Trial Evaluation Protocol
The 5Rs approach to GCSE Maths resits

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PROJECT TITLE	**The 5Rs approach to GCSE Maths resits, a two-arm cluster randomised trial**
DEVELOPER (INSTITUTION)	Julia Smith Ltd & Association of Colleges
EVALUATOR (INSTITUTION)	York Trials Unit, University of York
PRINCIPAL INVESTIGATORS	Pam Hanley & Louise Elliott
PROTOCOL AUTHORS	Pam Hanley, Louise Elliott, Caroline Fairhurst & Elizabeth Coleman
TRIAL DESIGN	Two-armed cluster randomised controlled trial with random allocation at the setting level (efficacy)
PUPIL AGE RANGE AND KEY STAGE	Aged 16-19; KS5
NUMBER OF SCHOOLS	80 post-16 settings
NUMBER OF PUPILS	Max 6400
PRIMARY OUTCOME	GCSE Maths raw mark
SECONDARY OUTCOME	GCSE Maths grade; attendance at exam sessions; student attitude towards mathematics

Protocol version history

VERSION	DATE	REASON FOR REVISION
1.0 [*original*]	06/06/2019	

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Intervention

The 5Rs is a well-manualised intervention that aims to enhance the support teachers give to students re-sitting their GCSE Maths to improve their attainment. It consists of both a set lesson structure and lesson content. The content is built on the 40 most common topics in GCSE exams, but also draws on good, pre-existing (mostly free) materials like the Corbett Maths revision cards. Three initial diagnostic tests, which each contain nine questions, are used to determine any gaps within the nine basic skills of maths, as these are targeted first within the 5Rs approach. The test was designed by Julia Smith, who designed the 5Rs programme, for AQA.

Teachers who have signed up to the trial and been allocated to the intervention (maximum five per setting) receive an initial day of training, which outlines the method and the theory behind the intervention. This will take place in September 2019, followed by one catch up day of training in each of the following two terms. Julia Smith will deliver the training to schools and colleges in the South of England and will train two additional personnel to deliver the training to schools and colleges in the North. After the first training day, teachers should be able to start using the model. Students will have access to various online resources via the Padlet application to facilitate their study outside the classroom. The lesson structure – the 5Rs approach - is outlined below:

5Rs	**Description**	**Duration (minutes)**
Recall of knowledge	This uses the Corbett cards and is a mix of different topics	5
Routine maths practice	Practice questions/worksheets on a range of topics	10
Revise a key topic	This focuses on one specific topic	15
Repeat with exam questions	Exam questions to reinforce the learning from the topic covered in revise, initially modelled by a teacher	15
Ready for exam	Focuses on good exam technique and commonly made mistakes	15

The logic model in Appendix 1 outlines the mechanism by which the intervention is expected to work. The 5Rs training and curriculum feed into improving teacher understanding of resit learning requirements and ensure that teachers understand the pedagogical basis of 5Rs. This in turn leads to changes in classroom practice, resulting in improvements in student study skills, student engagement with lessons and (in parallel with provision of online resources) boosting students engagement with online resources to revise outside the classroom. These are expected to enhance student understanding and application of maths skills; exam technique; and confidence, attitude and motivation towards maths, culminating in improved achievement in GCSE maths resits. Evidence from where the 5Rs is being used demonstrates that students are frequently using the student Padlet; as an example 77 Leeds City College students have used the revision approach Padlet 770 times in a one month period.

The programme will be delivered from early in the Autumn Term 2019 until the GCSE maths exam(s) in the Summer Term 2020. Teachers are expected to use the 5Rs approach in every maths lesson during this period.

Table 1 summarises specific aspects of what 5Rs will look like within the evaluation via a Template for Intervention Description and Replication (TIDieR), as adapted for EEF projects (Humphrey et al., 2016).

Table 1: TIDieR

Aspect of TIDieR	Exemplification relating to the evaluation
Brief name	5Rs (an approach for post-16 students studying and preparing to re-sit GCSE Maths, developed by Julia Smith)
Why: Rationale, theory and/or goal of essential elements of the intervention	The 5Rs approach has been developed to improve maths skills and outcomes through a revision focused curriculum. This will cover the mathematical basics, plug knowledge gaps, improve exam technique and introduce students to alternative mathematical methods that they will not have encountered in school. It aims to give students: • the skills to avoid common mistakes and to address misconceptions; • the ability to ensure they practice and maintain their existing maths knowledge and skills; • an increase in motivation and the ease of ability to revise outside of lessons by using technology effectively. It has been designed to look and feel different to students' previous learning experiences so as not to emulate previous experience and emphasises self-study outside lessons on the basis that this should increase success rates. The year-long approach is based upon revision techniques as the student starting point isn't that they know nothing. The curriculum model draws upon the work of: Awarding Body Chief Examiners – specifically AQA and Edexcel annual GCSE maths exam reports; Ofsted commentary on maths resit classes – every Ofsted report will have a reference to GCSE maths resit classes; the Department for Education's assessment objectives; and a wealth of advice and guidance from a range of post-16 resit practitioners. The 5R's is a structured format of five key components delivered during a one hour lesson, namely: 1. Recall (the 90 key maths facts) 2. Routine (to keep topics fresh) 3. Revise (one topic per lesson) 4. Repeat (key exam questions) 5. Ready (for the exam)
Who: Recipients of the intervention	Maximum of five teachers of maths resits per setting will undergo three days of training. All students in intervention settings aged 16-19 that have not yet achieved a pass (Grade 4 or above) at GCSE Maths and are studying to take GCSE Maths in either November 2019 or May/June 2020.
What: Physical or informational materials used in the intervention	Teachers will be provided with schemes of work and lesson plans. They will also have access to a secure website which will give them access to the intervention resources, videos demonstrating alternative methods and online support through an FAQ section with facilities for teachers to ask questions and to develop a community of practice. This is managed by Julia Smith. Students will have access to CorbettMaths cards and online resources via Padlet. The resources are a range of free websites including onmaths.com, mathsbot.com, corbettmaths.com, m4ths.com. There are 25

	resources available to students. These are popular areas for student revision which allow them to watch video instruction or sit past papers and questions which also self-mark.
What: Procedures, activities and/or processes used in the intervention	• Teaching staff CPD - 1 day per term – the training will be delivered according to geographical take up of the places in the trial. It will consist of face-to-face events – centralised or hosted in smaller hubs. The training will familiarise teaching staff with the approach and introduce the resources, scheme of work, lesson plans and Padlets. • Day 1 delivers the Autumn Term lesson plan materials, Padlet technologies and approaches as well as the rationale behind the 5RS; Day 2 the Spring term which includes the lesson plan materials and Top Tips and Day 3 the Summer Term up to and including exam time and more specific exam technique classroom work. • Any teachers not able to attend the training will be supported by the trainers, any colleagues who may have attended and through the on-line support mechanism via the website. • 5Rs schemes of work and lessons plans. The scheme of work is specific to the Department of Education GCSE maths specification and, as such, is not exam board specific. • Initial diagnostic tests to determine students' current level of knowledge/achievement • Online support through the secure 5Rs website. This support consists of a contact page where there are FAQ's or an online form can be completed and, if necessary, a phone call can be arranged for further assistance
Who: Intervention providers/implementers	The programme is designed to be delivered by the usual teaching staff for post-16 GCSE resit maths. The teaching staff will receive three days training from one of three trainers from the project team. Someone in each setting will be designated the project lead and will take responsibility for its smooth running as well as being the main contact with the delivery and evaluation teams. This will be a member of staff who the college decides is in the best position to deliver what is required from the project lead (probably either a member of teaching staff, a senior manager, or an administrator).
How: Mode of delivery	The CPD will be delivered as face-to-face, hands-on training with an online presence for guidance and support. The programme itself will be delivered to whole classes in the standard time slots for GCSE resit maths.
Where: Location of the intervention	The CPD will be delivered at a venue local to the setting. 5Rs will be delivered in the usual classroom space for GCSE resit lessons. Settings will be recruited across England.
When and how much: Duration and dosage of the intervention	The CPD will be delivered in single full-day slots at the beginning of each term. The 5Rs programme will be delivered as a replacement for the standard GCSE resit lessons for an entire academic year. It is anticipated that this will be around 3 hours a week.

Tailoring: Adaptation of the intervention	The structure of 5Rs lessons is well defined and teaching staff will be provided termly with a scheme of work and teaching resources. However, they may make surface adaptations in order to facilitate a sense of ownership and fit to learner context. Where the lesson slots do not equate to the one-hour sessions in the 5Rs model, teachers would be advised how to adjust the content accordingly. For instance, the Revise/Repeat sections can be repeated with an additional core topic to fill a longer lesson.
How well (planned): Strategies to maximise effective implementation	In order to maximise the effectiveness of the implementation the following strategies will be adopted: • Teaching staff to take part in face-to-face training sessions each term • On-going support provided to teaching staff through the 5Rs website

Study rationale and background

New funding regulations (2014/15) mean that full time students aged 16-19 who have achieved a grade D/3 in GCSE maths must continue studying GCSE maths as a "condition of funding" of their further education. Those getting lower grades and part-time students must also continue studying maths, but not necessarily to GCSE (e.g. they may choose Functional Skills). Recent surveys by the Association of Colleges identify pressures caused by maths resits as one of greatest concerns for colleges (AoC, 2018a) and vacancies for maths teachers as the third most difficult to fill (AoC, 2018b).

In 2017, a new "more demanding" maths GCSE was introduced along with the change in grading from A-G to 9-1 (Maughan et al., 2016). Only 22.6% of those aged 17+ taking GCSE maths achieved a pass mark (grade 4 or higher) in 2018 - the lowest rate since the resit policy was introduced, adding to the disquiet among some stakeholders who argue that young people should be learning more relevant maths skills (Burke, 2018).

It is notoriously difficult to conduct research with 16-19 year olds, and previous studies among those doing GCSE maths resits have reported attrition rates of 60% (Swan, 2006) and 65% (Hough et al, 2017) although the latter was across five data points (absence rates rising from 12% to 42% across the academic year). Another consideration is the different contexts of the post-16 settings: for instance, sixth form colleges are more likely to have qualified maths teachers and an academic slant whereas non-specialist maths teachers and students taking vocational courses will be more prevalent in Further Education (FE) colleges. A report from Hayward and Homer (2015) highlighted several differences between the two, including a higher proportion of maths teachers in FE colleges having only GCSE maths and being part-time.

There is some case study evidence that 5Rs has had a positive impact on student attendance rates and increased the proportion passing their GCSE maths resits. AQA have published a case study on West Suffolk College (WSC) for example[1]. This showed that resit pass rates rose from 20% in 2015 to 40% in 2017 (compared with national average pass rates of 31% and 29.5% respectively). The senior manager in charge of maths at WSC ascribed this to a change of delivery model in January 2016 to introduce the 5Rs approach and improve the tracking of student progress. It is unclear how widely the approach has been implemented: it is, for instance, available as a guide for teaching post-16 maths resits

[1] https://filestore.aqa.org.uk/resources/mathematics/AQA-GCSE-MATHS-POST16-CS-WSC.PDF

on the AQA website (AQA). A number of AQA centres attended training on the 5Rs approach such was the support from the Awarding Body. The 5Rs approach offers a pedagogically solid approach, drawing on a range of researched revision approaches from the influence of Dunlowsky; incorporates the work of Craig Barton and his diagnostic questions, working on many approaches of spaced and interleaved practice and effective teaching practice which fully incorporates digital technologies through QR codes and Padlet use.

As part of its post-16 theme, the EEF (with co-funding from J P Morgan) wishes to conduct an efficacy trial to find out whether the promising case study findings can be repeated in a more rigorous and larger scale evaluation.

Impact Evaluation

Research questions

The central aim of the trial is to evaluate the impact of 5Rs on GCSE maths attainment for students aged 16-19 who are resitting GCSE maths to try to achieve a pass grade (ie gain a Grade 4 or above).

The primary research question is:

- How effective is 5Rs compared to "teaching as usual" in improving outcomes in maths GCSE scores for resit students aged 16-19?

The secondary research questions, all framed in the context of comparing resit students aged 16-19 following the 5Rs programme with those receiving "teaching as usual", are:

- How effective is 5Rs in improving student pass rate for GCSE maths?
- Does 5Rs have an impact on student attitudes towards maths, as measured by the adapted Attitudes Toward Mathematics Inventory (ATMI)?
- Does 5Rs have an impact on student retention rates as measured by exam attendance?

The final research questions explore the impact of 5Rs on subgroups of the resit 16-19 year old students:

- Does 5Rs have a greater benefit for students doing resits in May/June 2020 rather than November 2019?
- What is the effect of 5Rs on those who have ever been eligible for free school meals (FSM)?

Design

Trial type and number of arms		Two-armed cluster randomised controlled efficacy trial
Unit of randomisation		Setting
Stratification variables (if applicable)		Type of setting (eg FE College); number of students
Primary outcome	variable	GCSE Maths attainment
	measure (instrument, scale)	GCSE Maths raw score converted to z-score for analysis (maximum mark varies by exam board, eg AQA & Edexcel 240, OCR 300)

Secondary outcome(s)	variable(s)	GCSE Maths pass Course retention rates Student attitudes towards Maths
	measure(s) (instrument, scale)	GCSE Maths grade (9-1) – achieving a grade 4 or above, i.e. a pass, as a binary measure Student attendance at each of the 3 exam sessions Adapted Attitudes Toward Mathematics (ATMI) (Tapia & Marsh, 2000)

The achievement of grade 4 or above is the aim of studying and re-sitting GCSE Maths but using GSCE grades allows very little differentiation since most learners will obtain a 3 or 4 on their resit; therefore, the GCSE raw mark will be used as the primary outcome. As the maximum mark and grade boundaries of the raw mark varies by exam board, the raw mark will be converted to 'standard' (z) scores for analysis. Although this differs from standard EEF statistical guidance (which generally recommends against the use of standardised scores), the approach was agreed by all stakeholders to be necessary to avoid restricting eligibility to only one exam board.

Randomisation

Once eligible settings have signed the MOU and provided baseline data (see Appendix 2), they will be randomly allocated to receive either the intervention or teaching as usual, using minimisation by type of setting (e.g. FE college, sixth form college, school sixth form, independent training provider) and number of students (estimated from the 2018-19 academic year's cohort; dichotomised at the median for the minimisation). These minimisation factors have been chosen to achieve balance across the trial arms in terms of the type of setting as this may predict outcome, and to achieve roughly equal numbers of students in each arm. The trial statistician at the YTU will be responsible for conducting the minimisation via the software, minimPY (Saghaei & Saghaei 2011). Settings could be randomised on a rolling basis to minimise the time they have to wait to hear the outcome once they have completed all the required pre-randomisation tasks. The analysing statistician will not be blind to group allocation.

Participants

Post-16 education and training providers in England are eligible to take part in the trial. This includes FE colleges, sixth form colleges, school sixth forms, university technical colleges (UTCs) and independent training providers.

Settings are eligible to participate if the following criteria are met:

- They have a minimum of 15 students aged 16-19 re-taking GCSE maths in the year 2018-2019 and expect this number to stay constant or rise in 2019-2020.
- GCSE students are enrolled by September 2019 for the full academic year.

Settings will <u>not</u> be eligible if any of the following apply:

- They operate roll-on roll-off recruitment of students.
- They are involved in the Maths for Life trial funded by EEF.
- They or their staff have previously been trained in or used the 5Rs programme, including accessing the 5Rs materials available on the AQA website. AQA have agreed to check potential participants against their records and will confirm whether

or not they have been previously involved (data protection regulations do not allow us direct access to this information).
- They have been selected as a Centre for Excellence in Maths (CfEM)[2].

Please note:

- Settings with more than one campus are eligible to apply as separate settings if they have completely independent, non-collaborative maths departments. Campuses that fulfil this requirement will be randomised separately.
- A maximum of five teachers can be trained per setting.
- An upper limit of approximately 80 students can participate in the evaluation per setting. Settings with more than 80 students can still deliver the intervention (if they are randomly allocated to the intervention group) to the whole cohort if they wish. However, in such cases the evaluation team will randomly select the teachers/classes to be involved in the evaluation (i.e. those that will be asked to provide data to the evaluation team).
- Where a setting chooses not to deliver the intervention to their whole cohort the evaluation team will randomly select the teachers/classes to be involved in the intervention and evaluation.
- Only students aged 16-19 years will be included in the trial.

Settings will be recruited by the delivery team, with support from the evaluation team. They will be recruited through mass mail-outs, publicity through professional bodies and at talks and conferences, and through personal contacts, as well as using social media to advertise the opportunity.

Students will be eligible to participate providing they have not already achieved a pass grade at GCSE maths (ie not achieved grade 4 or above) and are studying to re-sit GCSE maths in November 2019 or Summer 2020. There are two tiers to GCSE maths: foundation (targeted at grades 5 to 1), and higher (targeted at grades 9 to 4). Therefore, the higher tier paper is not recommended for students who are not expected to achieve grade 6 or above. For this reason, the vast majority of the students we will include in this trial will sit the foundation tier paper, however, we will include students sitting either tier. A sensitivity analysis will explore the impact of excluding any students who do sit the higher tier paper.

Incentives

Whilst the research is designed to minimise burden on participating settings, settings will be required to assist with data collection for both impact and process evaluations. Intervention settings will receive the 5Rs programme and training. Settings allocated to intervention are also expected to release specified staff for training. With this in mind, intervention schools will be provided with a financial payment of £300.

Control settings will be provided with a financial payment of £750.

Incentives to both control and intervention settings will be paid after final data submission (GCSE raw scores and grades for the Summer 2020 exams) to the Evaluation Team.

[2] Settings who are network partners in CfEM can participate in 5Rs unless they are taking part in the national CfEM trial

Sample size calculations

OVERALL

For this efficacy trial, the programme developers specified that they would have capacity to deliver the intervention within a maximum of 40 settings. Therefore, the aim is to recruit 80 settings into the trial and use 1:1 allocation. A maximum of 80, and a minimum of 15-20, learners per setting will be enrolled into the trial; we shall assume there will be an average of 60 students per setting at randomisation (the potential cohort size will vary between settings, eg. large FE colleges and smaller sixth form colleges). A large variation in cluster sizes has the potential to increase the minimum detectable effect size (MDES) that the trial is able to detect. It is possible to account for variation in cluster size in the calculation of the MDES by considering the coefficient of variation of cluster size in the design effect (DE) as per Eldridge *et al* (2006). The DE, also called the variance inflation ratio, is the factor by which the sample size (at analysis) for a comparable individually randomised trial should be multiplied to estimate the required sample size (at analysis) for a cluster RCT. A simple yet conservative estimate of the DE accounting for variable cluster sizes is:

$$DE = 1 + \{(cv^2 + 1)\tilde{m} - 1\}\rho$$

Where the coefficient of variation (cv) is the ratio of the standard deviation of the cluster sizes, s_m, to the mean cluster size, $\tilde{m}$. The average cluster size at randomisation is assumed to be 60; however, if we account for 15% pupil-level attrition at post-test (ie. pupils withdrawing from sitting the exam) then we might expect an average of 51 pupils per setting at analysis ($\tilde{m} = 51$). Since we do not know s_m in advance, this can be estimated by dividing the likely range of cluster sizes (at analysis) by 4 (so (68-13)/4=13.75) (Eldridge *et al,* 2006). Therefore, we assume a cv of 13.75/51=0.27. The symbol ρ represents the intracluster correlation coefficient (ICC). Allen *et al* indicate that the ICC for maths increases with each Key Stage. At Key Stage 4 they calculated an ICC of 0.15 for Maths based on over 500,000 pupils from 3058 schools. Since this trial involves a KS5 population, we shall conservatively assume a slightly increased ICC of 0.17. Within the analysis for this trial we shall adjust for KS2 maths score (KS2 has been chosen as a more discriminating baseline measure because most of the previous GCSE results will be Grade 3). This will correlate with the outcome to increase the power of the trial (ie. decrease the MDES the trial is able to detect). There are limited data on which to estimate the likely correlation between maths KS2 and GSCE resit score for pupils who fail their initial GSCE attempt. There are data to suggest that, nationally, the correlation between KS2 maths and GSCE maths is high (0.76[3]); we shall conservatively assume a lower correlation of 0.6 in this scenario.

Therefore, we anticipate to recruit 4800 students (80 settings with average of 60 students per setting), which will reduce to 4080 at analysis after 15% attrition. Inflating this by ($1-0.6^2$) (Borm *et al.* 2007) to take advantage of the pre-post correlation, and then deflating for the design effect of ~10.15 (accounting for variable cluster sizes), we obtain an effective sample size (for an individually randomised trial) of 628.

With 80% power, this sample size would give us a MDES of approximately 0.22 in the analysis (calculated in Stata v15).

FSM

[3] Appendix 1: http://www.cambridgeassessment.org.uk/Images/181034-exploring-the-value-of-gcse-prediction-matrices-based-upon-attainment-at-key-stage-2.pdf

Data from the Sixth Form Colleges Association (2018 key facts and figures[4]) indicate that 21% of pupils attending sixth form colleges and 16-19 academies are 'disadvantaged', defined as "those who were eligible for free school meals at any point in the previous six years or have been looked after by their local authority". We could find no published data relating to FSM prevalence in our specific trial population (ie. learners resitting GCSE maths). However, we may expect that it is slightly higher than the average of 21%. In the absence of evidence to support this, however, we shall conservatively assume a percentage of 21%. If we recruit 80 setting with an average of 60 pupils, we might therefore expect to have at least 856 FSM pupils in the analysis, assuming 15% attrition. Assuming a learner-level pre-post test correlation of 0.6 and a setting-level ICC of 0.17, this sample size would have 80% power to detect an effect size of 0.25. This calculation also accounts for variable cluster sizes as described above; however, the variation would likely be small and so, rounding to 2 decimal places, the MDES is the same when assuming equal cluster sizes at analysis.

Randomisation		**OVERALL**	**FSM**
MDES		0.22	0.25
Pre-test/ post-test correlations	level 1 (pupil)	0.60	0.60
	level 2 (class)	-	-
	level 3 (setting)	-	-
Intracluster correlations (ICCs)	level 2 (class)	-	-
	level 3 (setting)	0.17	0.17
Alpha		0.05	0.05
Power		0.8	0.8
One-sided or two-sided?		Two	Two
Average cluster size (at randomisation)		60	13
Number of schools	Intervention	40	40
	Control	40	40
	Total	80	80
Number of pupils	Intervention	2400	504
	Control	2400	504
	Total	4800	1008

Outcome measures

PRIMARY OUTCOME

The primary outcome measure is the resit GCSE Maths raw mark, from November 2019 or May/June 2020, which will be obtained directly from settings. Results from the latest sitting will be used in the analysis, ie combining results from November and June as appropriate (see Primary Analysis section below). This may have implications for analysis and interpretation, since there will be differences in dosage and perhaps in type of pupil etc. This will be explored further in the sensitivity analysis. Settings may sit exams from different

[4] https://sfcawebsite.s3.amazonaws.com/uploads/document/Sixth-form-colleges-Key-facts-and-figures-2018.pdf?t=1545390007

boards (we anticipate Edexcel, OCR and AQA to make up the vast majority of exam boards used, though there may be others which we will also include), which have differing scoring systems and grade boundaries and so raw marks across exam boards will not be comparable. It will therefore be necessary to identify which exam board each setting uses, and to convert the raw marks to 'standard' (z) scores for analysis. This technique can be used when the same score is assessed on different scales. Let x_{ij} be the score for student i sitting exam board j, then their z-score is:

$$z_{ij} = \frac{x_{ij} - \mu_j}{\sigma_j},$$

where μ_j is the mean of the population sitting the exam with board j, and σ_j is the standard deviation of the population sitting the exam with board j. These parameters will be obtained from the exam boards if possible, or else the sample mean and standard deviation, from the data observed, will be used.

SECONDARY OUTCOMES

The secondary outcome measures are: achievement of grade 4 or above at resit GCSE (ie. achieving a pass) as a binary measure obtained from the exam board via the settings; student attendance at exam session obtained from the exam board via the settings; and student attitudes towards maths using an adapted version of the Attitudes Toward Mathematics Inventory (ATMI). After comparing it with other attitude instruments available it was decided that, with modifications, ATMI would be the most appropriate for this study. Where necessary the language has been anglicised (the original being North American) and the instrument shortened with full agreement of the originator (Martha Tapia). The original instrument (Tapia & Marsh, 2000) has 40 items split into four sub-scales (Self-confidence, Value, Enjoyment, and Motivation). The 5-point response scale runs from 1=strongly disagree to 5=strongly agree with a neutral midpoint. For negative statements, the scoring is reversed at the analysis stage. The estimated completion time is 20 minutes, which was too long for practicality in this study, so it was necessary to create an abridged version. When statements less relevant or appropriate to 5Rs were removed, 29 questions remained, primarily from the Self-confidence and Enjoyment sub-scales. Since retaining (or losing) entire sub-scales maximises the validity of the shortened instrument, the Motivation and Value scales were deleted and Self-confidence and Enjoyment kept intact. The deleted sub-scales were of less direct relevance to 5Rs and its logic model - the Motivation statements tend to be about maths in general (rather than motivation to get through the resits) and Value relates more to attitudes towards maths that were not core to the intervention. Summary scores will be obtained by summing the item scores for each subscale, and as a total score (sum of two subscale scores).

Analysis plan

The statistical analysis will follow the most recent EEF guidance, and will be described in detail in a statistical analysis plan prepared within three months of randomisation. The proposed analysis is provided in brief below.

The main analysis will take place after completion of the 2019-2020 academic year to capture the results of the May/June 2020 resits. All analyses will be conducted on an intention to treat basis, using two-sided significance at the 5% level, using Stata v15 (or later). Baseline data will be summarised by trial arm and presented descriptively both for settings and students as randomised, and as included in the primary analysis. No formal comparison of baseline data will be undertaken, except that Hedges' g effect sizes for the difference between the groups for measures of prior attainment will be presented with 95% confidence intervals (CI).

The correlation between both GSCE maths grade (last one obtained prior to September 2019) and KS2 maths score with outcome GSCE score will be investigated. The ICC for KS2 maths score associated with school and class will be presented with a 95% CI.

PRIMARY ANALYSIS

Raw marks (within exam boards) and overall z-scores will be summarised by randomised group. The primary analysis will investigate any difference in z-scores between the two groups for the students' most recent resit attempt. This will be from November 2019 if the student was entered for, and passed, this sitting, or from May 2020 if, say, i) the student was not entered into the November 2019 resit, or ii) the student sat, but failed, the November resit and subsequently resat in May 2020. Mixed-effect linear regression will be used at the student-level. Group allocation, KS2 maths score, type of setting, and size of setting (in its continuous form) will be included as fixed effects in the model. Setting will be included as a random effect to account for the clustering. The predicted adjusted mean difference in scores between the two groups with an associated 95% CI and p-value will be presented.

The treatment effect size between the groups at post-test will be calculated by dividing the adjusted mean difference obtained from this model with the pooled, unconditional variance obtained from an unadjusted model that includes only treatment group and accounts for clustering at setting level. The 95% CI for the effect size will be obtained by dividing the 95% confidence limits for the adjusted mean difference by this same variance.

The ICC for the primary outcome associated with school and class will be presented with a 95% CI.

SENSITIVITY ANALYSES

The primary analysis will be repeated including timing of resit (November or May) and whether this was the students' first or (at least) second resit attempt as fixed effects in the model. The primary analysis will also be repeated excluding any student who sits the higher tier paper (as opposed to the foundation tier paper). Finally, the primary analysis will be repeated restricting to the results of the November 2019 resit and, separately, to the results of the May 2020 resit.

COMPLIANCE AND MISSING DATA

A Complier Average Causal Effect (CACE) analysis for the primary outcome will be considered to account for setting engagement with the intervention. The definition of 'compliance' has been agreed with the development team and the EEF as attending the first two of the three training sessions (or equivalent if a teacher joins partway through the trial

and has to be trained on a catch-up basis). A Two Stage Least Square (2SLS) instrumental variable (IV) approach with group allocation as the IV will be used.

Baseline characteristics of pupils who are included in the primary analysis will be compared with those not included in the model (due to missing outcome data). A mixed-effects logistic regression model with presence or absence of GSCE raw mark data as the outcome and including all baseline variables will be run to explore potential predictors of missingness. The impact of missing data on the primary analysis will be assessed by repeating the analysis on a data set where missing data has been completed using multiple imputation, in the case where more than 5% of cases are excluded from the primary analysis due to missing data. This will be discussed in detail in the Statistical Analysis Plan (SAP).

SUBGROUP ANALYSIS

Two subgroup analyses are planned. First, the hypothesis that the intervention will have a greater benefit on students sitting the resit in May than in November will be assessed via the inclusion of an interaction between time of resit and group allocation in the primary analysis model. Second, the effect of the intervention on students who have ever been eligible for FSM will be assessed both via the inclusion of FSM status and an interaction term between FSM status and allocation in the primary analysis model, and by repeating the primary analysis on the subgroup of ever FSM students. These subgroup analyses will be underpowered and thus are exploratory only.

SECONDARY ANALYSIS

A mixed-effects logistic regression, adjusted as for the primary analysis, will be used to compare the likelihood of students in the two groups achieving a pass (level 4 or above) at resit. The number of exam sessions the student attends (up to 3) will be summarised by trial arm and will be dichotomised as: sat all 3; vs sat 0-2 and analysed using a mixed-effects logistic regression, adjusted as for the primary outcome.

The total ATMI score will be analysed as described for the primary outcome of GCSE maths raw mark. The Self-confidence and Enjoyment subscale scores will be summarised descriptively but will not be formally analysed.

Implementation and process evaluation

Before the trial, we will explore with a few settings the likely efficacy of different approaches to data collection. The settings will be selected to represent different contexts (ensuring at least one FE college, one sixth form college and one school sixth form). We will consult with them on how to optimise student engagement with the evaluation and how best to deliver and (if necessary) incentivise the student attitudes/survey. It will also cover logistics such as likely timing of identifying resit teachers; the possibility of accessing student attendance and dropout data; and ideas for expediting the collection of GCSE data in November and at the end of the study year.

The implementation and process evaluation (IPE) will address the following research questions:

RQ1 How closely does the 5Rs as implemented follow the intended model, for instance in structure and content, frequency of delivery? How well is it being delivered?
RQ2 What is the dosage (how often do teachers deliver 5Rs lessons and how long do they last; what is the student attendance rate across lessons)?
RQ3 Is there any variability between different types of setting in fidelity, delivery, or attitudes towards the programme (eg FE colleges, school sixth forms)?
RQ4 What are the barriers and enablers to adopting the programme? Has 5Rs been adapted during the trial? How and why? (Including whether it has been adapted for delivery to functional maths classes)
RQ5 What is the level of compliance with the programme (measured as attendance at training)?
RQ6 How are students engaging with 5Rs and what impact does it have on their attitudes to maths (those elements not covered in the ATMI questionnaire)? How much work do they complete on their own, outside lessons?
RQ7 How are teachers engaging with 5Rs? What are their opinions about the training provision and subsequent support?
RQ8 What is the nature of the “business as usual” approaches? How does 5Rs compare to existing practice in post-16 maths resit classes?
RQ9 What can be learned from the IPE to inform a larger trial in terms of possible changes to the intervention and trial design?

The IPE will use mixed methods, incorporating the following:

- Pre-intervention teacher survey of all settings to collect information about “business as usual” practices
- Training attendance data (compliance measured as attending days 1 and 2 of three)
- Observations of training events (one per term)
- Setting visits (involving lesson observations, teacher interview, friendship pairs of students and departmental heads where possible). These “case study” schools would be chosen to represent a range of contexts (eg FE college, sixth form college, school sixth form; size of cohort; regional trainer). Ideally, the teacher taking the observed lesson would be interviewed and would help identify suitable pairings from those volunteering to participate in student interviews.
- Post-intervention teacher survey
- Post-intervention student survey
- Lesson attendance

The IPE has been designed to test the workings of the logic model (Appendix 1), to check whether the intervention is operating as hypothesised. Table 2, below, shows how the findings will be used to support or counter the logic model and its constituent elements.

Table 2: IPE elements mapped to logic model

IPE element	Aspect of logic model
Training observations Teacher interviews Lesson observations Online teacher surveys	Teacher understanding of resit learning requirements
Training observations Teacher interviews Lesson observations Online teacher surveys	Teacher understanding of 5Rs approach
Teacher/student interviews Lesson observations Online teacher/student surveys	Provision of resources eg Corbett maths cards
Teacher/HoD/student interviews Lesson observations Online teacher/student surveys	Change in teachers' classroom practice
Teacher/student interviews Lesson observations Online teacher/student surveys	Change in student study skills
Teacher/student interviews Lesson observations Online teacher/student surveys	Student engagement with lessons
Teacher/student interviews Online teacher/student surveys	Student engagement outside lesson
Teacher/student interviews Online teacher/student surveys	Change in understanding and application of nine basic maths skills
Teacher/student interviews Online teacher/student surveys	Change in exam technique
Teacher/student interviews Lesson observations Online teacher/student surveys	Perceived change in confidence, attitude and motivation
Teacher/student interviews Online teacher/student surveys	Perceived change in achievement

Table 3 summarises the range of methods that will be used, who will collect the data and how it relates to the Research Questions. The final column indicates when the data will be collected. Each case study visit will be completed within a single day to minimise the burden on the settings. The final research question ("What can be learned from the IPE to inform a larger trial?") will be addressed by reflecting on the emergent strengths and weaknesses of 5Rs and of the evaluation itself. Future refinements to the methods and instruments will be suggested as appropriate, as well as possible amendments to the intervention based on teacher and student feedback and researcher observation. Recommendations for the overall design of a prospective larger-scale trial will also be made

Where appropriate, data will be triangulated to build a fuller picture of how GCSE maths resit lessons are being delivered and the level of teacher and student engagement. A mix of inductive and deductive analysis will be used to build themes and identify patterns within the data. The deductive analysis will use the steps in the logic model as a preliminary thematic framework, e.g. teacher understanding of 5Rs; pedagogical approach; changes in teaching practice; student study skills; student engagement and so on (see Appendix 1).

Data from the different sources will be collected together and summarised by research question.

Table 3: Process evaluation methods overview

Method of data collection	Who is responsible	N	RQ	Why	When
HoD or teacher interviews	Evaluation team	3 or 4	NA	To consult over best practice in terms of student engagement with, and logistics of, elements of the evaluation.	April - July 2019
Baseline setting survey	Administered by development team, analysed by evaluation team	ALL	Informs 3	To ascertain setting context (type, size, expected cohort size); exam board; details of participating teachers.	March – July 2019
Pre-intervention teacher survey	Evaluation team	ALL	7, 8	To establish usual practice; teacher background and experience, motivation and engagement.	September 2019
Training attendance data	Collected by development team, shared with evaluation team	ALL	5	Compliance will be measured as attending days 1 and 2 of three.	April 2020 (after final training days)
Observations of training events (one per term)	Evaluation team	3	Informs 1	To establish the expected model and fidelity in terms of different trainers' approaches.	Beginning of each term (2019/2020)
Student attendance data	Setting	ALL	2	To measure dosage and engagement.	Sept 2019 – May 2020
Teacher download data	Collected by development team, shared with evaluation team	ALL	7	Teacher downloads of schemes of work and lesson plans would be used as proxy for their engagement with 5Rs, and triangulated with self-report of frequency of use.	Sept 2019 – May 2020
Case study visits: lesson observations (observation sheet co-designed with development team)	Evaluation team	10 (6I, 4C)	1, 2, 4, 7, 8	To explore what 5Rs looks like in the classroom – fidelity to lesson plan including timings; how different elements are received; adaptations and barriers; student engagement. To check the approaches used in control settings, including any overlap with 5Rs.	Nov 2019 – April 2020
Case study visits: teacher interview	Evaluation team	10 (6I, 4C)	2, 4, 6, 7, 8	To investigate usual practice. For 5Rs, opinion about different elements; adaptations, enablers and barriers; student reaction; response to training; perceived value of the approach.	Nov 2019 – April 2020

Case study visits: friendship pairs of students	Evaluation team	10 (6I, 4C)	2, 6, 8	To establish their reaction to the lessons and its different elements, especially in relation to previous GCSE maths teaching; activity outside lessons eg interaction with online resources.	Nov 2019 – April 2020
Case study visits: departmental heads where possible	Evaluation team	10 (6I, 4C)	2, 4, 6, 7, 8	To gather context about delivering maths resit lessons; assess 5Rs including embeddedness, student and teacher reactions, costs and school staff time involved.	Nov 2019 – April 2020
Post-intervention teacher survey	Evaluation team	10 (6I, 4C)	2, 4, 6, 7, 8	To explore current practice; motivation and engagement; perception of student engagement, motivation and confidence (including work outside lessons). 5Rs specific: feedback on training, frequency and scheduling of delivery, fidelity, opinion of different elements, any non-5Rs delivery, enablers and barriers to implementation. This will be developed and piloted with two settings not involved in the trial: one which is currently following the 5Rs approach and one which is not.	March/April 2020
Post-intervention student survey	Evaluation team	ALL	2, 6, 8	To investigate teaching approaches used; opinion of different elements; confidence in maths; frequency of class attendance and time spent in self-study. This will be developed and piloted with two settings not involved in the trial: one which is currently following the 5Rs approach and one which is not.	March/April 2020

Cost evaluation

Following EEF guidelines, the evaluation team will provide the cost per student over a three-year period for the intervention. Costs of implementation will be identified in the process evaluation and are likely to include training costs, ongoing support, any pre-requisite resources and time for staff training. Cost implications will be identified as per EEF guidelines through discussions with the development team, teacher surveys and teacher interviews.

Ethics and registration

This trial comes under the ambit of the University of York's Department of Health Sciences' Research Governance Committee. Ethics approval for the MOU was received in March 2019. A full ethics application will be made in June/July 2019.

All participating settings will sign a Memorandum of Understanding that covers information about the study, and the respective responsibilities of setting, evaluation team and development team. It also covers the acquisition of NPD data and data archiving. Teachers will give informed consent to be observed and to take part in interviews. Completion of online surveys will be taken as evidence of consent.

The student participants will be treated as capable of making their own decisions about participation since they are aged 16-19. They will be given the chance to withdraw from data collection. For ethical reasons we will request opt-in consent from those students taking part in the student interviews.

An ISRCTN Registration Number will be applied for on agreement of the protocol.

Data protection

All student data and any other personal data used for the project will be treated with the strictest confidence and will be used and stored in accordance with the General Data Protection Regulation (2018) and the Data Protection Act (2018).

The University of York will be deemed a Data Controller (as defined by the data protection legislation) with regard to the personal data used for this project. Information sheets, with the option of withdrawal from the research, will be provided to potential participants as appropriate.

This participant information sheet will be compliant with the requirements of the GDPR including a clear statement of the university's legal basis for processing personal data, which will be for the performance of a task carried out in the public interest (Article 6 (1) (e)). This is in line with the University's charter which states learning and knowledge will be advanced through teaching and research. If any special category data is processed by the University then this would be under the legal basis of archiving purposes in the public interest, or scientific and historical research purposes or statistical purposes.

For the purpose of research, the student data will be linked with information about the students from the National Pupil Database (NPD) and shared with the Department for Education, the EEF's archive manager and, in an anonymised form, the Office for National Statistics and potentially other research teams. Further matching to NPD data may take place during subsequent research.

A data sharing agreement will be put in place between the University of York and each setting which will include the details of the types of personal data being shared, the purpose and duration of that sharing and the responsibilities each party has in relation to that information. All data held by the Evaluation Team will be retained for three years after publication of the final report and then securely destroyed. All results will be anonymised so that no setting or individual student will be identifiable in the report or dissemination of any results.

Personnel

Delivery team:

Julia Smith, Maths Teacher Trainer and Author
Morag Gallagher, Head of Projects, Association of Colleges
Barbara Baidoo, Project Manager, Association of Colleges

Evaluation team:

Louise Elliott, University of York
Louise has been involved in a large number of trials including several for the EEF. She has broad experience of education research and has worked on a wide range of trials including science, literacy and mathematics. As Co-PI, she will be responsible for managing the trial, undertaking some of the fieldwork and writing the final report.

Pam Hanley, University of York
Pam has a broad background in education research. She has been involved in many RCTs, leading both impact and process elements. More recently she has led the evaluation aspect of a project to develop subject-specialist pedagogy in vocational science, engineering and technology at further education colleges. As Co-PI, her role will complement that of Louise.

Caroline Fairhurst, University of York
Caroline is an experienced statistician who has supported and analysed a large number of RCTs in health and education. She will undertake the randomisation, write the SAP, conduct the statistical analysis, and contribute to the report writing. Additionally, Caroline will be responsible for uploading the trial data to the FFT archive following the trial.

Professor David Torgerson, University of York
David is Director of the YTU, which is a large (>70 staff) research unit dedicated to leading and supporting randomised trials in health, education and the social sciences. He has been involved in over 100 RCTs and published widely on their methods. He will support the design, conduct and write-up of this trial.

Imogen Fountain, University of York
Imogen has many years' experience supporting education trials, helping ensure the smooth flow of a project including data collection, organising visits and maintaining records.

Andrew Haynes, University of York

Andrew has a background in education, having been headteacher at schools in the UK and overseas. As Trial Support Officer, he will work with Imogen to collect the requisite data.

Elizabeth Coleman, University of York
Elizabeth Coleman is a statistician with an MSc in Statistics with Medical Applications. She has worked on a range of trials, including previous education trials. Her role will be to support Caroline in the set-up, analysis and reporting of the trial data.

Risks

Risk	Preventative measures	Likelihood
Insufficient post-16 settings recruited	• GCSE maths resits are problematic for settings so there should be interest in exploring potential solutions • Emphasise that 5Rs is a promising intervention • Emphasise it includes 3 days staff development (might be attractive for non-specialists) • Stress ease of use and available support for non-specialist teachers • Work closely with the development team to combine experience of recruitment and knowledge of settings	Medium
Attrition of settings	• At recruitment all settings will be required to sign a MOU • Ensure buy-in at all levels of setting (principal, departmental heads, teaching staff) • Training burden is low • Regular communication with key contacts throughout the project • Provision of incentives to settings	Low
Attrition of teachers	• Training burden is low (and could be an attraction, particularly for non-specialists) • Provision of lesson plans etc should reduce workload • Check staff changes regularly with key contact • New staff to receive training as soon as possible • Well manualised intervention	Medium
Attrition of students	• We expect attrition to be **high** from students from the survey response and we will try to minimise this by minimising the length of the instrument and delivering in class • In contrast we expect attrition for the primary and key secondary outcomes (i.e., GCSE maths raw mark) to be **low** as these will be sent to the research team by the settings	High/Low
High attrition from intervention or poor implementation	• Termly training and consistent support from trainers should assist strong implementation and mitigate against withdrawal • Surface adaptation to suit context is permitted but needs monitoring • Poor implementation should be picked up by the process evaluation and will inform the evaluation	Low
Project staff turnover	• York Trials Unit has a range of experienced staff who could be drafted in if necessary	Low

	• All procedures will be documented to allow new personnel to takeover if needed	
Delays in settings providing student details and GCSE results	• The evaluation team has extensive experience of liaising with settings to obtain data • The team includes two Trial Support Officers to chase information • Settings will be given financial incentives for compliance	High
Contamination	• 5Rs approach available on AQA website (AQA) leading to possible use by control settings: it has been agreed that this will be withdrawn from the site	Low

Timeline

School Year	Specific Date	Evaluation Team	5Rs/AOC
2018-19	March – July	Setting recruitment led by AOC/5Rs with input from the evaluation team	
	July 2019	Randomisation of settings to the intervention or control group	
2019-20	September	Pre-evaluation teacher survey	
	September		Teacher training session 1
	September	Collection of student data from settings	
	October	Intervention delivery starts	
	November-April	Visits by evaluators to selected settings	
	January	Collection of November GCSE maths raw mark and grade from settings	
	January		Teacher training session 2
	March/April	Student survey/attitude to maths questionnaire	
	March/April	Post-evaluation teacher survey	
	April		Teacher training session 3
	May	Intervention period ends	
	June	Request access to NPD data (KS2 and GCSE grade (previous attempt 2019).	
2020-21	August/September	Collection of student attendance data from settings	
	August/September	Collection of summer GCSE maths raw mark and grade from settings	

	September-December	Analysis	
	End February	Submission of draft report	
	End July	Final report submitted and data uploaded to FFT	

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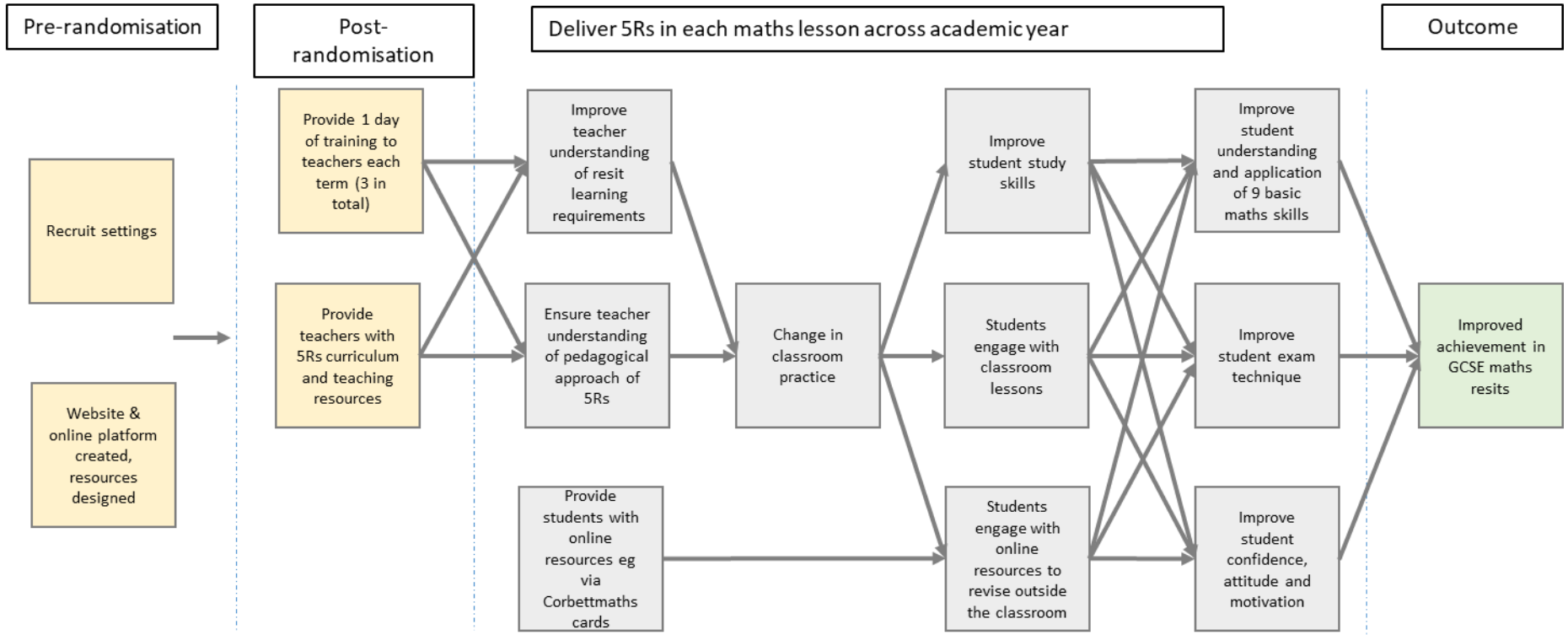
Appendix 1

Logic model



Appendix 2

Setting baseline information

Type of setting:

Further Education College	☐
Sixth Form College	☐
School sixth form	☐
University Technical Colleges	☐
Independent Training Providers	☐

Number of students on roll: ☐

Exam Board: AQA/Edexcel/OCR/Other Please specify:

_____

Student and teacher information

	2018-19 Actual	2019-20 Expected
Number of students aged 16-19 resitting GCSE Maths		
Number of students you intend to take part in the evaluation		
Number of classes		
Number of classes you intend to take part in the evaluation		
Number of teachers		
Number of teachers you intend to take part in the evaluation		

Details of teachers involved in the 5Rs evaluation (up to 5)

Teacher name	Email Address

If teacher names are not yet known please indicate below when you expect to have this information:

_____

Thank you for agreeing to take part in this research. Please return this form to:

[Project Team Contact details]