Researcher

Education Research projects by Researchers in Schools participants

2020 cohort





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Introduction

Researchers in Schools is the only dedicated route into school teaching for post-doctoral career changers in the world. Over the course of the programme, participants work toward the Research Leader in Education (RLE) award. The RLE award is designed to ensure that Researchers in Schools teachers are trained and supported to deploy the knowledge, skills and networks they have gained from their PhD to benefit pupils, schools, and universities in three important ways; by championing university access, increasing subject expertise and promoting educational research.

While working as a classroom teacher they have one day a week of protected time to complete the award. During this time, they work on a variety of projects that meet the three RIS aims above. This publication is the product of the education research strand of the RLE award. In their first year, participants complete an Education Research module. The module introduces them to methods of research, paradigms in social science and education research and some of the contemporary debates.

In their second year, RIS teachers deliver a pilot research project in their schools. We have partnered with Sheffield Hallam University, who deliver the Research and Development in Context module to our participants. RIS teachers get practical experience using mixed research methods and setting up a research project, while also gaining 30 master's credits.

Our teachers have summarised their projects' methods, findings, and analyses as well as any important insights and next steps. In this edition you can read about how study clubs can impact attainment and resilience, the impact of a targeted growth mindset intervention on white-working class boys' higher education aspiration and structured practice to improve science writing skills and more!

Dr Hannah McCabe

Why do students struggle with applying learned mathematical skills to their science lessons and how can this gap between science and maths be bridged?

There is a significant crossover with the subject of maths within the science curriculum and content being taught in maths lessons frequently needs to be applied in specific science topics. At GCSE level, mathematical skills make up 10 %, 20 % and 30 % of the biology, chemistry, and physics content respectively (AQA, 2016).

Despite the prevalence of maths in science at secondary school level, students often struggle applying mathematical skills to science content (Dood & Bone, 1995; Needham, 2016) and there is a disconnect that can be condensed into broad issues including differences in teaching between departments, the terminology used, and teacher confidence and student attitudes.

One of the ways the gap between maths and science could be bridged is using retrieval practice which is already a regular component of teaching that has been shown to improve learning (Pastotter & Bauml, 2014) by getting students to recall knowledge they have gained from previous lessons and topics. It allows students to make links between different content that is being covered and these links can then be made between subjects, for example, between science and maths.

Regular exposure to maths questions in the format of retrieval practice could help increase confidence in tackling maths problems within science. It could build up familiarity with and skills in manipulating numbers, rearranging equations, using correct units, and interpreting graphs. Since using retrieval questions at the start of every lesson is a standard part of normal teaching practice within the science department of the school, it is a good opportunity to implement maths questions within this part of the lesson to see if it can help improve students' ability to link the two subjects.

Research question - Does introducing maths questions into regular retrieval practice improve pupils' ability to tackle mathematical problems in science lessons?

Regular retrieval practice helps to transfer information back and forth between the working memory and the long-term memory (Agarwal, Roediger, McDaniel, & McDermott, 2020) and repeated exposure of topics can help to strengthen students' ability to retrieve information quickly (McDermott, 2011). The aim of this project is to determine whether adjusting the regular retrieval practice of normal science lessons to include questions that use mathematical skills can improve students' ability to tackle maths problems in science.

The regular practice within lessons is to give students five retrieval questions to answer that involves recalling knowledge from previous science lessons and topics. In this study, the proposed plan was to introduce an additional set of maths-specific questions into this retrieval practice activity for one of my Year 9 classes. This took place over a six-week period, occurring in an estimated 10-15 lessons. Students answered these added retrieval questions as part of their normal starter activity within lessons and the marks achieved were collected in a mark book.

Prior to the introduction of the maths retrieval questions, students were set a pre-intervention assessment consisting of 30 questions on an online platform that was already in use by the science department for homework. The questions were specific maths questions based on the different mathematical skills frequently occurring within the science curriculum and was used to set a baseline that showed the students' mathematical ability before the introduction of the retrieval questions. At the end of the six-week period, a similar set of questions using the same online platform were to be given as a measurement of the impact that adding the maths retrieval questions to regular lessons had on students

The data collected during this study included individual student marks from the retrieval questions in each lesson and their overall score in the pre- and post-study 'Maths in Science' set of questions. This data could then be analysed to compare scores achieved in questions before and after the intervention and determine the impact of the study and could identify particular areas of maths that were frequently more challenging.

Specific maths skills were chosen as the retrieval questions, and these were rotated to give students the opportunity to be exposed to different maths skills as well as a chance to improve on their recall with second exposure to the topic. Where students answered questions from one skill and then answered other questions from the same skill the next time they came around in the lessons, there was a general increase in the marks received for those topics.

When comparing the overall trend between the marks achieved in the pre-study quiz and the post-study quiz, the intervention appears to have benefited those students who struggled with maths at the start of the study more than those who had a competent enough grasp of the maths skills in order to apply them to a scientific context. Those students who scored highest in the pre-study quiz achieved similar marks in the post-study quiz but the four lowest scoring pupils in the pre-study test all achieved at least a 100 % increase in their score when they took the post-study test.

There were several limitations of the study, however, mainly attributed to time constraints that meant in individual lessons, not all participants answered the retrieval questions fully, and there was no control group who did not receive the intervention to compare the results to. The structure of the retrieval questions was also meant designed to be a quick snapshot of the content and did not allow for any in-depth analysis of maths-in-science problems.

Future areas of research could focus on addressing these issues, perhaps spreading retrieval questioning throughout a lesson to help strengthen the links between maths skills and new science content and provide opportunities for further analysis at the problems linking the two subjects. Another area for future research is an issue that was identified during the research for this project which is the language used by maths and science teachers and the fact that a common language was not yet standard practice in many schools.

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Dr Henry Allen

How does teaching metacognitive problem-solving strategies to Year 11 HPAs impact upon their ability to answer A03 exam questions?

Context

Metacognition, simply defined along the lines of "thinking about thinking" has been recognised by the Education Endowment Federation's Teaching and Learning Toolkit as a "High impact for very low cost, based on extensive evidence" strategy for improving pupils' outcomes, [1]. While all pupils will develop metacognition to some extent as they mature, the majority will not spontaneously develop the wide array of metacognitive strategies that they will need, e.g. [2]. Overall, research suggests that pupils should be explicitly taught metacognitive strategies, however, to be effective this should be done only after they have gained sufficient subject knowledge.

Is there a set of generic metacognitive skills that are particularly useful in mathematics? Successful problem-solvers display several shared metacognitive strategies: reading the problem more than once, checking what the problem was asking, showing the problem schematically, developing a strategy for solving the problem, thinking about how the solving process was going, asking whether answers were meaningful, checking calculations, and checking the information stated in the problem for anything requiring particular attention, [3]. Interventions that do not explicitly focus on teaching metacognition are not enough for pupils to develop their metacognitive skills, [2, 4]. Altogether, this suggests that there are generic metacognitive strategies that are useful in mathematics, however it does not necessarily mean that these strategies can be taught outside of mathematics classes.

The importance of problem solving for mathematics education has been appreciated since the 1980s, [5]. The seminal text on problem solving in mathematics describes the following framework: understand the problem, plan how you will solve it, carry out the solution plan, and reflect on the process, [6]. Understanding a problem requires sufficient subject knowledge, for example novices presented with problems with the same deep structure get distracted by surface features, [7,8].

The Research

Pupils took a three-week course and were instructed in metacognitive strategies for tackling A03 (problem-solving) mathematics questions. The instruction was based around the three steps of problem solving as discussed by Polya: understanding the problem, devising a solution, carrying out the solution, [6]. Each intervention session was based around one of the three steps to allow pupils to practise their metacognitive skills. Before the intervention began a baseline test was administered, and at the end of the intervention another test was administered to assess progress. The primary focus was to examine the impact on pupils academic attainment and ability to reason mathematically.

The first intervention focused around understanding the problem, and in order to promote understanding and recognition of I employed SSDD problems to help pupils see different deep mathematical structures from similar surface level problems, [9]. The second intervention focused around devising a solution to a problem. To aid devising of a solution I employed open problems where a scenario from an exam-style question is presented, and pupils are invited to work out everything they can from the scenario. The importance of open problems in mathematics education has been highlighted as a tool to increase understanding and motivation, [10,11]. The third intervention focused on pupils implementing solutions. This session involved pupils being presented a goal-free problem instructing them simply to "explore".

Pupils' progress was measured using pre- and post-assessments. In order to ensure that problem solving was the focus, AO3 questions (questions identified by AQA as having significant problem-solving elements) were selected. The pre data was taken from pupils' recent mock examinations, completed shortly prior to starting the project. In order to ensure that the data was comparable, the post-assessment was taken from AQA shadow papers – papers that have similar questions to the mock papers, [12]. For the post assessments AO3 questions in which pupils had performed relatively poorly were chosen, and a bespoke assessment containing those questions was created.

Participants were selected based upon their ability in mathematics, i.e. potential to achieve grades 8/9 at GCSE. Part of the purpose of the intervention is to expose pupils to grade 8/9 topics that they have not been able to access during their regular lessons, as well as to better prepare them for the potential of continuing to study mathematics at A-level.

Discussion

Table 1 shows the percentage change for each pupil for each question from their pre-assessment to their post-assessment. Results show a significant percentage change of between 17% and 27% for five of the six participants. Results also show a good improvement over most questions, between 11% and 50%. The exceptions are Question 6 which shows a 25% decrease in average score, Question 9 which shows no improvement for part a and only 8% improvement for part b, and Question 10 which showed only a 4% improvement.

Question	1	2	3	4a	4b	5	6	7	8	9a	9b	10	
Marks	3	3	4	3	2	4	4	5	3	2	4	4	41
P1	0%	0%	-25%	33%	0%	50%	0%	0%	-33%	0%	0%	0%	2%
P2	0%	67%	50%	67%	0%	0%	0%	80%	33%	0%	0%	0%	27%
P3	67%	33%	0%	0%	0%	75%	-50%	40%	0%	0%	0%	25%	17%
P4	-33%	0%	-25%	67%	100%	75%	-25%	100%	33%	0%	0%	0%	24%
P5	0%	33%	50%	0%	100%	0%	-50%	20%	67%	0%	50%	0%	20%
P6	33%	0%	50%	0%	100%	-25%	-25%	40%	67%	0%	0%	0%	17%
	11%	22%	17%	28%	50%	29%	-25%	47%	28%	0%	8%	4%	18%

Table 2 shows which question belongs to which topic strand, the total marks scored across all participants for each strand, and percentage change from pre- to post-assessment. This shows the significant improvement of between 22% and 37% for the Algebra, Ratio/Proportion, and Probability strands, with the largest improvement being Probability. Comparatively the change for the geometry strand is much smaller at only 5%, which includes the three questions shown to have the smallest percentage change in the previous slide.

Strand	Ques	stions	5				Pre	Post	% Change
Algebra	Q1	Q5	Q7				30	53	32%
Ratio/Proportion	Q2						9	13	22%
Geometry	Q3	Q6	Q8	Q9	Q10)	34	40	<mark>5%</mark>
Probability	Q4						8	19	37%

Although some promising results have been suggested, the small number of participants makes it difficult to draw conclusions from the data, further, due to the relatively small scope of this project two important strands of subject knowledge were not tested: Number and Statistics. One way to develop this project therefore would be to roll it out to a whole class. This study was restricted to pupils aiming to achieve grade 8s or 9s at GCSE, extending the intervention to pupils with targets of grades 5, 6, and 7 would therefore be interesting. Another interesting development would be to change the focus from being an intervention to part of normal class teaching. Refining the intervention to teach specific strategies for each topic could be useful. Finally, the intervention should be extended to allow pupils to reflect upon problem-solving endeavours.

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Dr Jennifer Miller

To what extent do you agree? Tackling evaluation in the English Language GCSE

Why does Critical Literacy Matter?

As an English teacher and lifelong lover of literature, I believe that supporting our students to develop their literacy skills is vital. Interpreting the world around us with words allows us to inhabit that world more meaningfully. Articulating our own opinions is a crucial catalyst to identity formation and the personal, social, and emotional development that, as educators, we strive to foster. However, waging war on reluctant writers in the classroom has made me painfully aware that most students struggle to express their views confidently on the page.

My revision intervention thus addressed the underperformance of high-attaining students in their GCSE English Language exam, with a specific focus on Paper 1, Question 4. This paper is designated 'Explorations in Creative Reading and Writing' and Question 4 gauges analysis and evaluation skills alongside students' ability to construct an argument.

School Context

When I embarked on my intervention, current department data indicated that Question 4 was a particular cause for concern (see Figure 1, below).

			Рар	er 1					Рар	er 2		
	Q1: Extract	Q2: Lang:	Q3:Struc	Q4: Eval	Q5: Content	Q5: SPAG	Q1: Extract	Q2: Sum.	Q3: Lang	Q4: Comp.	Q5: Content	Q5: SPA
Max Marks	4	8	8	20	24	16	4	8	12	16	24	16
Ave Mark	3.6	3.9	3.1	8.4	12	8.6	3.2	4.1	4.8	6.3	11.1	8.1
Lost	0.4	4.1	4.9	11.6	12	7.4	0.8	3.9	7.2	9.7	12.9	7.9
Marks	0.4	7.1										
Marks udents ac	chieving 4	4+ in PPE										
Marks udents ac	chieving 4	4+ in PPE	Pap	er 1					Рар	er 2		
Marks udents ac	chieving 4 Q1: Extract	4+ in PPE Q2: Lang:	Pap Q3:Struc	er 1 Q4: Eval	Q5: Content	Q5: SPAG	Q1: Extract	Q2: Sum.	Pap Q3: Lang	er 2 Q4: Comp.	Q5: Content	Q5: SPAG
Marks udents ac Max Marks	chieving 4 Q1: Extract 4	4+ in PPE Q2: Lang: 8	Pap Q3:Struc 8	er 1 Q4: Eval 20	Q5: Content 24	Q5: SPAG 16	Q1: Extract 4	Q2: Sum. 8	Pap Q3: Lang 12	er 2 Q4: Comp. 16	Q5: Content 24	Q5: SPAC 16
Marks udents ac Max Marks Ave Mark	chieving 4 Q1: Extract 4 3.8	Q2: Lang: 8 5.1	Pap Q3:Struc 8 4.3	er 1 Q4: Eval 20 12.1	Q5: Content 24 15	Q5: SPAG 16 10.9	Q1: Extract 4 3.7	Q2: Sum. 8 4.9	Pap Q3: Lang 12 7.1	er 2 Q4: Comp. 16 9.2	Q5: Content 24 14.4	Q5: SPAC 16 10.7

Figure 1

AQA Examiners' Reports also identify the evaluation question as a weakness. The June 2018 report instructed candidates to avoid 'forming an opinion during the course of their writing' (Jun 2018: p. 7). In June 2017, 'the biggest error made by students was that many of them failed to address

methods', and this was reiterated in June 2019 (Jun 2017: p. 6; Jun 2019: p. 6). I concluded that explicitly breaking down the AQA's requirements was necessary to improve attainment.

Can explicit discussion of language improve analysis and evaluation skills?

Babette Verhoeven has noted that teachers need to model the writing process more explicitly; she has also raised concerns about the 'conflation of literary analysis with language analysis' in the English curriculum (2021: p. 4). In 2016, a national study led by the University of Exeter collaborated with 54 participating primary schools to conduct 'a detailed analysis of teachers' orchestration of metalinguistic talk'. (Myhill, Jones, & Wilson, 2016: p. 40) Key findings highlighted the impact of discussing strategic language choices and the influence of teachers' own grammatical subject knowledge in supporting students' writing (Ibid: p. 38). My primary research question pinpointed the skills I wanted students to develop and the potential impact of doing so:

Does developing high attaining students' evaluation skills and metacognitive thinking impact on writing outcomes for GCSE English Language Paper 1 Question 4?

<u>Methodology</u>

A qualitative approach was appropriate for a small-scale (six students), context-specific intervention where words, and not numbers, were the analytical units under consideration. When I was planning my intervention, I did not teach any Year 11s and was therefore dependent on my mentor for participants. I felt that it would be unfair to expect her to change her own lessons to include the assignments I set for my intervention group. This meant that I had no control group. Although this reduced the robustness of my enquiry, I felt that pushing my own agenda on my mentor and her class would have been ethically questionable.

Data Collection and Analysis

1. Structured student questionnaires

These were devised by me and completed at the start and end of the project; I postulated that responses would allow me to gauge any changes in students' perspectives and confidence.

2. Baseline and final assignments

Responses to two different Question 4s were completed by students. I used the mock exams as a baseline, and students completed another at the end of the project to measure cognitive outcomes.

Research Design and Structure

I broke down my study into six sessions. Each lasted one hour, was delivered weekly, and developed a specific language analysis skill:

- 1: Putting your voice on the page: language as power
- 2: Constructing a persuasive argument
- 3: Employing textual evidence
- 4: Analysing word connotations
- 5: Writing about writers' methods
- 6: Synthesis and structure

Findings and Reflections

1. Affective Outcomes

Five out of six students completed pre-project questionnaires; one joined the project belatedly. Their responses made me realise that poor confidence might be affecting their attainment. One expressed anxiety about interpreting the text incorrectly, and two others felt unable to write on a topic they were not passionate about. Analysing in detail was identified as challenging by three of the five, and two were concerned about building an argument. Only three out of the six completed post-project questionnaires due to absence. Two students rated their confidence level at 4 out of 5 at the end of the intervention, while the third chose 3-4 out of 5. This implies a significant shift in students' perceptions of themselves. One participant wrote about enjoying the seminar-style discussions, while another identified expanding vocabulary as her favourite activity. However, one student still preferred previously taught strategies to answer evaluation questions and did not expect to achieve a top-level grade. When asked about the applicability of the skills gained, all three respondents focused exclusively on other components of the English exam, rather than recognising their wider value.

2. Cognitive Outcomes

My data measuring cognitive outcomes is also incomplete due to two student absences. However, four out of the six modestly increased their grades. One student moved up by 4 marks; the average increase was 2.25 marks. This improvement is not necessarily solely attributable to my intervention; however, all four grades were higher than those achieved in the mock exams.

Impact and Conclusions

The outcomes of my study were modestly positive and highlight the potential benefits of explicitly teaching the skills that evaluation questions demand. However, increased student revision at home, or work with the students' class teacher, may also have improved attainment.

Further research is needed to target a larger cohort, construct questionnaires with greater rigour, and measure the cognitive impact on individual skills. However, I have adapted some of the strategies for my Key Stage 3 classes and feel I am encouraging greater cognitive awareness of the writing process. Two students sought me out after the Language exam, eager to tell me that it had gone well. I am cautiously optimistic that they have learned that their own voices, on the page and in the world more widely, matter.

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Dr John Minto

How does 'cultural awareness' effect and impact student attainment for KS3, specifically can increased cultural capital increase the capacity for critical thinking, and afford an inclination towards enhanced engagement and wellbeing?

Introduction

That there are disadvantaged pupils in secondary schools is not surprising to anyone, but what is lacking, in practical pedagogy, is a more comprehensive approach to address an apparent lack of cultural capital: an awareness of being-in-the-world. This paper will discuss the philosophical and sociological theory of Martin Heidegger and Pierre Bourdieu to provide a framework from which to grasp this problem, and, moreover, develop a practical solution to impact on student 'cultural awareness'. In respect to the former, the dual focus united in an ontological education places emphasis on the self as a site of authentic action while, at the same time, insisting on an ability to be-aware alternative styles of word and sub-words. In respect to the latter, the reproduction of social disadvantage is levelled at a predisposed disposition to inherited fields of consciousness characterised by an interrelated habitus: economic, cultural, social, and symbolic capitol. Together, these conceptual tools can provide a means of thinking the complex effect of culture and society on education and, as both advocate, provide an educational praxis designed to alleviate educational ill-health.

Research Questions and Logic Model

The main aim of this project is to assess whether an increased 'cultural awareness' in Year 8 secondary students can lead to enhanced critical thinking through the development of an inclination towards a predisposed framework of study. In addition, a secondary concern will be with the wellbeing of the students with regards to their academic in school study in English, including assessment and classwork. The theoretical background to the study is based on the work of Heidegger and Bourdieu who advance an existential approach to the understanding and development of educational pedagogy (Heidegger, 1927, 1959 & 1967; Bourdieu 1977, 1979 & 1986). In social science scholarship, it has been suggested that increased cultural capital can significantly impact on a student academic attainment, an essential capacity for objective, open yet critical, forms of intellectual engagement (Ruggiero, 2012).

Research Hypothesis:	In view of the deprivation and disadvantage of pupils, an increased knowledge of cultural capital will improve educational attainment assets, including critical thinking, and an inclined motivation towards engagement and well-being.
Research Question:	How does 'cultural awareness' effect and impact student attainment for KS3, specifically can increased cultural capital increase the capacity for critical thinking, and afford an inclination towards enhanced engagement and wellbeing?

Art & Society Intervention

The intervention will take place after-school in twelve one-hour sessions. The students will be encouraged to compete coursework after each session, but this will not be mandatory, - at the end of the intervention an assessed presentation is required. It will be up to the students how they respond to the teaching and learning delivered in the sessions; either through art, written composition, or discursive analysis. The topic of study will be contemporary cultural and social issues and how art and literature can afford perspective on how society ought and ought not to be organised. To impact on cultural capital, the use of literary and visual artefacts (including paintings, photographs, street art, conceptual art, and short stories) will afford an understanding of art as criticism and enhance awareness of objective cultural capital. In addition to this, the use study of several Isms (including, Socialism, Feminism, Environmentalism, and Gender and Race Theory) will afford the conceptual vocabulary to criticise, in an objective way, a range of contemporary cultural and social debates and issues.

The potential benefits to the students are as follows:

- To become more familiar and confident regarding art and literature.
- To develop a critical perspective alongside one's own viewpoint.
- To work towards a 'mastered' grade in accord with in-school assessment.
- To develop research skills, including note taking, planning, and presenting.
- To collaborate with like-minded students in a 'safe' learning environment.
- To learn more about oneself and your place in culture and society.

Overview of Findings

Of the eight students invited to take part in the research project there was one early drop out (Student 7), and two further students who completed the content but not the writing part of the intervention – the required presentation to be delivered post-intervention. On the whole, this was an excellent uptake and completion rate for such an intervention-based research study, especially due to the after-school hours and the independent nature of the work required of the students for the completion of the course. During the course of the intervention it was decided to cut the content part of the course to afford an in-school focus on the writing part, due to concerns about completion. It was notable that although most of the students were undertaking independent work during the weeks of the intervention, the write up of the presentation was causing anxiety and with this in mind the decision was made to afford extra support for the writing. On reflection, this was a much more appropriate format due to the age range of the participants and the difficulties many of these disadvantaged students have in completing work at home due to a lack of objective cultural capital.

Questionnaire

In terms of significant impact on student cultural capital and associated aspects (critical thinking skills, motivation and well-being) it can be said that students reported an increase in confidence across all aspects of in school experience. The results from the pretest (M=34, SD=8.4) and posttest (M=40, SD=9) on confidence in school indicate that the intervention had a positive impact on student ability. Although a high degree of significant increase was not demonstrated, combined with in school observation, it can be said that students have become engaged in class, and, moreover, more confident in their general English reading and writing abilities.

Attainment

In terms of student progress the table below shows the average total percentage points attained by students in Term One, Term Two, and the first half of Term Three. The intervention began at the start of Term Two and continued until the end of Half Term Five. The results from the pretest (M=61, SD=7.4) and posttest (M=83, SD=11.2) demonstrate a high degree of student progress over the course of the intervention.



Post-Intervention Interview

On the whole, the students interviewed were able to show their understanding of the aims and goals of the intervention and link the developed skills, of cultural awareness and criticality, to potential benefits in their usual English reading and writing. Of the students who responded in the interview (those who completed fully the intervention), the reported experience was overwhelmingly positive with 80% of the final cohort stating that they would take a similar intervention in Year 9, if it were available.



Conclusion

To conclude this report on this research and development project, it can be said, first off, that the project was a success in terms of student participation and there is certainly scope and interest from the host school to continue such an intervention.



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Dr Kate Saunders

Does teaching STEM careers to Triple Science students increase engagement in STEM careers? Linking lesson content to careers

Introduction

Science is all around us, in understanding the way the world works to developing new technologies and health care. In recent years the UK economy has changed, leading to a technology driven society which has led to a skills shortage across the STEM fields at all levels in the UK¹⁻³. It has been estimated that by 2030 over 7 million jobs in the UK will be in science-based industries⁴. Furthermore, participation in STEM has shown to increase upward social mobility and with the increasing advances in science in our daily lives the general public will need to be increasingly science literate if they are to be an active citizen⁵⁻⁶.

Barriers to Science Careers

Despite these benefits, there is a growing disconnect between how students see science lessons in school and associate them with future aspirations⁷. Students often do not link STEM careers with creativity, innovation, technology or IT skills and often perceive science careers as rather isolated careers without much interaction or collaboration with others^{6,8}.

Several key barriers have been identified by studies preventing students from choosing STEM career pathways, these include;

- Limited knowledge of STEM careers and interaction with STEM professional^{7,9,10},
- Social inequalities of class, gender, ethnicity and science capital^{6,11},
- How science is represented in the media and whether students feel they are 'suited' to science⁶,
- Science is only for "clever" people⁶
- Lack of access to Triple sciences at GCSE

Entry for GCSE's and A-level science has increased in recent years¹. Triple science especially is seen as a fundamental route into STEM careers yet, there is still access problems for the most disadvantaged students^{2,12}.

This project focuses on whether including career information in science lessons can change the attitude of students towards pursuing a future science career in a medium size academy where 30-40% of each year group are PP students.

Study Design and Intervention

This study introduced STEM career information into our year 10 Triple science lessons for six weeks and observed whether students' altitudes changed over this period. This cohort was chosen as it allowed a control group. This was a mix methods study and students completed a questionnaire at the start and end which was analysed.

The intervention consisted of 2-5 minutes STEM career videos, with a STEM professional discussing their career path and background (<u>https://icould.com</u>). This was shown to one class, the second class, the control group did not receive any additional STEM career information. It should be noted that during the half term of this project, the academy was badly affected by COVID-19 absences and this has likely affected the results of this study.

Results and Discussion

Triple science had previously been offered as an option, after school, this is the first year it has been offered as an integral part of the timetable. Already impacting the number of pupil premium students (PP) opting to take the course from 0% to 12 %, but still not reflecting the average number of PP students per year of 30-40%. What are the perceptions of this cohort of students?

At the start of this study, students were not connecting the impact of science on their daily lives (Figure 1). However, during the study this increased by 21%, with 64% of students believing science affected their daily lives multiple times by the end. With those in the intervention group, showing an increased awareness (Figure 1).



Figure 1. How often does science affect your daily life?

Students consider science is important for a range of reasons including, "allow us to get a greater understanding of how things work" or "a greater understanding of the world", but few believed it was essential for a future career. It was notable, post-intervention, that the student's altitudes had changed, the majority still believed science was important, knowledge was still key, but 57%, as increase of 11% considered learning about how the world works was crucial.

Sixty-two percent of this cohort of students are aspiring to a STEM career and this did not change during the project. What was interesting is that by Year 10, these students had a defined career plan in mind. Perhaps the intervention here, was given too late in the student's education to influence their career aspirations and should be aimed at younger students.

To investigate students' perceptions of STEM careers, they were asked to name five (Figure 2) and listed over 40 STEM professionals, the most common being doctor, vet, chemist, biologist and teacher. Post intervention, students still highlighted a similar range of STEM careers. However, what did stand out were that some students in the intervention group, mentioned new careers such as air traffic controller, pilot, engineers, lab scientists, STEM careers they had learnt about in the intervention period. Those who could only name one scientific career at the start, could now name four or five STEM careers showing an increase awareness in STEM careers. Furthermore, during the course of the intervention, students in intervention group recognized that they actually knew more STEM professionals in the community then they believed.



Figure 2. STEM careers as given by Students (https://monkeylearn.com/word-cloud/)

Conclusions

In conclusion, the majority of students here believe science is important for their daily lives, but cannot always recognised the impact science has on their lives or the number of STEM professionals they interact with.

The inclusion of STEM career information in science lessons, did not increase the student's career aspirations, but it did alter some of the student's perceptions on the importance of science in the world around them. Introducing such STEM career information into the lessons did have a positive effect on some students broadening their perception of how often they use science in their daily lives.

As these students, self-selected to study triple sciences, it could be that the career intervention is too late in these students' education to truly alter their career aspirations at this stage. Earlier placement of such intervention, for example at KS3, may have a greater influence and help to engage more students in the importance of science. Such an intervention may also have a positive impact on the number of PP students opting to take Triple science and moving into a STEM career.

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Dr Louise Farmer

Does including currently active scientists from BAME and working class backgrounds in lessons raise student's science aspirations in my school context?

Introduction: There has long been an underrepresentation of BAME and working class individuals in STEM careers (Joice and Tetlow, 2020). There have been a variety of suggestions as to why this is, including a lack of scientific capital, differing priorities of cultures, teacher expectations, and a lack of representation of scientists from ethnic minorities at all levels of science education (Moote *et al.*, 2020). The UK curriculum has come under recent scrutiny for its lack of diversity and there are calls to diversify and decolonise the curriculum at all levels of education (Gandolfi, 2021).

Various studies have identified a link between role models that are of similar backgrounds to the individual and student engagement and career aspirations in STEM (Shin, Levy and London, 2016; Lawner *et al.*, 2019). This has also been reported in other fields and careers (Lee, Fernandez and Martin, 2015).

The importance of role models to working class students and students from deprived backgrounds has also been reported (Tuck and Yang, 2013; Hout *et al.*, 2011). In my school there are both high numbers of non-white and mixed race students and high levels of students who are eligible for free school meals. Schools with a high Free School Meals (FSM) eligibility have been reported to have lower levels of uptake for the separate sciences at GCSE(Ofsted, 2013). This is something that is true at my school, with only 5% of students taking triple science compared to 25% of students taking triple science nationally, data taken from 2016 (Department for Education; Gibb, 2014). At my school, of the year 10 year group as a whole 37.9% of students are eligible for free school meals. I therefore wanted to investigate if inclusion of more diverse scientists in the curriculum could influence students feelings about science and increase scientific aspirations.

Methodology

Students were shown a slide giving information about a scientist at the beginning of every science lesson for a term. The students chosen were two year 8 classes, one taught by myself and one by another teacher. The criteria for the scientists chosen were that they should be currently or very recently working, in a job related to science but not just the very top science jobs as these may not feel realistic to students, and from a community represented by the student demographic. I conducted questionnaires before and after to assess student feeling on science, scientists and their own scientific abilities. The questionnaires were mostly conducted on a Likert scale from 1-5 with 5 meaning strongly agree and 1 meaning strongly disagree. This meant that statistical analysis could be carried out to see if there was a significant effect on student feelings. Paired t-tests were conducted with a threshold of <0.05 for significance.

Findings and next steps

Of the questions asked to try and probe student feelings on their own scientific abilities, there were two that showed a significant change after the intervention. The first was 'I think of myself as a sciencey person'. Students were asked to answer questions on a likert scale from 1, strongly disagree, to 5, strongly agree. For this question student opinion changed from a mean of 2.8 before to 3.2 after with a significance of 0.007. The other question that saw a statistically significant change was 'People like me can be scientists' where the mean score went from 3.6 to 4.0, p = 0.04. There was also an increase from 3.0 to 3.3 in 'I would like to do a job related to science' although this was not statistically significant. Answers to the questions 'I feel confident to answer a question in science' and 'I am good at science' remained largely unchanged.

I then analysed questions that I designed to attempt to probe students views on scientists. There were no significant changes for any of these questions, however there were some trends in the data. There were trends in students agreeing less after the intervention with the statements 'scientists are usually from richer families' and 'most scientists are similar people to each other'.

Thirdly I looked at students views on taking the triple science qualification at GCSE as opposed to the combined science option. Although there was no significant change in the whole class data, there were two questions that had near significant trends in the answers. The first was 'I would like to take triple science' (3.3 before and 3.6 after, p = 0.067). The second was 'I think triple science is a good option for people like me' (3.2 to 3.6, p = 0.09). This shows a trend upwards in student attitudes towards triple science between the first and second questionnaire. Although we cannot prove that there is causation and not correlation, it is an interesting finding from the study.

Currently the only scientists named in my school's KS3 curriculum are white European men. Based on this data I would suggest that more scientists of other ethnicities are specifically named and included in our KS3 curriculum. The data suggests that this may have a positive impact and is unlikely to have a negative impact. It would also be of interest to conduct similar research with other year groups, including those at KS4.

In addition if these studies in other year groups were successful the intervention could be extended to other faculties to try a similar intervention with BAME professionals in other subjects.

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Dr Lucy Sneezum

How does aligning mathematical approaches between the maths and science departments impact year 10 pupil attainment and confidence when answering maths questions in science lessons?

Since 2015, government guidance dictates that 'no less than' 20% of the GCSE qualifications in both Single Science (Biology, Chemistry, Physics) and Combined Science must be mathematical skills (Ofqual, 2015a, 2015b). Therefore, a pupil's ability to successfully complete math skills in the context of science is a sizable contributor to attainment in science. Several studies report teacher observations that students struggle with maths in science lessons (Brodsky, 2008; Dodd & Bone, 1995), for instance because they have trouble applying the 'knowledge they have acquired in GCSE Mathematics to other subjects' (Porkess, 2013). The difficulty students face in transferring knowledge learnt in one subject to another is reported outside of just maths and science (Willingham, 2009). However, the literature lacks quantitative analysis of the success of pupils in maths in scientific contexts.

Despite the two subjects of maths and science being 'by no means mutually exclusive', teachers in various contexts have reported a lack of communication and collaboration between the two departments (Brodsky, 2008; Bryne & Brodie, 2012; Dodd & Bone, 1995; Wong, 2018). This may then create 'problems of consistency in terminology and approaches between the two subjects' (The Association for Science Education, 2016), which may build 'potential barriers to understanding between maths and science for pupils' (Bryne & Brodie, 2012). Again however, no quantitative data exists to support these speculations. Prior to this project, the maths and science departments in the study school had no existing formal dialogue.

The hypothesis investigated in this project is whether alignment of mathematical approaches between the maths and science departments in the study school would improve pupil attainment and confidence when answering maths questions in science lessons. The research project took place over a period of 9 school weeks whilst I taught two year 10 separate science classes Biology Topic 8 from Edexcel GCSE Biology (Pearson Edexcel, 2018). The main research question was divided as follows:

- What is the current attainment of pupils for maths questions in science, compared to pure science questions, in the study school?
- What mathematical approaches (terminology and methodology) are used by the maths department in the study school to teach maths skills required in Biology Topic 8?
- How aligned are the maths and science curricula in the study school for the teaching of maths concepts that are present in Biology Topic 8?
- Can attainment be improved through aligning mathematical approaches between the science and maths departments?
- Can pupil confidence in answering maths questions in science be improved through aligning mathematical approaches between the science and maths departments?

The two parallel classes were used as a control and a test group wherein whilst I taught the purely scientific content of the topic identically to the two classes, I taught the maths skills involved differently. The control group received teaching of the maths skills as I would have taught it in the absence of this research project. The test group on the other hand received maths teaching that I planned after collaborating with the maths department. This collaboration consisted of weekly meetings between myself and a member of the maths department where we discussed terminology, methodology and curriculum sequencing for mathematical concepts included in Biology Topic 8. To assess the impact of the differential maths teaching, the two classes completed paired pre- and post-tests that I designed to assess attainment (content test) and confidence (questionnaire), and so this project can be defined as having a 'pre-test-post-test control group design' (Cohen et al., 2017). The content tests contained past-paper GCSE maths in science questions and the confidence questionnaire was based on the 5-point Likert-scale method. Non-parametric statistical analysis was performed to compare the pre- and post-tests as well as to compare the control and test group.

The pre-public exam papers of two year 11 classes were analysed to assess attainment in pure science questions as opposed to questions that required maths skills (Figure 1). The two sampled classes achieved significantly higher in maths in science questions compared to pure science questions with the pupils achieving on average 17.0% and 21.7% more for Class 1 and Class 2 respectively. This data is in possible contradiction to the literature discussing that pupils struggle with maths in science, as it indicates that this sample of pupils actually perform better in science questions that include maths.

Figure 1. Attainment is percentage of marks achieved on pre-public exams, in marks defined as either a science question or a maths in science question. Wilcoxon matched-pairs signed rank test; error bars indicate mean ± standard deviation; ***P < 0.001; ****P < 0.0001.



Analysing attainment of the participating pupils demonstrated that the test group on average generally achieve lower in both maths and science compared to the control group (Figure 2A). Figure 2B shows that in accordance with the general attainment data, the test group achieved slightly lower (3.7%) on the pre-test than the control group. The test group then achieved a statistically significant higher attainment on the post-content test, scoring on average 8.6% higher than the control group. This data could excitingly suggest that aligning mathematical approaches between the maths and science departments can indeed have a positive impact on pupil

attainment when answering maths questions in science lessons. No positive or negative impact on confidence was found from analysing the pre- and post-questionnaires in either group (data not shown).

Figure 2. Attainment is percentage of marks achieved on end-of-topic assessments (A) or on the project pre- and post-test (B). Mann-Whitney test (A) and Wilcoxon matched-pairs signed rank test (B); error bars indicate mean \pm standard deviation; ns, not significant; **P* < 0.05; ***P* < 0.01.



Whilst I regard the quantitative and statistical nature of this research to be convincing, several limitations to the project must be observed. To further investigate how robust this claim is, similar research must be conducted with larger sample sizes, and with randomised groups. Furthermore, these results exist only in the context of biology and similar research should be repeated to see if similar results would be found in the context of chemistry and physics. Similarly, these results are also constrained to the context of the study school and year 10 separate science pupils and would need to be repeated in different contexts to see if the conclusions may have a wider significance.

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Dr Mark Taylor

What is the difference in understanding between using videos or demonstrations in science lessons?

Introduction

During 2020 and 2021 much of the UK was in lockdown and school pupils had no access to science labs or practicals, instead they only had online learning or at home experiments.

Whilst this was (hopefully) a once in a lifetime event, it has inspired some questioning of what to do when a student practical would be impractical. A lot of the literature expounds how important practical study is (Abrahams et al., 2013; Millar, 2010; The Royal Society, 2014). This can, however, be difficult due to shortages in equipment, time, money, or expertise. In these scenarios teachers may still want to exhibit the practical side of the science as much as possible. Two viable options are the demonstration and the video.

Pro Video:

The time required to plan, risk assess, set up and carry out a demonstration can be prohibitive. This often involves a large amount of time in and out of the classroom. This is in comparison to finding a video online, which could take just a few minutes.

The reliability of video can be persuasive. The risk of a demonstration going awry is sometimes enough to put off teachers. A video won't send the whole school out of the building by triggering the fire alarm.

Videos can ensure the best camera angle, be paused and re-watched and use slow-motion (Watters & Diezmann, 2007). Much of this, however, relies on the quality of the video.

Pro Demo:

The only control a teacher has over a video is the play and pause button. In a demonstration, the teacher can alter the set up themselves. They can self-sabotage and ask what went wrong. They can slow down or speed up depending on the students understanding or time allowances. The teacher has much greater control over a demonstration.

Quality of the teacher-led discussion is seen as very important in the literature. In particular the use of questioning as the demonstration unfolds (Chin, 2007; Moore et al., 2020).

Many teachers would also say "there's no substitute for the real thing".

The literature

Some literature showed no difference in enjoyment from the students watching a video or demonstration (Kestin et al., 2020; Sever et al., 2010). The literature here, however, is of relatively small number of university students in a lecture setting.

One study by Moore et al. was more relevant to the modern classroom context (Moore et al., 2020). Groupings were made from 1252 students who either watched a video, watched a teacher

demonstration, read about the experiment in a textbook format or performed the practical themselves. They then answered GCSE exam questions on the experiment.



The groups that watched the demonstration scored higher ($52.0 \pm 17.2\%$; mean \pm standard deviation) than those who watched a video ($45.4 \pm 20.2\%$), with statistical significance (p=.002, effect size=0.35).

Given access to only a small sample size I attempted to qualitatively ascertain how video or demonstration affected motivation and interest in the topic. More specifically how much the student enjoyed the overall experience of the lesson and their opinion on the effectiveness of the demonstration/video.

Project plan and rationale

The preparation of a soluble salt from an insoluble oxide or carbonate was chosen as the experiment that was demonstrated or shown as a video. The participants for this work were two groups of year 11 children studying for AQA GCSE.

The demonstration was given to a class studying for GCSE Chemistry, whilst the video was show to a class studying GCSE Combined Science. Both groups were then split into pairs and completed the practical. Both groups were given the same exam questions upon completion of the practical.

Data collection

A Likert scale was used to ascertain the students' feelings on how they enjoy the subject, the lesson, the demo/video and the practical. They were also asked how useful each section was in terms of answering the exam questions.

Findings

The number of total responses was 17 across the two groups: 16 from the Demo group, 9 from the Video group.

The difference in attitudes between how the two groups saw the video or demonstration was not particularly strong either way. The opinions expressed on the usefulness and interest of both video and demonstration were relatively similar and did not hint towards much of a difference. The

demonstration was slightly more well received but this group had already expressed a greater like of chemistry in general.



The most marked difference shown between the groups was the enjoyment of the practicals and how practicals helped students answer exam questions. The Demo group showed less enjoyment and less correlation between doing the practical and their ability to answer exam questions.



As previously higher attaining the Demo group may be more exam-orientated than the Video group. The Demo group may have seen the time performing a practical better spent practicing exam questions.

The Video group clearly enjoy practicals to a far greater extent, this could be for a number of reasons. These could range from novelty, autonomy, satisfaction of a positive result, or simply an opportunity to talk to their friends (Abrahams, 2009; Toplis, 2012). It could also be the fact that they see practicals as a useful way to obtain better marks on the exam questions, given they see this has a greater correlation.

Conclusions

As a whole this project showed there was no great differing in opinions on the use of video or demonstration. This may be due the number of participants being too low to discern any slight difference of opinions.

The clearer result was the difference of opinion in use of practicals in class; both the enjoyment of practicals and their usefulness in answering exam questions. The Combined Science group showed much greater appreciation for the practical compared to the higher attaining Chemistry GSCE group.

It has previously been recommended that practicals are used more heavily at earlier age groups and less as the students become more exam orientated (Sharpe, 2012). Could this also be applied to different attainment groups? The answer that most literature gives is that all groups benefit from practicals at all stages (Abrahams et al., 2013; Millar, 2010; The Royal Society, 2014). However, given the shortage of science teachers, technicians, equipment and technical know-how, there may be times in schools where one group will be unfortunately prioritised over another. Which group would gain the most from the practical may be a question asked all too often, some research-based guidance could be beneficial.

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Dr Peter Eardland

Do schools need to create new spaces to make outdoor learning more accessible?

The advantages of regular contact with green spaces include benefits to physical and mental wellbeing and increasing connection to our natural environment (Berman et al., 2008; Bratman et al., 2012; Keniger et al., 2013; Pritchard et al., 2020). In schools, studies suggest benefits to health, behaviour, engagement, attention capacity, stress levels, socialisation, enjoyment of school, and retention of knowledge (Bell & Dyment, 2008; Blair, 2009; Chawla, 2015; Kuo et al., 2018; Largo-Wight et al., 2018). However, despite these benefits, young people today are outdoors less than ten years ago, made worse by the impact of Covid-19. There are also clear inequalities in access to green space, depending upon both financial and ethnic background.

In my opinion, schools, where children spend most of their daylight hours, should encourage the use of outdoor learning as far as possible. However, use of outdoor learning is not often discussed in secondary settings (Edwards-Jones et al., 2018).

This may be due to concern about curriculum relevance, teacher knowledge/confidence in using the outdoor setting; concerns about class management and behaviour; and practical considerations such as: weather, equipment; lack of a dedicated learning space (Barfod, 2018; Edwards-Jones et al., 2018).

A solution to some of these difficulties may be to provide a dedicated outdoor learning space that mimics a classroom as much as possible, while still providing access to the school's green space. However, to my knowledge, little comparative research has been done to support the creation of such learning spaces.

My hypothesis is that, due to the similarities with a normal classroom, a dedicated outdoor learning space with clear boundaries would help to improve teacher/student confidence and behaviour during outdoor learning, compared to using a space with no set boundaries or learning features.

In order to test this hypothesis, I asked Year 10 students and their science teachers to use two outdoor areas during a GCSE Combined Science topic (Forces and Motion). One area was an 'enclosed space', with more feature similar to a normal classroom, such as tables and benches, and four sides. The other was a very 'open space', the school field.

Because it is always important to keep the number of variables small in an experiment, I originally planned to create a dedicated classroom on the field itself. However, due to the financial expense and competition for space in the school, I was unable to find the resources or agreement to do this. I therefore used an existing, tarmac outdoor seating area. The main distinguishing features between this area and my ideal area is the lack of grass underfoot, and reduced sightlines over open space (Table 1).

I asked each class to participate in four outdoor lessons, two in each space.

Each student then filled in a questionnaire about their experiences of the different outdoor environments, and I used these questionnaires to identify key themes raised by the students (Table 2). I also interviewed the two teachers involved, using an interview schedule designed to assess similar perceptions as for the students.

Finally, I designed a behaviour monitoring sheet, that two students could fill in each lesson, recording both positive and negative behaviours. However, when I compared results from both students for the same lessons, they had recorded quite different behaviours. Therefore, I decided that these data were unreliable, and I did not use them in my analyses.

Teachers were more forthcoming about positive features of the enclosed space, and made particular reference to the presence of boundaries, which were useful when organising classes, settling students, and attracting attention, supporting my initial hypothesis. One teacher also said it was easier to engage pupils in the enclosed space

However, the majority of students (54 %) felt that behaviour was better in the open area compared to the more enclosed learning space (Figure 5). Also, the open area made students feel engaged with the lesson, have fun in the lesson, or find the lesson interesting (stated by 14 students). By comparison, while students enjoyed the practical activities in both spaces, only six students commented on feeling engaged in the enclosed space. Students appeared to have enjoyed the open space, even though many of them commented on the negative factors, such as weather/bugs (20 students) and lack of facilities (8 students).

I also asked students which area they felt the most secure in, and which they felt the teacher seemed more confident in. The majority of students answered the open space for both questions. Again, this was different to the teacher responses, whose answers were generally more in line with my hypothesis.

The differences in students/teacher opinions about the spaces could be motivated by the students' extra sense of freedom, and perhaps by the greenness of the space, which I was unable to control for. There is a large body of work supporting the idea that humans naturally prefer greener, savannah-type environments, open spaces where resources and threats can be identified from a distance (Balling and Falk, 1982; Ruso et al., 2003; Ulrich 1986). This effect has also been found to be stronger in children and teenagers compared to adults, who have had time to adapt to their living environment. It is possible that this evolutionary preference could be related to the student preference for the open field, despite the challenges of working there.

If I were to repeat the study, I would aim to revert to my original conception of the enclosed space as an area of the field that could be set up to have a boundary, and perhaps also with tables for lesson use. In any case, the evidence suggests that this approach may represent a happy medium between the two extremes. Boundaries and learning facilities were helpful for the teachers, and could be added to a green space in such a way that sense of freedom and openness could be retained.

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Lesson compaction in post-16 Physics

Introduction and problematization

In post-16 Physics lessons in my school context, there is often a wide range of prior attainment, a proxy for relevant prior knowledge. For students with strong prior knowledge, listening to a reexposition of securely learned content is unlikely to be the best use of lesson time and could disincentivize independent preparation for lessons (Goedhart, Blignaut-van Westrhenen, Moser, & Zweekhorst, 2019). Meanwhile, the same teacher-led exposition could be excessively challenging for a pupil with weaker prior knowledge, due to the greater demand on limited working memory (Sweller, van Merriënboer, & Paas, 2019), suggesting strong potential benefits of a differentiated approach.

'Curriculum compacting' was first proposed and named in the context of Gifted and Talented education, as a way of enriching the educational experiences of gifted children while reducing the potential for boredom and frustration (Renzulli, Smith, & Reis, 1983). In the original concept, pupils are selected by pre-course testing to skip some regular timetabled lessons and complete enrichment or extension activities instead. I investigated the compaction concept in post-16 Physics lessons, but using a lesson-by-lesson implementation rather than at the level of whole units of work, to enable a timely assessment of the relevant prior knowledge and avoid potential longterm labelling of pupils as higher or lower ability. The feature defining a lesson as 'compacted' in the study was that students could skip a portion of teacher-led content exposition or routine practice tasks in favour of independent work on more challenging question sets, based on the results of a prior knowledge test (pre-test) at the start of the lesson.

Intervention and data collection

The overarching research question of the study was "In what ways can compacted lessons benefit post-16 Physics students?". I addressed the question through a small-scale qualitative study in an action research design. I taught several compacted lessons with my year 12 class, and held semi-structured interviews with student participants after the final lesson in the study. I resourced three additional lessons for two teacher participants, one for each of their A-level classes, and held semi-structured interviews with each teacher participant shortly after they had taught their compacted lesson(s). The semi-structured interviews were used as the main source of qualitative data, supplemented with students' responses on an initial questionnaire and short in-lesson reflection tasks, and with natural data in the form of students' work on the independent tasks.

Findings

Both student and teacher participants responded positively to the pre-test in and of itself, independently of any subsequent differentiation of the lesson. A major benefit of the pre-test is the nature of the feedback it provides. Different ways of addressing the various possible fine-grained outcomes of the pre-test are built naturally in to the lesson structure, especially in terms of responding in different ways to identified knowledge gaps, mistakes and misconceptions. In the case of knowledge gaps, further instruction rather than feedback is recommended (Hattie & Timperley, 2007), which is already part of the compacted lesson strategy. In the case of misconceptions, where simply stating the correct answer as feedback is unlikely to be effective (Black, Harrison, Lee, Marshall, & Wiliam, 2004) the degree of overlap in students' responses can indicate to the teacher a situation where a group or whole-class discussion of the misconception would be helpful, which was the approach taken by one of the teacher participants. Further, the compacted lesson structure provides an automatic opportunity for feed-forward, the application of feedback to a related task (Shute, 2008).

Initially, a rigid cut-off score from the pre-test was used to assign students to the independent work. However, student feedback and the decisions taken by teacher participants, considered in the framework of the self-determination theory of intrinsic motivation (Deci & Ryan, 2000) suggest strong benefits to a more flexible approach. Allowing students to self-select for the more challenging independent task is expected to sustain their intrinsic motivation if their choice is connected to their personal goals in line with autonomy support, and if the choice is informed (by the pre-test) and manageable (e.g. here, binary) in line with competence support (Katz & Assor, 2006). Allowing students to move up to the more challenging task after a proportionate amount of corrective work or routine practice based on the pre-test could avoid the perception of an unfair consequence for mistakes and reinforce students' general attitude to the pre-test as a chance to show competence rather than a way to access a reward. Additionally, both sets of participants described benefits of collaborative group work, which in the smaller class (year 12, class of 4) implies a default preference to avoid a task split, and more generally suggests that personalization of the independent task through question choice is likely to be unproductive.

Students viewed linking different items of knowledge as a key source of value gained from practicing exam-style questions in the independent tasks. The literature on problem-solving in Physics supports the idea that making links in knowledge is an important part of making progress, by building up progressively more complex connected chunks of knowledge that can be manipulated as single items, allowing complex problem-solving without working memory overload (Tuminaro & Redish, 2007). Within hierarchies of problem demand, the value of linking and organizing knowledge could be thought of opening up lower-demand routes to solving a similar problem in future, for example in the Physics Problem-Solving Taxonomy (Shakhman & Barak, 2019) a strategy-level problem could be turned into a retrieval-level problem. Students' classwork showed that even nominally low-demand questions can provide this type of benefit, as they may be solved by higher-demand routes if students do not initially recognize that a lower-demand solution is possible.

Teachers felt that question sets for independent practice could be efficiently assembled out of past A-level exam questions. There was no sense from student or teacher interviews that past exam questions provided insufficient challenge, possibly reflecting the remit of A-level exams from 2008 onwards to provide stretch and challenge to the highest attaining pupils (Department for Education and Skills, 2005). Additional preparation time associated with atomizing more synoptic problem sets associated with stretch and challenge (Isaac Physics, BPhO Senior Physics Challenge) was not reflected in any clear benefits to students. However, 'conceptual' questions requiring an answer or explanation in terms of underlying physical principles rather than explicit calculation, did not add much to the time needed to resource the lessons, added considerable challenge for students, and were appreciated by teacher participants.

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Dr Roger Christofides

Cold Calling has become a staple of classroom questioning in recent years, but can pupils creating their own questions offer more, especially to the confidence of Pupil Premium pupils?

The pedagogical techniques advocated by the edupreneur Doug Lemov have permeated British classrooms to such an extent that is has become national news (see Leslie, 2015). Cold Calling, for Lemov himself, is the most important technique because it substantially heightens the "level of expectations in the classroom" (2015, p.249). However, research indicates a contradiction. On the one hand, Cold Calling demands accountability and "can lead to greater participation of minority groups". On the other hand, it can also be "adversarial" and harm the self-esteem of pupils, especially those who face challenges to their learning (Levy and Bookin, 2014, pp.94, 95). Moreover, Cold Calling tends to reinforce lower-order questions, with "67-95 per cent of questions involv[ing] straight recall" (Knight and Benson, 2014, p.169). This research project explored whether pupils formulating their own questions, rather than being Cold Called, could break the cycle of adversarial, lower-order questioning and engender greater confidence, especially for Pupil Premium pupils.

Firstly, creating questions allowed processing time. Pupils are rarely given adequate opportunity to process information because "most teachers still find it impossible to tolerate increased thinking time" (Knight and Benson, 2014, p.169). Creating questions allowed pupils precisely that increased thinking time, opening up the space for more considered, advanced responses to the subject matter. Secondly, pupils were given the opportunity to be the questioners, placing them in the meta-cognitive position of reflecting on their own understanding. Indeed, pupils usually only average a question every six or seven hours (see Graesser and Person, 1994) and encouraging pupils to ask questions may well be "the biggest conceptual shift" needed in approaches to questioning (Knight and Benson, 2014, p. 185). Thirdly, from the perspective of English, Cold Calling best serves memorisation and comprehension rather than the higher tiers of Bloom's traditional taxonomy – analysis, synthesis, and evaluation: learning how to question the text is perhaps the most important subject-specific skill an English pupil can develop.

Over the course of a mini-scheme of work, Cold Calling was replaced with the creation of questions by pupils themselves. Using Likert scales, the participants were surveyed on their confidence when being Cold Called prior to the intervention and their confidence when creating questions after the intervention. Although quantitative measures, the interpretation of the data was qualitative due to the small sample size and the self-identifying nature of the task. Like so much education research, then, this project was a negotiation between theoretical principles and the practical realities of the lived educational experience (Bhaskar, 2008), resulting in a practical combination of quantitative and qualitative methods (Creswell and Clark, 2011; Tashakkori and Teddlie, 1998). The porous nature of the boundary between qualitative and quantitative methods also chimed with the critical approach that structured the project.

To effect Knight and Benson's "conceptual shift" towards pupil questions, I took a deconstructive methodological approach. Deconstruction is perhaps the most well-known of the popular poststructuralist methodologies used at undergraduate level and beyond in literary studies. It has, however, not permeated down into secondary schools. Deconstruction points out that the language we use is structured by oppositions that are hierarchical, with one term gaining preeminence over the other. Culture imbues these oppositional terms with particular meanings, so that, for instance, "man" becomes associated with certain values or ideals that then cannot be associated with "woman". Deconstruction argues that we learn what "man" means not because the word is magically imbued with meanings, but simply because it is not "woman" (or "fish" or "bicycle"). The opposition and the hierarchy are thus deconstructed, exposing both opposition and hierarchy as cultural constructs, not natural phenomena.

Transposing this to the material conditions of this research project, there are two oppositions that came under erasure in this project: the hierarchical opposition between pupil and teacher, in which the teacher traditionally has the authority to ask questions; and the hierarchical opposition between speech and writing, in which those questions are asked orally, especially for Cold Calling. So not only did this methodological approach challenge the assumptions surrounding Cold Calling, it was also part of a process of looking for ways to improve the cognitive structure of pupils in a school in which a persistent attainment gap exists between Pupil Premium and non-Pupil Premium pupils. The hypothesis of the project was that the creation of questions could improve Pupil Premium confidence and, as a result of this improved confidence, help address that attainment gap in the longer-term.

The first survey was completed prior to the intervention. Broadly speaking, the findings were as follows:

- 5 of 6 pupils believed answering Cold Call questions helps them understand the work better.
- 1 Pupil Premium pupil was neutral about whether Cold Call questions help them understand the work better.
- 2 of 6 pupils are not confident when answering questions and, specifically, when answering Cold Call questions. Both are Pupil Premium pupils.

This seems to support Lemov's contention that of all the techniques in *Teach Like a Champion* Cold Calling is the single most important (2015, p.249). However, if Lemov's claim is being substantiated here, why does the school still have an attainment gap between Pupil Premium pupils and non-Pupil Premium pupils? Has Cold Calling helped to improve attainment for all pupils equally, thereby maintaining the attainment gap? Or, given that Cold Calling can encourage the participation of minority groups (Levy and Bookin, 2014, p.94), is greater participation alone not enough to narrow the attainment gap? Lastly, what do we mean by "participation" and to what extent is it occurring? Two of the six pupils felt they were not confident when answering questions and, specifically, when answering Cold Call questions; both were Pupil Premium pupils. So how do we characterise "participation" when the results seem to indicate that Pupil Premium pupils lack confidence when answering Cold Call questions while non-Pupil Premium pupils feel confident? This schism is invisible and subjective, yet always a factor.

After the intervention there was no change in how confident pupils felt overall, or usually, in English. The findings regarding the creation of questions were as follows:

- 5 of 6 pupils mostly or strongly agreed that they felt confident creating their own questions;
- 5 of 6 pupils felt more confident creating their own questions than answering Cold Call questions;

• 4 of 6 felt that creating questions helped them to understand the work better, compared with 5 of 6 for Cold Calling.

This suggests that the pupils surveyed did feel more confident when creating their own questions, but that their perception of understanding the work better was not quite as unequivocal with creating questions as Cold Calling. Still, in a short space of time, pupils seemed able to adapt to the new task of creating questions and were comfortable doing so, feeling as though they were executing it in an assured manner. That five of the six pupils felt *more* confident creating questions than answering Cold Call questions seems to suggest that the intervention achieved an intermediate outcome of improving pupil confidence. If that figure remained broadly consistent in a scaled-up study, would that be an acceptable threshold for the school to then consider the creation of questions as a pedagogical tool to be instituted alongside Cold Calling as school-wide practice? What of the other third of Pupil Premium pupils? These are questions that would have to be considered in a scaled-up study.

In terms of limitations, the following should be considered:

- The sample size was small and, therefore, opens the door for larger, future studies rather than providing definitive answers;
- All pupils Pupil Premium and non-Pupil Premium were high ability.

As a consequence of the small sample size, many of the results must be treated as statistically inconclusive. Nevertheless, there was a definite trend. Pupils overall felt confident creating questions, and pupils overall felt that creating questions gave them more confidence when compared to answering Cold Call questions. As well as this, pupils overall felt that creating questions helped them understand the work. The inconclusive nature of the survey results does mean it's difficult to extrapolate general conclusions with regard to Pupil Premium pupils specifically. However, there seems to be an identifiable trend in the specific context of the school, a trend that indicates that creating questions may well be beneficial, helping with confidence in both Pupil Premium and non-Pupil Premium pupils. A larger, more substantive quantitative study would offer greater insights into how these trends clarify over a larger sweep of numbers and contexts.

Also, all the pupils were higher-ability pupils. So although free school meal eligibility (and therefore Pupil Premium funding) is above the national average, due to the geographical location of the school – at the cross-section of areas that range in scores significantly on Income Deprivation Affecting Children Index (IDACI) measures – the school also attracts pupils from more affluent backgrounds resulting in a school environment where access to, and experience of, education can often be radically different. The class involved in this project were a high-ability year eight class where the percentage of Pupil Premium pupils was actually below the national average. The results of the surveys – and the material conditions of the project itself – would have been very different with a typical lower-ability year eight class where the number of Pupil Premium pupils are usually, and often significantly, above the national average. A larger study would, then, need to see how lower-ability pupils respond, scrutinising any differences between higher-ability and lower-ability Pupil Premium pupils.

To conclude, the results indicate that there is an apparent direction of travel worth investigating further. And the worth of this, I would argue, does not revolve solely around the snapshot of generally improved confidence and comprehension. Alongside this snapshot is the deliberate, methodologically-defined opportunity this pedagogical intervention allows to facilitate a more heterogenous understanding of English, an understanding beyond the thematic strictures of the National Curriculum and the "dead white male" focus still frequently maintained by schools themselves, thus allowing a space in which the world view of the pupil – and not "cultural capital" as a monolithic, government-defined (and often Imperially Anglo-Saxon) concept filtered through the professional authority of the teacher – can enter the conversation. In this sense, this research

project also paves the way for a larger, future study on whether the creation of questions can help an ever-diversifying pupil demographic – and, specifically, the diverse economic crosssection of pupils at the school – bring their cultural knowledge and experiences to bear on a subject that has, for many decades now, simultaneously celebrated and constrained difference.

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Dr Ruth Abou Rached

Re-writing the script within Modern Foreign Languages: How does teaching Arabic in school impact on pupils' experience of learning?

THE ISSUE: Since 2001, Arabic has been considered a relevant subject for secondary schools for many different reasons: faith, commerce, and politics (Tinsley, 2015), its presence in school is often a reflection of government policies at a given time. In 2014, Arabic, with Farsi and Turkish, was deprioritised as an A-level (Slattery, 2001). In 2016, the Education Secretary announced that Arabic, among other languages, would be 'saved' at GCSE and A-Level (DofE, 2016). With Anti-Racist curricula developing apace (CRED, 2020), the politics of LTL language-learning – and linguicism, the marginalisation of some languages in relation to others (Skutnabb-Kangas 1988)- in England has become deeply connected to key debates on widening participation. These debates are key, concerning pupils of minoritized backgrounds who may lack confidence in their contributions to knowledge (Lander 2020).

THE GAP: Whatever the politics of Arabic within secondary schools, many pupils at pre-GCSE and GCSE -level experience access that learning Arabic outside of school settings is not systematic. It can often depend on geographical, cultural, and religious location. Ways of learning Arabic however differ from other languages due to its diaglossia in speech and writing: that Arabic that we speak at home, and what we write in in Arabic, regardless of script, are very different to each other. For speakers of other languages less taught in the UK, such as **Turkish** (Baykusoglu, 2009) and **Portuguese** (Demie & Lewis, 2010), the inclusion of these languages in school however did enhance pupil participation and outcomes

THE SPACE: While I cannot direct intervene into the provision of all community languages on a wider scale, I could intervene in my local setting: by teaching Arabic in my school for pre-GCSE pupils x1 a week/ The aim of this intervention is two- fold: firstly, as one way of preparing pre-GCSE pupils for formats of the GCSE. The second aim of the class was to build confidence in their learning in school.

My research, and its premises of inquiry concerning Arabic in school relates to how could the teaching of written Arabic in school impact on pupils' pre-GCSE learning experience & participation?

In terms of action, I have been delivering one lesson of written Arabic teaching per week in this school to pre-GCSE pupils identifying as Arabic-language-speaking. The project is called 'The Expert Linguists Programme. Pupils have joined for differing reasons. Some pupils have future GCSE attainment in mind. Others wanted to develop friendships. The share starting point was to establish for pupils a sense of pride in their very different ranges of knowledge and to foster belief in potential academic attainment in Arabic.

As the project has only been running for a short period of time, I have been exploring initial impact of this interventions from pupils' perspectives. I have divided up my scope of inquiry into 5 subsections:

- How pupils use written and spoken Arabic now
- How pupils do access and use language learning in school
- Opinions of learning written Arabic in school
- Opinions of others learning written Arabic in school
- How learning Arabic in school if at all, impacts on their learning in school.

The participants of this study were twelve pre-GCSE pupils on the Expert Linguists Course. Other participants were three teachers of Modern Foreign Languages (MFL) and English as an Additional Language (EAL) how had a wealth of experience on different generations of language learners.

I used a mixed methods approach to collect data (Denscombe, 2017; 2008) in that I used a combination of anonymous questionnaires and semi-structured interviews. I first collected data from pupils via anonymous questionnaires that pupils filled in at the beginning of the course and six weeks later. My second data collection was via semi-structured interviews with teachers of MFL and EAL.

Questionnaires were brief, in pupil-friendly English-language so that pupils did not find them 'highstakes. The questionnaires were in mixed formats: multiple choice where one option is possible and multiple choice where more than one option is possible. There were spaces for commentary.

I then 'tallied' up the responses and collated the results in another excel sheet tab. I created five visual representations to gain a snapshot of pupil opinions on the impact of learning Arabic in a school setting.



What the data shows is that differences of opinion on writing Arabic: a desire to write it seemed to emerge alongside a sense of writing Arabic being difficult in both the first and second survey. Responses given by pupils indicated that they were unsure of how learning Arabic would have impact, specifically on confidence in their school studies. In the first survey, enjoyment figured highly in the impact expressed by pupils, as was a sense that learning Arabic in school could help them progress. In the second survey, similar responses were given, but interestingly, some expressed that they felt confident and less confident in their Arabic. This response is not surprising,

as we had moved to writing sentences, rather than working on individual words. Writing even a verbless sentence in Arabic is process which requires cognitive load

In the second survey, all pupils felt that learning written Arabic helped them learn more in school. no pupil stated that it made no difference at all to their learning. The written responses from pupils included:



As Denscombe (2008) astutely pointed out, learning is however always situated, and educational research in this case is certainly no exception. This also applies in the context of gathering comments: very few pupils gave few written responses. Comments were brief in nature, albeit valuable. One reason could be that pupils felt cautious to write for fear of being identifiable. Another reason is a sense was that they found the surveys repetitive. Another limitation is that the learning of any language takes time. After a longer period of time that we can, perhaps, gauge fuller perspectives from pupils.

Future directions relate to what or how we teach formal Arabic. While the pupils enjoy writing, they also enjoy speaking Arabic too. This style of data gathering could not capture but I could only observe anecdotally as a teacher: the smiles on pupils' faces when they heard phrases in Arabic dialects, and when they realised words in their own dialect were welcomed and valued by others too. The pupils and I now keep a post-lesson diary of their dialect words used in class as part of the legacy of the project.

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Dr Sam Wharton

Can Physics Investigations in Mechanics Improve KS3 student's Extended Responses and Working Scientifically Skills?

Introduction

This project was motivated by a departmental target to improve the skills of KS3 students before they began their GCSEs. Students were underperforming on skills-based questions in GCSE tests, particularly written skills and those around experiments.

To do this, unit 1 of the year 9 physics curriculum was redeveloped to incorporate a more coherent strategy to teaching these skills.

Teaching Literacy and Working Scientifically Skills

A review of the literature suggested several possible strategies to improve student's scientific literacy through improving inferencing, comprehension and vocabulary. Kispal (2008) found that inferencing is hard to directly teach because it depends on a range of factors including background knowledge and cultural capital, but that the teacher's own inference can be effectively modelled. Students are most receptive to this kind of modelling at KS3. A report by the Education Endowment Foundation (2018) found that age-appropriate comprehension strategies can deliver six months additional progress, and Kesty (2018) suggests using science-related reports and news articles to do this. Conkerton (2021) also adds textbooks and suggests activities could include fact finding from articles and summarising them. The literacy toolkit by the Victoria State Government, (2019) recommends explicit teaching of tier 2 and 3 vocabulary and active reading of texts, where the students have an accompanying task. It is clear from these ideas that the students must be provided with opportunities to read throughout the project.

The working scientifically skills the students need to learn are broken down into five categories on the AQA Entry Level Certificate specification they have to follow, those being:

- 1. Experimental design
- 2. Working safely and making measurements/observations
- 3. Recording Data
- 4. Presenting Data
- 5. Identifying Patterns/Relationships

Various teaching resources websites were mined to find good examples of how to scaffold these skills. Wenner (2020) gave a particularly good breakdown of how to teach graph skills in stages, separating stages such as axes design and describing relationships.

One of the topics on the curriculum is energy resources. It was decided this would be run as a project using the structure described by Tsoubaris, Bencze, Curtis, & Zouda (2020) that encourages students to think about science's place in a wider society using reflection, teaching and their own

research. This would give the students plenty of practice at reading and analysing text and an opportunity to present it at the end.

Using Multi-Lesson Projects to Teach Skills

To bring these skills together, the curriculum was split into four projects outlined in **figure 1**. The Energy Resources project required them to reflect on their current knowledge, to read lots of short articles about energy resources and summarise the information into a group presentation they delivered in the final lesson.

The Energy, Forces and Acceleration projects were based around a practical in which they had to understand the aims, plan a method, record data, execute, then analyse and evaluate after. They were given opportunity to practice their writing through the methodology and evaluation. The students were given a carefully designed worksheet to guide them through the practicals that tested all of the required working scientifically skills. They also received further reading in the application lessons of energy and forces.



These lessons were delivered to nearly 300 students in year 9 by their usual teachers. Afterwards, the students and teachers were given similar questionnaires to measure their perceptions of how effective the projects were and four teachers were interviewed in detail. 153 students completed the questionnaires.

Student and Teacher Perceptions of the Project

The students were split into higher and lower ability groups to analyse their questionnaire responses. The only question that showed a significant difference in their responses was the first question, which asked what their favourite project was. **Figure 2** shows that the energy resources project that required more reading and a presentation was the most popular with the higher ability students, but there was no preference for this project over the experimental projects for the lower ability students.



Figure 3 shows the student's and teacher's perceptions of whether they thought the projects improved their extended writing, planning, analysis and evaluation/explanation skills. The students gave higher median scores for extended writing and analysis. It was perceived that planning and analysis skills were the most developed by the project and extended writing the least.

Four teachers were also interviewed in more depth with a structured questionnaire. From analysing these responses, three main themes were identified.

Student Learning

- Teachers were satisfied that their students had learned the content, although lower students struggled to retain the knowledge.
- Skills such as equation solving and planning practicals were perceived to be well developed. The scaffolded practical sheet received direct praise.
- Many students lacked the science capital to access some topics (e.g. tidal power) but they enjoyed linking science to the real world.

Adaptation, Variety and Differentiation

- □ Teachers were satisfied with the quality of the resources. However, they also requested more differentiation for lower ability groups, which they took upon themselves.
- □ More variety in tasks, particularly starter tasks, might improve engagement.
- □ The lack of required planning by teachers was clearly appreciated by all teachers.



Project Structure, Timing and Curriculum

- □ Teachers felt pressed for time to deliver the knowledge content within this structure.
- One teacher also questioned the practicality of the planning time that must have been devoted to the whole project.
- □ The overall project structure was popular though, as it gave consistency, a long-term outlook and more purpose for the students.
- □ A suggested change was to move the practical from the second to the third lesson.
- The project has inspired reflection on the current curriculum by some. One teacher liked this way of learning, but felt that with the knowledge demands of the current curriculum that the choice of curriculum should be changed to accommodate this project style of learning.

Conclusions

The project aimed to see whether doing multi-lesson projects could improve literacy and working scientifically skills in Year 9 students. The students and teachers engaged well with the projects, and the students planning and analysis skills were perceived to have improved, but less so their extended writing. It is clear that more thorough work would need to be done with these projects to improve their literacy. Having more time to teach the knowledge content and better differentiation of the resources was something most teachers wanted but they still liked the structure. It has been suggested the underlying curriculum should be reconsidered by some.

It should be noted that the results of this study are based on just a single school, and that the context of other schools should be considered if trying to implement these ideas somewhere else. Nevertheless, a large sample of 153 students were questioned here which gives our results validity that can often be difficult to achieve with small-scale education research.

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Dr Thomas Scambler

Do teachers talk too much?

Hattie et al show that around 80% of a pupil's time in a classroom is sat listening to teacher talk (Hattie, 2009) whereas only 10% of lesson time in science is allocated for reading (Lunzer, 1984; Raban et al., 1980). Whilst this exchange of information is essential, teacher-led lessons may not be the most effective format to impart information (Wilson, 1999). Pupils are expected to be passively listening or answering cold-called questions, leading to less inspiring science lessons as pupils get older (Porter & Parvin, 2009). This style of learning also impacts pupil literacy (Hattie, 2009). Without frequent and consistent periods of reading and writing pupils are often left ill-equipped when challenged with simple texts or when asked to complete extended writing tasks (Sherwood & Kovac, 1999). Poor literacy levels are particularly prevalent in Science. In 2018 the Education Endowment Foundation (EEF) (Education Endowment Foundation, 2018) published a report and subsequent recommendations for 'Improving Secondary Science'. The penultimate recommendation, 'developing scientific literacy' is the focus of this study. Writing about science is critical for developing pupil understanding of complex topics (Rivard & Straw, 2000). Writing provides the opportunity for pupils to consider their comprehension of a topic and advance their newly formed ideas (Wellington, 2001). In this study, I plan to combine the findings discussed above into directed activities related to text (DART) (Raban et al., 1980). These DART tasks will comprise of a range of meticulously chosen scientific literature that have been appropriately scaffolded. The information extracted from these texts will then be transferred into various structured activities to aid comprehension.

My research question 'How do activities related to text impact extended reading and writing in science for year 9 pupils?' was investigated using a set of alternative DART resources across a KS4 biology topic in year 9 were created.



Figure 1: A

summary of the study design, in which a year 9 class is split into two and provided the same

information in two different formats: through teacher-talk or text/literature. Both groups then attempt the same extended writing task using the same scaffolds and frameworks.

Both groups performed better in terms of total marks when part of the extended reading/writing group. On average, when pupils engaged with scientific text rather than teacher-led exposition they performed 14.27% better on extended writing activities. This was the case in all four pieces of extended writing and equated to 0.86 of a raw mark within each 6-mark extended writing question. These results are particularly interesting as both groups performed better when reading the text. This study showed that pupils were more likely to achieve band 3 scores when they carried out DART tasks prior to the extended writing instead of Teacher talk and discussion, with 18% more band 3 scores. The number of pupils receiving 1-2 marks in band 1 was higher (39.3%) in the groups receiving teacher talk compared with just 23.9% completing DART tasks. This difference may have been due to pupils having the opportunity to engage with the text, understand how to use the keywords in sentences and see them written in context, linking ideas together (Tishman & Perkins, 1997; Norris & Phillips, 2003). These same contexts and links may not have been communicated through teacher talk. Interestingly, there was no difference between the control group and intervention group when the percentage of correctly used key terms was analysed, with both groups using ~51% of the provided key words correctly on average. The use of correct terminology and the banding of marks can be correlated. Pupils receiving scores in band 1 and 2 may be able to recall and use the key words but not link them together, in context to achieve the marks required to reach band 3. In terms of spelling, punctuation, and grammar (SPAG) pupils, regardless of group, made more errors when in the teacher-led exposition group with 1.36 errors per pupil compared to 0.36 errors per pupil in the extended reading group. An interesting example of this is the 'amylase'. This was frequently misspelt in the group receiving teacher talk, with a common misspelling of 'amalyse'. The teacher in this study had a regional midlands accent, teaching in a school in South East London. It may be that hearing this word in an unfamiliar accent lead to a misspelling. O'Neill et al observed a similar phenomenon in Irish accented English with misspellings such as 'different' as 'difrunt' in 7-17-year-old pupils (O'Neill et al., 2021).

As with any small scale, action research study, limitations existing due to small sample size and scope existed that limit the conclusions that can be made based on these data. An important limitation of this study is that just one topic, in one subject was assessed. With a single extended writing question addressing a specific aspect of a topic. A further limitation was that the groups were in the same room at the same time. There is a real possibility, most likely a certainty, that the groups engaging in the scientific text also heard the teacher talk.

Overall, it can be concluded that DART tasks improved extended writing answers in this class, for this particular topic. The year 9 pupils performed better in terms of marks gained, level of answer and spelling and grammar in their extended writing answers, when completing DART tasks opposed to teacher talk and discussion tasks. Finally, the implications of this study may change the nature of teaching in a practical sense. If taken at face value, policy changes on the training of teachers may include DART tasks as a mainstream method of teaching. If the conclusions of this study were to be adopted by teachers in their classrooms, a facilitator-style of teaching would be required (Tout, 2016).

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Dr Tobias Thornes

Can a Targeted Revision Intervention Improve the Exam Performance of High Ability Year 11 Physics Pupils?

Able GCSE pupils from disadvantaged backgrounds often struggle to achieve their target grades in science (Banerjee, 2016). Studies suggest that this potential for underachievement amongst disadvantaged pupils is due to lack of resources to help their learning at home, and also lack of motivation or opportunity to learn independently (Bedford, 2017). Whilst existing in-class intervention techniques for these pupils do take place in the school, such as questioning and challenging these pupils more often than their peers, the rationale behind this project was to investigate whether more targeted, individualised intervention techniques can improve outcomes for these pupils.

The project hence focussed on pupils who are identified as requiring intervention and also flagged as Pupil Premium. It aimed to examine the efficacy of techniques such as one-to-one interviews, targeted small-group revision sessions and guidance on completing higher-level GCSE exam questions effectively, in relation to the performance of pupils in physics assessments. Such techniques have been demonstrated to show efficacy before in small-group settings in different contexts (Soong, 2010; Higgins et al, 2016) and revision interventions of this time have helped to identify misconceptions amongst maths pupils before (Leech, 2019).

The project explored whether such techniques can improve motivational factors such as pupil self-efficacy, pupil perception of the value of learning and pupils' ability to successfully handle revision and exams. The focus was on physics, a subject which relatively few pupils go on to study physics post-GCSE (Soong, 2010), which may be related to a general notion that it is too difficult, or an inability to succeed in physics. The findings from this project could help to begin to address this.

Thirteen Year 11 pupils from the two top science sets, who study separate sciences, took part in the study. Pupils were invited on the basis of the need for intervention: primarily, those flagged up by the department as having scored two grades below their target or more in previous assessments were invited to participate.

Fifty per cent of pupils invited to take part were Pupil Premium (PP), but only four of the participants were PP (31%), which implies that PP pupils were in this instance less likely to agree to participate in a lunchtime revision intervention in science. This may be because they are especially lacking in motivational factors such as parents who have attended university or an emphasis on academic success at home, but the reasons for non-participation are beyond the scope of this study.

The study consisted of four main stages:

1. All participants were invited to fill in a questionnaire which asked about their experience of physics revision, their perceived strengths and weaknesses and what they feel would help them to revise more effectively.

2. A series of four revision sessions was carried out at lunchtimes, targeted to meet the needs of the different pupils taking part. The sessions focussed on examination technique, how to revise content required for exams, and how to solve more difficult, lengthier exam questions that pupils often struggle with. These were carried out by the researcher in a science classroom.

Participants filled in a follow-up questionnaire to evaluate their confidence at answering physics exam questions, their enjoyment of the programme and their enjoyment of physics in general, including whether they planned to pursue the subject at a higher level in future.
Participants sat end-of-term assessments alongside their peers, and results of both participants and non-participants were compared with their results before the intervention took place.

For this last part, the progress of the participating pupils during the intervention period was calculated from the difference between their results in physics past papers before and after the intervention. This was compared against the performance of a control group, which consisted of top-set pupils who did not take part in the intervention. This comparison, alongside anonymised comments from the questionnaire, was used to evaluate the success of the intervention.

The main findings of the research were these:

- 1. Pupil Premium pupils were less likely than others to agree to participate. This may imply a lack of motivation, and could be due to fewer academic family members, other commitments, lack of resources
- 2. Attendance decreased over time. Sessions were not mandatory, and feedback from the follow-up questionnaire suggested that pupils who stayed to the end would have preferred it to have been mandatory. Non-attendance could be due to the problem of establishing a consistent time and communicating sessions to pupils. Or, pupils may simply have not enjoyed the sessions or not found them useful.
- 3. Mean percentage marks on exam-style questions increased by 17 for participants, but only 13 for their classes as a whole. This could imply that the intervention was successful. Alternatively, those who agreed to the intervention may have already been more motivated and more likely to do revision than their peers.
- 4. Pupils who stayed to the end tended to enjoy taking part and felt that it increased their confidence in physics, according to the follow-up questionnaire. This shows that at least some pupils enjoy having a revision intervention of this sort in place, and that they think it has increased their confidence. However, it is not surprising that the pupils who remained part of the intervention until the end said that they enjoyed taking part!
- 5. The project did not increase pupils' desire to study physics at a higher level overall. Some pupils said in the follow-up questionnaire that they would be more likely to study physics at a higher level, others did not. This study did not measure whether this was specifically because of the intervention, or whether the pupils would go on to study physics in reality.
- 6. revision intervention of this sort in place, and that they think it has increased their confidence. However, it is not surprising that the pupils who remained part of the intervention until the end said that they enjoyed taking part!
- 7. The project did not increase pupils' desire to study physics at a higher level overall. Some pupils said in the follow-up questionnaire that they would be more likely to study physics at a higher level, others did not. This study did not measure whether this was specifically because of the intervention, or whether the pupils would go on to study physics in reality.

Overall, this project has shown the potential for a Year 11 revision intervention to improve physics performance for high-ability pupils. It has not proven that the strategies used here are effective,

but it has shown tentative evidence that they may be a means of improving both exam technique and confidence, and indeed that such interventions are welcomed by some pupils.

Future studies into Year-11 revision interventions could improve on this one by:

- 1. Making the sessions mandatory
- 2. Establishing a fixed time from the outset
- 3. Following up pupils after the intervention regarding exam results and future subject choices
- 4. Using more than one group of participants, preferably from more than one context

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Dr Adam Lightfoot

What is the most effective approach to retrieval practice in a secondary school science classroom?

A student's ability to being able to retrieve information in an educational environment is extremely helpful for both the student and the teacher. If a student can retrieve prior knowledge effectively, then more time can get put towards further developing ideas and concepts. From a student's perspective, effective knowledge retrieval can lower the amount of new information in the working memory, thus preventing cognitive overload (Sweller, 1988; Willingham, 2010). If the foundation of a new idea, that has been previously taught, cannot be retrieved then this can overload the working memory as it may be received as "new information", thus making the important classroom time less effective.

Retrieval practice in the classroom is very important for effective future teaching and development of ideas. Research has shown that retrieval practice can increase knowledge retention (Spitzer, 1939; Roediger et al., 2011; Dunlosky et al., 2013; Karpicke, 2017; Agarwal et al., 2021). Despite the strong evidence of the benefits of retrieval practice, some educational researchers have questioned the use of it in the classroom. Classrooms and laboratories both serve a different purpose, and whereas retrieval practice has been shown to be beneficial in both, in a classroom it can take away from important learning time (Adesope et al., 2017). Therefore, it is important that retrieval tasks are effective and serve a real purpose, and not just a "tick box" exercise that is completed in a mundane way each lesson. There is a debate as to whether the approach or type of retrieval practice has any influence in the ability to recall prior taught knowledge (Rowland, 2014; Endres et al., 2020). Therefore, the rationale of this study is to assess the impact of two different approaches to retrieval practice (targeted and holistic) and to compare their impact on academic performance in a science classroom.

The aim of the project focused on how much of an influence retrieval practice has on academic performance and if the type of retrieval practice affected future retention of knowledge. Following a literature review, I believe that retrieval practice does have a significant impact on a student's retention of knowledge, and that the type of retrieval could have an impact when it came to answering certain types of exam questions.

The study used two key stage 3 classes both of which I teach. The two participant year 9 classes $(9_x = 12, 9_y = 13)$ are of equal ability as determined by the school. The effect of each retrieval method was assessed by students answering select exam questions that had been sourced from the ExamPro website by another teacher in the school for an end of term test that had previously been taken in December 2021. The previous test scores acted as a baseline (prior retrieval intervention) and would be compared to test scores from the selected questions from the test. Retrieval tasks were designed for each lesson and were based on the topics of exam questions. Students answered the final questions under exam conditions and were given the equivalent time available to them in the exam to do so (one mark per minute).

Both year 9 participant classes (9_x and 9_y) completed retrieval on the topics of cell biology and introduction to chemical bonds. Class 9_x had a targeted retrieval approach, whilst 9_y had a holistic approach. In all cases, the retrieval was carried out at the start of each lesson with each class having an equal amount of time to complete retrieval tasks. Each year 9 class was given the same focus topic in parallel lessons ensuring participants had an equal amount of practice on each topic prior to data collected at the end of the intervention Additionally, as feedback has been shown to enhance the effectiveness of retrieval practice (Kang et al., 2007), the levels of feedback for each group were kept the same for each equivalent retrieval task.

Mean average test scores for the selected questions were analysed for each population using a paired sample t-test allowing for a comparison to be made between retrieval types. This test indicated if there is a significant difference between baseline and post-intervention data.



The data from both participant groups suggests that retrieval practice does have a benefit on improving academic performance when it comes to tests in school. By completing the retrieval task intervention, students gained an average of around 10% more marks (p < 0.05, two-tailed paired students t-test) in the selected questions used in the post-intervention test for both targeted and holistic retrieval. This could be because of students being able to remember more information due to the recall nature of the retrieval tasks. However, when it comes to answering if there is a more beneficial approach to retrieval, from the data there is no clear difference between the two types of retrieval intervention.

An interesting observation made about between the participant groups is where the marks were generally picked up from. The final test paper was split into two topics (cell biology and chemical bonds) and contained a majority of closed answered questions. Participants in the targeted retrieval group scored better and showed greater improvement than those who did the holistic retrieval on the closed answered questions. On the contrary, students who were part of the intervention scored better on average, and showed greater improvement on the more open, application questions when compared to those who did targeted retrieval. This trend in data may suggest that targeted retrieval tasks would benefit answering questions of a closed nature whilst holistic retrieval tasks may have a greater benefit to answering more open-ended questions in tests.

If more time were available, I would expand this study into more year and ability groups. Both year 9 groups consisted of students set in the lower 40% of the year group in terms of academic ability. It would be interesting to investigate the impact of different retrieval approaches across different ability groups, particularly at key stage 4. Typically, foundation papers will contain more closed questions of multiple choice or short answers. The data set from the year 9 groups suggested that targeted retrieval had a greater effect on exam performance when the questions were of a closed nature.

To conclude, the data gathered from this short study suggests a positive impact for the use of retrieval tasks in the classroom. Although it was not made clear as to whether the type of retrieval has an impact, both targeted and holistic retrieval tasks can benefit students in retaining knowledge and on exam performance. With the scope of this project only extending as far as key stage 3 science classes, it would be interesting to see if there are similar trends in other subjects when it comes to retrieval practice. Due to the nature of different subjects taught across the National Curriculum, approaches to retrieval may differ

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Dr Ana Rodriguez Arguelles

How can we support students to overcome literacy barriers in science, so they raise their aspirations and fulfil their potential?

The problem

The Department for Children, Schools and Families (2021) defined Most Able Gifted and Talented (MAGT) students as "Children and young people with one or more abilities developed to a level significantly ahead of their year group". The Ofsted departmental report (January 2022) states that it is "important to test the school's response to individual needs by observing how well it helps all pupils to make progress and fulfil their potential" and that it may be relevant to pay particular attention to the achievement of "the highest attainers".

According to researchers in the field (Rogers, 2018; Schwartz et al, 2004), science literacy constitutes an aspirational barrier for high ability students mainly due to the lack of resilience and confidence for those individuals and the necessity of opportunities that promote higher achievement for them.

The intervention college is an all-boy comprehensive secondary school. In this school, mixed ability grouping is used in science. This arrangement has proved to benefit low-ability students by promoting discussion and collaboration. However, additional support has been identified as a need to stretch high-ability students, particularly MAGT students.

In the light of the above-mentioned, the main research question for this project has been stated as follow:

"How can we support MAGT students to overcome literacy barriers in science, so they raise their aspirations and fulfil their potential?"

Methodology

The MAGT research intervention was delivered during six one-hour tutorials that were guided by a tailored handbook. To offer an adequate learning environment for the students, the intervention was delivered outside of school hours and curricular constraints (Devora Eyre, 2007). Each chapter of the handbook looked at a different aspect of academic scientific papers and included a theoretical context, initial and final activities, a literacy glossary and additional material resources to guide and facilitate discussions.

The students' selection has been done with the collaboration of the MAGT school lead, the science department and the Head of year 10. Due to covid-19 restrictions, tutorials were moved to online sessions, following the school security protocols. This has been identified as one of the main reasons for student withdrawal: from the 10 initial students (size selected to allow productive group discussions), only 5 completed the course and provided all the data.

Data have been collected using "pre and post" intervention assessments and questionnaires. A quantitative data analysis approach was considered, following similar research in the field (Wiljes et al., 2019). For that, assessments were graded according to an analytic feedback rubric and the questionnaires' answers were associated with a tailored numerical scale.

Study limitations

It is necessary to acknowledge that, due to the small sample size of the study, with only 5 participants, these results may well not be indicative of the success of the research intervention on the students' ability to increase aspiration, motivation, and self-esteem over a bigger population.

Another limitation factor to consider is the short amount of time that the intervention ran for. With increased exposure to this language consistency, students' scientific literacy skills may continue to improve.

Is also important to consider that, due to covid-19 restrictions, tutorials were moved to online sessions and that a face-to-face intervention may have a bigger effect on the participants.

Conclusion and reflections

Although these limitations, this study was able to prove the positive effect of extracurricular interventions on MAGT students, providing a piece of informed evidence for Eyre's work (2007). As well as highlight the potential outcomes of these types of interventions to tackle science literacy barriers and stretch MAGT students by sparking their interest in the bigger concepts of science.

Based on the results, the following conclusions have been drawn from this research project:

- ✓ The intervention provided an opportunity to explore more demanding work out of the classroom for MAGT students, including higher knowledge, abstract concepts, communication skills and thinking skills.
- Regarding the academic achievement analysis, literacy skills and scientific knowledge, show a significant overall improvement for the participants, who were able to understand and extract information from specialised research papers more effectively after the intervention. The overall pre and post-assessment's mark increases by 15 points, this number constitutes a one-step upgrade in the postgraduate mark scheme.
- ✓ The questionnaires analysed suggest that an improvement in the science literacy abilities of MAGT students may have a positive impact on their self-confidence and perceived ability to progress to, succeed and fit in at university.
- ✓ Regarding deeper learning skills, no significant changes between pre and post results can be detected, particularly for self-efficacy. This is mainly due to pupils scoring very highly at pre, making it unlikely for the measure to detect further increases. However, some positive increase is still shown in participants' meta-cognition (14%) and motivation learning (17%) domains, when comparing pre and post-intervention questionnaires.

The findings of this study have implications beyond the science education field. According to Ofsted, all teacher is required to 'take responsibility for promoting high standards of literacy, articulacy and the correct use of standard English, whatever their specialist subject.' Regarding that, this project constitutes a framework for further intervention and can be adopted by other topics and subjects across the curriculum. The results of the research will be disseminated by internal school reports and presentations, to involve more staff and students in further interventions.

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