mandated testing, the voluntary use of MDTP tests by teachers had no detectable relation with students' gains in math achievement during the year. This contrary finding suggests that having a school systematically use the MDTP test rather than having individual teachers use the test piecemeal could be critical.'

The MDTP, as used in this study, is administered as a paper-based test, but it is a multiple choice test and so could easily be delivered on-screen.

Key Insights: This study describes the use of a diagnostic mathematics test to provide detailed feedback on a student's readiness to move on to a given course in the next academic year. It presents high-quality evidence from large numbers of 11- to 14-year-olds. The authors found that high quality formative/diagnostic testing, if used systematically, can support learner gains, primarily by providing teachers with the knowledge they need to identify and address specific student weaknesses in mathematics. However, simply providing diagnostic tests as a resource available to teachers does not appear to provide the same gains.

Section Summary

The two interventions in this section describing teacher professional development interventions were inconclusive: one was based on robust evidence and found no impact on outcomes, one was based on lower-quality evidence and showed some initial positive impact. The study into diagnostic mathematics testing was based on robust evidence and found a positive impact on mathematics outcomes.

4.7 Mathematics embedded within vocational programmes of study

4.7.1 Mathematics within construction and hairdressing

Dalby and Noyes (2015) report findings from a nested case study of student groups learning functional mathematics in two vocational areas—construction and hairdressing—in three large FE colleges in England. The evidence is reasonable quality, from a credible qualitative study. Seventeen student groups were recruited from the construction, hair and beauty, and public services areas. Each student group, together with their functional mathematics teacher, formed a case study nested within the college.

The paper describes organisational approaches to teaching functional mathematics that are centralised or dispersed—the latter where functional mathematics teachers are situated within vocational departments. The authors argue that these approaches to organising teaching tend to either isolate mathematics from the vocational experience, or help to integrate it. The paper provides qualitative evidence that integrated approaches impact positively on student engagement and attitudes to learning mathematics.

The paper provides qualitative evidence from the case studies to support the view that a more integrated learning experience—both in terms of colleges' organisational policies and through teachers' approaches to curriculum and pedagogy—has a positive impact on students' engagement and attitudes to mathematics. The authors comment that—

'many of the students in this study were disaffected by their experience of mathematics in school... There were, however, some significant shifts towards more positive attitudes in college [and] many students considered functional mathematics lessons in college to be less stressful, less difficult, less confusing and more interesting than GCSE mathematics in school. These students reported having more positive relationships with their teachers, better subject understanding and increased confidence' (p. 11).

Key Insights: The paper describes organisational approaches to teaching functional mathematics that are centralised or situated within vocational departments. It is focused on students in FE Colleges. The authors provide qualitative evidence from cases studies to suggest that integrated, contextualised functional mathematics is more accessible and engaging to vocational students who struggled with GCSE than a more traditional academic approach.

4.7.2 Online development of proportional reasoning¹⁶

Bakker *et al.* (2012) report on a reasonably high quality study into the use of an online tool to develop proportional reasoning skills. The quantitative evidence is limited due to the absence of a control group, otherwise the evidence presented is credible and rigorously reported.

The authors 'designed a computer tool with which students in laboratory schools at senior secondary vocational school level [in the Netherlands] could develop a better proficiency in the proportional reasoning involved in dilution of chemical solutions'. The tool was designed in collaboration with two teachers from different vocational schools. All participants were first-year students (aged 16–23), from three different schools, all studying to become lab technicians, and of mixed academic abilities. Pre- and post-tests of various computations involving dilution of solutions were used to assess the gains of students in proportional reasoning after 50–90 minutes instruction using the tool.

The study reports significant gains for learners after 50–90 minutes instruction time. However:

- the sample size was small (47 learners);
- there was no control group; and
- teachers from two of the three schools had contributed to the design, and might therefore be more likely to engage fully with the tool than a typical teacher.

There is therefore only limited credible quantitative evidence for the claims around gains. However, the report does provide qualitative evidence that the tool has been developed according to good practice (for example, it provides a layered progression from simple to more complex tasks and ideas). The design of the tool took into account the principle that 'learning tasks are more successful if the complexity of the underlying mathematics is layered' (Hoyles et al, 2010), and is well received by the students and teachers. In conjunction with the (limited) quantitative evidence, the paper does support the view that instruction based around the tool is effective.

Key Insights: The article reports on limited evidence from a study into the use of an online tool to develop proportional reasoning skills. The tool is used with senior secondary students in vocational schools in the Netherlands. In essence, the 'computer tool' is a high quality targeted eLearning resource, and so this paper provides some evidence that high quality, contextual eLearning can lead to gains in vocational mathematics.

¹⁶ A detailed summary of this intervention is included in Appendix 1.

4.7.3 Numeracy support within apprenticeships

Leung and O'Donnell (2006) publish two papers within one publication. The papers describe the work of the Learning Support Unit at Tropical North Queensland Institute of TAFE (Technical and Further Education). The two papers were published concurrently and describe different aspects of an intervention to support apprentices with their numeracy skills. The evidence produced is of reasonable quality (it is fairly small-scale project). Eighty-six apprentices were initially tested to see if they needed skills support; 78 of these were enrolled in the support module studied as part of this intervention.

The Learning Support Unit is an intervention technique seeking to change a viewed outcome. The Unit has developed a process to identify the literacy and numeracy skills of incoming apprentices and trainees. A range of pre-course literacy and numeracy indicators have been developed targeting concepts for specific training packages.

Personal interventions could include a combination of strategies:

- self-paced remedial materials;
- alternative assessments;
- in-class support;
- out-of-class support; and/or
- referral to diagnostic specialists.

The authors accept that they have not, as yet, definitively answered the question: 'Does this intervention make a difference?'. They find that many students have improved their off-the-job competencies but they need to follow up to see if this translates to better on-the-job competencies.

The authors found that, as the work of the Unit was being studied, the role of relationships was exposed as being of critical importance. This was an unexpected outcome leading the researchers to recognise the significant role played by personal relationships within the social, cultural, and personal lives of apprentices who were struggling to complete their apprenticeships. They claim that:

'The notion of providing an environment for the student to reframe themselves, from failure to competent, the building of a new identity with agency in numerical tasks is the challenge of the vocational trainers and learning support teams. In this instance, the model was expanded to an ecosystem incorporating and revealing the interrelatedness of the apprentice, the workplace, vocational training and learning support professional.'

In light of this finding a multi-disciplinary approach evolved, sustaining the view that a support plan that has, as its focus, an individual, is not sufficient in itself: a broader view of change has to be considered when aiming to raise attainment levels of a struggling apprentice. They also found that early intervention is important and this is better if diagnosis of learning is done at the start of the training.

Key Insights: The authors report on an intervention to support apprentices with their numeracy skills. It is a small study with qualitative findings. There is some evidence to suggest that supporting apprentices requires a broad approach—considering a range of social and cultural factors, and the wider relationships involved. Early diagnosis and early intervention was found to be crucial.

Section Summary

Overall, there is limited evidence in this section with only three papers each with relatively small-scale and/or qualitative evidence. Each case found some positive evidence suggesting that approaches to embed mathematics in vocational contexts is beneficial, either through making it more engaging, more relevant, or because it can allow personal relationships to develop.

4.8 Mathematics interventions outside of the classroom

4.8.1 Mathematics Tutoring¹⁷

Chappell *et al.* (2015) explored how outcomes of tutored middle school students in two U.S. schools compare to those of students exposed only to their schools' 'business as usual' mathematics instruction. The study adopted a mixed-method approach, using quantitative methods to address the tutoring's impact on mathematics scores, and qualitative methods to examine tutor and student perceptions. A quasi-experimental pre-test/post-test design was used to analyse within-group changes in achievement scores for students in each school, with separate analyses conducted for each school.

Forty-nine 11-year-old students from school one and seventy 12- and 13-year-old students from school two received tutoring during the 2013/2014 academic year. All student participants, both treatment and comparison, earned below passing scores on either the state standardised mathematics assessment for the 2012/2013 academic year, or failed the programme-specific pre-test assessment at the beginning of the 2013/2014 academic year. Tutored students were matched with non-tutored students and between-group differences were examined.

Within-group differences from pre-intervention to post-intervention for school one showed significant improvement in scores for the group: within-group effect size estimates for school one were $d = +0.95$ for tutored students. The within-group effect size estimate for tutored students in school two was $d = +1.47$.

In post-session commentary on the tutoring sessions by students, positive comments out-numbered negative comments by a ratio of three to one.

In summary, the authors claim that their study 'supports the extant literature on online math tutoring and provide[s] further evidence that the strategy can be successful in improving math achievement of underperforming middle school students when compared to their non-tutored peers'. However, they also note that 'these results were observed in a context where the schools were implementing a well-resourced and proven instructional model', and that 'the generalizability of the results is limited in that both samples included very low-performing students from rural populations, and both schools were already engaged in a substantial school-wide math instruction improvement initiative'.

The authors suggest that—

'Successful tutoring programs share some common characteristics including well-trained, focused tutors providing services, one-to-one tutoring experiences, a structured but flexible prescribed instructional plan, continual assessment to inform instructional efforts, and consistency in receiving tutoring services' (p. 6).

Key Insights: The study reports the outcomes of tutored middle school students in two U.S. schools compared to students following 'business as usual' mathematics instruction in the same school. This is a relatively small-scale study with limitations which are admitted by the authors. It is focused on students aged 11 to 13. The study's conclusion that online tutoring can be successful seems credible on the basis of the evidence provided.

4.8.2 Non-professional mathematics tutoring¹⁸

Karsenty (2010) reported on a single-school case study over two years. A total of 53 students took part from an urban secondary school in Israel. The intervention adopted a non-professional approach to tutoring students

¹⁷ A detailed summary of this intervention is included in Appendix 1.

¹⁸ A detailed summary of this intervention is included in Appendix 1.

with previous low grades for mathematics in school assessments. The tutors were 18- to 20-year-old high school graduate volunteers from across the country. A total of nine tutors took part, the majority were indifferent about mathematics, two were semi-positive. Students with discipline problems were included (as long as it had not involved physical violence).

The tutors had initial training that included revision of mathematics content, support to link mathematical concepts and representations, discussion concerning the difficulties students might have, and teaching approaches. Approaches were based on materials for lower set students to encourage informal reasoning to evaluate and make sense of everyday experience. Tutors were given a 'toolkit' of strategies and models to support gaps in prior knowledge.

The target of the tutoring was on new goals. The students were unfamiliar with the material to be learned, and on more advanced content. A student pre- and post-test was used.

The results showed a considerable mean gain in students' grades: overall 47 students performed better after tutoring, one student did not show any gain, and five students showed a decline. In several cases there was a notable change: six students who had received a fail grade previously (40 or under) attained a grade of 100 (or slightly less) at the end of the tutoring period. Of these six, five had had discipline issues and spent time outside the classroom. The other had an emotional problem. Those not improving had either high levels of absenteeism or test anxiety, and one had a learning difficulty.

The tutors' perception of factors most important to the success of the programme were: volunteers' ability to maintain warm and supportive relationship with students, professional instruction for the volunteers on mathematical content and pedagogy, selecting students with no learning disabilities, and the willingness of volunteers to embrace learning mathematical material.

Key features of the programme were the age and previous experience of mathematics of volunteer tutors, the use of small-group/personalised learning, and the teaching of new, more challenging topics. The authors argued that the improvements were based on the relationship between the tutor and the learner:

'[T]he same data suggest that tutors were able to identify with students on the grounds of the shared obligation to pass mathematical tests as part of schooling. Indeed, in conversations with tutors, most of them reported that they often encouraged students using arguments such as "mathematics was not my favorite subject either, but I nevertheless succeeded and so can you".'

Key Insights: The article reports on a single-school study of the use of non-professional mathematics tutors with students aged from 8 to 13. Forty-seven of 53 students performed better on tests after tutoring. Although this is a single case study it raises some interesting points regarding strategies that work with low-attaining students. Of particular interest is the role of relationships, in this case young people as tutors, and the teaching of challenging materials rather than remedial approaches.

Section Summary

Both the articles in this section focus on tutoring in mathematics learning and find positive findings. Although both studies are small-scale and do not provide robust evidence, there is some evidence that tutoring can have a positive impact on mathematics outcomes. However, both papers suggest that high-quality training for the tutors is essential.

4.9 Generic features of mathematics learning that lead to improved outcomes

4.9.1 International review of mathematics teaching approaches

The Education & Training Foundation (ETF) (2014) reported the outcome of a major review of approaches to teaching mathematics to learners aged 16 to 19 worldwide. This is a significant report in the precise area of interest for the EEF. The research was carried out in four phases:

- a UK literature review (focusing on innovative methods of teaching, measures that enhance learner motivation, and the experience of employers in supporting the teaching of mathematics);
- an international review focusing on countries that have performed well on international indices (countries used as case studies were China (Shanghai), Singapore, South Korea, Japan, Switzerland, the Netherlands, Estonia, Germany, Canada, Australia, Ireland and New Zealand);
- a call for evidence from mathematics specialist organisations, further education (FE) providers and individual consultants; and
- qualitative interviews with UK employers, providers, and mathematics specialist organisations to understand current challenges and best practices in post-16 vocational mathematics education.

The report acknowledged both that the majority of material available for the UK review was qualitative and small-scale, and that there was a ‘paucity’ of information available for the international review. Nevertheless, it concluded that there are pedagogical models and approaches that could be adapted to, and useful for, the UK context. These include:

- the Australian Reality, Abstraction, Mathematics and Reflection (RAMR) Model, which centres on problem-solving and creativity, linking students’ current knowledge to their social and cultural backgrounds, and the use of symbols;
- the Canadian approach of Discovery Math that encourages learners to apply problem-solving skills to mathematical problems; and
- the Realistic Mathematics Education (RME) initiative in the Netherlands which emphasises the use of real-world examples, contextualisation, and activity-based learning (summarised above).

The report also concluded that:

- Many studies have demonstrated the effectiveness of using technology to support learner progression—including support in vocational settings—and that where the possibility does exist to use online learning platforms, mathematics programmes can be tailored to each individual sector and, additionally, be personalised for individual learners.
- There is a need for accurate and informal assessment early in any course. Relying on previous formal assessments may give an incomplete picture of actual skills levels.
- Embedding mathematics into vocational and real-life contexts has been found to be highly valuable. Contexts should be aligned to the broader curriculum.
- Supporting learners to build their self-esteem is critical to improving outcomes. Learners with higher self-esteem are more likely to achieve well at school and college. Mentoring, one-to-one support, providing clear progression routes and ensuring that provision is directly tailored to the learner’s current level are highlighted as ways to build learner confidence.
- Learners’ motivations can also be influenced by the extent to which they find mathematics curricula to be relevant.

While self-paced training materials may work well in helping disengaged learners to build a positive relationship with vocational mathematics, they may not be appropriate for learners with low levels of literacy and numeracy.

Key Insights: This is an important review of approaches to teaching mathematics to learners aged 16 to 19 worldwide. It is based on high quality evidence. The authors list three specific interventions which may have a positive impact: the Reality, Abstraction, Mathematics and Reflection (RAMR) Model; Discovery Math; and Realistic Mathematics Education (RME, also included in this review). They also provide some conclusions about features that successful interventions may share including: (a) technology may be successful in supporting progression, (b) accurate and early assessment is useful, (c) embedding mathematics into vocational and real-life contexts is useful, (d) building self-esteem is important, and (e) motivation can be affected by the relevance of the curricula.

4.9.2 Mathematics readiness for college in the USA

Hodara (2013) presented a review of the extent and the quality of evidence on reforms intended to improve the ‘mathematics readiness’ of students entering college in the USA. The review focused on studies relating to changes in mathematics or college success, including early assessment programs in mathematics, mathematics catch-up programmes, and reforms of mathematics delivery or pedagogy. The report summarised the findings as follows:

- The evidence on catch up programmes suggests that short-term programmes may only have short-term effects.
- Research on compression (intended to accelerate student progress through remedial courses by changing the traditional sequence structure and/or curriculum, and offering only the content students need to succeed in college math) is limited but positive. It suggests that this reform is promising (in the context of supporting progression into U.S. college mathematics).
- Effects for learning communities (where students enrol in two or more courses in the same semester together in order to create a supportive network of peers and shared learning experiences) vary depending on their implementation.
- In terms of pedagogical innovations, the strongest evidence is in favour of structured forms of student collaboration and of building conceptual understanding through the use of multiple representations when teaching and solving problems.
- The evidence on computer-mediated instruction in the developmental maths classroom is very mixed, with some studies finding positive effects and others finding negative effects.

The quality of the evidence provided is medium high. This is a qualitative and, where possible, quantitative (calculating effect sizes) review of the available literature on a specific area of mathematics instruction in the U.S. system.

Key Insights: This is a review of the extent and the quality of evidence on reforms intended to improve the ‘mathematics readiness’ of students entering college in the USA. The students are pre-college age (approximately 17 years old). The quality of the evidence provided is medium high. The authors find that the evidence is limited.

4.9.3 Ofsted: tackling low numeracy skills

Ofsted, in ‘Tackling the challenge of low numeracy skills in young people and adults’ (2011), evaluated the quality of numeracy provision for young people and adults observed during visits in 2010. Inspectors visited 20 FE colleges, 14 independent training providers, 16 local adult and community learning providers, six prisons and three Probation Trusts. The survey examined quality of numeracy provision for post-16-year-olds in

programmes up to and including level 2. Some of the provision was integrated in vocational programmes, and some in discrete numeracy provision. Numeracy qualifications being worked towards were very varied and included:

- Key Skills Application of Number;
- Functional Skills in Mathematics;
- Foundation Learning Programmes;
- Certificate in Adult Numeracy;
- Skills for Life; and
- GCSE.

Locations were very varied and included classrooms, vocational workshops, village halls, health centres, and learners' place of work. The methodology is not stated, but it appears to be lesson observations and conversations with students and with centre staff.

The review stated that only 16 of the 35 providers that offered full-time provision had good arrangements for initial assessment. They went on to state that common features of effective numeracy teaching and learning included:

- developing learners' ability to tackle numeracy-related problems by setting them in purposeful contexts;
- showing learners how to build on their previous knowledge and skills to develop their understanding;
- providing opportunities for learners to work out the most appropriate approaches to problems individually and with other learners;
- encouraging learners to tackle their misconceptions by analysing incorrect answers;
- developing learners' conceptual understanding of numeracy through activities which helped them reach the stage where they could explain why a specific method worked; and
- enabling learners to apply mathematical techniques in their training, at work, or in their personal lives.

In contrast, the report suggests that:

'[T]he weaker sessions lacked variety, learning was segmented into the acquisition of disparate mathematical skills, and often involved working through repetitive exercises. Learners were typically preoccupied with memorising seemingly arbitrary rules and replicating steps in a method, often without understanding them. They were not encouraged sufficiently to make connections between what they had learnt and to draw on their existing knowledge and understanding in solving realistic problems.'

Key Insights: This study synthesised findings from Ofsted inspections in 2010 which evaluated the quality of numeracy provision for young people and adults. The findings are based on 49 visits and solely qualitative evidence. The authors concluded that the—

'most successful sessions observed during the survey were those for learners on vocational programmes which were set in their vocational contexts, either at the learners' workplaces or in vocational workshops in colleges or prisons. Typically planned and/or taught by vocational and specialist numeracy tutors together, learning involved work on discrete number-related skills and concepts in activities that were linked closely to practical activities at work or in training workshops' (p. 22).

4.9.4 Motivation in Key Stage 4 mathematics

Kyriacou and Goulding (2006) conducted a systematic review of strategies to raise students' motivational effort in Key Stage 4 (KS4) mathematics. Reviewers included academics, teachers, and parents. The report presents a

review of 25 studies from England (22) and Wales (3). Of these, the majority (16) gained a 'low' for weight of evidence.

The focus of the review was on classroom-based teaching and learning strategies for KS4 and the impact on motivational effort (rather than on outcomes). Four key types of strategy were identified from the literature: grouping, student identity, teaching for engagement, and innovative methods.

The authors concluded that there is a need for teachers to have ongoing support.

The authors were looking for evidence of 'what works', as well as why that might be the case: 'What is needed,' they write, '... is not just evidence of whether a strategy works or not, but much more detail about what features of how a strategy is used contribute to its effectiveness or otherwise' (p. 3).

The findings included the following:

- Grouping

There was no collective evidence from the studies reviewed that allocation to sets by prior attainment had a particularly positive impact on motivational effort, although there was some evidence that being in the bottom set demotivated students (Boaler *et al.*, 2000; Hallam and Deathe, 2002). This was attributed to students realising they could not achieve the higher grades (note that this was before the removal of the lowest tier in mathematics GCSE in which grade D was the highest possible grade). Teaching often differed depending on set, with students in the lower sets experiencing many more repetitive tasks whereas in the higher sets teaching was more likely to be challenging and taught at a faster pace. Setting at the correct level was an important factor identified for motivation.

- Student identity (the extent to which students, regardless of level of ability or setting, see themselves as 'mathematicians' and feel comfortable in their classroom setting)

The focus on increasing motivation is to get students to understand the mathematics. Students need to be challenged by the mathematics they are doing, rather than overprotected from making mistakes. The three studies of this type suggested that a caring attitude towards how students felt about themselves, together with teaching and learning that emphasised supporting students to understand the mathematics they are doing, had a positive impact on student motivational effort.

- Teaching for engagement

'Teaching for engagement' also emphasised, as in the previous section, the need to foster positive attitudes in students, both about themselves and the subject area. Small group work was identified as helpful in this respect, not only to increase engagement with the subject through discussion, but also helping develop student self-esteem. Rather than a direct focus on 'student identity', with its emphasis on subject understanding, this approach was more concerned with caring, support, and enjoyment. The idea of a 'high energy classroom', featured in the wider literature, was seen in these studies as a way of fostering motivational effort. In addition, these studies reflected the notion of 'personalized learning'—personalization of feedback, target-setting, rewards, teaching and course design, mentoring, and participation in school organization (based on facets of personalised learning developed by Rudduck *et al.*).

- Innovative methods

This section was subdivided into use of ICT and other methods. A range of uses of ICT was included in the study, for example, interactive white boards, videoconferencing, and software packages. A distinction was made by the authors between the motivational effect of ICT as novelty and the motivating effect of ICT in a way that enhances deeper understanding of mathematics. For ICT and other motivational methods to be effective, teachers need to have a good understanding of the theoretical basis concerning why and how the innovation can be effective, as well as the skills to implement it. The effectiveness of innovative teaching is sensitive to how it is implemented.

Key Insights: This is a high quality review of existing evidence into interventions that aim to improve motivation in mathematics learning for students aged 14 to 16. The authors rate the articles they include as mixed in quality. The authors found (a) no evidence to support grouping in mathematics, (b) that approaches that developed student identity as mathematicians had a positive benefit, (c) that approaches to increase student motivation were valuable, and (d) that innovative teaching methods can be positive if they are implemented sensitively.

Section Summary

The evidence reviewed in this section is of mixed quality. The ETF, the U.S. review, and the EPPI review all adopt a robust approach and conclude that the evidence that they find is limited. The Ofsted review is based on a more qualitative approach. However, there are three interventions highlighted in the ETF report that might warrant further investigation (including RME, which we have already covered in this review). Generally, there is some consistency in the conclusions drawn in this section. Key features appear to be: use of technology, diagnostic assessment at the start of the programme, use of real life contexts, teaching by vocational and mathematics specialist tutors, building self-identity, and approaches to improve motivation.

4.10 English and mathematics interventions

4.10.1 English and mathematics tutoring

Buchanan *et al.* (2015) reported on the evaluation of the Tutor Trust intervention. The study focused on impacts on Year 11 (age 15–16) outcomes based on a three-year intervention from Year 9 to Year 11. This evaluation reported reasonable quality evidence, although it was given a low security rating by the EEF due to the lack of a high quality comparison group. Students also received different ‘doses’ of the intervention. It is hard to tell, if not controlled for, whether it is the tuition itself or the opportunity to discuss mathematics in small groups that is the main contributing factor to any improvement.

The intervention was made up of small-group and individual tutoring using an approach developed as a result of earlier synthesis of evidence from the Sutton Trust (EEF toolkit) about the value of one-to-one tutoring on student attainment. Tutor Trust is a Manchester-based charity that aims to provide affordable small-group and one-to-one tuition focusing on disadvantaged students in schools in challenging communities. The tutors are university students or recent graduates and tuition is offered at a competitive rate.

The evaluation was carried out over a three-year period and measured the impact of the Tutor Trust tuition on the English and mathematics GCSE results of 1,029 Year 11 students. The evaluation used a quasi-experimental design—matching participating schools with other schools from local authorities that shared characteristics. The students did not receive a uniform number of hours of tuition—the amount of support varied, with some students receiving tuition in multiple academic years between Year 9 and Year 11.

The evaluation explored schools’ perceptions of the need for affordable tuition and their assessment of the quality of the service provided. Qualitative fieldwork took place in eight schools and was based on interviews carried out with senior leaders, classroom teachers, tutors, and students.

Tutors received a minimum of two-and-a-half days of structured and unpaid training before starting tutoring. Tutors were introduced to a seven-point tuition plan to structure tuition sessions (introduction, remember, model, try, apply, secure, reflect) during their training, but were encouraged to change as necessary to meet the needs of individual students.

Teachers, tutors and students were generally positive about the programme although it was felt that there may have been other contributing factors to students’ success. Interviewees felt that the quality of the tutor was the most likely contributing factor to the success of the intervention:

'In most cases, the school staff we spoke to reported that the quality of tutors was generally high and that the quality of tutors greatly influenced the impact of the programme. For teaching staff, "high quality" meant possessing the relevant pedagogical skills; being able to engage and interact successfully with pupils and target sessions appropriately; having good subject and curriculum knowledge; and being committed, reliable, flexible to changing needs, and willing to work with a range of different pupils' (p. 32).

The timing of the intervention—prior to Year 11—was important, and there should be liaison between subject teacher and tutor to ensure tuition is not seen as 'bolt-on'.

Participating students achieved slightly higher mathematics GCSE scores than students in the comparison group, and lower English GCSE scores than students in the comparison group. However, it is not possible to attribute either change to the tuition provided.

The FSM sub-group analysis identified that students receiving tutoring achieved a higher GCSE mathematics grade than those in the comparison group, but this difference was not significant.

Key Insights: This study reported on the evaluation of the Tutor Trust intervention, focused on the impacts on Year 11 (age 15–16) outcomes based on a three-year intervention. It is reasonable quality evidence. The study found some positive benefit of tutoring on GCSE mathematics outcomes. This adds to the evidence provided above, that tutoring can improve student outcomes in mathematics. The authors did not find positive benefits of tutoring on English outcomes.

4.10.2 16-19 Mathematics and English Resource

The Association of Colleges in the Eastern Region (ACER) (2015) produced a resource aimed at supporting colleges to plan study programmes for 16- to 19-year-olds studying GCSE mathematics and English. The resource was designed specifically for post-16 retakes. Although based on research, what was reported is not a report of the research evidence.

The resource is a guide with a range of approaches and materials to support teachers in further education based on findings from 15 case studies in the Eastern Region focused on four themes: models of delivery, use of ICT, embedded programmes, and personalised learning.

The guide is aimed at teachers in further education. It also signposts to two teacher training programmes developed in partnership with the ETF: the Maths Enhancement Programme and the English Enhancement Programme, both are aimed at supporting less experienced teachers to teach GCSE. The programmes (as outlined in this document) focus on the old specification GCSEs—probably due to the timeline for retakes and so on.

Key Insights: This is not a research report—there is no evidence to support the use of the approaches, techniques and materials included. The authors suggest that factors that may improve outcomes include: specific models of delivery, use of ICT, embedded programmes, and personalised learning.

4.10.3 Gaining Ground evaluation

Walker *et al.* (2012) reported on the evaluation of the Gaining Ground intervention. The intervention focused on students aged 11 to 16 in England at risk of not reaching target levels of attainment in English and mathematics. This is an evaluation of the impact and value for money of the Gaining Ground strategy (September 2009–July 2011). The strategy supported school improvement in secondary schools with reasonable-to-good GCSE results but poor progression rates in English and mathematics. There were four strands to the strategy: school-to-school partnership working, additional support from School Improvement Partners (SIPs), additional training in Assessment for Learning (AfL), and study support.

The paper provides detailed evidence of the findings of the evaluation team across all four strands of the strategy:

- School-to-school partnership working

Support from partner schools included the Senior Leadership Teams (SLT) conferring on planning and practice in a range of areas such as leadership and development, curriculum organisation, collection and use of student data, and in some instances team teaching or other kinds of observation of teaching.

- APP and AfL

The strategy did not impact significantly on these strands.

- Study support

This was often provided through after-school clubs and activities. There was no discernible difference between the schools involved in the strategy and the comparison schools on level of activity. Some activity was new, some was an extension of what was already on offer. Examples include:

- mentoring and coaching of students by staff (for students bordering on five A-Cs);
- intensive one-to-one or group support sessions;
- mentoring of students by members of SLT;
- peer support;
- immersion courses in mathematics at local university for those bordering C/D;
- breakfast clubs for borderline GCSE students;
- examination revision classes;
- a student conference;
- examination technique classes; and
- additional resources.

The evidence from the evaluation suggests that there was little difference between the strategy schools and the comparison schools, but data from the case studies and surveys provides a more nuanced perspective from those involved:

'[I]t appears prima facie that comparison schools were doing just as much as their counterparts who were involved with the strategy. However, it should be noted that the case studies yielded a more nuanced intervention narrative which revealed that Gaining Ground provided an impetus to initiate and follow through change, opportunities to learn and benefit from partner schools and SIPs, consolidation of institutional improvement interventions and enhanced ways of supporting students. The findings from this wider evidence base provide a more rounded picture of Gaining Ground' (p. 27).

The authors suggest that there was strong evidence that monitoring, tracking, and progress data led to a positive impact on average Key Stage 2-4 progress in English and mathematics including GCSE results. School-to-school support and study support were considered to be beneficial. The availability of additional funding was considered to be key, particularly as schools had a degree of freedom about how to spend the money.

The probability of a student attaining five A* to C grades (including English and mathematics) increased by an average of 13 percentage points. They also found a positive impact on capped total GCSE points score in all subjects equivalent to a student moving from eight D grades to three Cs and five Ds.

Key Insights: The study reports on the evaluation of an intervention focused on students aged 11 to 16 in England at risk of not reaching target levels of attainment in English and mathematics. It provides reasonable

quality evidence. The intervention included a range of different approaches to improving outcomes. The report found that the intervention had a positive impact on GCSE results across the curriculum by adopting a range of approaches, although the schools did not perform significantly differently to the control group who were also found to improve.

4.10.4 Graduation Really Achieves Dreams

What Works Clearing House (2007) reported evidence about mathematics, English, and science outcomes, supported through a range of different interventions. The project Graduation Really Achieves Dreams (GRAD) focuses on students in economically disadvantaged communities. Its aims are: to reduce drop out and increase rates of college enrolment and graduation by increasing reading and mathematics skills, to improve behaviour in school, and provide a service safety net. Support for high school students includes a four-year scholarship and summer school.

The GRAD project works with the feeder elementary and middle schools that send students to Project GRAD high schools. Project GRAD elementary schools provide professional development and coaches for teachers of reading and mathematics, and implement curricula such as MOVE IT Math, Everyday Math, or Success For All.

There were no statistically significant differences between Project GRAD students and comparison group students' ninth-grade attainment outcomes or the rate at which they were promoted to the tenth grade. There were also no statistically significant differences between Project GRAD students and comparison group students in the proportion that graduated, looking ahead at least three years.

Key Insights: This study reported evidence on an intervention aimed to improve mathematics, English and science outcomes for secondary school students. The intervention involved teacher professional development and coaches, and also some specific programmes, including MOVE IT Math, Everyday Math, or Success For All. The study was based on robust evidence. The report does not provide evidence about specific interventions and outcomes relating to mathematics or English. The evidence showed that the project had no significant impact on student outcomes.

4.10.5 Literacy support for indigenous students¹⁹

McGlusky and Thaker (2006) reported on the effect of literacy support for indigenous people in Queensland. The focus was on adult learners. This was a qualitative study identifying literacy and numeracy support systems available to indigenous students studying for vocational qualifications, and identifying those which worked best.

Twenty-nine students, eleven teachers, and seven community members were interviewed across a range of FE provision. The most effective support was identified as one-to-one support via in-class tutorials or peer tutoring (formal and informal) as opposed to students attending a separate learning centre. The authors also found a need for more indigenous teaching staff.

Key Insights: This is a small scale study of support for adult learners. The authors found that in-class support is more effective than withdrawing students.

¹⁹ A detailed summary of this intervention is included in Appendix 1.

4.10.6 Effective adult literacy, numeracy and language teaching²⁰

Benseman *et al.* (2005) reported on a literature review of the best available evidence about effective adult literacy, numeracy, and language (LNL) teaching. The purpose of the report was to provide a critical evaluation of effective practice in LNL provision in foundation learning by providing data demonstrating a clear relationship between learner outcomes and specific components of teaching or provision. It is a thorough review, but as it was published in 2005 it does not include more recent research. The findings were based on 300 studies drawn worldwide. There were limitations on the quality of data which mean that the findings can only be tentative.

The authors state that factors that enhance outcomes include:

- appropriately skilled teachers who can assess learner need in LNL—this requires full time teachers with adequate preparation time and opportunities for professional development;
- deliberate and sustained teaching focused on learner need;
- curriculum linked to authentic LNL events and the needs of learners;
- high levels of participation (probably more than 100 hours of tuition);
- explicit teaching of reading and writing;
- ongoing assessment; and
- clearly structured teaching using a range of methods.

There are other key factors that enhance outcomes that are more tentative, these include good pastoral care, regular CPD, a supportive environment, and so on. There are also other factors not supported by findings including type of delivery, progression in numeracy, and differentiation between dyslexic and not-dyslexic students.

Key Insights: This was a literature review of the best available evidence about effective adult literacy, numeracy and language (LNL) teaching. The purpose of the report was to provide an evaluation of effective practice in LNL provision in foundation learning. It is a thorough review although the literature it was based on was of mixed quality. Findings must therefore be considered tentative. The authors suggest that factors which may enhance outcomes are: appropriately skilled teachers, targeted and sustained teaching, relevant contexts, high levels of participation, teaching of reading and writing, assessment, and a diverse range of approaches.

Section Summary

The findings in this section are diverse and based on evidence of mixed quality. There is reasonable quality evidence that tutoring can improve outcomes in mathematics but not English. One policy paper (based on evidence which is not provided) suggests some features which may support post-16 learners, including: specific models of delivery, the use of ICT, embedded programmes, and personalised learning. The two evaluations of multi-faceted secondary school interventions in England and the U.S. do not find significant positive impacts of the programmes and do not provide evidence of particular features of the complex programmes that may have had an impact. There is some evidence from the studies with adult learners that factors which may enhance outcomes are: in-class support rather than withdrawing students, appropriately skilled teachers, targeted and sustained teaching, relevant contexts, high levels of participation, teaching of reading and writing, assessment, and a diverse range of approaches. The evidence, however, is not robust.

²⁰ A detailed summary of this intervention is included in Appendix 1.

4.11 Non-subject-specific interventions

4.11.1 Event and financial incentives

Sibieta *et al.* (2014) reported on a study to increase student motivation through the use of incentives. This was a reasonably high quality study, conducted as a randomised controlled trial, although there were some concerns about the size of the sample and the minimum detectable effect size. The target population was relatively deprived schools, classified by schools with an average student IDACI (Income Deprivation Affecting Children Index) score in the highest 10% in England.

Two hundred and seventy-nine eligible schools were invited to participate by the project team. Sixty-three schools finally agreed to participate in the intervention after an initial training event in July 2012; they then formed the final population of experimental schools. The RCT design was a cluster randomised controlled trial, with randomisation at the school level, and two treatment groups of schools and one control group of schools. In one treatment group, Year 11 students received financial rewards for making effort and successfully completing tasks. In the second treatment group, Year 11 students received a non-financial reward for similar success in the form of a trip or event.

A number of control schools did not provide effort data to the project team (18 out of 33) and robustness checks suggested that schools that dropped out may have been different in unobservable ways.

Overall, there was no evidence of a significant positive impact of event incentives on GCSE attainment in mathematics, English or science. There was also no evidence of a significant positive impact of financial incentives on GCSE attainment in mathematics, English or science, however there was a significant improvement in classroom effort across the three subjects. There was no evidence of impact on behaviour, attendance, or homework effort. The authors suggest that even when there is a marked improvement in classroom effort this may not translate into higher GCSE attainment. There was, however, a positive impact for students in both intervention groups who had low levels of prior attainment, but this was not statistically significant.

There was no process evaluation, so there is no independent analysis regarding the fidelity of the implementations.

Key Insights: This was a study into the use of incentives to motivate students to increase their effort in Year 11. It is a robust study. The authors found little or no impact of financial or event incentives.

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6 Appendix 1: Detailed summaries of interventions with most potential

The following tables include summaries of specific interventions with evidence suggesting they may warrant further research as to whether they will improve outcomes in English and mathematics for students in England. Each summary provides evidence, where it exists, about:

- Background to the intervention
- Context of delivery
- Detailed description of the intervention
- Size of impact
- Cost of impact
- Quality of evidence²¹
- Gaps in evidence
- Summary points.

6.1 Reading Interventions

Model 1: Interventions by English/ Language arts teachers

Article	Mostert, W. & Glasswell, K.(2012) Dreams to Reality: closing the reading achievement gap with a focus on fluency in Practically Primary, v17, no3.October 2012
Article	Guskey, T., Munoz, M. & Aberli, J. (2009) FAST TRACK TO LITERACY: Kentucky district targets struggling readers in urban schools in JSD, vol 30, number 4. Austin Texas
Article	Benseman, J., Sutton, A. & Lander (2005) Working in the light of evidence, as well as aspiration. A literature review of the best available evidence about effective adult literacy, numeracy and language teaching. J. Auckland Uni Services. Auckland
Background to the	The interventions took place across the USA. Australia and New Zealand.

²¹ High (3): authoritative, independent study/research paper/systematic literature review, or review of reviews including some quantitative information or case studies covering a range of settings and stakeholders.

Medium high (2): independent study, research paper or research/literature review (non-systematic), or official documentation, not covering as much quantitative information, and based on fewer case studies, settings and stakeholders, but based on sound theory.

Medium low (1): study, research paper, research review (non-systematic) or official documentation authored by organisation or individual.

Low (0): observation or opinion piece, based on one case study or views of one person.

<p>intervention²²:</p> <ul style="list-style-type: none"> • jurisdiction • subjects • learner profile • policy context 	<p>These are literacy interventions.</p> <p>The two interventions target students in 10th grade (15-16 year olds) (Guskey et al: 2009) and years 5-8 (10-14 year olds) (Mostert & Glasswell: 2012).</p> <p>The USA study worked with 40 10th grade English and arts teachers across 18 schools. There is no data on the number of students as the article is more an evaluation of the professional development programme (PD) than the actual intervention.</p> <p>Both interventions were introduced as a result of concerns about students' progress in literacy: 'students who are two or more years behind grade level in their language arts skills have little chance of successfully completing a rigorous programme of studies in high school' (Guskey et al: 2009 p32). 'Many of our classrooms are filled with a range of readers and some need extensive support to succeed' (Mostert & Glasswell: 2012 p16).</p> <p>The focus of the USA study was 'literacy skills and particularly the comprehension skills of struggling high school students' (Guskey et al: 2009 p32) and the Australian study on fluency because research 'suggests that readers who process words in a text effortlessly have more mental energy for thinking about those words in context (Samuels: 2006 in Mostert & Glasswell 2012 p16).²³</p> <p>Both interventions took place in settings where students come from disadvantaged homes. 'Jefferson County Public Schools a diverse metropolitan school district that includes 150 schools serving approximately 97,000 students 55% come from economically disadvantaged homes and qualify for free or reduced lunch benefits' (Guskey et al: 2009 p32). 'The partner schools in the project were identified as amongst the lowest in the area (Brisbane) in terms of NAPLAN²⁴ reading scores ... and 3 or 4 years behind what we might expect' (Mostert & Glasswell: 2012 p16) on TORCH (test of reading assessment).</p>
<p>Context of delivery:</p> <ul style="list-style-type: none"> • setting eg FE college, workplace • wider training or qualification context • teacher qualifications and training • other supporting features, such as learning 	<p>Both interventions took place in schools. The USA intervention (Guskey et al: 2009) aimed at those students preparing for national qualifications. The Australian study does not specify a particular goal other than improving literacy.</p> <p>The Australian/Mostert & Glasswell study does not specify any particular training or PD undertaken by teachers in the project, although there is mention of professional learning (p17). There is no detail about how this took place. A key component of the USA/ Guskey et al. study was the PD undertaken by staff.</p> <p>In the USA study teachers took part in a three-day summer programme looking at the Ramp-Up programme and 'worked together to develop implementation strategies, practice and gain feedback' (Guskey et al: 2009 p34). This was followed up by five, three-hour follow-up sessions every six weeks throughout the school year. In these sessions (after-school) teachers could share their successes, discuss problems and develop workable solutions.</p>

²² NB the first table includes the full prompts used by the researchers but these are removed from subsequent tables.

²³ Samuels, S.J. 2006, Reading Fluency: Its Past, Present and Future in Rasinski T., Blachowicz C., Lems K., (eds), *Fluency Instruction: Research-Based Best Practices*, The Guilford Press, NY, USA pp. 7–20

²⁴ The National Assessment Program—Literacy and Numeracy (Australia)

<p>mentors</p> <ul style="list-style-type: none"> • role of employers • equivalence to GCSE context 	<p>(Guskey et al: 2009). The programme coordinator also visited classrooms on a regular basis to offer help, support and feedback. Immediate help was available via email or phone call. A similar programme was available to teachers joining the programme in its second year—this was facilitated by the coordinator and the teachers who had already participated in the first year.</p>
<p>Detailed description of the intervention including:</p> <ul style="list-style-type: none"> • key features • pedagogies used • individuals, small groups, whole classes • assessment approaches • time scale • description of outcomes 	<p>Australian intervention (Mostert & Glasswell: 2012) Research and design collaboration between schools and Griffith University. Three-year project (2009-11). Worked with 133 classroom teachers, 3149 students and 12 schools in culturally diverse, low socio-economic area south of Brisbane. Challenge was to motivate and engage students ‘who won’t read, don’t read and can’t read’ (Mostert & Glasswell: 2012 p16). Aim to ‘close the achievement gap by helping teachers develop extensive knowledge about reading so that they design best-fit literacy instruction for every reader in their care’ (Mostert & Glasswell: 2012). Professional learning by teachers centred on:</p> <ul style="list-style-type: none"> • Accuracy: readers need to be effortless and accurate word-readers • Speed: fluent readers can read at a rate that is conducive to thinking • Prosody: fluent readers read with paraphrasing and expression. Even in their heads, their rendition of the text is similar to authentic spoken language (Mostert & Glasswell: 2012 p17). <p>Focus was on teaching fluency though included explicit teaching to build fluency:</p> <ul style="list-style-type: none"> • Model good oral reading • Provide oral support and assistance • Offer plenty of opportunities for practice • Encourage fluency through phrasing. (Rasinski: 2010 in Mosert & Glasswell: 2009 p17) <p>Classroom practices included:</p> <ul style="list-style-type: none"> • Tape assisted reading • Poet’s corner • Reader’s theatre • Timed repeated readings. (Mostert & Glasswell: 2012 p18) <p>Results: ‘Project schools using these fluency practices soon reported great improvement in student achievement, motivation and engagement... (and) readers quickly became enthusiastic about reading’ (Mostert & Glasswell: 2012 p19). In 2011 89% of the year level cohorts demonstrated ‘a rate of improvement on TORCH that was greater than the gain expected in the national sample’ (Mostert & Glasswell: 2012 p19). For 65% of the 2011 cohorts, significant acceleration was evident. Gains were tracked showing year level cohorts making between 1.5 and 4.0 times the expected rate of progress. In 10% of the cohorts, gains were in excess of 4.5</p>

times the growth expected. The 2011 NAPLAN results told a similar story. In Year 5, the cohort gain was greater than the national cohort gain in 88% of project schools in reading and 77% of project schools in writing. In the Year 7 cohort, 100% of project cohorts showed acceleration on NAPLAN reading and writing. This is a significant achievement for schools that have traditionally experienced a widening achievement gap in literacy and low levels of student and teacher confidence (Mostert & Gladwell: 2012 919).

Authors 'do not advocate fluency instruction as a substitute for comprehension instruction' (Mostert & Glasswell: 2012 p19) but felt that for this cohort struggling with self-confidence and motivation was disrupting their ability to make meaning.

USA intervention (Guskey et al: 2009)

RCT in improving and accelerating students' literacy skills using the Ramp-up Program²⁵. Little detail of the RCT itself as article evaluating the PD programme.

Evaluation process designed alongside implementation using Guskey's 'backward planning model' (2001a & b):

- Level 1: participants'²⁶ reactions to the experience
- Level 2: participants' learning
- Level 3: organisation support and change
- Level 4: participants; use or implantation
- Level 5: assesses impact on students' learning.

Worked with 40 self-selected English and arts teachers in 18 schools. No data on numbers of students taking part.

Aim was to increase fluency; develop wider vocabularies and comprehension of grade-level texts through a variety of instructional strategies' (Guskey et al: 2009 p33).

Ramp-up Program is a two-year course in which 'activities focus on helping students make rapid progress towards becoming fluent readers' (Guskey et al: 2009 p33).

See above for details of PD programme.

Ramp-up Programme focuses on:

- Independent reading in which students read a book of their choosing (Allington: 2001 & Beers: 2003)
- Read aloud/think aloud/talk aloud. Students hear proficient read aloud and voice their thoughts and problems as they read (Davey: 1983, Hahn: 2002 & Richardson: 2000)
- Work period: whole and small group instruction using texts appropriate to students' level and transferring what they have learned to other materials (Fountas & Pinnell: 1996)
- Cross-age tutoring where older students are paired with elementary students (Labbo and Tearle: 1990)¹.

²⁵ Ramp-up Program is a USA Pearson programme, not available in the UK

²⁶ Participants in this instance means teachers

Results:

- Teachers exceptionally satisfied with professional learning experiences, teachers reported a significant increase in their knowledge of critical programme elements and reasonably satisfied with level of support given.
- Some teachers need more help and guidance with implementing the programme in order to ensure greater fidelity. This data was gathered via classroom observations. In other words there is a difference between learning about the elements of a programme and actually using the strategies in the classroom.
- Students learning outcomes were looked at in several ways. There were differences in achievement depending on whether the students were in a low-implementation group or high-implementation group, that is where the programme was implemented fully or partially:
- There were statistically significant differences between the scores of students in the high versus the low-implantation groups using the KCCT reading scores²⁷.
- In Kentucky student assessment statewide is classified as novice, apprentice, proficient and distinguished. The percentage scoring novice declined more rapidly following implementation of the Ramp-up Program (Guskey et al: 2009 p37). (Graph on page 36).
- The gap between black and white students also narrowed following the implementation of the Ramp-up Program and the reading index also rose rapidly (graphs page 37)

Teachers were self-selecting and this may mean that the results reflect the positive motivation of teachers to implement the programme.

Linking professional development to improvements in student learning outcomes is a challenge. 'At a time when educators are being pressed by increased demands for accountability it is imperative that we be able to demonstrate an associative link, if not a causal link, between professional development and improvements in trusted measures of student learning' (Guskey et al: 2009 p38).²⁸

Worldwide: Benseman et al. (2005) appears in each model

Purpose of report to provide critical evaluation of effective practice in Language, Literacy and Numeracy (LNL) provision in foundation learning. Findings based on 300 studies drawn worldwide.

Intent to provide data demonstrating clear relationship between learner outcomes and specific components of teaching or provision.

Limitations on quality of data mean findings tentative.

Detailed findings in report relating to specific components of LNL e.g quality, retention, reading, writing etc.

Key results:

- Appropriately skilled teachers who can assess learner need in LNL.

²⁷ Kentucky Core Content Scores

²⁸ Many of the interventions looked at include professional development and cite its importance in successful interventions.

	<p>Need for full time teachers with adequate preparation time and opportunities for professional development</p> <ul style="list-style-type: none"> • Deliberate and sustained teaching focused on learner need • Curriculum linked to authentic LNL events and needs of learners (could relate to skills for GCSE) • High levels of participation • Explicit teaching of reading and writing • On-going assessment • Clearly structured teaching using a range of methods. <p>There are other key findings that are more tentative that include good pastoral care, regular CPD, supportive environment and so on. There are other factors not supported by findings including type of delivery, progression in numeracy and differentiation between dyslexic and not-dyslexic students.</p>
Size of impact	High for the two interventions. Details given in the section above.
Cost of delivery	<p>Estimated to be high as the interventions require significant, sustained time.</p> <p>Australia: funded in part by Australian Research Council Linkage grant. No figures given.</p> <p>USA: no information on funding.</p>
Quality of evidence	<p>Mostert & Glasswell 3. Three year study independent study in range of school settings.</p> <p>Guskey et al. 3. Although light in evidence of the RCT itself it is an authoritative well-designed evaluation of an RCT.</p>
Gaps in evidence	There is little evidence of the RCT itself in the Guskey article and what is gleaned is through the evaluation process. The Mostert article does not explain how the teachers used their training in the classroom.
Summary points	<p>Both interventions report success within the English and or/ language arts context. Professional development is a key component of both interventions.</p> <p>No data on whether the impact of the improvements in English were seen in other content areas.</p>
Contact details of researchers if available	Kath Glasswell drkathg@gmail.com

Model 2: Interventions across the curriculum (English and core subject/content)

Article	Corrin, W., Lindsay, J., Somers, M., Myers, N., Myers, C., Condon, C. & Smith J. (2012). Evaluation of the Content Literacy Continuum: Report on Program Impacts, Program Fidelity, and Contrast. NCEE. Washington DC
Article	Lai, M., Wilson, A., McNaughton, S. Hsiao, S. (2014) Improving Achievement in Secondary Schools: Impact of a Literacy Project on Reading Comprehension and Secondary School Qualifications in Reading Research Quarterly v49 (3). Pp 305-334
Article	Rose, D. & Acevedo, C. (2006) Closing the gap and accelerating learning in the Middle Years of Schooling in Australian Journal of Language and Literacy, volume 14.2, pp 32-45
Article	Benseman, J., Sutton, A. & Lander (2005) Working in the light of evidence, as well as aspiration. A literature review of the best available evidence about effective adult literacy, numeracy and language teaching. J. Auckland Uni Services. Auckland ²⁹
Background to the intervention	<p>The interventions took place in the USA, Australia and New Zealand. They are cross-curriculum literacy interventions. (Maths is included in the NZ study but not reported on).</p> <p>Grade 9 and 10 (aged 14-16) (Corrin et al: 2012), students aged 13-16 (Lai et al: 2014) and grade 5-9 (aged 10-15) (Rose & Acevedo: 2006).</p> <p>All interventions as a result of concern over students' reading achievements. There is evidence that improvements at an early age are not sustained into adolescence in the NZ study (Lai et al: 2014 p306). There are concerns that students are making less progress in their middle years of schooling and the gap between top and bottom achievement widens at this time, particularly among boys in the Australian study (Rose & Acevedo: 2006).</p>
Context of delivery	<p>The USA study took place in schools where there were significant numbers of low income and low achieving students (Corrin et al: 2012). The NZ study took place in a rural and small town area in schools serving low to middle socioeconomics communities (Lai et al: 2014 p309). The Australian article describes a literacy programme implemented across schools in Melbourne as part of a learning project of the Catholic Education Office Melbourne (CEOM). In all three interventions teachers undertook some form of professional development (PD) which is detailed below.</p> <p>In the USA intervention site coordinators introduce content teachers to the intervention and this is followed by monthly PD sessions 'during which they provide on-site professional development, modelling, and coaching of core content teachers on the teaching routines and learning strategies that are key aspects of the instructional side of CLC (that is, Content Enhancement Routines and Learning Strategies)' (Corrin et al: 2012 p11). Teachers are also observed and they also have support via email and telephone.</p> <p>Although all staff in each of the schools participated in the NZ intervention only the English and mathematics teachers participated the content literacy PD in a series of workshops (summary on page 313)(Lai et al: 2014 p309). All teachers participating in the Australian intervention from primary and secondary schools attended a four-day professional learning programme. This</p>

²⁹ Benseman appears in each model as it provides an overview of good practice.

	<p>training includes supporting teachers to facilitate the learning of their colleagues back at school by ‘exploring models of action learning and developing leadership skills’ (Rose & Acevedo: 2006 p34). A further two days training each year is provided by CEOM which combine expert-led teaching and learning based on action research. (Rose & Acevedo: 2006 p34).</p>
Detailed description of the intervention	<p>In these studies a common element was a concern that as students progress through school the ‘demand for strong reading and writing skills increases as students get promoted to high school grades. Not only do high school teachers rely more heavily on textbooks to convey critical course content to students, but the content in those textbooks also gets more challenging (Heller and Greenleaf, 2007³⁰; in Corrin et al: 2012 xiii). As specialisation occurs in the curriculum so does the need to understand ‘how knowledge is constructed differently within the discipline areas’ (Wyatt-Smith and Cumming: 2003 in Rose & Acevedo: 2006 p33). Learning increasingly takes place within subject or content area classrooms and this content tends to have its own ‘particular epistemology and ontology (Lai et al: 2014). The question then arises about what is generic literacy and what is subject specific literacy? Who should teach it and how should teachers be trained to teach it? (Lai et al: 2014).</p> <p>USA intervention (Corrin et al: 2012)</p> <p>RCT across 33 schools, all grade 9 students in year 1 and all grade 9 and 10 students in year 2 over a two-year project (2008-10).</p> <p>Participating in the RCT were ‘high schools within states served by REL Midwest (Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin)—where at least one-third of students scored below proficient on state standardized reading or English language arts assessment, at least one-fourth of students were eligible for free or reduced-price lunch, and there were at least 100 grade 9 students—were recruited for this evaluation project’ (Corrin et al: 2012: pxviii). Schools also had to be willing to participate in an intervention designed to improve literacy but not already using the proposed scheme or anything similar.</p> <p>The evaluation focused on the implementation and impact of the intervention. The impact study looked at the effectiveness of the intervention on student outcomes. The focus in terms of literacy was improvement in reading comprehension though the CLC programme includes reading and writing.</p> <p>‘Within their school districts, participating schools were randomly assigned to implement the CLC intervention (CLC schools) or continue with “business-as-usual” school programming (non-CLC schools). Random assignment resulted in 17 CLC schools assigned to implement CLC and 16 non-CLC schools. Twenty-eight of the 33 participating high schools continued their participation in the evaluation throughout the entire study period (reasons for discontinuing were school closure and fear of conflict with state-mandated changes resulting from state sanctions). For this final sample of 28 schools, 15 were CLC schools, and</p>

³⁰ Heller, R., & Greenleaf, C. L. (2007). Literacy instruction in the content areas: Getting to the core of middle & high school improvement. Washington, DC: Alliance for Excellent Education. Retrieved from www.all4ed.org.

13 were non-CLC schools' (Corrin et al: 2012 p xviii).
 Testing of Content Literacy Curriculum (CLC)³¹—an intervention designed to improve adolescent literacy—across randomly selected schools in which there are significant numbers of low-income/low achieving students.
 Subject/content teachers integral to levels 1 & 2 of CLC. Specific training for them. L3 also requires specialist training.
 CLC is a multi-level framework, a hybrid of whole-school and targeted approaches to improving literacy:

- Level 1: enhanced content instruction across all core subjects by content teachers. Teachers of core subjects (that is, English language arts, mathematics, science, social studies) develop and use instructional routines designed to help students at all literacy levels master critical content, acquire vocabulary and background knowledge to improve comprehension and communication skills, and be better able to organize complex content. These instructional routines are referred to as Content Enhancement Routines.
- Level 2: embedded strategy instruction aligned to specific demands of the content. Core content teachers work with students to develop one or two learning strategies (such as paraphrasing or self-questioning) that align with the specific demands in their courses.
- Level 3: intensive strategy instruction in supplemental classes. Teachers in stand-alone, supplemental reading classes (Fusion Reading) provide more intensive instruction to students who are reading two to five years below grade level (that is, students who need to develop comprehension strategies).
- There are a further two levels in the CLC offering more intensive support but these were not introduced into this RCT. (P7-8)

Instructional features of the CLC are clearly laid out as routines that must be undertaken at each session. Details of these can be found on page 13-17³².

The site coordinators (mentioned in the PD bullet above) also take on an organizational role within the school(s) working with the school leaders to implement the CLC as a whole.

Full implementation includes collaborative planning, CPD, literacy leadership teams that will make structural changes in schools which in turn create conditions in which instructional change can take place.

Results - Key findings: no statistically significant differences in reading comprehension scores between CLC schools and non-CLC schools. No statistically significant impact on students' core credits in the second year.

(More detail in report which is a 276 page report). Some evidence compromised because of school dropout in project and changes of staff.

Further detail can be found in C7 p122.

However, the lack of difference in achievement is not necessarily down to the CLC itself but rather the implementation of the CLC in schools. Results highlight the need for full implementation of scheme in terms of:

³¹ Developed by the University of Kansas Center for Research on Learning.

³² NB Some of the lack of fidelity is due to schools not following the programme as closely as they should have.

- Time. Three to five years rather than two. This time frame of two years affected the planning of the intervention—CLC recommends at least one semester. CLC should be phased in to schools rather than introduced wholesale.
- Theory underpinning CLC means that structural components need to be fully implemented to enable teachers to engage in CPD and use the routines and instructions with students. Supplemental classes should also be provided. Evidence in report points to failings in all of these aspects (thus compromising results).

Findings reflect lack of fidelity in implementing CLC strategy in schools in the study.

Non-CLC schools were not strictly implementing 'business as usual' or total non-intervention as all schools have some kind of literacy intervention and this is a priority in schools.

Grade findings compromised as not all students completed assessments.

Observation of classes in CLC. Not all observed. Some data not wholly reliable. Also reported that the CLC strategies not seen in play in significant number of classes.

New Zealand intervention (Lai et al: 2014)

Design-based research in collaboration between researchers and schools involved. Iterative cycles of data collection to inform instructional design.

Researchers adopted a blended view of literacy in secondary schools where both generic and content area literacy are important (p308). Students will use both generic and content specific literary knowledge in reading and writing.

The generic skills are those general skills such as prediction, summarizing and questioning. Content area skills are those where words have specific meanings in a particular context e.g. mouse in biology and mouse in technology.

Examples given in article are learning about the conventions in word problem genres in mathematics and the use of foreshadowing in fictional writing (p308).

Seven schools in a rural small town area took part in the research. The schools serve an area of low to middle socioeconomic communities. Three of the schools were secondary schools (years 9-13, age 13-18) one a composite school (years 7-13 age 11-18) and three were school years 1-13.

The actual processes of the interventions are described in O' Brien, P., & Lai, M.K. (2014): Students' beliefs about what influences achievement. Manuscript in preparation and Wilson, A., McNaughton, S., & Lai, M.K. (2012, September). Reading achievement over the transition to secondary school: Profiling a problem. Paper presented at the Symposium on Assessment and Learner Outcomes, Victoria University, Wellington, New Zealand.

Demonstration of intervention impact had two steps: one would show that generic reading comprehension could be raised and two that achievement in content-based literacy skills could also be raised. Measures used were a standardized reading assessment and the national qualification at level 1.

Only English and mathematics teachers participated in content area literacy PD though 'all staff at each of the schools participated in the intervention (p309). It was delivered in two phases via 45 minute workshops (details p313 and 315).

Data was collected across five partially overlapping groups of students. Initial

profiling came from group 1 (all years 9-13 students). Group 2, a baseline group consisted of years 9 & 10 for whom the researchers had reading comprehension information. The third group were followed longitudinally and were present at all four points of data collection. The fourth and fifth groups were students where the secondary school qualifications at level 1 were available. Data collection included classroom observations.

Summary of findings (which are very detailed in the article). The evidence we have suggests that the workshops were used in schools, that there was some increase in teachers' content literacy pedagogical content knowledge (albeit variable), and that students reported greater levels of explicit literacy teaching and vocabulary instruction. Successful implementation of the PD was also indicated by no noticeable increase in teacher turnover and no school dropout as in the early stages of school reform programs (Slavin & Madden, 2001)³³. Similarly, more needs to be known about the relative importance of content area literacy PD in improving achievement, particularly what teachers have learned and are able to transfer to their classrooms from both content area and generic literacy PD. It is also important to test whether a blended model of PD involving both generic and content area literacy is more effective than focusing solely on content area or generic literacy PD, as well as the most effective sequence of introducing content and generic literacy components within a blended design (p332).

Australian intervention: Rose and Acevedo (2006)

Programme 'learning to read: reading to learn'³⁴ implemented over 3 years with 1000 students. Project with Catholic Education Office, Melbourne (CEOM), Victoria, AU. Linked to The Victorian Quality Schools Project, a longitudinal study. Concerns around learners making less progress in middle years, gap between top and bottom achievement widens and significant underachievement among boys. Transition from primary to secondary school problematic for some students.

Setting is school (clusters of schools both primary and secondary). Identified gap in literacy provision for all adolescent students, but particularly those educationally disadvantaged or at risk.

Many schools have withdrawal programmes aimed at students at risk of poor literacy achievement. Many focus on deficit or remedial approaches which results in a mismatch with the practices and pedagogies of the mainstream classroom (Luke et al. 2013: 116)³⁵

³³ Slavin, R.E., & Madden, N. (2001). *Success for All: Research and reform in elementary education* . Mahwah, NJ : Erlbaum .

³⁴ Commercially available <https://www.readingtolearn.com.au/#1450398072181-4410d2e7-dbf6>. Workshops in Europe

³⁵ Luke, A., Elkins, J., Weir, R. L., Carrington, V., Dole, S., Pendergast, D., Kapitzke, C., van Kraayenoord, C., Moni, K., McIntosh, A., Mayer, D., Bahr, M., Hunter, L., Chadbourne, R., Bean, T., Alvermann, D., & Stevens, L. 2003, *Beyond the Middle: A Report about Literacy and Numeracy Development of Target Group Students in the Middle Years of Schooling, Volume 1*, Commonwealth Department of Education Science & Training, Canberra.

Learning to Read: Reading to Learn (Rose, 2005a, 2005b)³⁶ (LRRL) designed to improve outcomes of at risk learners using an intensive approach to scaffolding student literacy.

‘Approach can be used in mainstream classroom or withdrawal contexts. The distinctive features of this approach are that it uses high quality, challenging, age-appropriate texts, articulates strongly to mainstream curriculum and assessment practices and redesigns classroom teaching patterns to enable success for all learners. The approach can be used in mainstream or withdrawal contexts and models literate language features in both fiction and factual texts. Furthermore it is capable of extending the learning of the most competent students in the class or group’ (p35 of PDF).

Evidence shows that approach is capable of extending the learning of the most competent students in the class or group as well as those at risk (p36 of PDF). The approach involves teachers in preparing students through the ‘scaffolding interaction cycle’. Teachers prepare students by providing background information and knowledge about the text before it is read by students. This is followed by detailed reading one sentence at a time and then a third step which is preparing for writing. Step 4 is ‘joint rewriting, followed by step 5, individual writing. (This is a precis of what is quite an involved process detailed in the paper).

‘The Learning to Read: Reading to Learn program (LRRL) provides teachers with two sets of skills for accelerating learning and closing the ‘ability’ gap in their classrooms. The first is a set of skills for interacting with students around written texts that supports all students in a class to read high level texts with critical comprehension, and to use what they have learnt from their reading to write successful texts. The second is a set of skills for selecting key texts in the curriculum to work with intensively, and to analyse the language patterns in these texts to plan their lessons’ (p36 in PDF).

The LRRL approach is designed to systematically tackle the complexity of written language by drawing on a similar approach to the text, sentence and word approach. It adds in syllable and letter pattern.

As part of project all teachers in study undertook off-site professional development, participated in local area professional clusters and school-based professional action learning.

Teachers across curriculum took part (key element of project).

Teachers had access to email and telephone support from Education Officers from CEOM.

Results:

Page 38 of PDF shows figure ‘widening or closing the ‘ability’ gap in relation to taking the whole class approach to improving literacy.

³⁶ Rose, D. 2005a, Learning to Read: Reading to Learn: Submission to the *National Inquiry into the Teaching of Literacy 2005*. (Online.) Available:

Rose & Acevedo

http://www.dest.gov.au/sectors/school_education/policy_initiatives_reviews/key_issues/literacy_numeracy/national_inquiry/documents/pdf2/sub_315_pdf.htm

Rose, D. 2005b, Democratising the Classroom: a literacy pedagogy for the new generation. In *Journal of Education*, Vol 37 (Durban: University of KwaZulu Natal), 127-164

Quotation below reports on teachers' views on success of intervention. There are a number of actual quotes from teachers on page 45 of PDF.

'Using this model of language to scaffold reading and writing requires a high investment in professional learning for teachers. However the payoff over time is that all students are better able to engage successfully in classroom learning, and are more able to succeed at tasks. Teachers consistently report that their whole approach to teaching is transformed through the LRRL program (Carbines, Wyatt & Robb 2005, Culican 2005, 2006, McCrae et al., 2000, Rose 2006a)³⁷ (p43 of PDF).

The paper reports significant improvement in literacy outcomes for those students targeted by the approach.

'Analysis of pre and post DART scores, and corresponding CSF-rated scores, showed that average literacy gains across all schools and classes, and among students from all backgrounds and ability ranges, was consistently more than a CSF level in improvement within approximately three school terms, or approximately double the expected rate of literacy development.

Furthermore, 20% of students made gains of two or more CSF levels, or four times the expected rate of literacy development' (Culican 2006: 6).

The evidence suggests that the approaches adopted in the UK around embedding English and maths are likely to be more successful than withdrawing students or isolating English and maths provision.

There is also a suggestion that greater success in improving English and maths comes from an approach that includes a number of strategies including whole language approach, linguistics and phonics rather than relying on one approach.

Worldwide review: Benseman (2005)

This is included in each model because the purpose of the report was to provide a critical evaluation of effective practice in LNL provision in foundation learning.

Findings based on 300 studies drawn worldwide.

Intent to provide data demonstrating clear relationship between learner outcomes and specific components of teaching or provision.

Limitations on quality of data mean findings tentative.

Detailed findings in report relating to specific components of LNL e.g quality, retention, reading, writing etc.

Key findings:

- Appropriately skilled teachers who can assess learner need in LNL.
Need for full time teachers with adequate preparation time and opportunities for professional development

³⁷ Carbines, R., Wyatt, T. & Robb, L. (2005). *Evaluation of the Years 7-10 English Aboriginal Support Pilot Project, Final Report to the Office of the NSW Board of Studies*.

Sydney: Erebus International

Culican, S.J. (2006) *Learning to Read: Reading to Learn: A Middle Years Literacy*

Intervention Research Project, Final Report 2003-4. Catholic Education Office

Melbourne (Online.) Available: <http://www.cecv.melb.catholic.edu.au/Research> and

Seminar Papers

McCrae et al. (2010) reference not available.

	<ul style="list-style-type: none"> • Deliberate and sustained teaching focused on learner need • Curriculum linked to authentic LNL events and needs of learners (could relate to skills for GCSE) • High levels of participation • Explicit teaching of reading and writing • On-going assessment • Clearly structured teaching using a range of methods. <p>There are other key findings that are more tentative that include good pastoral care, regular CPD, supportive environment and so on. There are other factors not supported by findings including type of delivery, progression in numeracy and differentiation between dyslexic and not-dyslexic students.</p>
Size of impact	Mixed, some high and some no impact (due to fidelity?).
Cost of delivery	<p>Estimated high due to need for sustained input.</p> <p>USA: no details of funding in article</p> <p>NZ: no evidence of funding in article</p> <p>AU: no evidence of funding in article</p>
Quality of evidence	<p>USA: 3. Very full study with thorough evaluation.</p> <p>NZ: 3. Very full study report with detailed information on design and findings for which this detailed summary falls short in detailing.</p> <p>AU: 3. Thorough summary of research</p>
Gaps in evidence	<p>USA: none.</p> <p>NZ: little detail on processes of intervention but references to articles which give greater detail. Appendices are also available on the publisher's website.</p> <p>AU: This paper is a summary of the intervention and there is a suggestion that more data is available (judging by the quotes within the paper).</p>
Summary	<p>All three interventions suggest there is a benefit in interventions aimed at increasing the comprehension and fluency skills of students as they encounter more complex texts in school. There is an acknowledgement that students need both generic reading/writing skills together with the content specific skills required for different subject areas. All interventions included professional development for teachers with the suggestion that this is an essential component of any intervention. Commitment of all staff and the time to implement interventions are also common themes across these interventions. However, the evidence base is not strong and all articles suggest the need for further research in order to provide more robust evidence.</p>
Contact details of researchers if available	N/A

Model 3: Interventions targeted at those preparing for national qualifications

All three articles cited in this model appear in more detail in the other models. This document draws any specific details relating to the model rather than repeating everything here.

Title of article	Benseman, J., Sutton, A. & Lander (2005) Working in the light of evidence, as well as aspiration. A literature review of the best available evidence about effective adult literacy, numeracy and language teaching. J. Auckland Uni Services. Auckland (not an intervention). Appears in each model.
Article	Guskey, T., Munoz, M. & Aberli, J. (2009) FAST TRACK TO LITERACY: Kentucky district targets struggling readers in urban schools in JSD, vol 30, number 4. Austin Texas. Intervention. Also appears in more detail in model 1.
Article	Corrin, W. et al (2012). Evaluation of the Content Literacy Continuum: Report on Program Impacts, Program Fidelity, and Contrast. NCEE. Washington DC. Intervention. Also appears in model 2 in more detail.
Background to the intervention	USA (Corrin 2012) RCT looking at the effectiveness of reading comprehension in grades 9 and 10. Whole class and withdrawal. Across the curriculum. USA (Guskey 2009) RCT looking at improving and accelerating students' literacy skills of grade 10 teachers. Whole class. English and arts subjects.
Context of delivery	See details in model 1 for Guskey and model 2 for Corrin. Benseman appears in detail in models 1 and 2.
Detailed description of the intervention	See details in model 1 for Guskey and model 2 for Corrin. Benseman appears in detail in models 1 and 2.
Size of impact	
Cost of delivery	See details in model 1 for Guskey and model 2 for Corrin. Benseman appears in detail in models 1 and 2.
Quality of evidence	See details in model 1 for Guskey and model 2 for Corrin. Benseman appears in detail in models 1 and 2.
Gaps in evidence	See details in model 1 for Guskey and model 2 for Corrin. Benseman appears in detail in models 1 and 2.
Summary	<p>It is not possible with the evidence available to say whether targeting those older students preparing for national qualifications is more effective than the other models. The Corrin RCT could provide no statistically significant differences between those students who had been part of the intervention and those that had not. However, this is more likely to be due to lack of fidelity in the RCT as the article reported a loss of fidelity due to dropout of schools participating in the RCT and the level of commitment of some schools and teachers. The CLC is a very detailed programme requiring a commitment to clearly laid out routines (it is quite a prescriptive programme) and the conclusion was that schools would need more time to introduce the programme and a longer programme time to see any significant changes in improvement and achievement.</p> <p>The Guskey intervention (again an RCT) did report statistically significant differences in students' scores in high-implementation groups. Again there were differences in the level of commitment by schools and teachers to the intervention.</p> <p>Despite the lack of evidence from the articles searched it could still be worthwhile to undertake further research on whether intensive support at this</p>

	stage makes a difference to achievement.
Contact details of researchers if available	See other models.

Model 4: Interventions in which students are withdrawn from class

Article	Benseman, J., Sutton, A. & Lander (2005) Working in the light of evidence, as well as aspiration. A literature review of the best available evidence about effective adult literacy, numeracy and language teaching. J. Auckland Uni Services. Auckland. Not an intervention. Details of good practice in models 1 and 2
Article	Guskey, T., Munoz, M. & Aberli, J. (2009) FAST TRACK TO LITERACY: Kentucky district targets struggling readers in urban schools in JSD, vol 30, number 4. Austin Texas. Intervention. See model 1
Article	Corrin, W. et al (2012).Evaluation of the Content Literacy Continuum: Report on Program Impacts, Program Fidelity, and Contrast. NCEE. Washington DC. Intervention. See model 2.
Article	Smith, R. & Wright, V. (2015) The possibilities of re-engagement: cultures of literacy education and so-called NEETs in Research in Post-Compulsory Education, 20:4, 400-418, DOI: 10.1080/13596748.2015.1081751
Article	McGlusky, N & Thaker, L. (2006) Literacy support for indigenous people: current practices in Queensland. NCVER. Adelaide
Background to the intervention	<p>There were no specific studies in which students were withdrawn from mainstream classes in the articles reviewed. However, there is a suggestion that withdrawing struggling readers/writers either through separate courses (as in some NEETS programmes) (Smith & Wright: 2015) or separate literacy sessions (in learning centres for example) (McGlusky & Thacker): 2006) is not beneficial to students.</p> <p>Most effective support is identified as one-to-one via in-class tutorial support or peer tutoring (formal and informal) as opposed to students attending a separate learning centre (McGlusky & Thaker: 2006).</p> <p>However, it is still worthwhile including this as a model because it is what happens in schools and colleges currently. There is evidence (not included in the list of articles we have) that an embedded approach does work or at least that any withdrawal needs to take account of context and content of support.</p>
Context of delivery	<p>Several of the studies do not give enough detail on the processes and delivery of the interventions and so it has not been possible to say in all cases how the intervention worked day-to-day.</p> <p>Corrin et al (2012)</p> <p>This intervention is a blend of whole class and supplemental class support. The supplemental classes are intended to provide more intensive teaching to students who are reading two to five grades below their grade level. The teachers receive additional training to take these classes.</p> <p>Guskey et al (2009)</p> <p>Because the articles focuses on evaluating the professional development programme there is little detail about the 'how' the programme is delivered</p>

	but small and whole group teaching.
Detailed description of the intervention	See other models.
Size of impact	
Cost of delivery	See other models.
Quality of evidence	See other models.
Gaps in evidence	See other models.
Summary	See background.
Contact details of researchers if available	

Article	Wexler, J., Reed, D., Pyle, N., Mitchell, M. and Barton, E. (2015). A Synthesis of Peer-Mediated Academic Intervention for Secondary Struggling Learners. <i>Journal of Learning Disabilities</i> , vol. 48, no. 5, 451–470
Background to the intervention	<p>This detailed summary focuses on three specific examples of interventions included in a wider synthesis of peer-mediated academic interventions by Wexler et al. The three interventions are considered in more detail in this summary within the context of findings from the full synthesis and the wider literature referred to by the authors of the paper.</p> <p>Only 1 of the 13 studies included in the paper was an intervention for maths, the rest were reading interventions. The studies took place in middle and high schools (with the majority in middle schools)—ages 11–18 in USA.</p> <p>The three specific studies looked at in this detailed summary were all based in middle schools (ages 11–14) and focused on reading.</p> <p>The focus of the synthesis was on students who were identified as at risk, low achieving, struggling, below grade level or had learning difficulties.</p> <p>The policy context: the need for more rigorous academic preparation in middle and high schools to prepare students for college and careers (career readiness skills)³⁸. A range of factors were considered to result in middle and high school teachers minimising exposure to text reading resulting in students not developing the skills and knowledge required for the study of subjects at a higher level. Low academic attainment is considered responsible for high levels of drop out from high school³⁹. Factors identified included:</p> <ul style="list-style-type: none"> • Interventions become more difficult to implement in the upper grade levels because teachers feel the need to cover a large amount of content in a short amount of time and may opt not to use strategies to support lower attaining students if this is likely to deemphasise content⁴⁰ • Secondary classes larger than primary, have students with a wider range of prior attainment and behaviour issues⁴¹ • Schools with greatest need often have limited resources to support evidence based teaching⁴² • Many young people who have struggled academically for years exhibit low motivation and engagement.⁴³
Context of delivery	Middle and high schools (11–18 year olds). The majority of reading sessions took place in English language arts (ELA) and reading classes and the

³⁸ The Common Core State Standards (CCSS) Initiative (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010)

³⁹ Glennie, Bonneau, Vandellen, & Dodge, 2012

⁴⁰ Siebert & Draper, 2008

⁴¹ Blatchford, Bassett & Brown, 2011

⁴² Carr, Gray & Holley, 2007

⁴³ Casillas, Robbins, Allen & Kuo, 2012; Docan, 2006.

	<p>remainder were in social studies classes.</p> <p>The three example studies used standardised outcome measures for letter word recognition, reading fluency and comprehension.</p>
Detailed description of the intervention	<p>The review identified common features/ components that supported a definition of peer mediation: reciprocal tutoring, partner reading and pairing students who are at different levels, peer discussion, and the use of small groups.</p> <p>This section is based on three example interventions: 1. Calhoon (2005), 2. Kim et al. (2006) and 3. Vaughn et al. (2010)</p> <ul style="list-style-type: none"> • ELA/R class (quasi-experimental design—teachers randomly assigned to condition). Peer-assisted learning strategies (PALS) • Scripted phonics lesson and directed practice followed by peer partners practising the skills three times a week (approx. 40 mins x 31 weeks) • Partner reading every other day (peer tutor reads first—modelling, once both partners have read one student retells the story sequence for 2 minutes, student summarise the text by composing a main idea statement followed by a prediction activity) • ELA/R class (quasi experimental—class sections randomly assigned to condition). Collaborative strategic reading (CSR) • Twice weekly (50 minute x 17 -23 sessions) - modelling of comprehension strategies (for example, preview, click and clunk, gist, wrap-up) followed by working in pairs to partner read, discuss and answer questions about the passages on computer assisted programme. • ELA/R class (experimental—students randomised to classes and classes randomized to conditions). Collaborated strategic reading (CSR) • Sessions were twice a week (50 mins) x approx. 18 weeks—teacher modelled each comprehension strategy and delivered short lessons for practice and review. Students assigned to roles within a small group and read through the text applying strategies—learning logs used to record. <p>Interventions using a formal peer-mediated strategy overall had the largest impact on comprehension but less on reading fluency (where measured)—effect sizes for comprehension ranged from 0.84—2.73.</p> <p>Peer-mediated instruction has been used within literacy learning for some time. While overall there is evidence supporting formal approaches—evidence becomes more limited when aggregated by type of formal approach.</p>
Size of impact	<p>Intervention 1: WJ-III letter word identification: $T v C = 0.95$; WJ-III passage comprehension: $T v C = 0.84$; WJ-III word attack: $T v C = 1.01$; WJ-III reading fluency: $T v C = 0.09$.</p> <p>Intervention 2: WRMT-R Passage Comp: $T v C = 0.4$; CSR 4th grade gist: $T v C = 0.92$; CSR 4th grade comprehension questions: $T v C = 1.14$.</p> <p>Intervention 3: Gates-MacGinitie reading comprehension: $T v C$ (low on test of</p>

	word reading efficiency) = 2.73 (although a wide range of effect sizes were found on other standardised measures of comprehension used in this study—ranging from -0.10—2.73).
Cost of delivery	There was no discussion about the cost of teacher time or resources in the paper. With the exception of the use of computer programmes, the interventions outlined are about the use of different pedagogies, so potentially cost is initial training for teachers in the approach.
Quality of evidence	3
Gaps in evidence	The studies reviewed worked mainly with middle school children and the majority took place during English lessons—there was no focus, and therefore evidence, about the extent to which the types and contents of texts studied made a difference.
Summary points	The synthesis suggested that studies with peer-mediated interventions, particularly when incorporating some type of feedback component, can help secondary struggling learners to improve their reading comprehension and/or content acquisition.
Contact details of researchers if available	Email: jawexler@umd.edu

6.2 Maths Interventions

Article	<p>Karsenty, R. (2010). Nonprofessional mathematics tutoring for low-achieving students in secondary schools: A case study</p> <p><i>Educational Studies in Mathematics</i>, Vol. 74, No. 1, 1-21.</p>
<p>Background to the intervention</p>	<p>Israel, Mathematics, Secondary school, Students at risk of failing the Matriculation Exam in mathematics</p> <p>Link between failure in maths and social issues such as disadvantaged communities, civil rights, and inequalities associated with race, ethnicity, social class, and language. Gaining the Matriculation Certificate (17-18 years) is the 'gatekeeper' to higher-level study.</p> <p>The proportion of students gaining their Matriculation Certificate varies considerably among different Israeli cities. The example given in the article compared the difference in outcomes between the city where the study took place, 37.65% - in 2001, in comparison to 64.22% in a nearby city of a similar size. The gap is reported as greater in relation to higher education for the age 20—29 cohort: the percentages of students enrolled in higher education programs in 2001 in these two cities were 6.48% and 27.58%, respectively (Israeli Central Bureau of Statistics, 2001).</p>
<p>Context of delivery</p>	<p>School</p> <p>Use of volunteers (recently graduated from school)</p>
<p>Detailed description of the intervention</p>	<p>In the paper Karsenty draws on the research of Gaustad (1992) to identify two main features of tutoring: '[...]adapting to the individual learner's cognitive needs and the emotional benefits of the tutor-tutee relationship. Gaustad includes the following aspects within the first feature: (1) adapting instruction to the learner's pace, learning style, and level of understanding; (2) providing immediate feedback; (3) identifying and resolving basic misunderstandings; and (4) providing practice tailored to the student's readiness. Emotional benefits include the opportunity given to students to progress without being compared with faster learners, extra attention and support, a private learning environment in which students feel more comfortable to make mistakes, and lastly, immediate encouragement and recognition of progress, which build up students' confidence and belief in their capabilities to succeed.'(p.2)</p> <p>53 students and 9 tutors participated in the programme (between November 2004 and March 2006), within five separate tutorial periods. Groups of 2—4 students for 8—10 hours a week during maths class time and some time from other subjects. Intervention was for two months—after that students returned to normal maths classes.</p> <p>Approach:</p> <p>For each of the five tutorial periods the following took place:</p> <ul style="list-style-type: none"> • Focus grade level and the mathematical targets were decided based on, for example, the number of struggling students in a particular

	<p>grade and the extent to which particular topics/ concepts were a prerequisite for further topics - learning goals for all tutoring periods were the same as for the rest of the students in the groups from which tutees were drawn</p> <ul style="list-style-type: none"> • Assigning students to a certain tutor was based as much as possible on tutor preference, for example, some tutors liked working with the 'troublemakers'. Great emphasis was put on creating a positive atmosphere about the tutoring process—students' acceptance onto the programme was 'celebrated' and promoted as a 'beneficial opportunity' • Tutors visited students' homes and introduced the project to parents • Volunteers received one day's training • At the end of each tutoring period a social event was held, which parents and students were invited • Volunteer tutors were supported by a programme councillor <p>Volunteer training</p> <p>The instruction model would cover (this was repeated for each tutorial period):</p> <ul style="list-style-type: none"> • Mathematical concepts (e.g. slope of a linear function) and representations (e.g. graphical, algebraic) • Students' conceptions and possible difficulties • Different approaches to the subject • Building on students' existing resources (e.g. intuition, common sense, visual reasoning, daily life experience) • Toolkit of strategies and models. <p>Content of tutoring sessions:</p> <ul style="list-style-type: none"> • 'Fresh start' ethos—not based on previous knowledge but willingness to think and be open-minded about new material • Each tutor sat with his/her students in a separate area - no teacher was present • Sessions were usually based on: 'introductory informal activities, leading to more formal concepts and procedures. For example, the topic of equations began with exploring the meaning of unknowns and operations by which they may be found, through games such as "I wrote a number on this folded piece of paper, if you double my number and then add 10, you get 50. Can you guess my number? Can you write a number of your own and challenge me to find it?". Gradually students moved to more formal representations and solving methods' • The tutors aimed to maximise the benefits of a tutoring approach and to use pedagogical tools which were less likely to be familiar to the student - examples given were personalised tasks and immediate feedback. <p>Outcomes</p> <p>Results showed a considerable mean gain in pupils' grades. 47 pupils</p>
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	<p>performed better after tutoring. One pupil did not show any gain and five pupils showed a decline.</p> <p>In several cases there was a notable change—six pupils who had received a fail grade previously (40 or under) attained a grade of 100 (or slightly less) at the end of the tutoring period. Of these six, five had had discipline issues and spent time outside the classroom. The other had an emotional problem. Those not improving had either high level of absenteeism or test anxiety and one had a learning difficulty.</p> <p>Tutors' perception of factors most important to the success of the programme: volunteers' ability to maintain warm and supportive relationship with pupils, professional instruction for the volunteers on mathematical content and pedagogy, selecting pupils with no learning disabilities, willingness of volunteers to embrace learning mathematical material.</p> <p>Tutors were able to identify with pupils regarding shared obligation to pass school maths tests.</p> <p>Key features of the programme were: age and previous experience of maths of volunteer tutors; small group/ personalised learning, new more challenging topics were taught.</p>
Size of impact	N/A
Cost of delivery	Training of volunteers, coordination (time and expenses)
Quality of evidence	1 -2
Gaps in evidence	This is a single case study but part a wider programme of support/ research. There is no description of the assessment tools used for pre- and post-intervention.
Summary points	<p>Although this is a single case study it raises some interesting points re strategies that work with low attaining pupils, which are reflected in the wider literature. Of particular interest is the role of young people as tutors (and the effectiveness of a tutor/tutee relationship where both can relate to one another as the school experience is still recent) and the teaching of challenging materials rather than remedial approaches.</p> <p>'[...] the same data suggest that tutors were able to identify with students on the grounds of the shared obligation to pass mathematical tests as part of schooling. Indeed, in conversations with tutors, most of them reported that they often encouraged students using arguments such as "mathematics was not my favourite subject either, but I nevertheless succeeded and so can you". This point is demonstrated in Hanna's concluding comment, written in her questionnaire: It was an amazing experience, especially for me, because the system and ways of my own high school did not suit me, and I succeeded for myself and for the kids because I understood them.' (p17)</p>
Contact details of researchers if available	Davidson Institute of Science Education, Weizmann Institute of Science, Rehovot, Israel e-mail: ronnie.karsenty@weizmann.ac.il

Article	Swan, M. (2006). Learning GCSE mathematics through discussion: what are the effects on students? <i>Journal of Further and Higher Education</i> , vol. 30, no. 3, 229—241.
Background to the intervention	<p>England, Maths, GCSE retakes</p> <p>Intervention a response to criticisms of low attainment in GCSE maths and the transmission-oriented approach often taken by teachers ‘delivering’ a one-year ‘retake’ course in further education colleges (FE). The focus of lessons was reported as mainly emphasising procedural learning rather than the understanding of mathematical concepts. Many of the students retaking fail to improve their GCSE grade—only 20% improve their grade (Kelly 2005). The Further Education Funding Council (FEFC, 1997) reported that for many the experience ‘reinforces failure and decreases motivation’.</p> <p>The intervention here was developed along similar design principles to resources developed by the DfES Standards Unit Mathematics Team—the research was considered by the author to offer hard evidence that the resources are effective in typical FE contexts. Teaching resource developed for this study (learning materials through discussion and reflection: algebra at GCSE, Swan and Green 2002) was designed and developed, and then sent to all FE colleges in England. The study reports on the effectiveness of the intervention in 44 colleges.</p> <p>The underpinning theoretical basis for the design is the ‘dialogic classroom’.</p>
Context of delivery	<p>FE College</p> <p>One year GCSE retakes (post-16)</p>
Detailed description of the intervention	<p>Based on learning from previous pilot study which involved four teachers over two years.</p> <p>‘Design-based’ research (highly interventionist, pragmatic, design of learning environments and developing learning theories ‘intertwined’ (p.230), iterative process.</p> <p>Algebra was chosen because it is considered the language of generalization and describes ‘underlying structures of mathematics’ (p231).</p> <p>Teaching resource developed learning mathematics through discussion and reflection: algebra at GCSE (Swan and Green, 2002).</p> <p>Paper reports on findings from work with teachers and students from 44 FE colleges and differentiated between teacher-led and student oriented pedagogies.</p> <p>Pre- and post-intervention algebra test covered:</p> <ul style="list-style-type: none"> • evaluating expressions involving numbers • simplifying simple algebraic expressions • substituting numbers into formulas • interpreting an expression set in a simple everyday context • extending a linear sequence and finding the nth term

- constructing an algebraic expression from a simple everyday context
- constructing an equation from a simple everyday context
- solving linear equations
- handling simple inequalities
- rearranging formulas.

Confidence, anxiety and motivation attitude scales ('to measure the degree to which students feel able to accept mathematical challenge, the degree to which they feel mathematics is a rewarding experience and the degree to which they feel anxiety when tackling algebra questions') used:

- Confidence in Learning Mathematics Scale,
- Effectance Motivation Scale
- an adaptation of the Mathematics Anxiety Scale (Fennema & Sherman, 1976).

The approach:

The theoretical principles underpinning the resources are summarised in this paper (Swan, 2006) as follows: lessons are conducted in supportive social contexts; lessons consist of rich, challenging tasks; students are encouraged to make mistakes and learn from them; teaching emphasizes methods and reasons rather than just answers; students create links between mathematical topics; the purpose of each lesson is communicated clearly to students, and appropriate use is made of technology (p231).

The materials offered generic approaches for fostering collaborative cultures within the classroom. 'Algebraic concepts and their representations could be identified, described and discussed intensively and alternative conceptions (or misconceptions) explicitly recognized and worked on.' (p231). Student creativity, decision making, explain, prove, reflect and interpret.

Tasks were differentiated, so students could take on different levels of challenge depending on their starting point—'cognitive conflict' was introduced through the choice of examples.

Multiple representations of the same idea were used to create links. Algebra was conceptualized as active construction rather than 'inert' facts.

The materials were developed around three generic types of activity:

- evaluating the validity of statements and generalizations, interpreting and classifying multiple representations of mathematical objects, and creating and solving new problems
- Evaluating the validity of statements and generalisations:

This type of activity was used to 'encourage reflection on generalizations concerning the laws of arithmetic, the meaning of letters in algebra and the difference between identities, equations and inequations', and develop reasoning skills.

Students were encouraged to reflect on common convictions about mathematical concepts. They were provided with a number of statements (generalisations) which contained common errors or misconceptions—the statements used words, symbols or both—the students had to decide upon the validity of each statement (always true, sometimes true or never true) and justify their decision using examples, counterexamples and explanations. The focus here was on reasoning skills.

Collaborative discussion and group accountability was encouraged further with each group needing to design a poster.

Interpreting and classifying multiple representations of mathematical objects

This type of activity was used to support understanding of concepts and definitions, and the ordering of operations.

Card sorting activities allowed a range of representations (words, diagrams, symbolic formulas, tables and graphs) to be ‘shared, interpreted, compared and classified; in identifying ‘sameness’ or ‘difference’ in representations students would create and refine concepts and definitions, and consider the order of operations

As above, students were encouraged to design a poster, annotated with their reasoning

Creating and solving new problems

These activities intended to give an opportunity for ‘creative endeavour’

Students created their own problems and examples and their students were invited to solve them. Creators and ‘solvers’ worked collaboratively to understand where difficulties arose.

The task involved students in understanding the structure of problems—and made explicit the process of ‘doing and undoing which permeate mathematics’.

The researchers observed that students would frequently create problems more difficult than the teacher and because students now ‘owned’ procedures that had created the problems they were able to advise other students if they got stuck trying to solve the equations.

Training the teachers:

- One participant from each college was invited to attend three workshops—a two-day introductory residential with two follow-up one-day workshops
- Teachers from the same colleges who did not attend the workshops acted as the control group
- 28 teachers attended all the workshops and returned student data - 20 teachers from the same colleges returned student data without

	<p>attending the workshops</p> <ul style="list-style-type: none"> Resources included: classroom materials, teaching guidelines, video clips of resources being used in classroom settings, questions for teacher reflection and discussion. Resources on CD-ROM, with accompanying video. Support for 10 lessons (approximately 17-20 hours of class time) Teachers were categorized into three groups according to how many of the 'discussion-based' lessons they used and their involvement in the research: 17 teachers used at least 7 of the (notionally one hour) lessons from the supplied resources. A further 17 teachers used a 'few' lessons from 3 to 6 lessons Teacher who didn't use any of the materials taught algebra using 'chalk and talk' with practice using textbooks and worksheets <p>Outcomes:</p> <p>Final sample of students 334 (from original sample of 834)—high level of attrition (final reduced sample was drawn from a range of colleges considered representative of general student population retaking GCSEs) of these 312 were age 16-21 years old took the algebra pre-test and post-course questionnaires and attended at least 60% of their mathematics classes.</p> <p>Results from algebra (pre/ post-course tests)—greater number of discussion sessions used and the more student-centred the teaching style the greater the gains in algebra learning.</p> <p>Classes that had not used any discussion activities showed an overall decline in students' confidence and motivation and an increase in anxiety about algebra.</p>
Size of impact	<p>The student-centred approach (as reported by students) showed some positive change between mean pre- and -post-intervention test scores regardless of whether the materials were used or not. However the impact was greatest (approx. one standard deviation) where the resources were used in a greater number of lessons and a student-centred approach was used. Mean pre-intervention mark (out of 60) 14.12 and post-intervention 23.10 . A gain of +8.98. Where no resources were used and there was a teacher-centred approach there was a negative change between tests (-0.12). No resources used but a student-centred approach was used there was also a positive change (+4.23)</p> <p>The gains overall are not large and it is likely, as argued by the author, that this reflects the difficulty students have with algebra. The uses of the resources offered activities and approaches to encourage discussion and appear to enhance the learning compared to the use of student-centred approaches alone.</p>
Cost of delivery	Cost of teacher training workshops, including teacher attendance and cover costs
Quality of evidence	<p>3</p> <p>There was a high-level of attrition but this fits with our experience/ understanding of working with this cohort. It is also unclear from the report how many of the original 44 colleges were still involved by the end of the</p>

	study and how the 'control' group was managed.
Gaps in evidence	Any breakdown of outcomes, using demographic/ background data.
Summary points	The study suggest that the use of activities that encourage and support the implementation of collaborative, discussion-based approaches to learning algebra enhances learning and improves student outcomes, especially if used in student-centred ways.
Contact details of researchers if available	The University of Nottingham, Jubilee Campus, Wollaton Road, Nottingham NG8 1BB, UK. Email: malcolm.swan@nottingham.ac.uk

Title of article	Evaluation Report on the Realistic Mathematics Education Pilot Project at Manchester Metropolitan University
Author (s)	Dr Jeff Searle and Dr Patrick Barmby
Date of publication	2012
Background to the intervention	<p>RME originated from the Freudenthal Institute in the Netherlands in the 1970s to meet a perceived need to improve the quality of mathematics teaching in Dutch schools. Following the success of RME in Holland this approach to teaching and learning mathematics was taken up in the 1990s in Wisconsin in the USA within a project called Mathematics in Context (MiC).</p> <p>In 1991, The University of Wisconsin, funded by the National Science Foundation (USA), in collaboration with the Freudenthal Institute, started to develop a curriculum and pedagogy based on RME, which they called Mathematics in Context. The initial materials were drafted by the staff from the Freudenthal Institute on the basis of 20 years' experience of curriculum development. After revision by staff from the University of Wisconsin, the material was trialled, revised and re-trialled over a period of five years. The trialling not only involved checking a variety of versions of questions for effectiveness but also involved the careful examination of pupil strategies and of teacher needs, beliefs and expectations. The first version of Mathematics in Context (MiC), together with comprehensive teacher materials, was published in 1996/7 and has undergone several revisions since then. There is also in place a comprehensive support infrastructure for teachers using MiC.</p> <p>In 2003 researchers from Manchester Metropolitan University (MMU) purchased a set of MiC materials, with a view to training teachers to use them in a project based in some of the local schools.</p> <p>MMU obtained funding from the Gatsby Foundation to pilot the RME project using MiC materials. This pilot project ran from 2004 to 2006. It was aimed principally at lower ability KS3 pupils, particularly those in Year 7. In 2007 MMU began work on developing the RME approach for KS4 pupils; the project was called Making Sense of Mathematics (MSM), and was, again, targeted at lower ability pupils, aiming for Foundation tier GCSE. It was hoped that this project would help these pupils have a positive and meaningful experience of mathematics as well as helping them to achieve at GCSE.</p> <p>MSM materials were subsequently also developed for use with more able pupils aiming for the Higher tier GCSE.</p> <p>The curriculum development body, Mathematics in Education in Industry (MEI) became interested in the RME approach, believing this approach has the potential to make a substantial contribution to mathematics education. MEI commissioned CEM to conduct the evaluation of the approach published in</p>

	<p>2012.</p> <p>The project team also received grant funding from ESRC. The ESRC Project was entitled, “Investigating Effective Strategies for Maths Teaching at Key Stage 3” and ran during 2005/06.</p>
Context of delivery	<p>The materials have been used in schools in the Manchester area, both at key stage 3 and at key stage 4. They have been used with the low ability maths groups and, more recently, with higher ability groups.</p> <p>In some schools, RME is being used by all the teachers across all the year groups, but in some schools there is a mix of those who use RME and those who don't. The intervention has been delivered by qualified teachers. Teachers were selected based on their interest in the approach and were given training on following it. Most of the teachers had had personal involvement with MMU. Several did their initial teacher training there, used MiC when on their teaching practice, and then took up posts in MiC trial schools. MMU supplied resources to the schools and provided ongoing support in the form of twilight training sessions and school-based observations.</p> <p>It is noted in the evaluation report that some teachers ‘prefer more traditional methods, based on a three part structured lesson plan and an explicit lesson objective, and see no reason to change’. They go on to note that pupils are therefore likely to experience both types of teacher as they progress through the year groups, and add that this may confuse pupils. They also report the view expressed by teachers that imposing RME on unwilling colleagues will not be successful.</p> <p>This project is directly related to the focus of the EEF review in that the materials have been used explicitly with low ability learners in maths to support them to improve their GCSE results. There is concern over perceived incompatibility of GCSE questions and RME-type problems.</p>
Detailed description of the intervention	<p>Realistic Mathematics Education (RME) is an intervention in which children learn maths through engaging in solving problems in contexts that are meaningful to them. RME uses realistic contexts and a notion of progressive formalisation to help pupils develop mathematically. A key feature of RME is the integrated development of conceptual and procedural knowledge. Pupils engage with problems and scenarios using common sense/intuitions, collaboration with other pupils, and teacher and textbook interventions.</p> <p>The aim of the intervention is to provide contexts and related activities that interest the pupils and so engage them in the maths learning. Pupils experience a range of activities, including practical work and discussion. Discussion takes place in pairs, in a group or whole class and is an essential part of the RME approach.</p> <p>RME uses investigative and problem solving strategies and pupils discuss their work to resolve issues. Pupils remain in context throughout and stay with a topic for a much longer period of time than would be usual.</p>

	<p>The RME approach is different to the approaches traditionally used in England in a number of respects:</p> <ul style="list-style-type: none"> • use of realistic situations as a means of developing pupils' mathematics as opposed to using contexts as an introduction to mathematics or as an application of mathematics • less emphasis on algorithms and more on making sense of and gradual refinement of informal procedures • emphasis on refining and systemising understanding • less emphasis on linking single lessons to direct content acquisition and more on gradual development over a long period of time • greater emphasis on research into learning and teaching and of trialling and refining materials in schools. <p>For the project aimed at foundation tier GCSE students (Years 10 & 11) new resources were produced as a result of collaboration between the Freudenthal Institute and MMU. These resources consist of ten booklets which together cover the Key Stage 4 Foundation tier curriculum (for the pre-2010 GCSE specifications). It was noted in the evaluation that the use of the intervention required the re-writing of school Schemes of Work.</p> <p>Researchers commented in the evaluation that normal statements of objectives given at the start of the lesson and traditional formal lesson plans can be a hindrance rather than a help in the RME approach.</p> <p>The evaluators found that to develop effectively and to involve more teachers, a support network that can offer initial training and ongoing professional development is essential.</p> <p>Teachers believe RME promotes links in mathematics through being visual and making sense to the pupils. They noted the need for discussion to promote this, both between pupils in pairs or groups, or a whole class. It is important for the pupils to share their ideas with each other. This is also reinforced with practical work. Generally the teachers agreed that RME makes pupils think as opposed to, for example, being shown how to solve a type of equation, which is then reinforced with practice, but might not be understood and will soon be forgotten with the need to "move on to the next topic".</p> <p>There was concern that MSM may not lead to the higher, more abstract, ideas needed for Higher tier GCSE,</p> <p>Several of these teachers emphasised the need to use RME over a long period of time if it is to be successful. RME needs to be viewed as a long term project, with pupils being introduced to this approach in Year 7, and, possibly, earlier in the primary school, and then ideally developing over the five years of mathematics education through RME to GCSE.</p>
Size of impact	<p>2008 What Works Clearing House review into Mathematics in Context found:</p> <p>'No studies of "Mathematics in Context" that fell within the scope of the Middle School Math review met What Works Clearinghouse (WWC) evidence standards. The lack of studies meeting WWC evidence standards means that,</p>

	<p>at this time, the WWC is unable to draw any conclusions based on research about the effectiveness or ineffectiveness of “Mathematics in Context.”</p> <p>The CEM evaluation in 2012 of the MMU work found the following.</p> <p>As part of the quantitative analysis assessment data from Year 7 pupils from the 2004-06 MiC project were reanalysed using Rasch modelling in the 2012 evaluation. Pupils from Year 7 who were taught using the MiC materials by teachers involved in the 2004/05 project, were assessed on a range of questions to test their ability to solve a problem and explain their strategy in a finding a solution. The same assessment problems were also given to a control group of Year 7 pupils who had not experienced the RME approach nor used the MiC materials. The pupils were matched on the level they had achieved in the Key Stage 2 mathematics standard attainment test (SAT) taken in Year 6.</p> <p>‘ The result of the t test indicates that the project group pupils showed a higher average ability in solving these types of problem and explaining the strategies they used to solve them, than the matched Control group pupils. In terms of effect size, the difference between the two groups corresponded to an effect size of 1.05, $\{(-0.69 - -1.37)/0.65 = 1.05\}$, or a difference of over one standard deviation in favour of the project pupils. Cohen (1969) categorises effect sizes of 0.3, 0.5 and 0.7 standard deviations as ‘small’, ‘medium’ and ‘large’ respectively. The difference between the two groups could, therefore, be considered to be very large.’</p> <p>Qualitatively, teachers commented that ‘pupils who have followed an RME approach will be well prepared for the applications and functional skills aspects of GCSE. Through RME, they will have developed problem solving skills and the ability to think around a problem and will find it quite natural to get started on a new problem. There was some concern, though, about adequate preparation for the more abstract questions, with some saying they revert to traditional methods to prepare pupils to answer such questions.’</p> <p>It was felt that the impact was greatest on the foundation pupils, although higher level pupils would still benefit by being able to apply the models they had acquired through RME.</p>
Cost of delivery	Estimated to be high as this requires sustained delivery and a complete change of approach to teaching maths in schools.
Quality of evidence	3
Gaps in evidence	<p>One teacher noted that there are sometimes gaps in the books which a teacher can fill, with sufficient experience.</p> <p>Match to new GCSEs. Evidence does need to be gathered when it comes to formal examinations and progress as to how RME-taught pupils fare and how many go on to study mathematics at advanced level.</p>
Contact details of researchers if available	

Title of article	Does Diagnostic Math Testing Improve Student Learning?
Author (s)	Julian R. Betts, Youjin Hahn, Andrew C. Zau
Date of publication	2011
Additional articles included:	<p>Karen Volz Bachofer, Andrew C. Zau, Julian R. Betts (2012a) The Impact of the Use of the Mathematics Diagnostic Testing Project in San Diego Unified School District: Teacher Interview Component</p> <p>Bachofer, Karen Volz, Julian R. Betts, and Andrew C. Zau. (2012b). The Impact of the Use of the Mathematics Diagnostic Testing Project in San Diego Unified School District: Teacher Survey Component.</p>
Background to the intervention	<p>This study reports on the effect of diagnostic testing on student achievement in subsequent summative tests in mathematics. The intervention was not introduced as a result of any particular concern about student progress, nor for any particular cohort.</p> <p>Diagnostic assessment is used to understand a learner's current skills and to identify skills gaps. Information from diagnostic assessment can help teachers personalise instruction and avoid re-covering ground the learner is already familiar with. Diagnostic assessments are already used quite widely in maths in the UK context (especially in FE), but often in a rather ad hoc manner. However the current study is one of the first large scale quantitative analyses of the impact of systematically applied diagnostic assessments in maths on summative outcomes. The summative tests in question are the California Standards Tests (CSTs) which measure the achievement of students against California content standards; the diagnostic maths assessments were provided by the Mathematics Diagnostic Testing Project (MDTP).</p> <p>The Mathematics Diagnostic Testing Project (MDTP) is a joint program of the California State University and the University of California. The MDTP offers free diagnostic maths testing, with efficient and detailed feedback. Each MDTP test lasts 45 minutes and contains, depending on the subject matter, 40 to 50 multiple choice questions. Teachers typically receive printed results within a week of test administration, along with overall and student-by-student information on student performance on individual topics within the subject of the test. Note that the MDTP tests are not formative assessments - i.e., they are not a series of tests that teachers can use to gauge how much students have mastered materials just taught during a course. The MDTP consists of a set of "readiness" tests designed to give students and teachers diagnostic information about student preparedness to move on to a given course in the next academic year. For example, the Geometry Readiness Test evaluates a student's understanding of first-year algebra topics required to do well in a subsequent geometry course. This information can help identify specific areas where additional study or review is needed and can help teachers identify</p>

	<p>topics and skills that need more attention in courses.</p> <p>The MDTP is unusual in that it is not a commercially designed or administered test, and it is not adaptive. It was originally developed by a group of mathematics professors back in the early 1980s, all of whom taught at public institutions of higher education in California. The goal of the test was not placement, initially, but was to give feedback to high schools on how well-prepared their students were for entry in the University of California or California State University systems. The MDTP is used now in both high schools and community colleges in California.</p> <p>The MDTP test are now developed and validated by workgroup members who include faculty from CSU, UC, community colleges, and secondary schools. A part of the test development process is an extensive review of item statistics to ensure that each item tests appropriate knowledge and skill, that each item discriminates reasonably well between stronger and weaker students, and that the difficulty levels of the items are not too widespread. MDTP now provides an online version of the tests that makes feedback to teachers about the performance of their students virtually instantaneous.</p>
Context of delivery	<p>The MDTP is delivered across a wide range of ages in California school and across all abilities. The MDTP is used in two ways: firstly, many teachers have voluntarily used the tests for their classes, and secondly some districts have mandated end-of-year testing of all students in certain grades. The MDTP is administered by qualified teachers in California schools. However significant support is available to them. Representatives from the ten regional offices that score tests are available to visit schools and provide training to math teachers on how to use the tests and interpret results. Staff from regional offices visit the schools they serve from once to several times per semester. In addition, the MDTP sites hold regional conferences, teacher leadership institutes, and smaller focus group meetings to help teachers make the best use of MDTP tests and other materials.</p> <p>Unlike GCSE, both the CST and the MDTP are both multiple choice tests (which are of course well suited to scalable, computerised delivery). The diagnostics tests of the MDTP were therefore well aligned with the summative CSTs. Both GCSE and functional skills maths tests are very different in assessment methodology.</p>
Detailed description of the intervention	<p>This study reports on the use of the paper version of MDTP within California schools. The study used data from 2001–2002 through 2006–2007, modelling individual students’ trends in math achievement, as measured on the CST test, and looked for a break from each student’s trend in years after the student took a district-mandated MDTP test or took an MDTP test voluntarily adopted by his or her teacher.</p> <p>The MDTP test results provided to teachers show the distribution of answers by their students on each individual question on a test. Because the multiple choice answers are carefully designed with distracters, it is often straightforward for a math teacher to infer from the most frequent wrong answer chosen what specifically it is that the student is misunderstanding. For example, if a question requires a student to add together two fractions, one of</p>

the wrong choices might be designed to test whether the student mistakenly believes that the lowest common denominator is found by adding together the denominators from the two individual fractions rather than identifying the smallest integer that is a multiple of the denominators.

The MDTP tests were used in two ways: firstly, many teachers have voluntarily used the tests for their classes, and secondly some districts have mandated end-of-year testing of all students in certain grades. The voluntary tests occurred throughout the school year but were clustered in September, May, and June (so near the beginning and the end of the school year). Mandatory tests were delivered towards the end of the school year. The goal of the mandatory testing was to help teachers place students in mathematics classes of appropriate difficulty in the following academic year. The study find quite different outcomes for the two modes of operation.

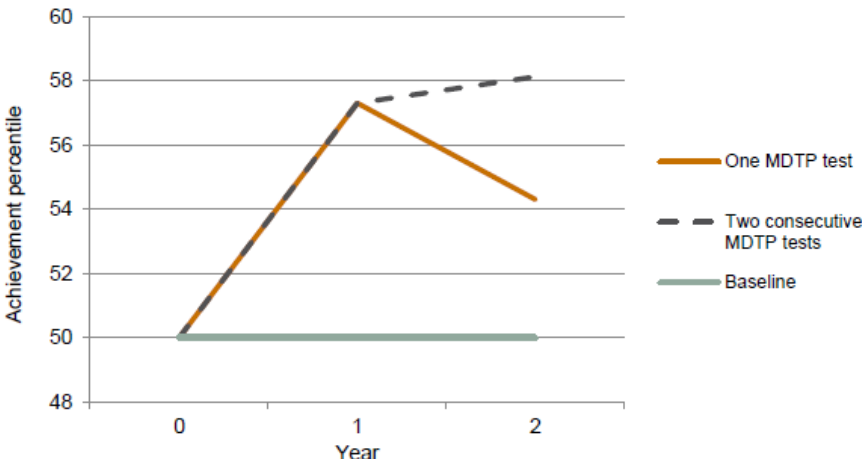
The study found a positive effect of mandated MDTP testing on student maths achievement in the following year. The median student who ranked at the 50th percentile in year 0 rises to the 57th percentile, on average, in year 1, a year after the district-mandated testing.

In contrast to district-mandated testing, the voluntary use of MDTP tests by teachers had no detectable relation with students' gains in math achievement during the year. This contrary finding suggests that having a school systematically use the MDTP test rather than having individual teachers use the test piecemeal could be critical.

Although the study only finds a positive effect for mandated testing, only about 11 percent of the positive effect of MDTP can be attributed to its use as a placement tool producing more homogenous abilities within maths classrooms in the following year. Therefore most of the effect of MDTP occurs for reasons other than appropriate classroom placement. In the original study the authors speculate that the MDTP provides teachers with the knowledge they need to identify and address specific student weaknesses in maths, and that it could be that the coordinated use of the MDTP across all students within a grade might induce a systematic examination among math teachers about strategies to address the most common problem areas among students.

In a follow up study (Bachofer, Zau, Betts (2012a)) extended the previous study by exploring the ways in which mathematics teachers have used MDTP tests and investigating the extent to which voluntary and mandated use of MDTP tests are associated with student learning in mathematics. They found that teachers who administered the MDTP voluntarily were more likely to report that they reviewed test results on their own (rather than with other teachers) than teachers who administered an MDTP test under the district mandate. In addition, teachers who reported administering an MDTP test under the district mandate were more likely to have discussed MDTP results with their students and distributed MDTP student letters. These findings may partially explain the Betts, Hahn, and Zau (2011) finding that voluntary use of MDTP testing had no detectable relationship to student gains in mathematics.

A further follow up study (Bachofer, Volz, Betts, Zau. (2012b)) concludes that

	<p>all of the teachers whose MDTP test use and students’ mathematics gains were above the median reported that the decision to voluntarily administer MDTP tests was made by their schools’ mathematics departments. This suggests that voluntary schoolwide administration and district mandated administration may have a similar impact on student mathematics achievement.</p> <p>The study also found that if a student is given the MDTP test two years in a row, the benefits that accrue the year following the first test persist and strengthen slightly, as illustrated by the dashed line in the figure below. Similarly the authors found that the benefits of MDTP testing decay over time. In the case in which a student is given an MDTP test in only one grade, two years after having been tested, only about 60 percent of the first-year effect remains. The solid line in the above figure indicates this scenario. One explanation offered is that maths teachers pay particular attention to information from the prior spring’s MDTP administration, rather than from earlier periods.</p> <p>Estimated effects of taking mandated MDTP test for one year only or for two years, in terms of percentile rankings for a median student</p>  <table><caption>Estimated effects of taking mandated MDTP test (Percentile Rankings)</caption><tr><th>Year</th><th>One MDTP test</th><th>Two consecutive MDTP tests</th><th>Baseline</th></tr><tr><td>0</td><td>50</td><td>50</td><td>50</td></tr><tr><td>1</td><td>57.5</td><td>57.5</td><td>50</td></tr><tr><td>2</td><td>54.5</td><td>58</td><td>50</td></tr></table>	Year	One MDTP test	Two consecutive MDTP tests	Baseline	0	50	50	50	1	57.5	57.5	50	2	54.5	58	50
Year	One MDTP test	Two consecutive MDTP tests	Baseline														
0	50	50	50														
1	57.5	57.5	50														
2	54.5	58	50														
Size of impact	<p>The study found that district-mandated diagnostic math testing produces positive gains, enough to move a student originally at the 50th percentile to somewhere between the 54th and the 57th percentile in the subsequent year. Researchers used two statistical models to estimate gains, and obtained very similar results with each.</p> <p>The authors found evidence that MDTP testing lowered variation in prior achievement within math classrooms in the following year. However this is only found to account for about 11 percent of the positive effect of MDTP. The remaining (majority) of the effect is not specifically evidenced but the authors speculate (reasonably) that the MDTP provides teachers with the knowledge they need to identify and address specific student weaknesses in mathematics.</p> <p>The authors also estimated the effects on students of taking different MDTP tests (pre-algebra, algebra, geometry) and found that each of the three types of MDTP tests produced a significant gain the following year. Thus, the results</p>																

	<p>do not hinge upon any one level of MDTP test.</p> <p>The authors also examined whether a student's gain from the mandated testing depends in any way on prior math achievement (quantified as low, medium, and high) and found that all three groups of students gain from mandated MDTP testing, but that the middle and higher achievement groups tend to gain more than the lowest achieving group.</p>
Cost of delivery	<p>First, to consider what the nature of the intervention would be in the UK context. These studies shows that diagnostics maths tests can provided positive outcomes if:</p> <ul style="list-style-type: none"> • they are used systematically across a department or institution • teachers are provided with suitable training on how to use the tests and interpret results • the tests are targeted on specific maths topics. <p>Each of these points is likely to be crucial. In relation to the first point, as the authors note, "Simply providing teachers with diagnostic testing with quick turnaround does not appear to guarantee that their students will learn more. The recipe that has demonstrably worked in San Diego is to make a systemwide decision to test students diagnostically near the end of a grade, and to use the results to identify students in need of remediation and to place students into appropriate math classes in the next grade."</p> <p>This last point about providing a range of targeted tests is also worth noting - it contrasts strongly with a typical maths diagnostic test in FE which uses an ad-hoc adaptive testing algorithm to attempt to provide diagnostic feedback information across the entire curriculum. The MDTP provides a number of specific diagnostic tests. The ability to choose the appropriate assessment tool(s) as well as determine the frequency and timing of its administration allows the teacher to gather data that is relevant, sufficient, and valid in order to make judgements about student learning during the learning cycle.</p> <p>Finally, to meet the scalability requirement, it is likely that any intervention in the UK context would involve providing online diagnostic tests.</p> <p>Therefore the cost of the intervention in the UK would have to include:</p> <ul style="list-style-type: none"> • test development and piloting • test delivery platform (license or buy) • provision of training to use and interpret tests • on-going promotion of adoption with schools and colleges in order to achieve systematic use within departments. <p>This could be part of a wider technology enhanced learning intervention which also includes low cost provision of online tutoring (see "An examination of an online tutoring program's impact on low-achieving middle school students' math achievement" summary) and/or high quality targeted eLearning resources (see "Proportional reasoning in the laboratory: an intervention study in vocational education" summary).</p>
Quality of evidence	High. Large scale high quality study, but needs to be interpreted with care for

	the UK context, as noted above.
Gaps in evidence	<p>This is a convincing study of the positive effects of maths diagnostic assessment when mandated in schools in a US state. It is not clear that the approach can be easily adopted in the UK context. In particular:</p> <ul style="list-style-type: none"> • Systematic use (mandated testing) was deemed to be key to the success of the approach • At least part of the gain was due to streaming students into the most appropriate class for subsequent years' teaching. <p>Neither of these two aspects is likely to be a feature of any UK development. However the core of the intervention remains interesting:</p> <ul style="list-style-type: none"> • Providing high quality diagnostic maths assessments targeted at specific areas of mathematical skill (aligned to the curriculum) • Supporting teachers in using and interpreting the tests • Encouraging institution wide adoption in order to induce a systematic examination among math teachers about strategies to address the most common problem areas among students.
Contact details of researchers if available	

Title of article	An examination of an online tutoring program's impact on low-achieving middle school students' math achievement
Author (s)	Shanan L. Chappell, Pamela Arnold, John Nunnery
Date of publication	2015
Background to the intervention	<p>Many tutoring programs have been successful in improving student outcomes. There is no specific model of effectiveness, but researchers mostly agree that successful tutoring programs share some common characteristics. These characteristics include well-trained, focused tutors, one-to-one tutoring experiences, and continual assessment to inform teaching.</p> <p>The purpose of the current study was to determine the impact of Focus Education's (FEV) synchronous online tutoring service on struggling middle school students' math achievement. Students from two middle schools (age 11–13) participated in this study: a large, rural school in southern Virginia, and a large rural school in central Kansas. No information is given as to the choice of schools. Forty-nine 11 year old students from school one and seventy 12 and 13 year old students from school two received tutoring during the 2013-2014 academic year. All student participants in the study, both treatment and comparison, earned below passing scores on either the state standardized mathematics assessment for the 2012-2013 academic year, or failed the FEV program specific pre-test assessment at the beginning of the 2013-2014 academic year.</p>
Context of delivery	<p>This study adds to the body of knowledge surrounding online math tutoring by exploring how outcomes of tutored middle school students compare to those of students exposed only to their schools' business-as-usual math instruction.</p> <p>The intervention was delivered in two middle schools in the US. Tutoring services were provided via a supplier's (FEV) online tutoring system. Participating students were "pulled out" of normal maths class time for individual tutoring.</p> <p>Students attended tutoring twice a week for 20 weeks. A total of 61 tutors provided services for these students, with students working with an average of 8 tutors over the duration of the program.</p> <p>FEV also administers diagnostic assessments that allow development of an individualized learning plan for each student. Learning plans are aligned with the school's curriculum standards and scope. Tutors were able to make use of the learning plan in their tutoring.</p>
Detailed description of the intervention	<p>This study explores how outcomes of tutored middle school students in two US schools compare to those of students exposed only to their schools' business-as-usual mathematics instruction. The study adopted a mixed-method approach, using quantitative methods to address the tutoring's impact on maths scores, and qualitative methods to examine tutor and student perceptions. A quasi-experimental pre-test/post-test design was used</p>

to analyse within-group changes in achievement scores for students in each school, with separate analyses conducted for each school.

The tutoring was provided by FEV tutors. Each had a minimum of a four-year degree and two years teaching or tutoring experience, had undergone background checks, and was subject to quality and performance monitoring.

No specifics are given on whether tutors were trained or encouraged to use any specific methodology. However the study did try to capture the approaches they adopted:

- Almost all tutors discussed implementing pre and post assessments (features of the FEV system) of student learning during each session, and analyzed these data to guide the instruction provided in the session
- Almost all tutors described the delivery of guided practice to students, and many discussed the use of multiple explanations and representations of target concepts
- Tutors described interventions focused on accessing prior knowledge, modelling, explaining the steps in mathematical processes, identifying both process and operational errors, and scaffolding through the use of questions or prompts.

Analysis of student post-session commentary on the tutoring sessions revealed both positive and negative perceptions. Positive comments outnumbered negative comments by a ratio of three to one. Approximately 40% of students spontaneously indicated that they found the session to be helpful for their mathematics learning, and about a quarter of students identified specific learning outcomes of the session. For example, one student commented, “Good session—now I understand integers.” Another noted, “Now I get irrational numbers and rational numbers.”

Student negative commentary about the tutoring sessions was far less frequent than positive commentary, but was often more specific in nature. The two most prevalent themes of negative response to tutoring were related to pacing of the sessions and the desire for more explanation. Students who made comments about pacing were far more likely to say the session went too slow rather than too fast. Some students did specifically articulate that too much time was spent on tutor explanation, and not enough on student work. For example, one student noted, “He doesn’t let me work out the problem even when he tells me to solve it on my own.”

The quantitative analysis of impact involved conducting paired samples t-tests for each school using pre-treatment and post-treatment scores to determine within-group changes in each school. Tutored students were also matched with non-tutored students and between-group differences were examined.

Within-group differences from pre-intervention to post-intervention for school one showed significant improvement in scores for the group, with a mean improvement of 22.88 points ($t = 5.99$, $p < .001$). Within-group effect size estimates for school one were $d = +0.95$ for tutored students and $d =$

	<p>+0.24 for non-tutored students. The within-group effect size estimate for tutored students in school two was $d = +1.47$ (there was no between-group for school two).</p> <p>In summary, the authors claim that their study “supports the extant literature on online math tutoring and provide further evidence that the strategy can be successful in improving math achievement of underperforming middle school students when compared to their non-tutored peers”. However they also note that “these results were observed in a context where the schools were implementing a well-resourced and proven instructional model”, and that “the generalizability of the results is limited in that both samples included very low-performing students from rural populations, and both schools were already engaged in a substantial school-wide math instruction improvement initiative.”</p>
Size of impact	<p>Within-group effect size estimates for school one were $d = +0.95$ for tutored students and $d = +0.24$ for non-tutored students. The within-group effect size estimate for tutored students in school two was $d = +1.47$ (there was no between-group for school two).</p>
Cost of delivery	<p>This is a small scale study, involving only two US middle schools. Furthermore it is a study of a particular online tutoring service, provided by a commercial supplier. Nevertheless it is interesting for two reasons:</p> <ul style="list-style-type: none"> • While the evidence in the literature does seem a little mixed, there is a growing body of evidence to support the effectiveness of online tutoring (if done well) • This is a potentially scalable approach using the internet and low costs tutors e.g. PhD students, trainee teachers, overseas tutors etc. <p>The latter point, suggesting that online tutoring could be effective using relatively low cost tutors, is not currently supported (nor disproved) by evidence. However this is an emerging model in technology enhanced learning, and a number of suppliers are now offering services around this model. It is likely that we will see a sharp increase in coming years of internet-based tutoring services being purchased as part of exam preparation by parents to try and ensure their children achieve at GCSE and A level. The tutoring is likely to be delivered not by qualified UK teachers, but by overseas teachers, PhD students, etc.</p> <p>Therefore the model which could be investigated by EEF is targeted, low cost provision of online tutoring to convert sub-C grades. This could be part of a wider technology enhanced learning intervention which also included provision of high quality diagnostic maths assessments targeted at specific areas of mathematical skill (see “Does Diagnostic Math Testing Improve Student Learning?” summary) and/or high quality targeted eLearning resources (see “Proportional reasoning in the laboratory: an intervention study in vocational education” summary).</p>
Quality of evidence	<p>Medium high (2). This is a small scale study within limitations which are admitted by the author. Nevertheless their conclusion that their study provides further evidence that online tutoring can be successful seems credible on the basis of the evidence provided.</p>

Gaps in evidence	The study did not randomly assign students to treatment, so it is not possible to definitively attribute outcomes to the tutoring program. Further they note that the generalizability of the results is limited in that both samples included very low-performing students from rural populations, and both schools were already engaged in a substantial school-wide math instruction improvement initiative.
Contact details of researchers if available	Dr. Shanan L. Chappell, Research Assistant Professor, The Center for Educational Partnerships, Old Dominion University, Norfolk, VA 23508 schappel@odu.edu, 757-683-6957

Title of article	Proportional reasoning in the laboratory: an intervention study in vocational education
Author (s)	Arthur Bakker & Djonie Groenveld & Monica Wijers & Sanne F. Akkerman & Koeno P. E. Gravemeijer
Date of publication	2012
Background to the intervention	<p>The study is focussed on an example of vocational maths that is explicitly carried out by employees: computing concentrations of chemical substances in a laboratory. It is an application of proportional reasoning, a type of mathematical reasoning considered difficult for many students.</p> <p>The researchers designed simulations of chemical dilution experiments with accompanying learning tasks in order to gain more insight into how such vocational mathematical knowledge for workplace tasks can be developed. The simulations were tested on students in laboratory schools at senior secondary vocational school level in the Netherlands (students enter senior secondary at the age of 16). The aim was to see if the simulations could engender a better proficiency in the proportional reasoning of students calculating dilutions of chemical solutions. In essence the “computer tool” is a high quality targeted eLearning resource, and the mathematical computations were situated in the core work task of determining chemical concentrations. Therefore this study provides some evidence that high quality, contextual eLearning can lead to gains in vocational mathematics.</p> <p>All participants were first-year students (aged 16–23), from three different schools, all studying to become lab technicians.</p>
Context of delivery	<p>The context was senior secondary vocational school level in the Netherlands.</p> <p>The “computerised tools” (i.e. the simulations) focus on practical applications of mathematics within specific, relevant workplace tasks (computing concentrations of chemical substances in a lab).</p> <p>The tool was designed in collaboration with two teachers from different vocational schools. Classroom delivery was by the students’ regular teachers; some, but not all sessions were observed by the researchers and also involved an introduction to the simulated tasks. Students were asked to work through the series of tasks in pairs due to indications that learning collaboratively has advantages for motivation and performance, although some chose to work on their own.</p> <p>In essence these “tools” are high quality, targeted eLearning resources. Thus they have certain advantages in the vocational context. For example, they can assist in highlighting just those operations that designers intend students to engage with, which not always easily accomplished possible in vocational tasks. A second advantage is that time-consuming tasks can be speeded up so that students can concentrate on just those aspects of the key tasks they find</p>

	<p>difficult.</p> <p>The research is therefore firmly in the vocational context rather than the academic (GCSE) context. This is a more developed example of contextualising mathematics, embedding the required theory and calculations in specific occupational tasks.</p>
Detailed description of the intervention	<p>Researchers designed the simulations in collaboration with two teachers from different vocational schools. In designing the tool the authors take a holistic view in instructional design and (in line with quoted best practice in competence-based education) assume that a clear link to tasks carried out by the profession stimulates learning because students can then better integrate the different types of knowledge involved. The design also follows the paradigm that learning tasks are more successful if the complexity of the underlying mathematics can be layered; that is, addressed in several stages of difficulty. The simulations layered the complexity involved, starting with simple colour strips and moving from using a graph to using a mathematical formula.</p> <p>The proportional reasoning involved in determining concentrations after dilution is a typical case of reasoning with situated abstractions. The tool provided a number of simulations involved in measuring concentrations of substances, progressing from simple to more complex tasks. The simulations involved on-screen depictions of pipettes, measuring flasks, liquids, measuring scales, pH strips, and charts of data. The tool foregrounds proportional reasoning of a core work task.</p> <p>The simulations were administered to three groups of students as part of their normal vocational instruction (to be a lab technician). Pre- and post-tests of various computations involving dilution of solutions were used to assess the gains of learners in proportional reasoning after 50—90 minutes instruction using the tool. These tests consisted of four open-ended tasks and lasted up to 25 min (pre-test) and 20 min (post-test). The items in the pre- and post-test were pairwise similar, using only different substances and quantities. Four laboratory teachers independently judged the tests to be equally difficult.</p> <p>The study reports significant gains for learners after 50—90 minutes instruction time using the tool. However:</p> <ul style="list-style-type: none"> • the sample size was small (47 learners) • there was no control group • teachers from two of the three schools had contributed to the design, and might therefore be more likely to engage fully with the tool than a typical teacher. <p>There is therefore only limited credible quantitative evidence for the claims around gains. However the report does provide qualitative evidence that the tool has been developed according to good practice (e.g. provides a layered progression from simple to more complex tasks and ideas) and is well received by the students and teachers. In conjunction with the (limited) quantitative evidence, the paper does support the view that instruction based around the tool is effective.</p>

Size of impact	The researchers tested whether the students scored significantly better on the post-test. Working on the tool for approximately 50 - 90 minutes on two occasions had a significant effect on test outcome; the effect size ($r=0.63$) shows a large effect. Note however this was on a very small sample—only 47 students.
Cost of delivery	<p>In essence the tool is a high quality targeted eLearning resource. This paper therefore provides some evidence that high quality, contextual eLearning can lead to gains in vocational mathematics.</p> <p>However the tools described were the result of about 300 hours of programming. The authors concede that it would be expensive to develop such tools for all challenging mathematical aspects of occupations.</p> <p>The conclusion here is probably that while high quality targeted eLearning resources can be effective in helping students develop practical (perhaps workplace related) mathematical skills, it is not clear a) the extent of the curriculum this is applicable to, nor b) whether such an approach is scalable, given the cost implications. However any investment in custom eLearning for specific mathematics applications could perhaps be recouped over time, as the resources would be reusable over many years.</p> <p>Therefore this intervention could form part of a wider technology enhanced learning intervention which also includes low cost provision of online tutoring (see “An examination of an online tutoring program’s impact on low-achieving middle school students’ math achievement” summary) and/or provision of high quality diagnostic maths assessments targeted at specific areas of mathematical skill (see “Does Diagnostic Math Testing Improve Student Learning?” summary).</p>
Quality of evidence	Medium high (2). As above, the quantitative evidence is limited due to the sample size and the absence of a control group. However the evidence which is presented is credible and rigorously reported.
Gaps in evidence	As above, a) the extent of the curriculum this is applicable to, nor b) whether such an approach is scalable, given the cost implications.
Contact details of researchers if available	A. Bakker (*) : D. Groenveld : M. Wijers : S. F. Akkerman, Freudenthal Institute, Utrecht University, Utrecht, Netherlands: e-mail: a.bakker4@uu.nl

7 Appendix 2: Search Strategy

7.1 Bibliographic databases

The search strategy for each database reflects the differences in database structure and vocabulary. Throughout, the abbreviation 'ft' denotes that a free-text search term was used and the symbol * denotes truncation.

Australian Education Index (searched via ProQuest 15/03/16)—1477 records

The Australian Education Index (AEI) is a subscription database produced by the Australian Council for Educational Research (ACER) consisting of more than 200 000 entries relating to educational research, policy and practice.

#1 16-18 (ft)

#2 16-19 (ft)

#3 Apprenticeships

#4 further education (ft)

#5 further education colleges (ft)

#6 High School Students

#7 High Schools

#8 post 16 (ft)

#9 Postsecondary Education

#10 Secondary Colleges

#11 Secondary Education

#12 Secondary Schools

#13 Secondary School Students

#14 sixth form* (ft)

#15 sixth form college* (ft)

#16 study program* (ft)

#17 TAFE

#18 TAFE Colleges

#19 TAFE Students

#20 Upper Secondary Years

#21 Vocational Education

#22 Vocational Education and Training

#23 vocational training (ft)
 #24 work based learning (ft)
 #25 Work Place Learning
 #26 #1 or #2 or #25

#27 English
 #28 English Curriculum
 #29 English instruction (ft)
 #30 English Teaching
 #31 functional English (ft)
 #32 Functional Literacy
 #33 functional math* (ft)
 #34 functional numeracy (ft)
 #35 Functional Reading
 #36 Literacy
 #37 Literacy Education
 #38 Mathematics
 #39 Mathematics Curriculum
 #40 Mathematics Education
 #41 math* instruction (ft)
 #42 Mathematics Skills
 #43 Numeracy
 #44 Reading
 #45 Workplace Literacy
 #46 Writing Composition
 #47 #27 or #28 ... or #46

#48 Academic Achievement
 #49 assessment (ft)
 #50 diagnostic assessment (ft)
 #51 Educational Assessment
 #52 Educational Attainment

#53 Low Achievement

#54 Mathematics Achievement

#55 Outcomes of Education

#56 outcomes (ft)

#57 Reading Achievement

#58 Writing Achievement

#59 Certification

#60 functional skills (ft)

#61 GCSE (ft)

#62 General Certificate of Secondary Education (ft)

#63 key skills (ft)

#64 Qualifications

#65 Intervention

#66 program* (ft)

#67 Programs

#68 support (ft)

#69 Employers

#70 Mentors

#71 Mentoring

#72 one to one (ft)

#73 Tutors

#74 Tutoring

#75 Curriculum Materials

#76 instructional material* (ft)

#77 online material* (ft)

#78 online support (ft)

#79 support material*(ft)

#80 teaching material* (ft)

#81 catch up (ft)

#82 disengag* (ft)

#83 learner engagement (ft)

#84 Learning Motivation

#85 remedial instruction (ft)

#86 resit* (ft)

#87 retak* (ft)

#88 second chance (ft)

#89 Student Motivation

#90 Cognitive Style

#91 collaborative working (ft)

#92 contextuali*ed learning (ft)

#93 Grouping (Teaching Purposes)

#94 instruction (ft)

#95 Learning Processes

#96 learning style* (ft)

#97 pedagog* (ft)

#98 Teaching Methods

#99 Teaching Process

#100 Teaching Styles

#101 continuing professional development (ft)

#102 CPD (ft)

#103 English Teachers

#104 Inservice Teacher Education

#105 Mathematics Teachers

#106 Professional Development

#107 specialist teacher* (ft)

#108 TAFE Teachers

#109 teacher collaboration (ft)

#110 Teacher Cooperation

#111 Teacher Education

#112 Teachers

#113 Disadvantaged

#114 Economically Disadvantaged

#115 Educationally Disadvantaged

#116 High Risk Students

#117 Low Income

#118 Low Income Groups

#119 #48 or #49... or #118

#120 #26 and #47 and #119

British Education Index (searched via EBSCO Host 15/03/16)—761 records

The British Education Index (BEI) includes all aspects of education policy and administration, evaluation and assessment, technology and special educational needs providing extensive coverage of UK research journals.

#1 16-18 (ft)

#2 16-19 (ft)

#3 apprenticeship* (ft)

#4 Apprenticeship Programs

#5 further education (ft)

#6 further education college (ft)

#7 High School Students

#8 High Schools

#9 post 16 (ft)

#10 Secondary Education

#11 Secondary Schools

#12 Secondary School Students

#13 sixth forms (ft)

#14 sixth form colleges (ft)

#15 study program* (ft)

- #16 upper secondary (ft)
- #17 Vocational Education
- #18 Vocational training (ft)
- #19 Work based learning (ft)
- #20 workplace learning (ft)
- #21 #1 or #2 or #20

- #22 English (ft)
- #23 English curricul* (ft)
- #24 English Instruction
- #25 functional English (ft)
- #26 Functional Literacy
- #27 functional math* (ft)
- #28 functional numeracy (ft)
- #29 Functional Reading
- #30 Literacy
- #31 Literacy Education
- #32 mathematics (ft)
- #33 mathematics education (ft)
- #34 mathematics instruction (ft)
- #35 mathematics skills (ft)
- #36 Numeracy—Study & Teaching
- #37 Reading
- #38 Workplace Literacy
- #39 Writing
- #40 #22 or #23 ... or #39

- #41 Academic Achievement
- #42 assessment (ft)
- #43 diagnostic assessment (ft)
- #44 educational assessment (ft)
- #45 Educational Attainment

#46 Educational Evaluation

#47 Educational Tests & Measures

#48 low achievement (ft)

#49 mathematics achievement (ft)

#50 outcomes of education (ft)

#51 outcomes (ft)

#52 Reading Achievement

#53 writing achievement (ft)

#54 Certification

#55 functional skills (ft)

#56 GCSE (ft)

#57 General Certificate of Secondary Education

#58 key skills (ft)

#59 qualifications (ft)

#60 intervention (ft)

#61 program* (ft)

#62 support (ft)

#63 employer* (ft)

#64 Mentors

#65 mentor*

#66 one to one (ft)

#67 tutor* (ft)

#68 Tutors & Tutoring

#69 instructional material* (ft)

#70 online material* (ft)

#71 online support (ft)

#72 support material*(ft)

#73 teaching material* (ft)

- #74 catch up (ft)
- #75 disengag* (ft)
- #76 learner engagement (ft)
- #77 learning motivation (ft)
- #78 Motivation in Education
- #79 remedial instruction (ft)
- #80 resit* (ft)
- #81 retak* (ft)
- #82 Re-testing in Education
- #83 second chance (ft)
- #84 Student Engagement
- #85 student motivation (ft)

- #86 Ability Grouping (Education)
- #87 Cognitive Styles
- #88 Collaborative Learning
- #89 collaborative working (ft)
- #90 contextuali*ed learning (ft)
- #91 grouping (ft)
- #92 instruction (ft)
- #93 learning process* (ft)
- #94 learning style* (ft)
- #95 pedagog* (ft)
- #96 Teaching Methods
- #97 teaching style* (ft)

- #98 continuing professional development (ft)
- #99 CPD (ft)
- #100 English Teachers
- #101 Inservice teacher education
- #102 Mathematics Teachers

#103 specialist teacher* (ft)

#104 Teacher Collaboration

#105 Teacher Education

#106 Teachers

#107 Teachers—In-service Training

#108 At-risk Students

#109 disadvantaged (ft)

#110 Educationally Disadvantaged Students

#111 low income (ft)

#112 low income group* (ft)

#113 Low-income High School Students

#114 Low-income Students

#115 Socioeconomically Disadvantaged Students

#116 #41 or #42 ... #115

#117 #21 and #40 and #115

ERIC (searched via EBSCO Host 10/03/16)—5136 records

ERIC—the Education Resources Information Center—is an extensive collection of US and international educational research, policy and practice resources sponsored by the Institute of Education Sciences (IES) of the U.S. Department of Education.

#1 16-18 (ft)

#2 16 to 18 (ft)

#3 16-19 (ft)

#4 16 to 19 (ft)

#5 Apprenticeships

#6 further education (ft)

#7 further education colleges (ft)

#8 High School Students

#9 High Schools

#10 post 16 (ft)

#11 Secondary Education

#12 Secondary Schools

#13 Secondary School Students

#14 Vocational Education

#15 Vocational training (ft)

#16 Work based learning (ft)

#17 Work Place Learning

#18 #1 or #2 or #17

#19 English

#20 English Curriculum

#21 English Instruction

#22 functional English (ft)

#23 Functional Literacy

#24 functional math* (ft)

#25 functional numeracy (ft)

#26 Functional Reading

#27 Literacy

#28 Literacy Education

#29 Mathematics

#30 Mathematics Instruction

#31 Mathematics Skills

#32 Numeracy

#33 Reading

#34 Reading Instruction

#35 Workplace Literacy

#36 Writing

#37 #19 or #20 ... or #36

#38 Academic Achievement

#39 assessment (ft)

#40 diagnostic assessment (ft)

#41 Educational Assessment

#42 Educational Attainment

#43 Low Achievement

#44 Mathematics Achievement

#45 Outcomes of Education

#46 outcomes (ft)

#47 Reading Achievement

#48 Certification

#49 Functional Skills (ft)

#50 GCSE (ft)

#51 General Certificate of Secondary Education (ft)

#52 Key Skills (ft)

#53 Qualifications

#54 Intervention

#55 program* (ft)

#56 Programs

#57 support (ft)

#58 Employers

#59 Mentors

#60 mentor*

#61 one to one (ft)

#62 tutor* (ft)

#63 Instructional Materials

#64 online material* (ft)

#65 support material*(ft)

#66 teaching material* (ft)

#67 disengag* (ft)

#68 Learner Engagement

#69 Learning Motivation

#70 resit* (ft)

#71 retak* (ft)

#72 second chance (ft)

#73 Student Motivation

#74 Cognitive Style

#75 collaborative working (ft)

#76 contextuali*ed working (ft)

#77 Grouping (Instructional Purposes)

#78 Instruction

#79 Learning Processes

#80 learning style (ft)

#81 pedagog* (ft)

#82 Teaching Methods

#83 Teaching Styles

#84 continuing professional development (ft)

#85 English Teachers

#86 Inservice teacher education

#87 Mathematics Teachers

#88 specialist teachers (ft)

#89 Teacher Collaboration

#90 Teacher education

#91 Teachers

#92 Disadvantaged

#93 Economically Disadvantaged

#94 Educationally Disadvantaged

#95 Low Income

#96 Low Income Groups

#97 employability

#98 further study

#99 labour market outcomes

#100 progression

#101 #38 or #39 ... #100

#102 #18 and #37 and #101

#103 GCSE English (ft)

#104 GCSE Maths (ft)

#105 GCSE Mathematics (ft)

#106 post-16 English

#107 post-16 literacy

#108 post-16 maths (ft)

#109 post-16 numeracy

IDOX Information Service (searched 15/03/16)

All free-text

#1 GCSE maths

#2 GCSE mathematics

#3 GCSE English

#4 post-16 English

#5 post-16 literacy

#6 post-16 maths

#7 post-16 mathematics

#8 post-16 numeracy

#9 post-16 literacy

7.2 Journal ‘hand searches’

Volumes of the following journals published between January 2005 and March 2016

[Journal of Vocational Education and Training](#)

[Journal of Further and Higher Education](#)

7.3 Website searches

We also browsed the publications/research/policy sections of the following websites:

Advisory Council on Mathematics Education (ACME), Association of Colleges (AoC), Association of Colleges in the Eastern Region (ACER), Association of Employment and Learning Providers (AELP), Best Evidence Encyclopaedia, Best Evidence in Brief, Centre for Evaluation and Monitoring (Durham University), Centre for Post-14 Education and Work (IOE), Confederation of British Industry (CBI), Education and Training Foundation (ETF), Excellence Gateway, Gatsby, GOV.UK (Department for Education (DfE), Department for Business, Innovation and Skills (BIS), OFSTED and UKCES), Learning and Work Institute, Mathematics in Education and Industry, MRDC, NRDC, National Association for Numeracy and Mathematics in Colleges, National Centre for Excellence in the Teaching of Mathematics, NFER including the ‘On the Web’ archive, National Literacy Trust, National Numeracy, Nuffield Foundation, OECD, RSA, Scottish Government, SRDC (Canada), Sutton Trust, Welsh Government and What Works Clearing House.

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