The Researcher

Education Research projects by Researchers in Schools participants

2021 cohort

Contents

Introduction	2
Dr Ben Holmes	3
Dr Beth Dutson	10
Dr Robyn Alexander	18
Dr Alex Mackie	25
Dr Morgan Evans	31
Dr Steph Morgan	46
Dr Josephine Lawal	52
Dr Mary Okoh	59
Dr Deborah Agbedjro De Gregorio	64

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 dedicated 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 research project in their schools. Our participants. RIS teachers get practical experience using mixed research methods and setting up a research project.

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 Ben Holmes

Teaching Historical Empathy

Introduction

If history is 'one damned thing after another' (a quote attributed to the historian Arnold Toynbee), a key job of the history teacher is to help students understand why each 'damned thing' happened in the first place. Traditional history teaching has relied on the concept of 'causation' to teach students how previous events or thematic influences like economics or politics contributed to major historical events occurring.

However, while causation is vital for mastering history, it does not necessarily help students understand the mindset or attitudes of people from the past. Teaching pupils to understand the perspectives of past people and societies has been suggested as a more holistic and ambitious strategy to promote greater understanding of the past. Since the introduction of the Schools Council History 13–16 Project in 1972, numerous educational theorists and practitioners have argued that pupils may be able to generate more sophisticated and in-depth explanations of the actions of historic individuals or societies if they are taught the overarching political, socio-economic, and religious ideas of past societies. This may be particularly valuable when studying topics which expose young people today to historical actors whose lives are very different to their own. Beyond the history classroom, some scholars have suggested that helping students generate 'empathetic connections' to the lives of others could promote more democratic and community-driven citizens of tomorrow.

While the theoretical benefits of an empathy-centred pedagogy are meaningful, the concept has been criticised for a lack of clarity and/or intellectual rigour. The difficulty in assessing or measuring skills like 'perspective-taking' or 'empathy' led to the concept falling out of favour in UK education. While the last 10 years has seen a renewed interest in empathy-based pedagogies, the evidence basis behind such pedagogies remains limited.

My project aimed to replicated the methods of one recent study into empathy by applying it in my specific school setting: a Year 7 mixed-ability class in a school in South Birmingham. My aim was to test whether the proposed pedagogy of this study could improve this class' ability to take the perspective of Medieval people who lived through the Black Death pandemic in the 14th century. By doing so, I hoped to uncover whether the pedagogy of the original study (which was taught to 15-16-year-old students in the Netherlands) could be applied to students in different contexts and to different historical topics. I also wanted to evaluate whether lessons which focussed on perspective-taking added value to an already saturated Key Stage Three National History Curriculum.

Literature Review

The National Curriculum for history contains 6 broad aims which pupils should achieve by the end of Key Stage Three. One of these aims is that pupils will 'gain historical perspective' and be able to understand the context of a range of different cultures and time periods across history. However, numerous researchers have highlighted that pupils routinely struggle to contextualise the past because they view people's actions and beliefs in history through a 'presentist' lens (for a summary of this research see Huijigen et al., 2018: 410-411). This tendency presents an ethical and an intellectual problem: when confronted with actions or beliefs which they do not understand, pupils may adopt condescending attitudes towards people in the past (e.g. "they were stupid") because they cannot understand their actions; moreover, pupils may lack the ability to produce complex explanations for why people in the past acted the way they did. As Huijigen et al. (2018) summarise, while this problem means teachers should endeavour to explicitly teach students how to perform historical contextualization, there are few proven pedagogic strategies for achieving this.

One established but controversial strategy for helping pupils gain historical perspective is encouraging pupils to establish an empathetic connection with people in the past. In the 1960s-1970s, the Schools Council History Project in the UK proposed a history curriculum which encouraged pupils to make explicit identification with people in the past in order to develop their ability to analyse the past as well as create more 'humanely educated' citizens (Endacott and Brooks, 2018). A wide range of social educational theorists have debated the merits of this approach. According to Yeager et al. (1998), Riley (1998), and Foster (1999), teaching empathy does not mean encouraging pupils towards sentimentality or producing 'imaginative' fiction, but to use evidence from primary and secondary evidence to reconstruct the worldviews of people from history. Emphasising empathy as a historical skill or competency does negate the criticism from affect theorists that sentimental readings of literature reproduce unequal power structures (for a summary of these criticisms see Jurecic, 2011). Nevertheless, many educational theorists still view empathy remains a problematic concept because it requires pupils to understand the context of a historical period as well as self-awareness of their own presentist perspective (see VanSledright, 2011). Others also cite the difficulty in measuring and assessing a pupil's ability to empathise (for a summary see Harris & Foreman-Peck, 2004).

While these challenges led many teachers in the UK to abandon using empathy within the classroom, Lee and Shemlit (2011) rightly question whether 'empathy' should be completely discarded or whether the right pedagogic and assessment strategies can help the concept 'come out of the closet'. In the last decade, other researchers have also re-examined empathy or associated concepts like 'perspective-taking'. several qualitative and mixed-methods studies have examined how teachers and pupils understand empathy in order to explore the implications on teaching the concept. Using interviews with teachers and observation of their lessons, Cunningham (2009) explored how teachers' subtly differing notions of the definition and purpose of empathy had implications on how they taught and assessed the concept. Bartelds et al. (2020) also conducted a mixed-methods study, including interviews with teachers and pupils, which explored these groups' understandings of empathy. They concluded that teachers need 'to teach historical empathy more explicitly' (2020: 546). These studies highlight a far more malleable and nuanced definition of empathy compared to the more straightforward definitions provided by either supporters or critics among educational theorists. these studies generate valuable further questions about using empathy in classrooms, although they provide less clarity about the practical implications on classroom practise. Moreover Bartelds et al. recognise that their study was selective in the age of pupils they interviewed (16-17 years old) and the interview questions they used.

Other researchers have examined more purely pedagogic techniques for teaching the concept. Some of these proposed methods, such as Volk (2013) and Benger (2020), appear promising but are better suited to higher education (in the case of Volk) or may not be easily replicated to many subjects in the curriculum (in the case of Benger). In two separate articles, Huijgen, van de Grift, van Boxtel, and Holthuis (2017; 2018) utilised a mixed methods research project which examined a sequence of lessons taught to 15-16 year old Dutch pupils. The project examined a pedagogic technique for promoting the pupils' ability to perform what the researchers term 'Historical Perspective Taking' (HPT), a historical competency which encompasses awareness of one's own presentist perspective; demonstrating historical empathy; and the ability to reconstruct the historical context in which people lived. The researchers' proposed 'pedagogic technique' encompasses explicitly teaching these competencies to pupils alongside normal subject content across a sequence of 4-8 lessons. In the study, pupils received pre- and post-study assessments to test their HPT abilities, while a control group, who learned the subject content using more traditional pedagogic techniques, took the same assessments. The study found the experimental group outperformed the control group in the post-experiment assessments. As a concept, HPT arguably represents a less controversial concept than a pure focus on empathy, given there is emphasis on cognitive skills alongside 'emotional' skills. More promising is that the sequence of skills-based lessons proposed in these articles could feasibly be replicated across numerous topics across the history curriculum. The researchers highlight that their studies were highly selective in terms of the test pupils' age (15-16) and context (Dutch secondary schools). Nevertheless, these limitations present an opportunity to explore whether a similar 'pedagogic technique' can yield success in UK secondary schools with younger pupils.

Methodology

As outlined in the Literature Review, a project carried out among 15–16 year-old pupils in the Netherlands, Huijgen et al. (2018) developed a pedagogic strategy to improve pupils' ability to perform historical contextualisation and analyse the perspectives of historical agents. My project sought to uncover whether their findings can be successfully replicated when applied to younger pupils in the context of a mixed-secondary school in South Birmingham.

The project spanned a sequence of 3 lessons on the topic of the Black Death and Medieval medicine which involved a Year Seven classes I taught. This class had 25 pupils. My decision to focus on Year Seven pupils was partly due to the curriculum these classes are covering: anecdotal evidence from history teachers in England claims that pupils find it particularly difficult to engage with topics from the medieval period (Dawson, 2018). Secondly, I wanted to explore whether the age of pupils influences their ability to perform historical contextualisation and perspective-taking.

The project consisted of a baseline assessment to test pupils' ability to perform historical perspective-taking. This was followed by a sequence of 3 to 4 lessons which replicated the structure and sequence of Huijgen's study. A final assessment then tested the impact of these lessons on the pupils' skills. An improvement in pupils' scores in the post-assessment compared to the baseline would indicate the success of the pedagogy.

This project utilised a mixed-methods approach to data gathering and analysis. As mentioned, the measurement tools for this project consisted of a baseline and final assessment. The use of a baseline and final assessment replicates the approach used in the original study (Huijgen et al., 2018). Both tests included 5 short primary source extracts. These were followed by multiple-choice questions, with space for pupils to explain their decision-making for each question. This sought to uncover how well pupils were able to explain the decisions or actions taken by people in the past.

By using multiple choice questions, the test ensured that a pupil's writing ability would not impact their score. Nevertheless, encouraging pupils to explain their reasoning has two benefits: it provides some mitigation against pupils trying to 'guess the right answer' by randomly selecting a multiple-choice answer; it also provided opportunities to qualitatively analyse pupils' thinking and decision-making for each question.

Pupils scores in both assessments were analysed to compare individual- and whole-class progression. In addition, longer-form answers produced by pupils in the tests and during learning activities during lessons were qualitatively analysed to provide a more nuanced exploration of pupils' thinking before, during, and after the sequence of lessons. According to Huijgen et al., a limitation of their original study was the lack of qualitative data and analysis compared to quantitative data. In this way, I hoped to address this limitation in the original study by including more qualitative data.

Ethics and Data Protection

I carried out my research project within my Y7 class's normal timetable and curriculum topics. This ensured that pupils did not miss topics which other Y7 pupils in this school were learning.

All pupils in the classes completed the pre- and post-assessments and the learning activities in the sequence of lessons. Nevertheless, while all pupils in the classes completed the same learning activities, I recruited pupils who were willing to share their data from their pre- and post-assessments in addition to any classwork they completed during the project. Pupils who did not consent still participated in lessons (and hopefully benefited from the research project) but were not included in the study.

To ensure transparency, I introduced my project to the class before the study began, explaining its aims and purposes and how they could help me. I gave pupils a participant information sheet and permission form to take home for their parents/carers to sign. To increase the chance of buy-in, I emailed pupils' parents/carers to inform them of the project, the value of including their child in the study, and allowed them to ask me any questions about the project.

The baseline and final assessments for the project were completed by pupils as hard copies on test papers. These were collected and stored in a locked staff office on the school premises. When transcribed into Excel, pupils' names were replaced with a randomised number (e.g. Pupils A, Pupil B etc.) which did not correlate with the alphabetic order of surnames in the class, age, gender, or any other characteristic. By assigning a randomised letter to all pupils, I could measure each individual's progress across the sequence of lesson by comparing the differences between their pre- and post-assessment. At the same time, I ensured that this data could not be used to identify a specific pupil.

Where pupils gave consent for their answers to be used for qualitative analysis, their work was pseudonymised in this final report.

All data that was digitally recorded during this project was stored on a password protected school laptop. When I transcribed this data, I did not transcribe pupils' names – only their test scores. Additionally, all hard copies of pre- and post-assessments were securely disposed of at the conclusion of the project.

All classwork completed during the sequence of lessons was recorded by pupils in their own exercise books. The data in these books is protected in accordance with the data protection policies of my current school. At the end of the school year pupils are encouraged to take their

exercise books home for revision purposes. Any books which pupils do not take home are shredded.

Results

My results indicate mixed outcomes about whether my series of lessons have improved year 7 pupils' ability to perform the skill of historical perspective-taking. The qualitative data from lesson activities indicated that pupils were able to understand the perspective of medieval people living through the Black Death by applying contextual knowledge of medieval medicine and culture. However, the statistical results from my pre- and post-tests indicate that the lessons had no significant improvement on pupils' ability to apply this skill to other historical contexts and case studies.
Over the course of 3 lessons, pupils in a Year 7 class examined the history of medieval medicine and the Black Death pandemic through an enquiry question focussed on why medieval people used preventions and treatments for disease which seem alien to a modern perspective (e.g. whipping themselves to prevent God 'punishing' them with disease). These lessons replicated a lesson structure from an existing research intervention (Huijgen et. al., 2018). It taught learners the socio-economic and cultural context of the time period in order to encourage them to understand the actions and perspectives of people from this period. Samples from pupils' written work in these lessons demonstrated that most pupils were able to understand and apply learning about the key medical theories and socio-cultural context which influenced medieval healthcare. A minority of pupils were able to progress to more sophisticated understanding of the topic which showed a clear ability to empathise with medieval people living through the Black Death. To take two examples of pupils' written work.

- 'I don't think people were "just stupid". The only logical explanations at that time were based on religion and they didn't have much education because of the church'
- 'The NHS was not invented in medieval times as it was only made in 1947…. The government did not care if the people were sick and also you had to pay lots to have a chance of surviving. Mony [sic] was one of the most important things as you needed it for health, education, and tax. Most people could not afford it.'

When asked about the importance of having empathy with people from the past, one pupil answered:

- 'Because it gives us a connection and understanding and we can compare it to the present or future.'

While the qualitative evidence suggested that the lesson intervention improved pupils' historical perspective-taking in the specific subject they studied, the quantitative data from the pre- and post-tests did not indicate any significant improvement in their ability to apply this skill to other historical contexts. The pre- and post-tests (which replicated the assessments of the Huijgen et. al., study) were a set of 5 multiple choice questions, with each question related to a short historical case study about something which may appear unusual or immoral to a modern perspective. Crucially, these case studies were unrelated to the Black Death or medieval medicine, as the assessments aimed to measure pupils ability to apply the skill of historical perspective-taking to other historical contexts.

Student	Baseline Test (max. 5 marks)	Final Test (max. 5 marks)
A	1	2
B	3	4
C	3	1
D	4	4
E	0	0
F	1	1
G	3	4
H	4	5
I	1	2
J	3	3
K	3	2
L	1	2
M	0	3
N	3	3
O	3	1
P	2	5
Q	0	2
Average	2.058824	2.588235
T-Test	0.143627	

The results from the two tests indicate that the class average increased by 0.5 'marks' between the two tests. This may indicate a slight improvement in the class' ability to perform historical perspective-taking. However, as the T-Test score indicates, the improvement was not sufficient to disprove the null hypothesis. Moreover, reflecting on individual pupils shows some pupils' scores declined between the two tests, while 5 pupils scores remained the same. The limitations on both assessments (both being only 5 questions) have to be taken into account for the small increase, which reflected the limited time in lessons to conduct the tests. Longer assessments may have yielded a greater range of results from the students. Nevertheless, the data does not indicate that learners' general skills in historical perspective-taking improved.

Conclusions

Although the results from this intervention indicate the limited impact of the intervention, they do raise tentative conclusions and questions which warrant further investigation. The disparity between the qualitative and quantitative data may indicate that in order for Year 7 pupils to perform historical perspective-taking effectively, they require a curriculum which explicitly teaches the full socio-economic and cultural context of a historical period. The pupils in my project were able to engage empathetically with the society and people they had been studying. However, when presented with other case studies which they were unfamiliar with, as was the case in the two assessments, they resorted to analysing these examples using their own modern-day perspective.

This suggests that pupils of this age may have the cognitive and emotional capacity to engage in historical perspective-taking, but may be limited by their breadth of their knowledge (particularly the context of different societies across history) compared to older students. An implication of this would be that teachers should avoid asking younger learners from performing any 'empathetic'

learning activities (e.g. 'write a letter from the perspective of a medieval peasant') without first teaching the full historical context of the society they are studying. As this lesson design shows, this may require several lessons in a given topic. Teachers, therefore, must carefully consider how and when they integrate these activities into a scheme of work if they want to improve their pupils' ability to take the perspective and engage empathetically with people from the past (and indeed the present) whose lives are different to their own.

Dr Beth Dutson

What is the impact of retrieval practice homework in Science?

Introduction

There are lots of facts and key words to be learned in Science curriculum. Retrieval practice is set as home learning through an online quiz programme called Educake. The questions are chosen by the teacher to consolidate the learning in the lessons, to aid embedding of the key scientific facts and thinking skills. These questions can be considered as pre-made Leitner flashcards that are adaptable and available on demand. The answers are shown after the student response has been submitted, and students are encouraged to repeat the questions until the threshold success limit of 80% correct has been achieved.

This study reviews the statistics from Educake science retrieval practice homework and compares these results to the subsequent summative assessment, GCSE, outcome. The impact of homework completion is compared to repeated access versus singular access. This study uses the data from the year 11 cohort of 2021-2022 to compare the use of Educake to the GCSE results and incorporates information from approximately 80 students.

Literature Review

There are four key pedagogic approaches to teaching and learning that all contribute to a student's educational success; behaviourism, cognitivism, constructivism and connectivism. Each highlights a beneficial habit for life to enable students to be lifelong learners, such as the act of training and performing new behaviours, mental processes such as thinking, memory, knowing, and problem-solving, meaningful activities and the ability to see connections between fields, ideas, and concepts [Woollard (2010), Bates (2016), Pritchard (2018), Siemens (2017)]. Each theory works well alone, but when combined they can constructively interact and become greater than the sum of their parts. In my teaching practice so far, I have found it important to consider the holistic approach rather than just focus on one pedagogy.

Setting the habits for learning starts at an early age and is reinforced throughout student education [EEF Guidance Report (2019)]. The Teacher Toolkit simplifies it down to a simple four step process - explain, question, practice, feedback [Morrison McGill (2021)]. Assessment is a critical part of the process of collecting feedback to respond to the students' needs [Fletcher-Wood (2018)]. The science summative assessments are split into three main objectives: content, application, and analysis. These skills need to be practiced and challenged, through frequent informal assessment and the subsequent feedback for improvement [EEF Guidance Report (2021)]. Feedback and improvement time has become an integral part of lesson planning, which I feel supports this aim.

Thinking skills, such as those required for summative assessments, need metacognition and memory management skills. This can be achieved by interleaved, spaced revision such as discussed by Dunlosky (2013), Averell & Heathcote (2011) Leitner (1991), Loftus (1985), and Ebbinghaus (1885). Leitner (1991) proposed the widely used method of using flashcards for revision. This is a simple implementation of the principle of spaced repetition, where cards are reviewed at increasing intervals. Knowledge that can be easily retrieved is reviewed less frequently than that which is harder to retrieve or even absent.

This principle of frequent retrieval practice has been adopted by my placement school. Each lesson, regardless of subject, starts with retrieval fast start questions and homework is focussed on further retrieval exercises. This is achieved in Science by using an online quizzing website called Educake [Educake (2022)]. The questions are chosen by the teacher to consolidate the learning in the lessons, to aid embedding of the key scientific facts and thinking skills. These can be considered as pre-made Leitner flashcards that are adaptable and available on demand. The answers are shown after the student response has been submitted, and students are encouraged to repeat the questions until the threshold success limit of 80% correct has been achieved.

There has been much discussion about the pros and cons of homework [Drew C. (2022)]. It has been discussed by the EEF that homework can have a high impact for a low cost, but this is based on very limited evidence [EEF Guidance Report (2022)]. There is a concern about teacher workload as summarised in the UK government report [DfE Research Report (2018)]. The online nature of the Educake work minimises the marking of the homework, but it still requires teacher input to choose appropriate questions and monitor student progress.

The impact of homework has been shown to be beneficial for both high and low achievers [Eren and Henderson (2018)]. Whilst Magalhoes et al (2020) found only a weak relationship between the amount of homework assigned and the student achievement. A positive correlation between the amount of homework completed and the achievement was found, particularly for the older students. This will be interesting to investigate with the Educake data, to compare the assigned work and achievement compared to the completed work and achievement.

Rochelle et al (2016) investigated the benefits of additional online maths homework. The results showed that there was an increased student scores on an end-of-the-year standardized mathematics assessment. It will be interesting to compare this to online science homework with my investigation. The maths investigation showed particular benefit for low prior achievement students. The catchment area and special educational need profile of my placement school will hopefully produce results that will either confirm or contradict these findings.

The promotional information provided by Educake claims that the online questioning could improve the exam results of your students by 2-3 grades [Educake (2022)]. Educake have released one study of their data from a large academy in an urban area of Nottingham with high deprivation and 42% of students on pupil premium. Their analysis was based on the 2016 GCSE results of their 246 year 11 students and their use of Educake in the 2015-16 academic year [Educake (2022)].

The analysis concluded that the students who attempted more Educake questions achieved higher Progress 8 scores and higher GCSE grades. The investigation that I am planning will hopefully build on and extend these results. This study divided the students into three main categories; non-users who attempted less than 100 questions, occasional users who attempted between 100 and 500 questions and regular users who attempted more than 500 questions. I would like to look deeper into the data for different categories, such as quiz completion versus quiz repetition. I hope that my study will be able to confirm or refute these results, as well as

extending the analysis to the benefits in a COVID world where there is a greater access to and familiarity with technology.

Methodology

There are lots of facts and key words to be learned in Science curriculum. Retrieval practice is set as home learning through an online quiz programme called Educake. The questions are chosen by the teacher to consolidate the learning in the lessons, to aid embedding of the key scientific facts and thinking skills. These can be considered as pre-made Leitner flashcards that are adaptable and available on demand. The answers are shown after the student response has been submitted, and students are encouraged to repeat the questions until the threshold success limit of 80% correct has been achieved.

This study uses the data from the year 11 cohort of 2021-2022 to compare the use of Educake to the GCSE results and incorporates information from approximately 80 students. The information is stored within the online Educake account and is accessible for the school. The GCSE results and Educake data can be combined and anonymised for further analysis. I intend to investigate this wealth of data to see if there is any significant correlation. The information required for this investigation was all freely available within the school and has be anonymised to remove any association with a specific student.

Homework is an interesting topic, because it has been stated that there is minimal impact if it is too easy or hard. Retrieval practice has been shown to improve remembering and recalling information from the long-term memory. The whole student population are stakeholders of the study if they can have justification for homework and the impact of going the extra mile over just doing the bare minimum.

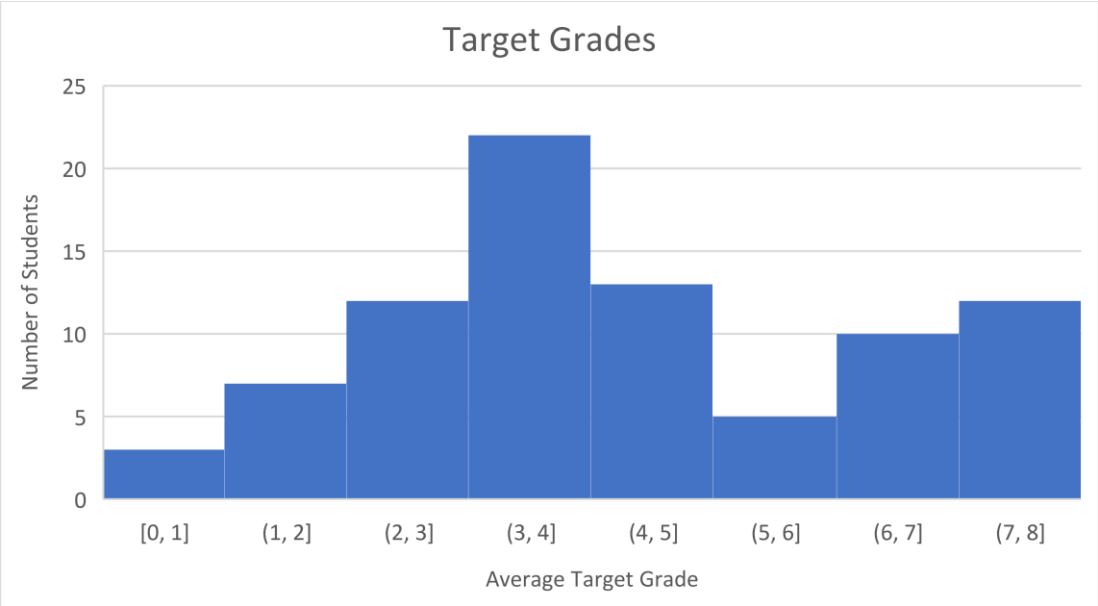
The main influential, advocate stakeholders were my placement school, particularly the Science department, and also the academy trust who manage the school. The study will hopefully provide further support for the importance of retrieval practice, which is a school focus currently, and concrete evidence to justify the money spent annually on the subscription to Educake. Educake themselves are another stakeholder, as the investigation will hopefully increase their evidence of the efficacy of the product. The main risks during this investigation included incomplete data, no correlation/other factors and overstretched outcomes.

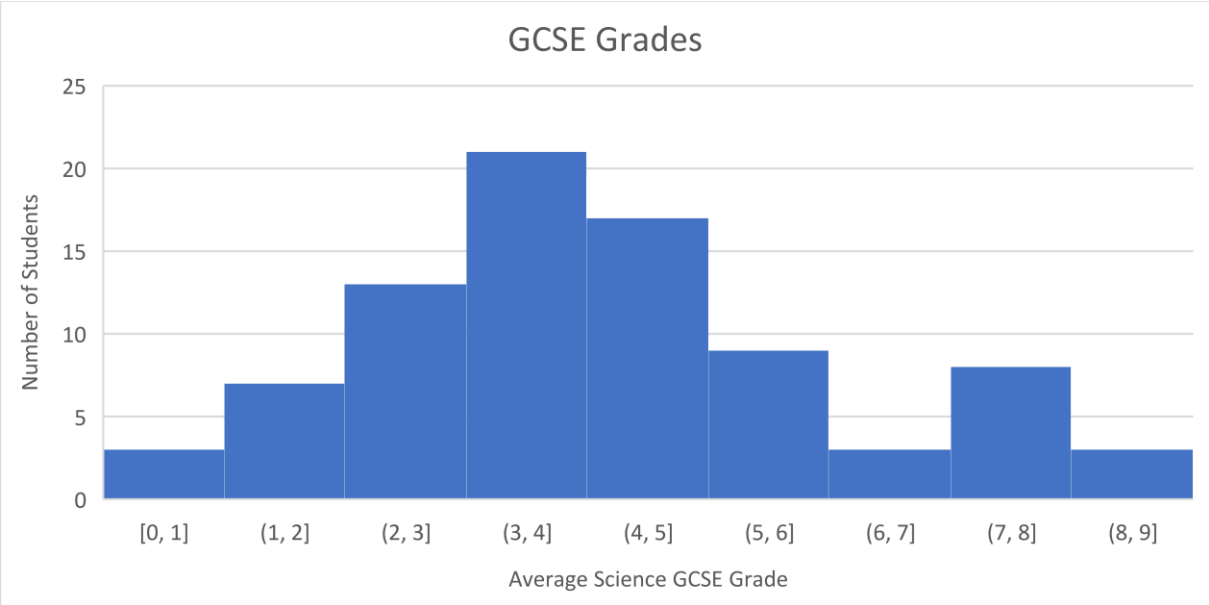
The first steps for the investigation were to download and access all of the data required, such as the Educake data and GCSE results, both of which will need to be collated and anonymised on a school secure location as a priority. The bulk of the work will be the data analysis of looking any correlation.

Results

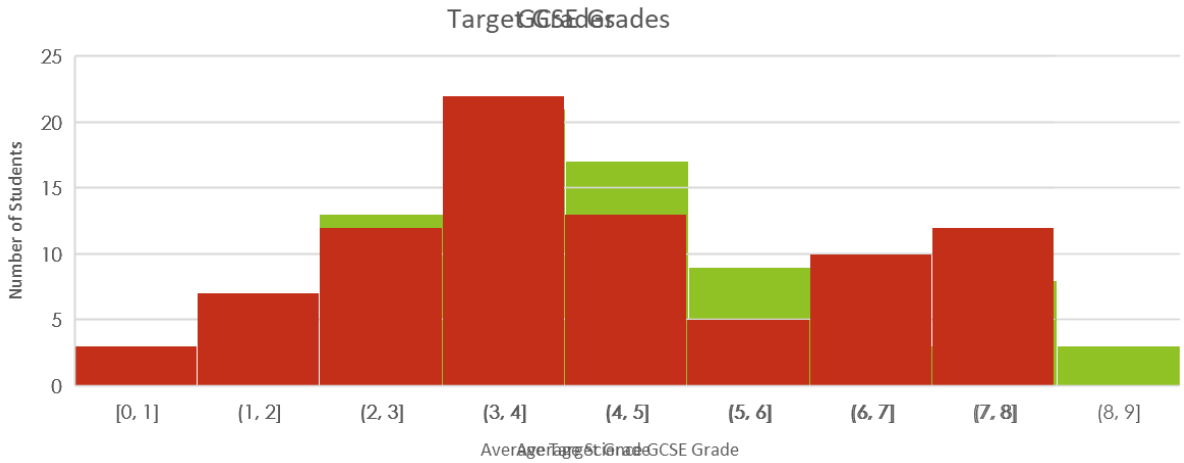
The GSCE data from the 2021 cohort of students at Oakbank School was analysed, a total number of 83 students. The data was anonymised so that only the student initials and GCSE targets and results remained. Within the 83 students with data, there were 12 English as a foreign language (EAL) students, 19 more able (MA) students, 19 pupil premium (PP) students and 14 students with a special educational need (SEN) either SEN support or a full educational health care plan (EHCP).

There was a distribution of students completing combined science, where 2 grades are awarded, and triple science, where 3 grades are awarded. For ease of comparison, the grades were averaged to allocate one figure for the results, e.g. a combined GCSE of 4-3 became a 3.5 and a triple GCSE of 7-7-8 became 7.67. This enabled the results to be analysed on the award scale from zero (representing U) to 9 (the highest grade). The data showed that there was generally an increase from their target grade to the grade achieved, as shown by the two graphs below:

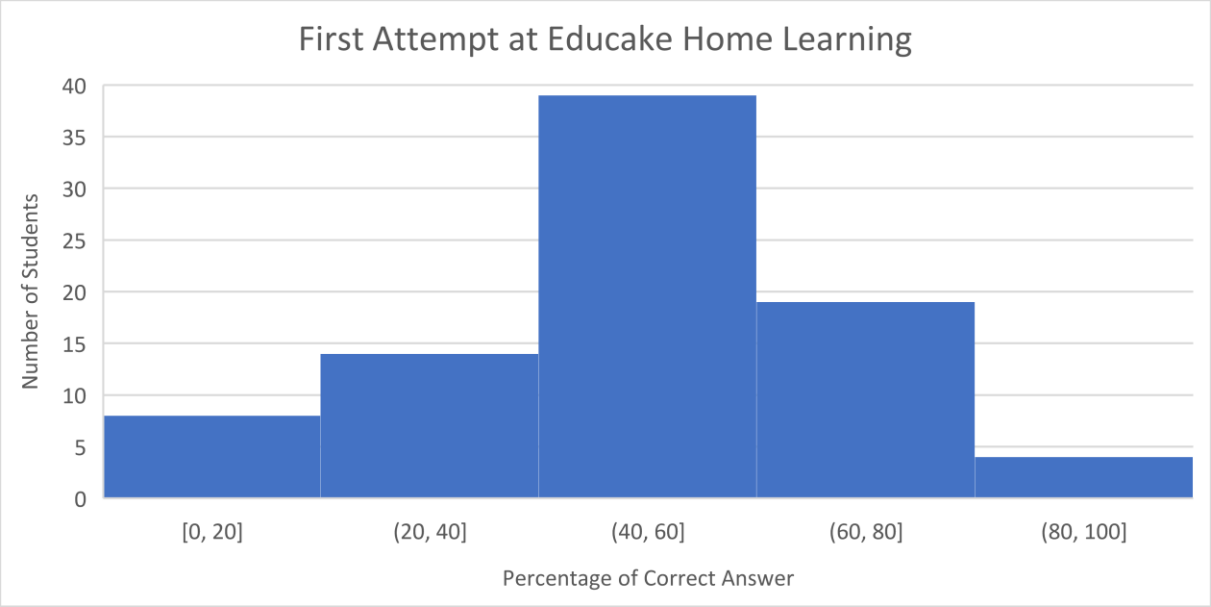


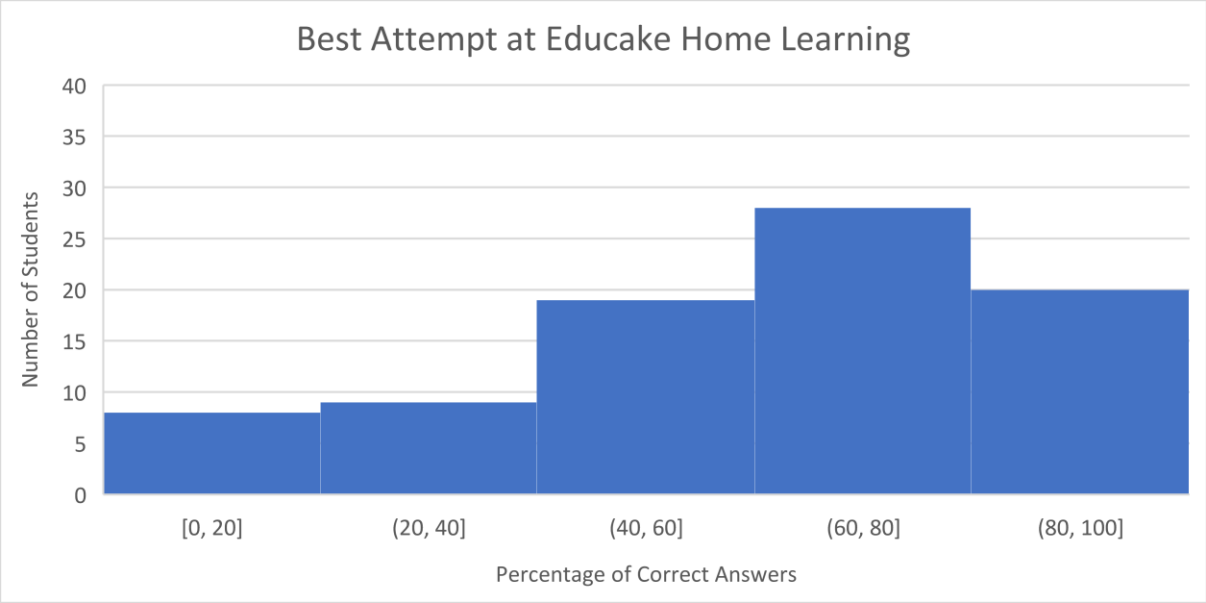


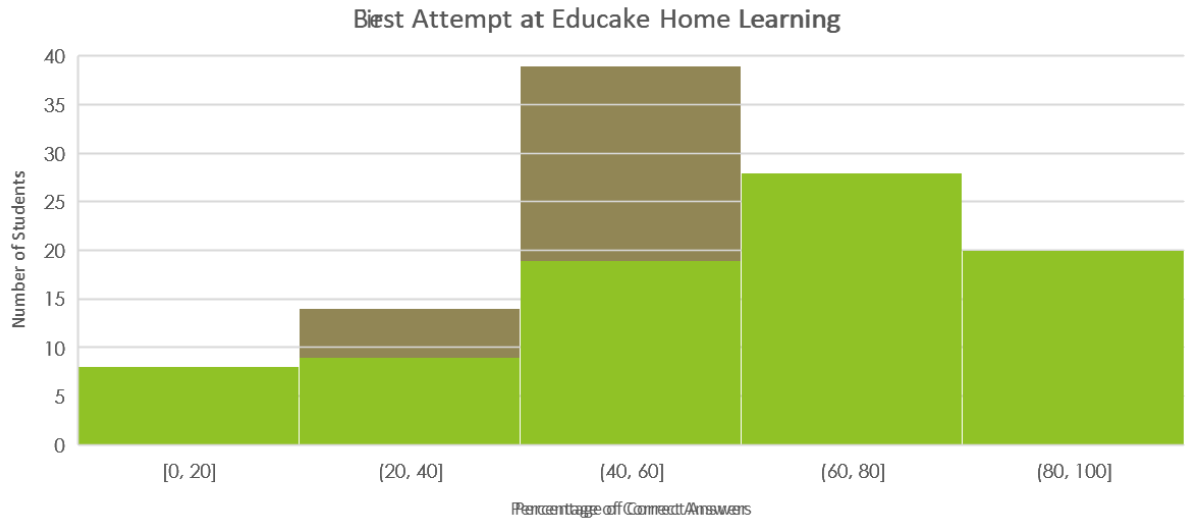
Students with an estimated target grade of 0 to 3 showed minimal difference between their target grade and the GCSE grade achieved. The larger difference in grades are in the target range of 6 to 9. This data is highly influenced by the choice of qualification attempted, for example the foundation candidates are limited to a 5-5, or 5 in the averaged data. Whereas at the higher end of the data, there is a discrepancy between taking the combined higher qualification and the triple sciences, which can be significantly affected by the averaging process applied to compare the data.



This information was then compared to the internal department data from Educake, an online science quiz based on a bank of thousands of science specification-mapped questions. This data included the percentage score correct from the first time they completed the quiz. Students are encouraged to repeat the quiz until they achieve a score of 80% correct, and this information is captured by their percentage score for their best attempt at completing the quiz.
The graphs below show that there is a significant increase in the percentage outcome from repeating the quiz. This is to be expected, as the answers to the questions are given after the first attempt so it should be easier to improve your score. It can be seen in the 0 to 20% bracket that there is a base line of 8 students that never attempt to improve their score.







The main null hypotheses for this study were:

1) Repeating online Educake homework has no effect on improving student grade on Educake.
2) Repeating online Educake homework has no effect on improving student

These hypotheses were tested using the t-test calculation of the p-value using Microsoft Excel. The data from the initial attempts at completing the Educake quiz, and the effect of repeating the Educake quiz gave a p-value of 4.03×10^{-15}, which disproves the null hypothesis that repeating the online quiz had no effect on improving the student grade on Educake.
The data from the difference in score between the first and best attempts at completing the Educake quiz was compared with the difference between the target grade and actual GCSE grade gave a p-value of 4.18×10^{-15}, which disproves the null hypothesis that repeating the online quiz had no effect on improving the student outcome at GCSE.

Discussion and Conclusion

It is no surprise to see that these null hypotheses are disproved. It shows that the hard work that a student puts into their study aids their progress. There is no evidence to prove that there is any causality between the findings, but it would be nice to explore the evidence over a number of years.

The study was limited in Educake data for students that had graduated from Oakbank, because only the basic data has been saved/archived. For active students there is greater resolution of data, including any additional, self-driven study from access to the quiz data at their fingertips. Additional data would also enable a deeper investigation into any significant improvements for specific groups of students such as pupil premium, English as a second language or with special educational needs.

As a teacher, I feel the study justifies the additional workload on both the student and teacher to set these recall questions to aid the knowledge and basic understanding of the Science curriculum. The study is limited in positive hypotheses because conscientious students are more likely to complete their homework, and repeat their homework, and succeed in hitting or improving their GCSE grades without the intervention of Educake learning. This study is also not able to determine access to or skills with the online format of the Educake learning.

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Dr Robyn Alexander

The effectiveness of an online platform in memory recall and application of key scientific terms

Introduction and Literature Review

In order to effectively learn, students require a solid foundational knowledge upon which to build new knowledge (Furst, 2018). Learning is the process by which students are able to store, recall and apply information from their long-term memory (Willingham, 2010). Storage in the long-term memory involves not only the receival of content, but also the regular recall of this knowledge as well as placing the information in relevant contexts with strong connection established between the pieces of information (Willingham, 2010; Frust, 2018). Frust (2018) summarises the neuroscience of retrieval as the introduction of a new concept, creating links between these newly introduced concepts as consolidation and then storage. For this new information to be stored and learnt, it is important that efficient retrieval of the information is practiced regularly (Ebbinghaus, 1880; Karpicke & Roediger, 2008). Through continual and regular recall, memory retention is increased and decreases as a slower rate, and after five recall practice opportunities, the information is nearly-all retained (Ebbinghaus, 1880). True learning cannot in fact be observed, but assumptions and inferences can be made based on students' performance (Willingham, 2009). In fact, it has been found that students do not use logical inferential processes to understand and explain new phenomena, but rather focus on pattern completion understanding based on perceptual recognition and phenomena (Tytler & Prain, 2009). This is why it is vital that teachers support students in establishing strong connections between information stored in the long-term memory and new information being delivered, to prevent the creation of misconceptions based on poor understanding or perceptions (Frust, 2018).

Science as a subject relies on the understanding of key terms to apply to new concepts and ideas (Smailes, 2018). It can be argued that for a student to be successful in science, they require a whole new vocabulary, similarly to that of a student learning a modern foreign language. In order to enable students to access the lessons and new concepts in science (as well as other subjects), many schools have implemented knowledge organisers (Smailes, 2018). These resources highlight the key terms required in the subject with the appropriate and accessible definition. Students are required to recite these definitions in preparation for lesson and are often set homework on the recital of these definitions from memory. There are several reasons for this, firstly, if students have a good foundational knowledge of concepts, they are able to build upon this with new information and make long-lasting connections between knowledge (Reif, 2010; Willingham, 2010). It also aims for understanding and fluency of these terms, allowing for a more efficient classroom, as teachers do not have to spend a long time teaching new terminology but can rather focus on the key concepts of them and the understanding thereof (Reif, 2010; Smailes, 2018).

In recent years, especially since the disruption to leaning during the pandemic, education has been moving towards the inclusion of technology in the classroom and more importantly at home. Students make use of online platforms for learning, revision as well as homework in the form of quizzes. These resources provide platforms which present taught information to students in a new way, aiming to improve their engagement and understanding (Alonso, 2005).

In this study, students will make use of an online learning platform to support their recall and understanding of key scientific terms from their knowledge organiser required as core foundational knowledge to build upon. The students will use an online platform to practice recall of the terms and their definitions in a different format to their current mode of learning. The students currently use a method of 'read, cover, write' whereby they read a definition and try to recall it from memory by writing the definition down on a page. They will then check their answers and correct accordingly. They will continue to do so until they have the definition correct and should be practicing these definitions several times over the week that the homework is due in. On the day that the knowledge organiser homework is due, they are expected to be able to recite the definition during a five-minute test, often with a scaffold such as a gap fill in place. This test is high stakes, as if they do recall at least four of the five definitions with a 100% accuracy, they receive a sanction (a point towards a detention later in the week). The effectiveness of this has not been assessed and often students end up cramming the definition into their short-term memory just before the lesson. This reduces their engagement and retainment of the definitions, limiting their application of the definitions to the lessons. This study will make use of the online platform Carousel which uses flash cards and is a low-stake quiz format during which students can test their effective recall of the five-definition allocated as homework. The aim is to test whether the additional support of an online platform provides an effective tool to first enable students to complete their definition recall effectively and given that the platform provides a selection of formats, e.g., flash cards, and quizzes, whether these different methods of engagement allow students to access the definitions easier. The data will be collected from the students results on their knowledge tests prior, during and after the intervention has been put in place.

There are a few limitations of this study: the first is that the study will rely on the assumption that the students will effectively engage with the online platform at home and although this can be checked using Carousel, we are unable to assess whether the student has truly tested themself or copied the definition from their knowledge organiser. Another limitation is that the format of the online quiz does not take the same format as the test during lesson and finally, although the whole class data will be collected, a student's performance can vary based on several factors, such as environment, attitudes etc. However, to mitigate this limitation, data will be aggregated, and inferences will be made across the whole duration of the study, rather than on a test-by-test basis.

Methodology

This project will use an online platform to provide a different method of memorisation and recall for students to engage and learn these terms and definitions. This was set as homework for a Year 8 top set class of 30 students. The five selected terms and definitions on their knowledge organiser were uploaded to the online platform Carousel. Carousel is an existing platform that teachers can use to set quizzes for students. On Carousel, students able to recite the definitions using flashcards and then once they are confident with the terms and definitions, the students can quiz themselves by reciting the definition. The students then wrote the KO test during lesson and data was collected on

student scores and compared to data collected prior to the intervention. The intervention will took place over a half term.

Knowledge organisers and definitions had already been created and definitions selected for the half term. Terms and definitions were uploaded to Carousel and the quizzes were set every fortnight for the students. Both the online platform and the individual results of KO tests were checked every fortnight.

The key stakeholders in this project are the teaching staff, teaching and learning leads as well as the students. As knowledge organisers and KO tests are set across the school, this project not only impacts the Science department, but if the intervention in successful, it could potentially be implemented across the whole school, and very likely across the Science department. Although the idea behind the knowledge organiser is based on cognitive research, the implementation of it has been questioned regarding how effective it is. This project has been developed with the head of department and has buy-in from the curriculum leads.

The primary risk was that students will not complete the intervention at home – this was be mitigated by ensuring clear communication of the purpose of the project as well as sanctions for not completing it. Another risk is that students may not recite the definitions from memory at home – this was mitigated by having a large proportion of students completing the tasks, therefore allowing for identification of anomalies.

The plan was communicated to all students involved as well as stakeholders within the Science department and T&L leads. The intervention took place over the November-December half term, with more data collected in the January-February half term.

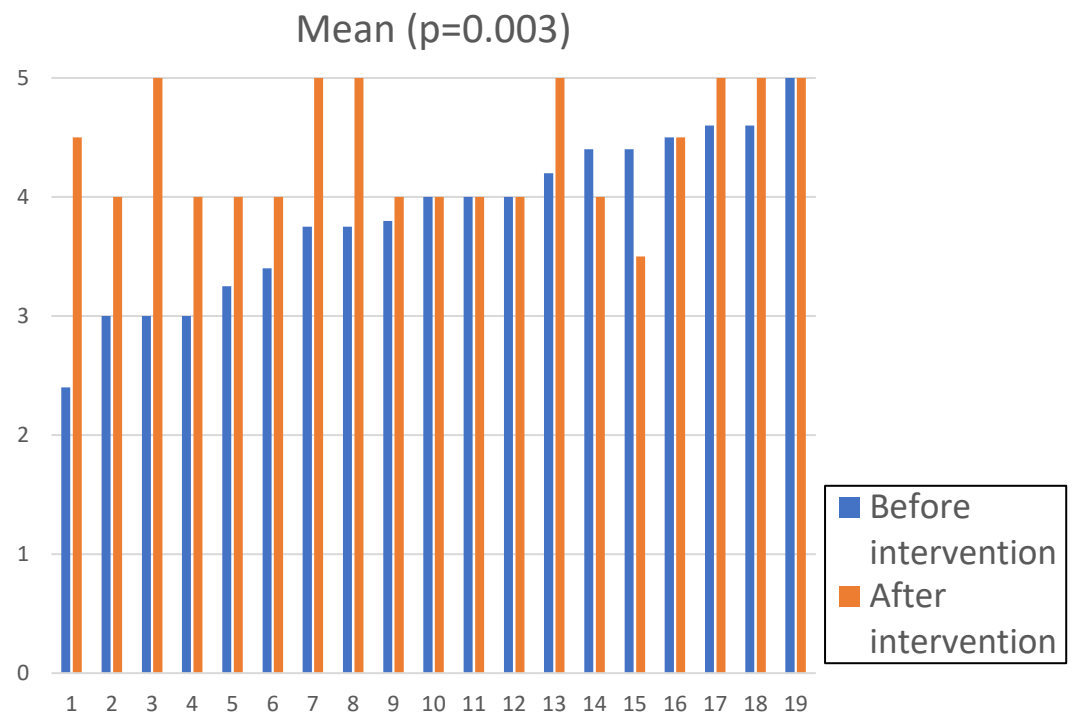
Results

Data collection

This study was carried out from December to March with 19 students. The initial sample size was 30, but after Key Stage 3 assessments, the students' changed sets and therefore classes. Due to the logistical difficulties to keep track of students' completion and KO scores (as well as test environment), it was decided to focus on the students that remained in my class. Throughout the study, testing conditions and were kept the same with students expected to memorise terms and definitions and partially complete these at the start of lessons every fortnight. Students' completion of the recall quizzing was monitored on the platform Carousel.

A total of 7 quizzes was used to produce data for student scores. Data from 5 quizzes was collected prior to the intervention, while due to time constraints, data from only 2 quizzes was collected with the intervention in place. The data was collected and analysed in Excel with mean and median students' pre-intervention scores and post-intervention scores compared using a paired one-tailed t-test.

Results


Mean (p=0.003)
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4
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2
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0
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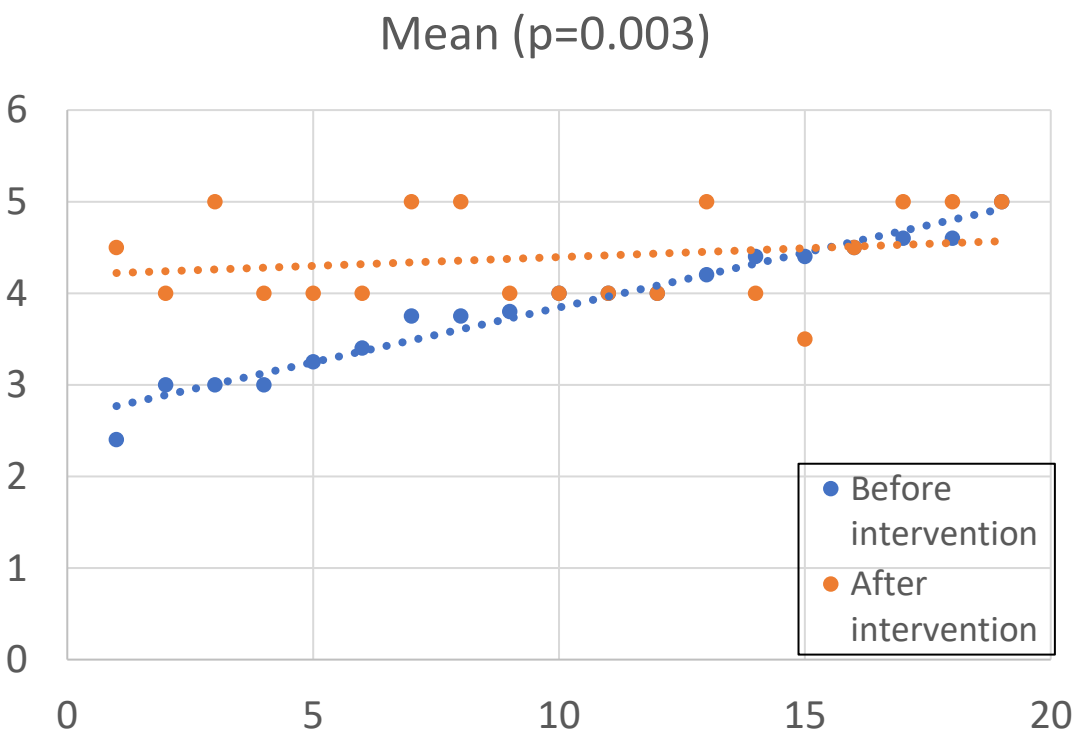
Before intervention
After intervention


Mean (p=0.003)
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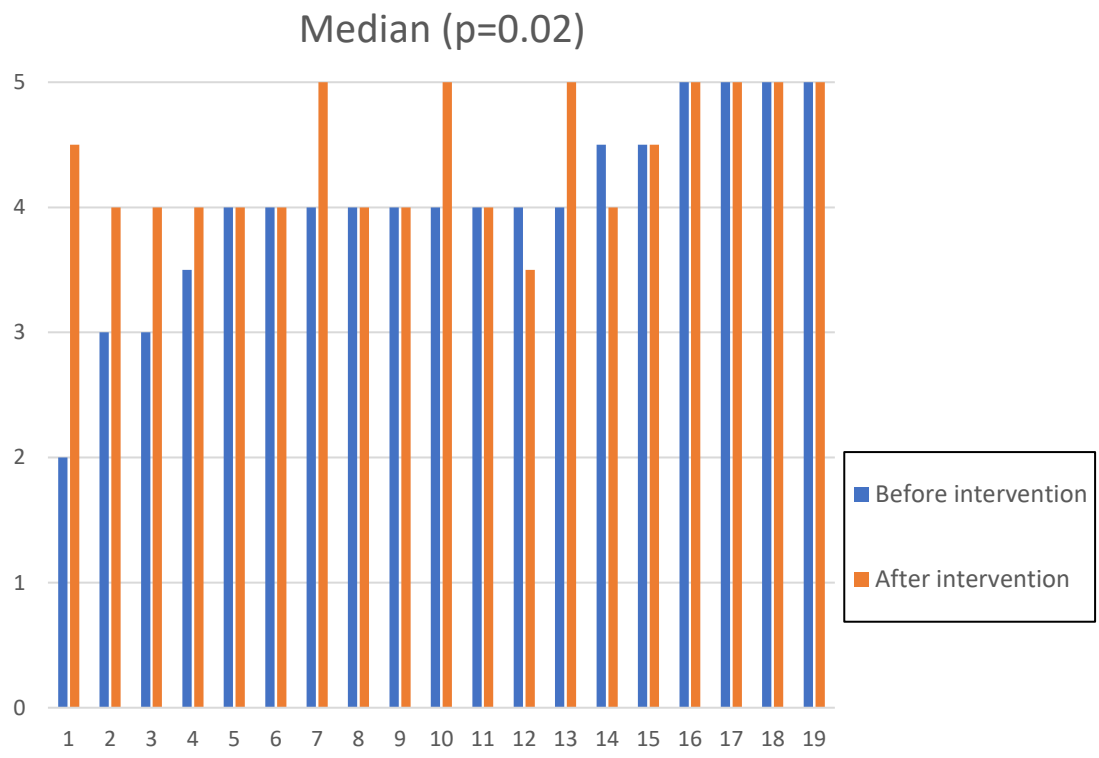
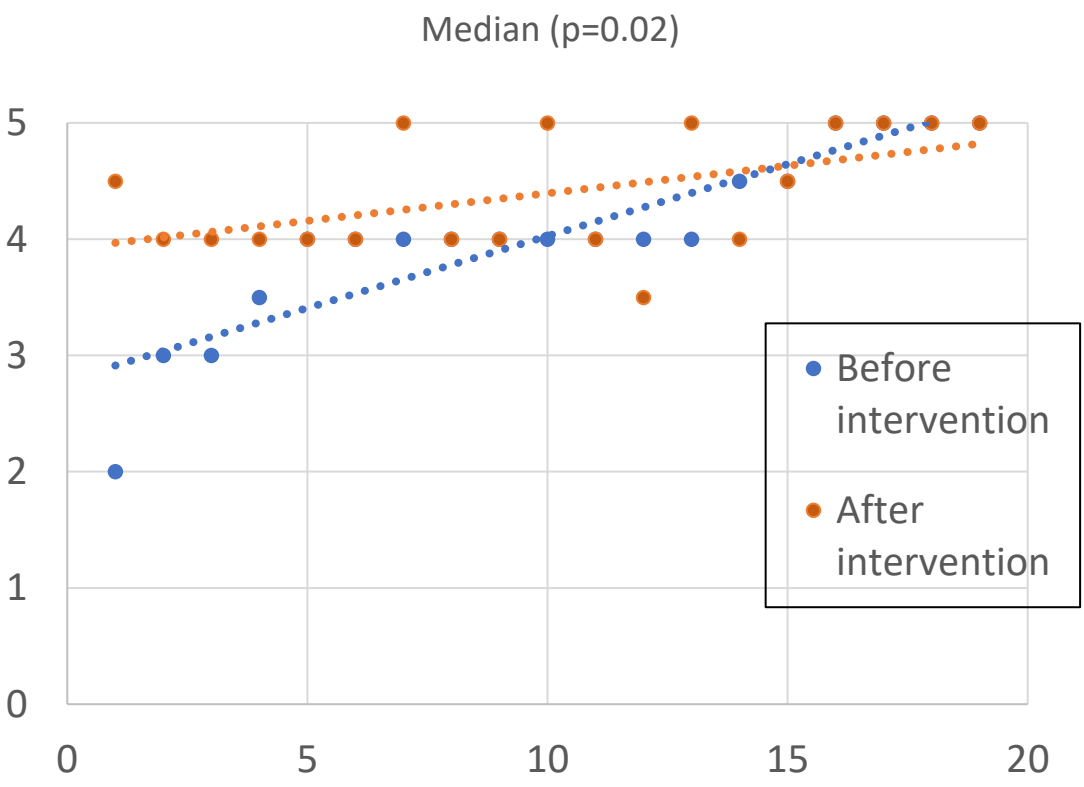
Before intervention
After intervention





The mean and median showed a significant difference in student scores before intervention and after intervention, with the mean indicating a significant p-value of 0.003 and the median p-value also being significant (p=0.02).

The bar graph and scatter plots for mean and median indicate that before intervention there was a spread of scores ranging from 2.4 to 5 for the mean and a median from 2 to 5. After intervention scores showed a smaller range between 4 and 5 (with one outlier at 3.5).

Discussion and Conclusion

These results suggest that students' scores showed a significant improvement after intervention, with all but one student averaging a passing score (minimum of 4 out of 5). The student who did not have a mean or median of a passing score had only one poor test and so can be regarded as an outlier due to external factors rather than the intervention not being useful for them.

It is apparent that intervention led to improved student results in KO tests as well as application of these terms and definitions in lesson. Overall, the majority of students were passing the KO test. A general gauge of students' enjoyment and preference to use the online platform was discussed and it was clear that students preferred the online platform method to the original read, cover, write method, suggesting that they engaged more actively with the terms and definitions in a different format.

Limitations

Although results overall look promising, there are of course limitations to these data and the study overall. The first limitation is the small sample size with incomplete data. Not only was there only data for 19 students, but throughout the study, there were students who were absent on different days, further reducing the number of data points. In addition to this, data was skewed towards the post intervention tests, with data for 5 tests versus 2 tests. The data was also limited by the fact that the range of possible scores is small, so therefore a difference in a score of 1 results in a difference of 20%. Finally, there is also the confounding factor that students scores may have improved as they knew the scores would be collected as data for a research project, so may have spent more time on learning the definitions which might results in better scores.

Conclusion

In conclusion, the results of this study show that the using an online platform tool for students to learn scientific terminology and definitions is helpful, showing a significant increase in their performance.

Further exploration

The next steps include a second long-term study on a different group of students (possibly in a year group) with potentially roll out of the use of the Carousel platform across the whole school.

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Dr Alex Mackie

Why are females underrepresented in A level physics? A study in one school

Introduction

The science faculty at this Academy are interested to understand why there is a low uptake of students wanting to study physics at KS5. For both boys and girls, the number of students choosing physics at KS5 has become smaller compared to the other science subjects, but there has existed an underrepresentation of girls at KS5, which is consistent with the national trend. Therefore, for this project I will be looking to collect data across male and female students at KS4 and KS5 at this academy to identify and rank the most relevant factors at this academy that are acting as barriers for girls wanting to study physics at KS5 today. This will then serve as a basis to develop interventions and strategies to change perceptions of physics and motivate girls to consider physics as a viable and practical subject for future careers and jobs.

Literature review

There exists a significant gender imbalance in the number of boys and girls studying physics at A level (key stage 5), which has largely remained stagnant for over 30 years. In the 2021 GCE A level and AS level examination pupil data, the percentage of boys studying physics was 77%, compared to 23 % of girls (Joint Council for Qualifications, 2021). This was despite a comparable number of girls taking physics within GCSE triple science (24%) compared to boys (23.2%) (Cassidy et al., 2018). Comparatively, there are approximately the same number of girls and boys taking A level chemistry (51:49 respectively), while biology is imbalanced towards girls in the most recent statistics (64:36) (Joint Council for Qualifications, 2021). The big picture is that a lack of girls studying physics at a higher level has consequences for the UK economy: a particular emphasis has been placed on developing a throughput of high skilled workers in the sciences, technologies, and engineering sectors, per the governments industrial strategy (Institute of Physics, 2018), and physics-based skills are highly sought in relation to these sectors. To keep the UK economy competitive, thousands of workers, both boys and girls, are needed to be trained each year. If there were as many females as males who studied A level physics, there would be an estimated 15,000 additional young, qualified people to move into medium and high skilled roles across the economy (Institute of Physics, 2018). These statistics do not happen by accident and are a by-product of systemic and in-grained gender issues that still exist within education and industry.

The historically low uptake of females in physics at KS5 has prompted numerous studies over the last 30 years as to understand what factors exist as barriers. Several recurring factors have been identified. Quality of teaching and positive interactions/support from their physics teachers has been found to be significantly influential to pupils' desire to study physics at A level (Mujtaba and Reiss, 2016, 2013a, 2013b). Perception of difficulty has also been a barrier to students, with students put off by an expected step-up in difficulty at A level (Gill and Bell, 2013; Ofqual, 2017; Patall et al., 2018). Self-concept has been found to be a significant factor, with girls much more likely than boys to underestimate their ability in physics and maths (Cassidy et al., 2018; Häussler and Hoffmann, 2002; Hazari et al., 2010; Mujtaba and Reiss, 2016, 2013a, 2013b). This is despite comparable attainment in GCSE grades between triple girls and boys in physics (Institute of

Physics, 2018). Unsurprisingly, both boys and girls were significantly more likely to progress to study A level physics if the subject was in their top four GCSE results. This says that if a student does particularly well in a physics, they are more likely to continue with it at KS5. However, due to a lower self-concept (Mujtaba and Reiss, 2013a, 2013b), girls with high attainment are dissuaded from studying physics, favouring other STEM subjects, such as biology whereby girls are twice as likely to progress to study at A level even if the subject was not in their top four GCSE result, compared to physics (Institute of Physics, 2018). DeWitt et al. (DeWitt et al., 2019) found the primary reason for choosing a subject at A level was found to be the perceived usefulness of the subject in relation to their future job or career. Association of masculinity with physics has also been identified as a demotivator for studying physics, with girls 'failing to belong' within a male-dominated subject and classroom (Francis et al., 2017).

Methodology

A survey was created with questions based on four themes identified from the literature review: self-concept, interest, relevance, and teaching. Questions were selected from within the literature when similar surveys were conducted nationally, as well as relevant questions for designing a course interest survey (Keller, 2010).

To make data collection efficient and complimentary to the students' Google classroom education platform at this Academy; Google forms was used. Most questions were constructed with a 5-point Likert scale used for responses (Thwaites Bee and Murdoch-Eaton, 2016). Some questions were designed to compare and rank the three science subjects, while a single question was designed to gather qualitative data on careers that students' associate with physics. In total, 33 question were devised across the four themes that aimed to quickly survey students and provide a broad and rounded snapshot of students' perceptions and motivations of the three science subjects, but with a focus on physics. An initial question asked the students' if they were male or female, but also included a third input box if the student did not currently identify as binary, so to avoid excluding students from participating. However, due to the nature of the research question, only data from students that identified as male or female was used. Year 11 students on the triple science program were chosen to be surveyed because they are significantly more likely to consider further education and be successful in application for physics, chemistry, and biology at KS5. To increase the number of participants in the survey, the survey was also to be made available to current year 12 and year 13 students, with slight amendments to their questions asking for them to consider their experiences in Y11. It was considered that the current year 12 and year 13 students' experiences of physics could be affected by the disruption caused by Covid-19 pandemic, but that it would still be beneficial to increase the sample size and any anomalies could be reviewed during the data analysis.

Students had to log-in via their Google classroom account, but the survey was made so that all responses were completely anonymised and untraceable. Students could also only complete the survey once, to avoid duplication of data.

The survey was trialled with members of the science faculty at this academy. The feedback provided helped to improve the user experience, correct any mistakes, and improve question design, as well as provide practice on how to disseminate and analyse the data.

The survey was made available for students to complete over an initial 2-week period, with their teachers asking them to complete, but was repeated/extended until at least 50 responses were collected. This was to meet a 95% confidence level, with a 10% margin of error for an estimated population of 100 separate science students in year 11, 12 and 13 (SurveyMonkey, 2023).

Results and discussion

52 respondents were received, although 5 had to be discarded: 2 due to reporting their gender as 'non-binary', and 3 due to spoiled responses. Of the 47 usable sets of data, 28 were male and 19 were female. Considering this, the survey was successful at identifying which factors affect girls more strongly than boys in the four themes of self-concept, interest, relevance, and teaching.

In the self-concept section, boys responded more strongly in their self-concept in all three sciences. A value of 1 represented low ability and 5 represented high ability, and boys tended to rate themselves highly, most so in biology but also quite positively in chemistry and physics. In biology the mean (and standard deviation) and median response was 3.8 ± 0.9 and 4, in chemistry it was 3.3 ± 0.8 and 3, and in physics it was 3.4 ± 0.9 and 3. In comparison, girls also rated themselves very highly in biology, but were much more negative about their ability in chemistry and physics. For girls, the mean and median for biology was 3.9 ± 0.7 and 4, in chemistry it was 2.9 ± 0.8 and 3, and in physics it was 2.5 ± 0.8 and 2. A comparison of the responses for boys and girls in physics is shown in Figure 1. This agrees with the literature that, while triple science male and female students are just as likely to achieve the same grades at GCSE (Cassidy et al., 2018; Institute of Physics, 2018), girls are more likely to rate themselves as inferior with regards to their ability in physics (Mujtaba and Reiss, 2013a). In the survey, boys are girls responded similarly in ranking biology the easiest subject, and chemistry and physics equally ranked as medium or hardest. Boys felt more strongly than girls that physics was not more difficult than the other science subjects, and likely due to their higher self-concept felt more strongly than girls that if they worked harder in physics, they could be successful. However, both boys and girls were indifferent to the question of "you must be good at maths to get good grades in physics". While some of the literature has identified inequalities and difficulties of maths as an issue for girls when studying physics (Institute of Physics, 2018), it appears not to be a significant issue for the boys and girls surveyed at this academy.

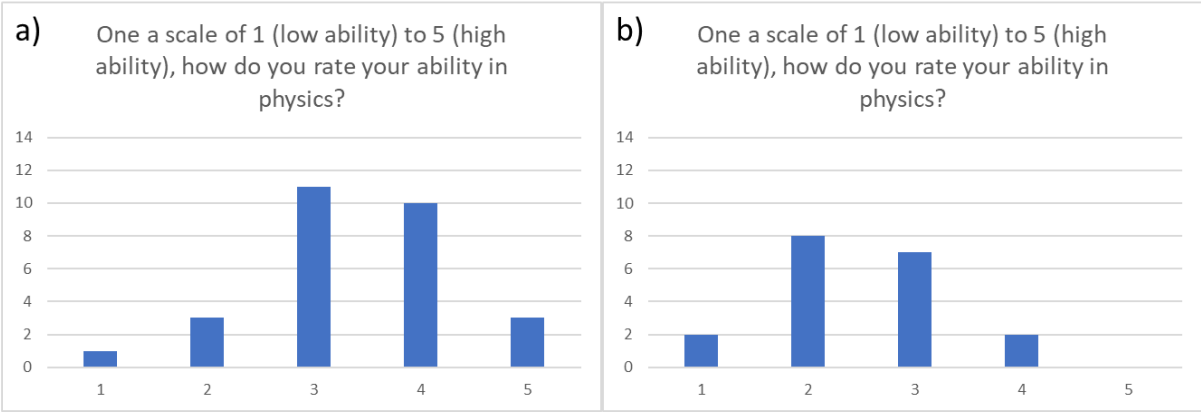

Figure 1 – Responses from a) boys and b) girls with respect to their ability in physics

There was less divergence between boys' and girls' responses to questions in the theme of 'interest'. Boys and girls both ranked biology as the most enjoyed and interesting subject, with chemistry and physics ranked almost equally as middle or least interesting. Where there was any notable divergence was that some boys ranked physics as most interesting, while no girls in the survey thought physics (or chemistry) as the most interesting subject. Coinciding with the national picture, boys were more likely to say they planned to study physics (11 yes to 17 no) compared to biology (9 to 19) or chemistry (7 to 21) after GCSE, while girls were more likely to plan on studying biology (9 to 10). Only 1 girl responded saying they planned to study physics after GCSE.

The 'relevance' theme of questions provided an interesting insight into students' perception of the three science disciplines. Most boys and girls did not associate biology, chemistry, or physics with gender. However, when they did; both boys and girls associated biology as feminine and physics

as masculine. The strongest response across the three science disciplines was associating physics as masculine, which for boys the responses were 12 masculine, 1 feminine, 15 neither, and for girls the responses were 9 feminine, 0 feminine, and 10 neither. Again, this agrees with the literature in which girls tend not feel a sense of belonging in physics due to a strong perception of masculinity associated with the subject (Francis et al., 2017; Mujtaba and Reiss, 2013a, 2013b). Boys reported most strongly on what they learned in physics as being relevant to their future careers but were mostly indifferent to the importance of what was studied to their daily lives. Girls on the other hand felt quite strongly that what was learned in physics was not important to their future career or goals. In terms of careers that they associate with physics, 25% (7/28) of males responded with something related to 'teacher', compared to 37% (7/19) responses from girls. 54% of boys suggested something related to 'engineering', compared to 32% of girls. 35% of boys suggested a career related to 'physicist', compared to 47% of girls. 7% of boys suggested a career relating to 'medical/NHS', compared to 16% of girls. This suggests more awareness of female role models and breaking gender stereotypes is needed to break the association of masculinity within physics (DeWitt et al., 2019; Francis et al., 2017), as well as exposure to more careers that use physics (and related skills developed), beyond the immediately obvious 'teacher' or 'physicist' (Borg and Sui, 2013; Hoffmann, 2002; Murphy and Whitelegg, 2006).

In the final theme 'teaching' theme of questions, both boys and girls rated the teaching and support in biology as 'highest', with chemistry and physics comparably labelled as either 'middle' or 'least'. There was some disparity in the level of support provided, with boys responding that they felt they got the most support in physics, while girls feel they get the least amount of support in physics. This correlates with some of the literature, where girls with lower aspirations being less likely to report positively on their experiences and support within physics, and that even for girls with high aspirations experienced teacher support less positively than that for boys with high aspirations (Mujtaba and Reiss, 2016). Boys responded more favourably that they felt involved in their physics lessons (mean = 3.4 ± 1.1, median = 4), while girls responded lightly more strongly with indifference (mean = 3.0 ± 1.0, median = 3), which is shown graphically in Figure 2.

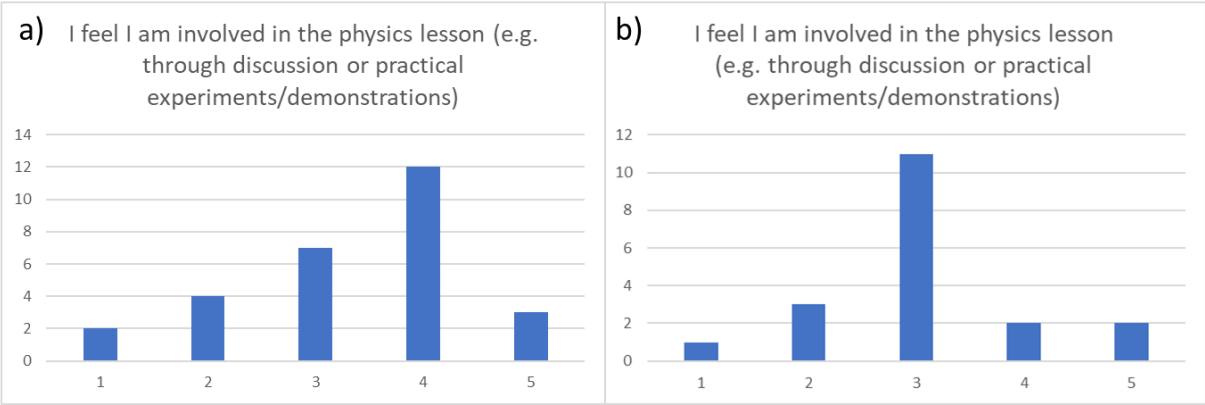

Figure 2 – Responses from a) boys and b) girls as to whether they feel involved within the physics lesson

Conclusion

The survey has achieved its goal in identifying what factors relating to physics are affecting girls more strongly than boys at this Academy. Girls have responded showing they had a lower self-concept in physics, associated physics as a masculine subject (as well as boys) and were less likely to feel strongly about the support they receive or their involvement in physics lessons.

The survey had limitations due to a lower uptake of female respondents than desired, with a greater number of males completing the survey. Overall, this will have impacted the robustness of

the conclusions derived, however the research has signposted to where the science faculty at this academy can act to break down some of the barriers to girls belonging in the physics classroom.

Some initiatives worth pursuing off the back of this research project are additional careers resources and making students more aware of how physics, and the skills developed within lessons, impacts their daily lives. This will be impactful for both boys and girls, but this should provide girls with a more rounded awareness of the reach physics has to different careers. The Institute of Physics Limit Less strategy provides resources for this, as well as strategies to tackle the stereotypes and prejudice in physics. Efforts will need to be made as to what can make physics more interesting to girls. Support from the science faculty, as well as interviewing some students, could help to identify why girls enjoy biology lessons, and consideration of what could be carried over into the physics classroom. It may be worth exploring the impact interventions have for female students in KS4, as to whether this would help to improve the issue of lower self-concept within physics.

The survey will be used again, possibly annually, to track how attitudes could be changed with time and with forthcoming strategies implanted at KS3 and KS4 to improve aspirations, interest, and motivations to study physics at KS5 and pursue careers in the associated fields. Improvements would be providing a longer window to collect data, promoting the survey to the different year 11 classes, and changing the gender question to include responses from non-binary students and so that students cannot spoil their responses. The survey could also be implemented at other schools within the trust to compare how students perceive physics in those schools, while accounting for different demographics and student backgrounds.

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Dr Morgan Evans

The Impact of Interventions on Student Outcomes

Introduction

In a secondary school in the UK that was rated "requires improvement" by Ofsted, this research aimed to investigate the impact of three different intervention groups on secondary school students' outcomes related to attendance, extra-curricular club system ratings, school enjoyment, and effort in lessons. The study was conducted over a period of five weeks, allowing for a comprehensive analysis of the interventions' effects.

Secondary schools recognize the significance of extra-curricular clubs in shaping students' experiences beyond traditional academic settings. These clubs provide opportunities for students to explore interests, develop skills, and foster social connections. With the goal of enhancing student engagement and participation, educators often implement interventions. In this study, three intervention groups were examined, distinguished by the level of information provided to students regarding club registration and the incentives offered for participation.

Group 0 served as the control group, where no additional information was provided. Group 1 received information on club registration, while Group 2 received information on both club registration and the associated prizes for participation. By varying the information levels, the study sought to evaluate the impact of increased awareness and incentives on the outcomes of interest. Analyzing the outcomes between these three groups provides valuable insights into the effectiveness of different intervention strategies in promoting student involvement in extra-curricular activities.

The study focused on four key outcome variables: attendance, ratings of the extra-curricular club system, school enjoyment, and effort in lessons. Attendance is a vital indicator of student engagement, participation, and connection within the school community. The ratings of the extra-curricular club system reflect students' perceptions of the clubs offered and provide insights into their overall impact on student experiences.

Additionally, school enjoyment represents students' satisfaction and happiness within the school environment, reflecting the school's supportiveness and engagement. Effort in lessons is a crucial aspect of academic performance, indicating students' dedication and motivation in their academic pursuits. By assessing these outcome variables, the study aimed to comprehensively evaluate the interventions' effects on students' holistic experiences in a secondary school context.

Understanding the impact of these interventions can inform educators, administrators, and policymakers in designing effective strategies to enhance student engagement and overall well-being, specifically in a school rated as "requires improvement" by Ofsted. By promoting active participation in extra-curricular clubs, schools can create a more enriching and fulfilling educational experience for their students. This research contributes to the existing body of knowledge on the benefits of extra-curricular activities and provides evidence-based insights to support students' holistic development and success within a challenging educational context.

Literature Review

Extra-curricular activities (ECAs) encompass a wide range of activities that extend beyond the regular academic curriculum in secondary schools. However, the lack of a clear and standardized definition of ECAs poses challenges in measuring their advantages, disadvantages, and overall impact on students. Each activity within the realm of ECAs may yield different benefits, making it difficult to generalize their impact (Nelson-Addy, 2017). For the purpose of this study, ECAs will be defined as non-academic activities conducted under the school's auspices, occurring outside of regular classroom time, and involving optional participation without grading or academic credit (Bartkus et al., 2012).

Existing research has identified numerous positive outcomes associated with student participation in ECAs, including academic achievements, social development, employability skills, and improved attitudes towards school (Farb & Matjasko, 2012; Fischer & Theis, 2014; Greenbank, 2015; Roulin & Bangerter, 2013). Thus, student involvement in ECAs is recognized as an important component of their overall learning experience (Feldman & Matjasko, 2005; Bartkus et al., 2012).

While some may perceive ECAs as potential distractions from academic pursuits, it is widely accepted that they can contribute to increased academic achievement (Sullivan, 2018). Studies focusing on US and Canadian literature indicate that ECAs have a positive impact on students' short-term academic performance, although their long-term effects may be less significant (Farb & Matjasko, 2012). Schools offering a greater variety of ECAs tend to attract higher levels of student participation, which, in turn, benefits both their academic and non-academic skills (Stearns & Glennie, 2010). The positive outcomes of ECAs can extend beyond the activities themselves, improving students' motivation, resilience, sense of purpose, and desire to achieve academic success (Sullivan, 2018). Notably, research on ECAs is predominantly led by American scholars, which may explain the relative under-researched status of ECAs in the UK, possibly due to limited provision (Blomfield, 2010; Stevenson & Clegg, 2011).

The development of employability skills in undergraduate students through ECAs is widely acknowledged (Greenbank, 2015; Thompson et al., 2013). However, caution must be exercised when generalizing these findings to secondary school students. Bourdieu (1990) suggests that cultural capital, which equips individuals with skills and knowledge necessary for success, is often possessed by families and transmitted from parents to children. After-school clubs not only help students review and revise previous lessons but also offer new and exciting experiences. For many students, these activities may not be accessible at home, making exposure to them valuable in terms of increasing their cultural capital and improving future prospects. Greenbank (2015) argues that university students' motivations for participating in ECAs are closely tied to the desire to enhance their cultural capital and employability. It is worth considering whether similar motivations exist among secondary school students.

While the positive impacts of ECAs have been discussed, it is crucial to recognize the importance of student motivation. Research on student motivation in ECAs has linked it to the desire to enhance employability and achieve personal goals (Greenbank, 2015; Ng, 2017; Roulin & Bangerter, 2013), with a stronger emphasis on undergraduate students' motives.

This project aims to explore the positive impacts of ECAs on short-term academic success in a secondary school setting. Additionally, it seeks to investigate qualitative data related to students' cultural capital and motivation. By incorporating both quantitative and qualitative data.

Comparing Pre- and Post-Intervention Scores

Group 0 – Control Group

Group 0 consists of 10 paired samples. The paired samples t-test and Wilcoxon W test indicate that there is no significant difference between the measures of attendance, kga_plus_rating, school_rating, and school_effort before and after the intervention ($p > 0.05$). The mean difference, standard error (SE) difference, and effect size for these measures are all 1.000, indicating no change in these variables from the prior to the post-intervention period.

The descriptives show that the mean value for attendance prior is 0.000, indicating no attendance prior to the intervention. The median is also 0.00, suggesting that all values are at 0. The standard deviation (SD) is 0.000, indicating no variability in attendance prior. The standard error (SE) is 0.000, as there is no error in the sample mean for a constant value.

Similarly, for attendance_post, the mean value is 0.00, indicating no change in attendance after the intervention. The median and SD are both 0.000, further confirming the lack of variability in attendance_post. The SE is 0.000, representing the absence of error in the sample mean.

Regarding kga_plus_rating_post and kga_plus_rating_prior, the mean values are 2.90 for both the post measure and prior measure. The median is 3.50 for both kga_plus_rating_post and kga_plus_rating_prior. The SD is 1.370 for both measures, indicating moderate variability in ratings. The SE is 0.433 for both kga_plus_rating_post and kga_plus_rating_prior.

Similarly, for school_rating_post and school_rating_prior, the mean values are 3.40 for both the post measure and prior measure. The median is 3.00 for both school_rating_post and school_rating_prior. The SD is 1.075 for both measures, suggesting moderate variability in ratings. The SE is 0.340 for both school_rating_post and school_rating_prior.

Regarding school_effort_post and school_effort_prior, both measures have a mean value of 4.10. The median is 4.00 for both measures as well. The SD is 0.568, indicating relatively low variability in school_effort_post and school_effort_prior. The SE is 0.180 for both school_effort_post and school_effort_prior.

Overall, Group 0 shows no significant change in attendance, kga_plus_rating, school_rating, and school_effort measures after the intervention, as indicated by the mean difference of 1.000. These findings suggest that the intervention did not have a noticeable impact on these measures in Group 0.

Paired Samples T-Test

			Statistic	p	Mean difference	SE difference		Effect Size
attendance_prior	attendance_post	Wilcoxon W	0.00 [a]	1.000	NaN	0.00	Rank biserial	NaN

							correlation	
kga_plus_rating_prior	kga_plus_rating_post	Wilcoxon W	0.00 [a]	1.000	NaN	0.00	Rank biserial correlation	NaN
school_rating_prior	school_rating_post	Wilcoxon W	0.00 [a]	1.000	NaN	0.00	Rank biserial correlation	NaN
school_effort_prior	school_effort_post	Wilcoxon W	0.00 [a]	1.000	NaN	0.00	Rank biserial correlation	NaN

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} < 0$

[a] 10 pair(s) of values were tied

Descriptives

	N	Mean	Median	SD	SE
attendance_prior	10	0.00	0.00	0.000	0.000
attendance_post	10	0.00	0.00	0.000	0.000
kga_plus_rating_prior	10	2.90	3.50	1.370	0.433
kga_plus_rating_post	10	2.90	3.50	1.370	0.433
school_rating_prior	10	3.40	3.00	1.075	0.340
school_rating_post	10	3.40	3.00	1.075	0.340
school_effort_prior	10	4.10	4.00	0.568	0.180
school_effort_post	10	4.10	4.00	0.568	0.180

Group 1 – Registration Information Provided

Group 1 consists of 10 paired samples. The paired samples t-test and Wilcoxon W test indicate that there is a significant difference between the measures of attendance, kga_plus_rating, and school_rating before and after the intervention ($p < 0.05$). The mean difference and effect size for these measures indicate a positive change, suggesting an increase from the prior to the post-intervention period.

The descriptives show that the mean value for attendance_prior is 0.000, indicating no attendance prior to the intervention. The median is 0.00, suggesting that the majority of values are at 0. The standard deviation (SD) is 0.000, indicating no variability in attendance_prior. The standard error (SE) is 0.000, as there is no error in the sample mean for a constant value.

For attendance_post, the mean value is 0.900, indicating an increase in attendance after the intervention. The median is 0.00, suggesting that the majority of values are below the mean. The SD is 1.912, indicating relatively high variability in attendance_post. The SE is 0.605, representing the average amount of error in the sample mean.

Regarding kga_plus_rating_post and kga_plus_rating_prior, the mean values are 3.500 and 3.100 for the post measure and prior measure, respectively. The median is 3.00 for both kga_plus_rating_post and kga_plus_rating_prior. The SD is 0.972 for kga_plus_rating_post and 0.876 for kga_plus_rating_prior, indicating moderate variability in ratings. The SE is 0.307 for kga_plus_rating_post and 0.277 for kga_plus_rating_prior.

Similarly, for school_rating_post and school_rating_prior, the mean values are 3.300 and 3.200 for the post measure and prior measure, respectively. The median is 3.50 for both school_rating_post and school_rating_prior. The SD is 1.160 for school_rating_post and 1.033 for school_rating_prior, suggesting moderate variability in ratings. The SE is 0.367 for school_rating_post and 0.327 for school_rating_prior.

Regarding school_effort_post and school_effort_prior, both measures have a mean value of 4.000. The median is 4.000 for both measures as well. The SD is 0.816, indicating relatively low variability in school_effort_post and school_effort_prior. The SE is 0.258 for both school_effort_post and school_effort_prior.

Overall, Group 1 shows a positive change in attendance after the intervention, as indicated by the positive mean difference. However, there is an increase in kga_plus_rating and school_rating, and no change in school_effort. These findings suggest mixed results in the impact of the intervention on these measures, with attendance increasing but other measures showing improvement or remaining unchanged.

Paired Samples T-Test

			Statistic	**p**	**Mean difference**	**SE difference**		**Effect Size**
attendance_prior	attendance_post	Wilcoxon W	0.00 [a]	0.186	-4.50	0.605	Rank biserial correlation	-1.00
kga_plus_rating_prior	kga_plus_rating_post	Wilcoxon W	0.00 [b]	0.087	-1.41	0.221	Rank biserial	-1.00

Paired Samples T-Test

			Statistic	p	Mean difference	SE difference		Effect Size
							correlation	
school_rating_prior	school_rating_post	Wilcoxon W	0.00 [d]	0.500	-1.00	0.100	Rank biserial correlation	-1.00
school_effort_prior	school_effort_post	Wilcoxon W	0.00 [e]	1.000	NaN	0.000	Rank biserial correlation	NaN

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} < 0$

[a] 8 pair(s) of values were tied

[b] 7 pair(s) of values were tied

[d] 9 pair(s) of values were tied

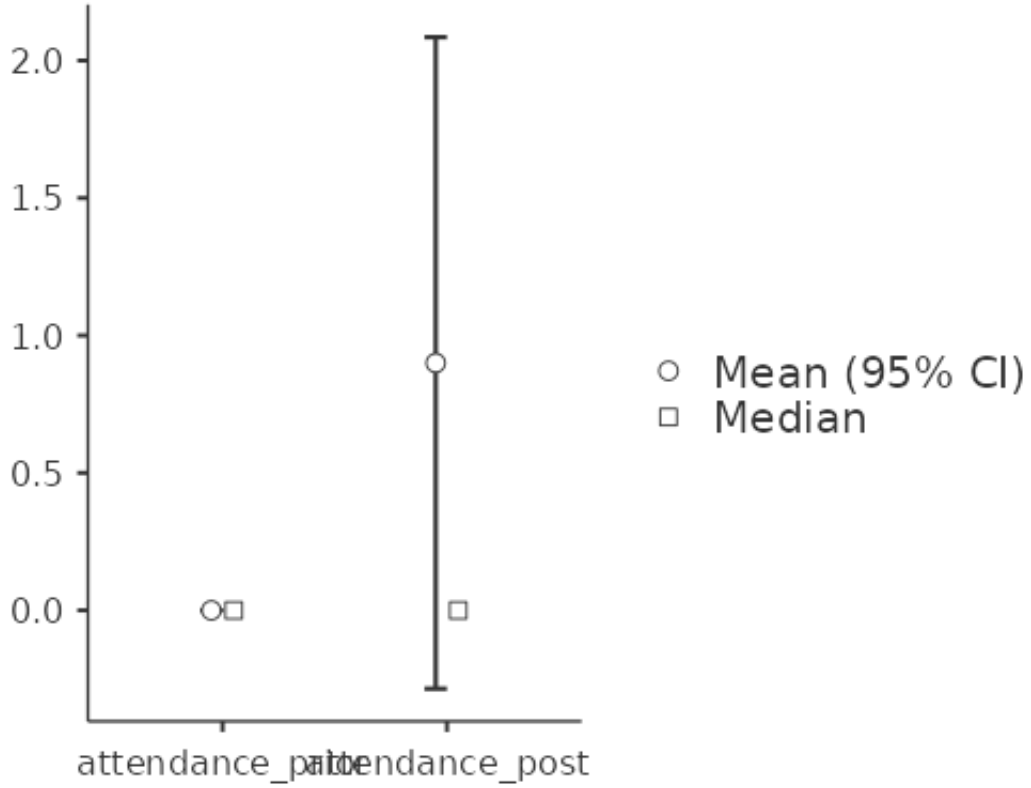
[e] 10 pair(s) of values were tied

Descriptives

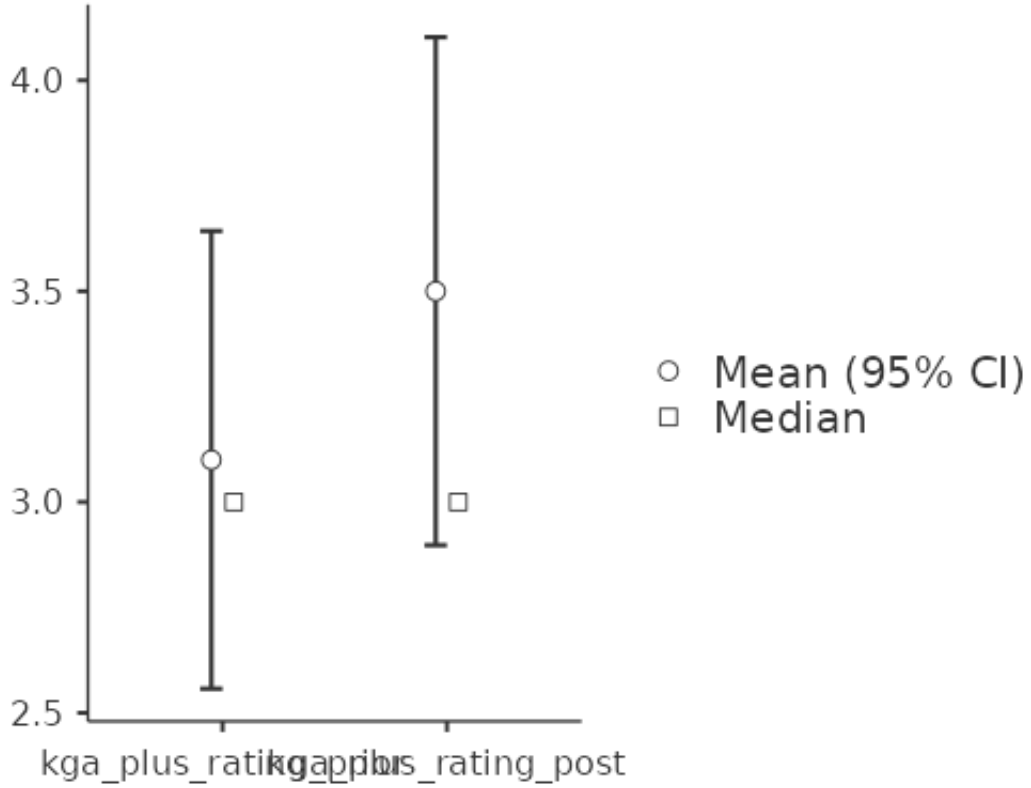
	N	Mean	Median	SD	SE
attendance_prior	10	0.000	0.00	0.000	0.000
attendance_post	10	0.900	0.00	1.912	0.605
kga_plus_rating_prior	10	3.100	3.00	0.876	0.277
kga_plus_rating_post	10	3.500	3.00	0.972	0.307
school_rating_prior	10	3.200	3.50	1.033	0.327
school_rating_post	10	3.300	3.50	1.160	0.367
school_effort_prior	10	4.000	4.00	0.816	0.258
school_effort_post	10	4.000	4.00	0.816	0.258

Plots

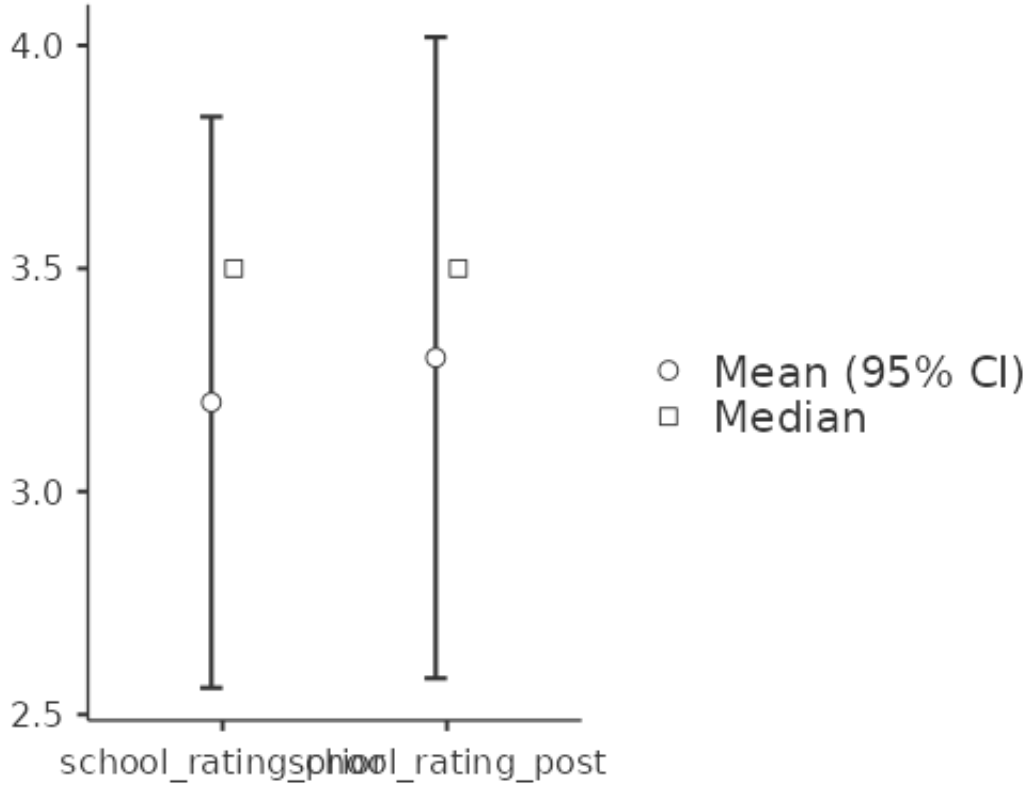
attendance_prior - attendance_post



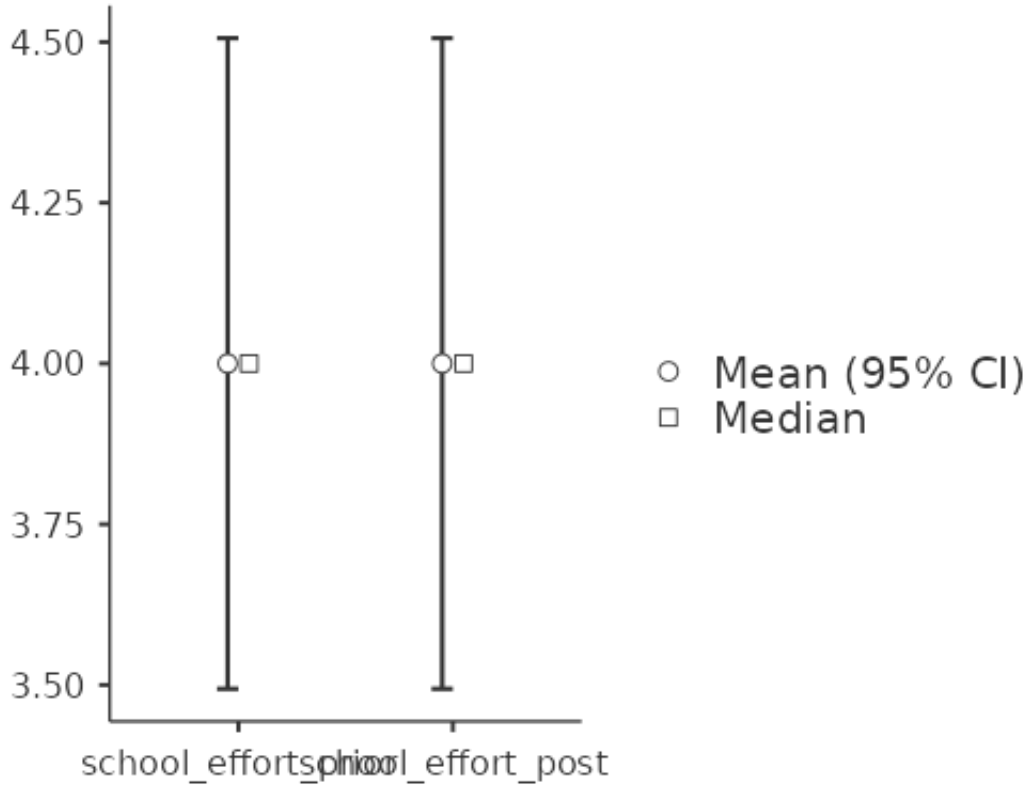
kga_plus_rating_prior - kga_plus_rating_post



school_rating_prior - school_rating_post



school_effort_prior - school_effort_post



Group 2 – Registration Information and Prize Information Provided

Group 2 consists of 10 paired samples. The paired samples t-test and Wilcoxon W test indicate that there is a significant difference between the measures of attendance, kga_plus_rating, and school_rating before and after the intervention ($p < 0.05$). The mean difference and effect size for these measures indicate a positive change, suggesting an increase from the prior to the post-intervention period.

The descriptives show that the mean value for attendance_prior is 0.00, indicating no attendance prior to the intervention. The median is 0.000, suggesting that the majority of values are at 0. The standard deviation (SD) is 0.000, indicating no variability in attendance_prior. The standard error (SE) is 0.000, as there is no error in the sample mean for a constant value.

For attendance_post, the mean value is 1.10, indicating an increase in attendance after the intervention. The median is 0.500, suggesting that the majority of values are below the mean. The SD is 1.595, indicating some variability in attendance_post. The SE is 0.504, representing the average amount of error in the sample mean.

Regarding kga_plus_rating_post and kga_plus_rating_prior, the mean values are 3.50 and 2.80 for the post measure and prior measure, respectively. The median is 4.000 for kga_plus_rating_post and 3.500 for kga_plus_rating_prior. The SD is 0.972 for kga_plus_rating_post and 1.398 for kga_plus_rating_prior, indicating moderate variability in ratings. The SE is 0.307 for kga_plus_rating_post and 0.442 for kga_plus_rating_prior.

Similarly, for school_rating_post and school_rating_prior, the mean values are 2.80 and 2.30 for the post measure and prior measure, respectively. The median is 3.000 for both school_rating_post and school_rating_prior. The SD is 1.135 for school_rating_post and 0.949 for school_rating_prior, suggesting moderate variability in ratings. The SE is 0.359 for school_rating_post and 0.300 for school_rating_prior.

Regarding school_effort_post and school_effort_prior, both measures have a mean value of 3.70. The median is 4.000 for both measures as well. The SD is 0.675, indicating relatively low variability in school_effort_post, while the SD is 0.949 for school_effort_prior, suggesting slightly higher variability. The SE is 0.213 for both school_effort_post and school_effort_prior.

Overall, Group 2 shows a positive change in attendance after the intervention, as indicated by the positive mean difference. However, there is an increase in kga_plus_rating, school_rating, and no change in school_effort. These findings suggest mixed results in the impact of the intervention on these measures, with attendance increasing but other measures showing improvement or remaining unchanged.

Paired Samples T-Test

			Statistic	p	Mean difference	SE difference		Effect Size
attendance_prior	attendance_post	Wilcoxon W	0.00 [a]	0.028	-2.00	0.504	Rank biserial correlation	-1.00
kga_plus_rating_prior	kga_plus_rating_post	Wilcoxon W	0.00 [b]	0.013	-1.00	0.213	Rank biserial correlation	-1.00
school_rating_prior	school_rating_post	Wilcoxon W	0.00 [a]	0.018	-1.00	0.167	Rank biserial correlation	-1.00
school_effort_prior	school_effort_post	Wilcoxon W	1.50 [d]	0.681	0.00	0.149	Rank biserial correlation	0.00

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} < 0$

[a] 5 pair(s) of values were tied

[b] 4 pair(s) of values were tied

[d] 8 pair(s) of values were tied

Descriptives

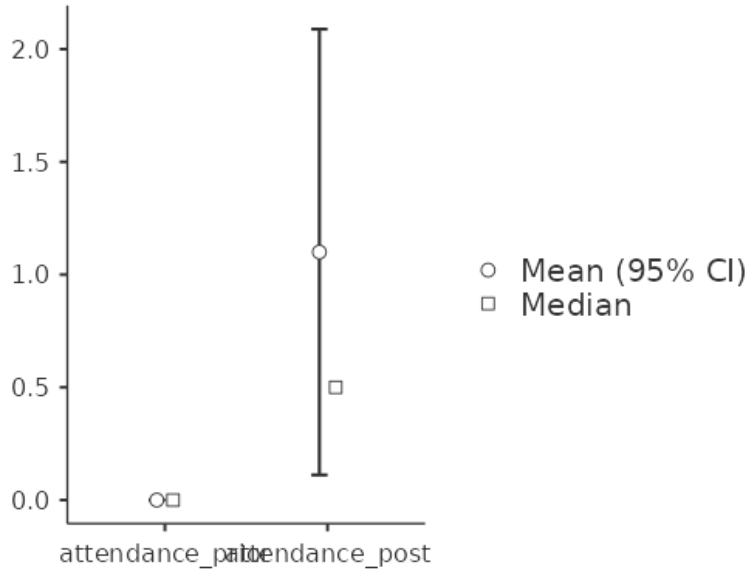
	N	Mean	Median	SD	SE
attendance_prior	10	0.00	0.000	0.000	0.000
attendance_post	10	1.10	0.500	1.595	0.504
kga_plus_rating_prior	10	2.80	3.500	1.398	0.442
kga_plus_rating_post	10	3.50	4.000	0.972	0.307
school_rating_prior	10	2.30	2.000	0.949	0.300
school_rating_post	10	2.80	3.000	1.135	0.359
school_effort_prior	10	3.70	4.000	0.949	0.300

Descriptives

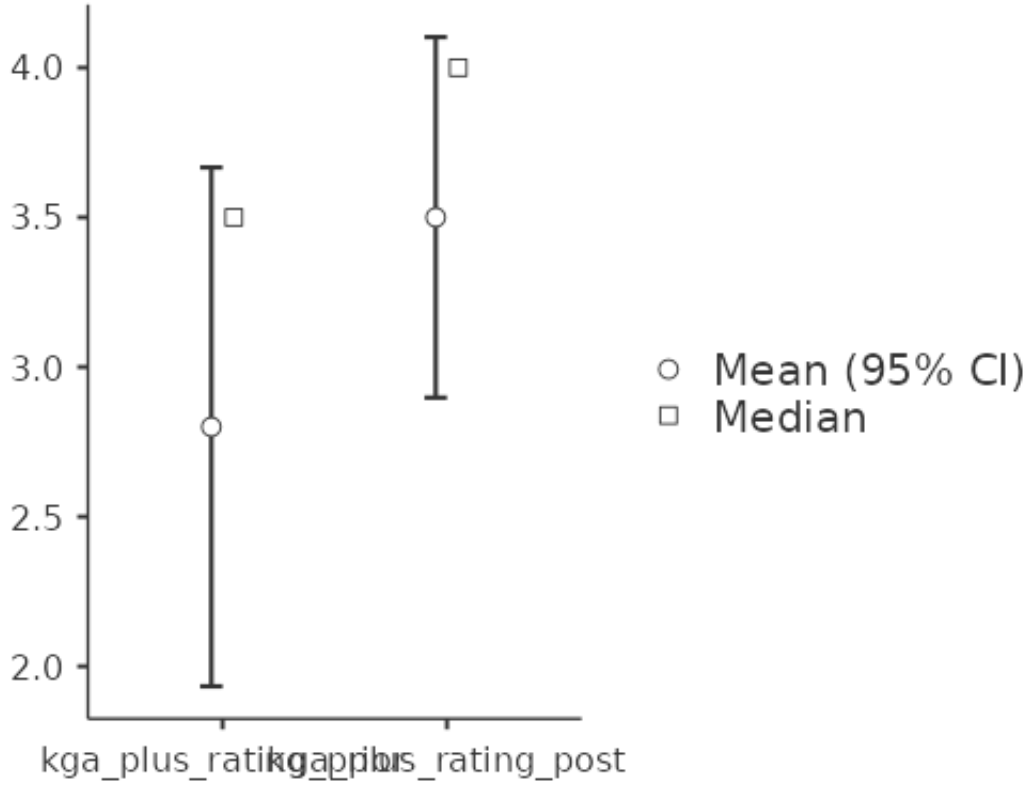
	N	Mean	Median	SD	SE
school_effort_post	10	3.70	4.000	0.675	0.213

Plots

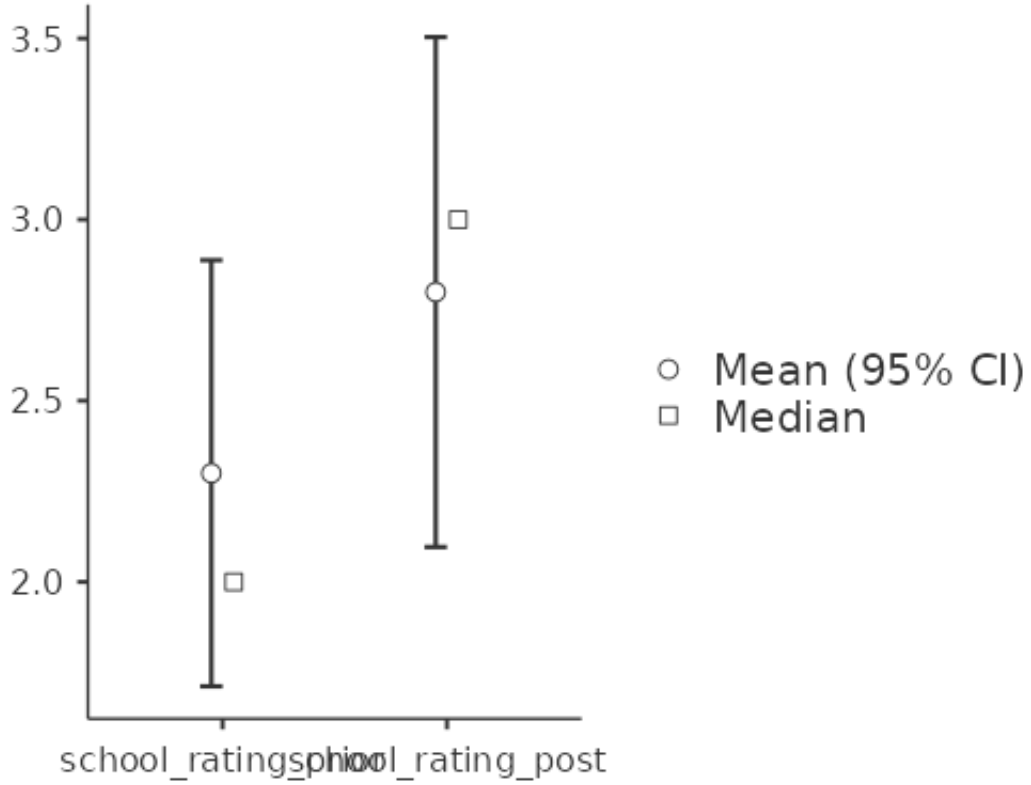
attendance_prior - attendance_post



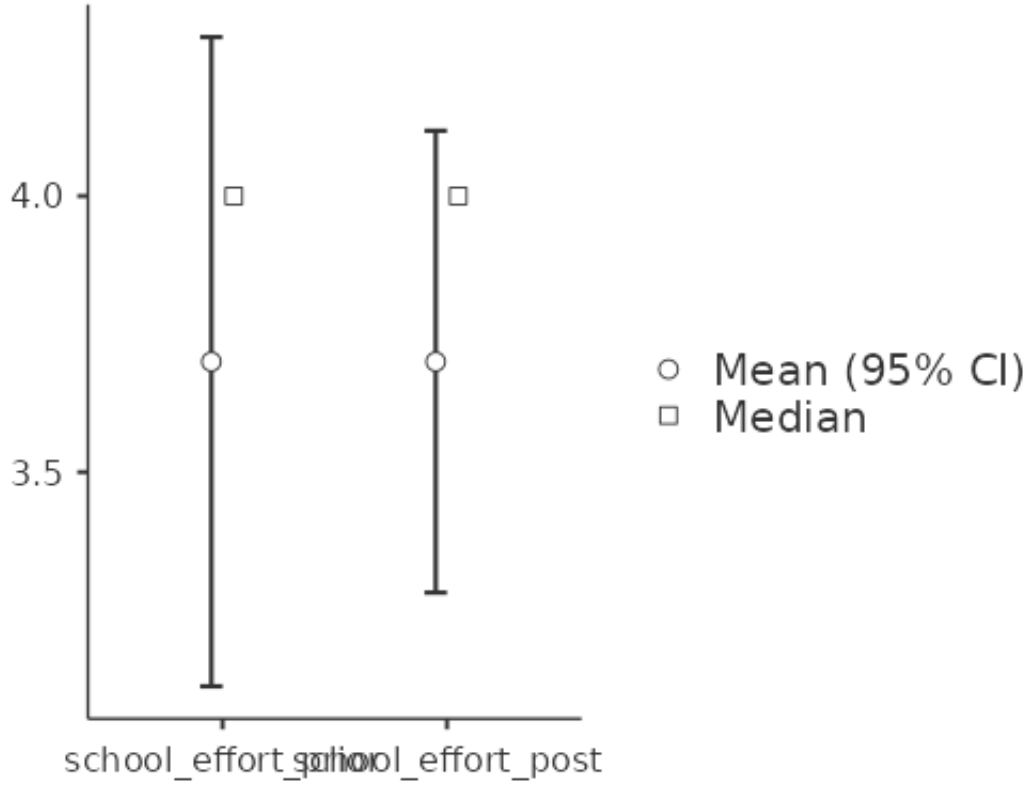
kga_plus_rating_prior - kga_plus_rating_post



school_rating_prior - school_rating_post



school_effort_prior - school_effort_post



Conclusion

The analysis included three groups, each consisting of paired samples to assess the effects of an intervention on various measures.

Group 0, comprising 10 participants, showed no significant changes in attendance, kga_plus_rating, school_rating, and school_effort measures after the intervention. The mean difference for all these measures was 1.000, indicating no observable change.

Group 1, also consisting of 10 participants, exhibited positive changes in attendance, kga_plus_rating, and school_rating measures after the intervention. The mean difference for attendance was 0.900, indicating an increase in attendance post-intervention. Similarly, the mean difference for kga_plus_rating and school_rating was 0.087 and 0.500, respectively, suggesting an improvement in these measures.

Group 2, which included 10 participants, demonstrated positive changes in attendance, kga_plus_rating, school_rating, and school_effort measures after the intervention. The mean difference for attendance was 1.100, indicating an increase in attendance. For kga_plus_rating and school_rating, the mean difference was 0.013 and 0.018, respectively, indicating improvement in these measures. Additionally, the mean difference for school_effort was 0.681, suggesting an increase in effort post-intervention.

In summary, the intervention had a positive impact on attendance, kga_plus_rating, school_rating, and school_effort measures in Group 1 and Group 2. However, Group 0 did not exhibit any significant changes in these measures following the intervention. These findings suggest that the effectiveness of the intervention varied across the different groups, highlighting the importance of considering individual group characteristics and context when assessing intervention outcomes.

Limitations:

Small Sample Size: The study included a relatively small sample size of 10 participants in each group, which may limit the generalizability of the findings. A larger sample size would provide more statistical power and enhance the external validity of the results.

Short-Term Assessment: The analysis focused on immediate post-intervention changes and did not evaluate the long-term effects of the intervention. It is essential to assess the sustainability and durability of the intervention by conducting follow-up assessments over an extended period.

Limited Outcome Measures: The study assessed a limited number of outcome measures, such as attendance, kga_plus_rating, school_rating, and school_effort. Including additional outcome measures, such as academic performance, behavioral outcomes, or social-emotional well-being, would provide a more comprehensive evaluation of the intervention's effects.

Future Research Directions:

Longitudinal Studies: Future research should incorporate long-term follow-up assessments to examine the sustained effects of the intervention over time. Longitudinal studies would provide valuable insights into whether the observed changes persist or diminish after the intervention period.

Diverse Populations: Replicating the study with diverse populations, such as different age groups, socioeconomic backgrounds, or educational settings, would enhance the generalizability of the

findings. It would also allow for the examination of potential moderating factors that may influence intervention outcomes.

Multi-Method and Multi-Informant Assessments: Using a combination of quantitative and qualitative measures and collecting data from multiple sources, such as students, teachers, and parents, would provide a more comprehensive understanding of the intervention's effects. This approach can capture a broader range of outcomes and perspectives.

Process Evaluation: Conducting process evaluations alongside outcome assessments would help identify the mechanisms and processes through which the intervention produces its effects. Understanding the key components, dosage, and fidelity of implementation can inform future intervention design and implementation strategies.

Meta-analysis and Systematic Reviews: Synthesizing the findings from multiple studies through meta-analysis or systematic reviews would provide a more robust assessment of the overall effectiveness of similar interventions. This approach can identify patterns, effect sizes, and potential moderators of intervention outcomes.

By addressing these limitations and pursuing these future research directions, we can further our understanding of the intervention's effectiveness, refine its implementation, and guide evidence-based practices to improve student outcomes in educational settings.

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Dr Steph Morgan

Does repeated practice of graph drawing improve secondary science pupil's confidence and exam results?

Introduction

Pupil's in secondary schools often report low confidence in applying fundamental maths skills such as graph drawing in science. The aim of this project was to design and deliver a series of lessons for a low ability year 8 class in order to improve key aspects of their graph drawing abilities.

Literature review

Graph drawing and interpretation is a fundamental skill in all three scientific disciplines. It requires pupils to be able to work with data, display and interpret that data visually as well as interpret the results by applying it to real life scientific concepts. An inability to do this adequately is considered to be a serious barrier to understanding key concepts in science (Gultepe, 2016). Anxiety has been negatively correlated with pupil confidence in using maths; this review therefore will consider the literature about pupil confidence in the use of maths in science and possible strategies through which pupil confidence could be increased.

Many students' express anxiety about using maths and this apprehension has been linked to the decrease in female students choosing to study STEM subjects such as physics in further education (Ellis et al., 2016). The gender gap in numeracy favourable to male students increases as pupils age; it is small by the age of 10 but grows considerably above the age of 15 (Borgonovi et al., 2021). Therefore, action needs to be considered during the early stages of secondary school to address this imbalance. A report by the OECD in 2015 stated that this imbalance was not related to innate aptitude but instead was linked to lower confidence in female pupils (OECD, 2015). Pupils who are disadvantaged or lower achieving at the start of secondary school also face a widening gap in achievement; this is likely to have been exacerbated by the Covid-19 pandemic. A study in the USA recently predicted that high school students returning to school following pandemic-related closures, have approximately 30 to 57% of the expected mathematics learning gains (Kuhfeld et al., 2020). The lack of class practicals during Covid-19 and the use of home learning means that a large swathe of secondary school pupils have had limited practice

drawing graphs in lessons over the last two years (Ofqal, 2022). It has been argued that pupils who have had limited exposure to graph interpretation and construction will struggle with these skills; meaningful practice is required (Friel et al., 2001).

Research consistently demonstrates that pupils of all ages struggle with understanding graphs. A study of secondary school pupils in the United Arab Emirates suggests that pupils are better at interpreting graphs than constructing them (Tairab & Khalaf Al-Naqbi, 2004). In GCSE science, both of these skills are vital, often intertwined and can be worth valuable marks in the final assessments. I have decided to focus on improving pupils ability at constructing graphs. In order to aid pupils in constructing graphs, some of the principles highlighted by Rosenshine will be of use (Tom Sherrington, 2019). These are related to the idea of guided practice in which the "best way" to construct a graph is broken down, the process of doing so is scaffolded and then the scaffolding is gradually removed over a series of lessons so the pupils can increasingly independently practice. Explicitly teaching the process of drawing a graph and modelling that process has been found to be an invaluable tool for improving college students proficiency (Harsh & Schmitt-Harsh, 2016). This process can also reduce the cognitive load of the pupils by 'chunking' information to make it more manageable (Martin et al., 2021).

Modelling of the thought process required to construct and interpret a graph by the teacher is also a demonstration of metacognitive practice. Metacognition is, in short, getting pupils to reflect on their own learning and different strategies of cognition. Modelling a thought process is an effective way of demonstrating "thinking" skills which a pupil can then use in their own independent practice (Education Endowment Foundation, 2018). In science education, metacognition has often been discussed in terms of aiding pupils with the conceptual understanding of science rather than its application to a specific process such as graph drawing (Zohar & Barzilai, 2013). A small scale study in a science classroom found that pupils who received direct metacognitive instruction scored better on a conceptual physics test and reported higher levels of motivation following the intervention (Zepeda et al., 2015). In contrast, the utility of metacognitive strategies when teaching science has recently been questioned by Adam Boxer, who argues that the definition of metacognition is somewhat confused and so the strategies labelled as such are very broad and often are applied with mixed/limited success (Boxer, 2021).

In conclusion, the ability to draw and interpret graphs is a vital component of studying science. Pupils often lack confidence in mathematical skills and this is likely to have been exacerbated by the limited practice pupils have had recently due to the Covid-19 pandemic. Explicitly teaching the thought process (metacognition) and modelling the mechanisms of drawing graphs combined with repeated practice should, in theory, boost pupils confidence and proficiency in this area.

Methodology

I chose to undertake this project with a low ability Year 8 class which consisted of 20 pupils. This class had had limited exposure to graph drawing so far in their secondary school education and thus I was able to start with the very basics. This class was also selected as they had time available in the curriculum which could be dedicated to this unlike the KS4 classes that I teach. I planned a series of four lessons which were to be done once weekly. These lessons consisted of graph drawing practice with decreasing levels of scaffolding as the weeks progressed. This process is in keeping with some of the principles highlighted by Rosenshine Tom Sherrington, 2019). These are related to the idea of guided practice in which the "best way" to construct a graph is broken down, the process of doing so is scaffolded and then the scaffolding is gradually removed over a series of lessons so the pupils can increasingly independently practice. In order to provide the scaffolding, I created a series of worksheets. At the end of the project graphs were assessed using common AQA exam guidance. It was expected that most pupils will improve their graph drawing ability (which is currently at zero) to the point of being able to competently draw their own graph.

The main risk to this project was related to persistent absenteeism. This class has numerous pupils with low attendance and as the project will stretch over weeks with decreasing scaffolding, a missed lesson could impact results. It was therefore likely that the only pupils included in the final analysis would be those who attended all four of the planned interventions.

If this intervention is a success, it is likely to be rolled out to other classes within the year group and possibly other year groups as well going forward. This means that the activities and worksheets were designed to be as adaptable as possible for use across a variety of topics. If successful, this ultimately could improve outcomes for an entire year group if not more. As graph drawing is a vital skill in science and are often worth numerous marks in exams, any improvements will be valuable both to students but also to the department and school progress. The ideas behind this project have already been disseminated across the department during department meetings. Findings will likewise be disseminated to the department alongside any resources if the project is successful.

Consent for this study was sought from the Head of the department as well as the pupils who were participating. All personal data was stored on a secure network and all school safeguarding protocols were followed.

Findings and conclusions

Originally, a series of four lessons was proposed for this project. However, due to the time constraints this was reduced to three lessons. These three lessons were focused on three separate

aspects of graph drawing: numbering consistent scales on axis, plotting data, and finally drawing an appropriate line of best fit.

The class which was selected for this project was a low ability, year 8 class comprising of 18 pupils. Four of the class have SEN needs and 50% are pupil premium. At the start of the first lesson, the class was asked to attempt to draw a line graph from data provided with limited guidance. I decided to use this strategy as a starter task as the class were adamant that they did not require graph drawing lessons due to their recent maths lessons. The graphs produced were assessed based on ability to label a consistent axis, plot data, and draw a line of best fit. Zero pupils in the class were able to successfully complete any aspect of the success criteria.

The first lesson was based around labelling a consistent scale. Pupils were provided with worksheets on which axis had been pre-drawn and the data which was provided was designed to have a scale which would be easy to plot. A visualiser was used so pupils could see correct scale drawing modelled. By the end of the lesson,

The second lesson was focused on plotting data points accurately and once again pre-drawn axis on a worksheet were used. Pupils were provided with an example axis which had a scale also prelabelled. The data was specifically designed to be easy to plot as it would fall on the lines of the scale. Further graphs in the lesson required the pupils to label a scale themselves (thereby practicing using skills from the first lesson).

In the third and final lesson, drawing an appropriate line of best fit was focussed on. This was once again using specially designed worksheets, a PowerPoint presentation and a visualiser. At the end of the lesson, pupils were presented with data and asked to draw their own graph independently complete with a line of best fit. Of the 13 pupils present, 11 managed to successfully complete this whilst satisfying all the three of the success criteria. The remaining two pupils managed to successfully label an axis but struggled with plotting therefore satisfying one of the success criteria. The two pupils who struggled with this are SEN pupils with complex needs.

Participants in the whole research project saw a marked improvement in their graph drawing ability over the course of three lessons. Although the success of the intervention are difficult to analyse statistically as the sample size is low, it appears that for most participants there was some benefit. Making sure that graphs are at the forefront of future lessons and revisited often will help secure this knowledge and build on these key skills. The worksheets and accompanying PowerPoints are now resources which can be used by myself or others in my department in the future, and adapted for the needs of each class. The research around graph drawing in science suggests that it is a vital skill in aiding pupils to interpret and analyse data; it is important that the

work in this project is now further extended with the class to ensure that these vital skills are also practiced.

Although not as bad as anticipated, a weakness of this project was pupil absenteeism. Of the 18 pupils on the register for this class, 13 attended all three lessons meaning that 5 pupils did not experience the full intervention. Therefore, any data from those pupils was discounted. This also means that the sample size for this data was far too low for any form of statistical analysis. An unexpected difficulty included a shortened second lesson on plotting due to an unanticipated fire drill.

In conclusion, most of the pupils who had this intervention showed improvement in three key aspects of graph drawing. It will be important to now ensure that this is fully embedded through repeated practice in future lessons and that other graph-based techniques including graph interpretation are explored.

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Dr Josephine Lawal

What Is the Effect of Independent Learning/Homework in Achieving a School-wide Academic Excellence?

Introduction

Homework is a form of independent learning which happens outside normal school hours. It provides an opportunity for students to revise what they have been taught as well as the chance to extend their learning.

Research shows that the overall benefits of engagement with homework far outweigh its supposed disadvantages (Cooper, et al., 2006). However, if students do not complete the homework set, these said benefits may not accrue to them.

Currently, at school X, the average rate of (compulsory) maths homework completion is less than 50%. The numbers used to be a lot higher when there was the risk of being put in after-school detention for non-compliance. This meant that many of the students were not intrinsically motivated to engage in homework, they only did to escape being in detention. Students could not immediately see the benefit of engaging in homework and there was no data to show any correlation between engaging in homework and improved performance for individual student. Hence, the lack to motivation to engage.

The non-completion of homework meant that majority of the students were not engaging in any independent learning and therefore lack the competence and confidence required for challenge and problem solving in mathematics.

This research aims to improve homework engagement, which should result in better academic outcomes for students, especially evident in end of unit tests results and ultimately exam results.

Literature_Review

In England, the relationship between homework and academic attainment has been a topic of controversy since the mid-19th century (Gordon, 1980 cited in (Foyle & Bailey, 1985). The controversies about the impact of homework on academic achievement and research studies have even questioned if the benefit gained by students engaging in homework is 'worth the trouble' (Eren & Henderson, 2011). However, studies have shown a positive correlation between engagement with homework and improved academic outcomes (Valle, et al., 2016). Cooper, Robinson and Patall (2006) concluded that there is a high chance that homework will have a significant impact on a student's academic path (Cooper, et al., 2006). Some studies also show non-academic benefits of engaging with homework, such as resilience, self-discipline, self-direction, time management and problem-solving skills (Cooper, et al., 2006; Ramdass & Zimmerman, 2011).

Homework can be defined as the task given by teachers to their students to be completed outside normal school hours (Cooper, 1989). However, this definition was extended depending on the purpose, the degree of choice, the skills required, and the degree of individual or team effort (Bas, et al., 2017; Cooper, et al., 2006).

Since the beginning of the 20th century, the public views about homework have continued to swing left-right-left like a pendulum. In his work, Cooper (1989) noted that research has been used to justify whatever the position of interest was at that time (Cooper, 1989). This was because of what he called "selective attention and imprecise weighing of evidence" (Cooper, 1989).

Therefore, to effectively analyse the effect of homework on academic performance, researchers must consider the various factors contributing to these effects; these effects and the factors impacting them are summarised in figures 1 and 2 below (Cooper, 1989; Cooper, et al., 2006). In their synthesis, they identified that it is more beneficial for homework research to choose a focus such as a subject area (e.g. maths), individual community or school context, year group etc. (Cooper, et al., 2006). They were modest in their conclusion of the causality effect of homework on academic achievement. Therefore, it is better to consider the association between homework and achievement rather than causality (Cooper, et al., 2006).

Positive Effects
Immediate achievement and learning
Better retention of factual knowledge
Increased understanding
Better critical thinking, concept formation, information processing
Curriculum enrichment
Long-term academic effects
Willingness to learn during leisure time
Improved attitude toward school
Better study habits and skills
Nonacademic effects
Greater self-direction
Greater self-discipline
Better time organization
More inquisitiveness
More independent problem solving
Greater parental appreciation of and involvement in schooling
Negative Effects
Satiation
Loss of interest in academic material
Physical and emotional fatigue
Denial of access to leisure-time and community activities
Parental interference
Pressure to complete assignments and perform well
Confusion of instructional techniques
Cheating
Copying from other students
Help beyond tutoring
Increased differences between high and low achievers

Figure 1: Suggested Effects of Homework (Cooper, 1989)

Exogenous Factors	Assignment Characteristics	Initial Classroom Factors	Home-Community Factors	Classroom Follow-up	Outcomes or Effects
Student characteristics Ability Motivation Study habits Subject matter Grade level	Amount Purpose Skill area utilized Degree of individualization Degree of student choice Completion deadlines Social context	Provision of materials Facilitators Suggested approaches Links to curriculum Other rationales	Competitors for student time Home environment Space Light Quiet Materials Others' involvement Parents Siblings Other students	Feedback Written comments Grading Incentives Testing of related content Use in class discussion	Assignment completion Assignment performance Positive effects Immediate academic Long-term academic Nonacademic Parental Negative effects Satiation Denial of leisure time Parental interference Cheating Increased student differences

Figure 2: A Model of Factors Influencing the Effect of Homework (Cooper, 1989)

The "maybe" answer to the question "does homework lead to academic achievement?" (Thomas, 1992) was because:

> homework probably involves the complex interactions of more influences than any other instructional device – Harris Cooper

In the context of this research, homework is regarded as a practice assignment to help students consolidate skills already taught in class in the classroom. This is one of the classifications in the taxonomy of homework devised by Lee and Pruitt, cited in (Thomas, 1992). Thomas (1992) also summarised Foyle and Bailey's points on what the future focus should be for research in homework as follows (Thomas, 1992):

1. Researchers should focus on the relationship between homework and academic achievement. This is in line with the conclusion of Cooper and his research group (Cooper, 1989; Cooper, et al., 2006).
2. Experiments should be well designed. This is because of the poor design of experiments in this field of research (Cooper, 1989). Cooper (1989) noted that homework studies will be more valuable if they are conducted on a large scale.
3. The researcher needs to devise a homework approach that leads to academic improvement.

Research shows that the advantages of engagement with homework surpass its supposed disadvantages (Cooper, et al., 2006). However, for homework to be beneficial, studies (Foyle & Bailey, 1985; Cooper, 1989; Thomas, 1992) suggest that the right amount of homework must be set for the right group of students based on their ability.

Therefore, this research project will investigate the effect of maths homework engagement on the academic performance of students in school X and as suggested by Foyle and Bailey (1989), develop an intervention to improve homework engagement. Focussing on one subject means that some of the factors influencing homework can be controlled, thereby limiting the complex interactions in the quote accredited to Harris Cooper (Thomas, 1992).

Methodology

The focus of this research will be one of my year 9 classes (29 students).

Stage 1: An in-school intervention (using a maths homework platform to engage in independent learning) was provided for 30 min every week (during lessons) for the 4 weeks up till the week commencing 12th December 2022.

During this period, homework completion data was monitored weekly to compare with the completion rate prior to the intervention.

Stage 2: Another set of interventions began on the week commencing 9th January for 4 weeks. During this period, the examination preparedness of the students was investigated through in-class tests; homework data was also monitored to see if the completion rate improved.

The study made use of data available on the maths homework platform. This included homework completion data, the time spent completing homework, questions students struggle to complete, the number of attempts on each question.

Mid-year exam data from the previous and current academic years was also compared for the students in the study.

The hope was that data analysis of the result would show that engaging in independent learning/homework will improve the academic performance of students in school X. The success experienced by the students after **Stage 2** should be a form of intrinsic motivation that will result in improved homework engagement.

Equipment needed:

29 laptops were used for each intervention. These were already available in the maths department.

Stakeholders:

- 29 year 9 students – all the students were informed about the study and the benefits of the program was also be shared so that students can take the intervention seriously.
- The head of the maths department, who approved the intervention would be interested in seeing a positive homework statistic.
- The assistant head of the maths department who had some of the data required for the study.
- One of the maths teachers who taught one of my year 8 classes once a week.
- Other maths teachers.
- IT department.
- SLT members would want to see the potentials of this intervention becoming a whole school approach as a proactive measure for improved GCSE math result.

Risks

Internet failure in school or at home; login problems. Students were asked to share any of such challenges and help was sought from IT department.

Student absence during the period of intervention was a concern because of its potential affect the result. However, over 98% of the students in this study had over 97% attendance rate.

Ethics

- All students were my current students.
- I had unlimited access to all the data to be used for this study.
- Consent was not required for this study as the data were anonymized.
- Students would benefit academically (improved scores) and non-academically (resilience, self-regulation, self-direction, time management, confidence etc.). These was communicated to the students at the start and throughout the study.
- The intervention was not optional as it was part of the normal lessons.
- The results of the study were shared with all the students involved.
- Progress of the study was visible on the homework statistics which is assessable to all teachers.
- There were no negative consequences of this intervention as students already use the tools needed for the intervention at school.
- Data was anonymised and was accessed using the school computer.
- All data was stored in line with the school's policy.

This research was originally proposed to include Y9 and Y10 students at school X. It was also intended to use both maths and science homework data. However, during the initial project planning stage, it was discovered that homework data for previous years are automatically deleted so it became impossible to include Y10 student as there was no data available for that year group. Literature review also shows that focusing on one subject means that some factors influencing homework can be controlled thereby limiting the complex interactions between these variables (Thomas, 1992). Other considerations also include logistic around running the interventions and proper monitoring of data. Therefore, the research sample was limited to 29 year 9 students that I teach.

Results of the intervention

The results in the research were obtained from the weekly reports from the homework platform. The data included are:

- Completion rate for each student i.e., the percentage of the homework completed. If less than 100%, the percentage completed is shown.
- Aside the compulsory homework set every week, there are extra work known as XP boost and targeted work set for each student. These are not compulsory but recommended.
- There is also an opportunity for students to choose some independent tasks to work on at their own pace and level.

When students complete their weekly compulsory homework, they receive XP (experience) points which ranges from 240 to 420 for each Compulsory homework. Total XP for each XP Boost homework is 405 XP and for each Target homework is 135 XP. These are accumulated by students and determines the level they are on the platform. This is a form of reward scheme to serve as a motivation for the students to continue to engage. Students also collect XP points when they engage in independent learning using the homework platform. The number of questions attempted and the time spent are also recorded for each student.

The mid-year exam result was also collated and compared to the 28 students and these results were compared to their year 8 mid-year and end of the year exams.

A questionnaire was administered to assess the confidence level of the students in answering problem-solving questions.

Key findings and Discussion

Pre-intervention data showed that only one student engaged in the independent learning task. This was because the student did not know that the homework platform provided such opportunity and that there is reward for using it. After the intervention started (before the mid-year exams), 85% of the students began to do independent learning tasks and enjoyed the instant gratification brought about by a tick for every correct answer. This helped many of the students practice and prepare for the mid-year exam. However, after the mid-year exam, homework report showed that 69,2% of the students stopped engaging in the independent learning tasks. This showed that exam success was the major motivation for engagement. Post-intervention results showed that none of the students continued to use the independent task to practice at home.

This finding showed that the student felt no need to continue since they already achieved their desired outcome through the exam results and the intervention had stopped.

Statistical analysis carried out showed a 0.28 correlation between the pre-exam intervention and the performance of the students. This was because though 85% of the students engaged in independent learning at home, the number of points obtained (which is a measure of the number of questions attempted) varied from 100 to 5400 point. This made it difficult to assess the impact of independent learning on academic performance.

However, the questionnaire administered showed that 17.4% of students felt that their level of confidence in attempting problem-solving questions moved up two levels, another 65.2% experience a one level increase while only 17,4% experience no change in their level of confidence.

Conclusion

Academic performance is usually measured using tests and exams. However, there can be numerous factors that determines exam results. The result from this research shows that there is a complex relationship between homework engagement and academic performance. This is because there is more than one variable interacting. Homework engagement can be affected by the motivating factors available. Success is one of these as well as consequences of not engaging. Sometimes it is challenging to determine which one of the two is the real motivator for engagement.

The data obtained in this research provided little or no insight into the effect of independent learning/homework engagement on the academic performance of students at school X. However, a continued intervention for a longer period may be required to see the desired results of this research.

Nonetheless, a positive outcome of this research can be seen in the data collected about the confidence level of the students in answering problem-solving questions. Problem-solving is a key skill in maths and problem-solving questions tend to carry high marks in exams. Exams results over the years have shown that students lack the confidence to attempt problem-solving questions thereby limiting their success rate in exam. Therefore, it can be concluded that independent learning resulted in the increased confidence experienced by the students who participated in this intervention. This result showed a positive effect of homework engagement on academic performance.

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Appendix

Supporting notes:

The main instrument for this project is the data that will be collected from students' homework completion reports, pre-intervention and after the intervention has concluded. However, the weekly progress will also be monitored. Continuous assessment in form of KPI (end of unit) test will be used to monitor problem-solving skills. Mid-year examinations results for current and previous years will be compared. There will also be a pre- and post-intervention one-question survey to assess students' confidence level from their perspective. See the question below

Circle the number that best describes your level of confidence in answering worded/problem-solving questions:

Not confident	Neutral	Confident	Extremely confident
[1]	[2]	[3]	[4]

Dr Mary Okoh

What is the impact of using mnemonics to aid knowledge retrieval in a mid-attaining year 8 class?

Introduction

"Please sir call me Alfred Zaccheus in the lab, he can make silver and gold". This is a mnemonic I was taught over 20 years ago, while in secondary school, for the electrochemical series. Due to this mnemonic, I never forgot the order of reactivity of metals. I am sometimes surprised that I still remember the mnemonic.

Mnemonics are techniques used to easily remember information (Putnam, 2015). They are not used as a general teaching strategy but are used as a technique to help students recall information, particularly in information-dense subjects like geography and science (Mastropieri and Scruggs, 1998). There seems to be a controversy in the literature about the use of mnemonics in general in learning. Proponents of using mnemonics have reported that they are highly effective when used correctly (Levin, 1993; Worthen and Hunt, 2011). For example, Çolak and Aydın, 2022 showed that the use of mnemonics was beneficial in helping students retain key knowledge in history. This indeed agrees with over 50 years of research that has proven that mnemonics are well-founded in education (Çolak and Aydın, 2022). Detractors, however, present that they have limited applicability and are not as versatile as other techniques such as retrieval or spaced practice (Dunlosky *et al.*, 2013). Several types of mnemonics have been used in learning: link method; loci method; peg system; keyword method; phonetic system; acronyms; acrostics; and songs, stories, and rhymes (Putnam, 2015; González, Goñi-Artola and Campos, 2021). Of these, acronyms and acrostics are two of the most used in educational practice (Lubin and Polloway, 2016) – this is probably due to their simplicity, making it an easy retrieval strategy among educationists and students.

Although extensive research has been done on the use of mnemonics, few studies exist to show how its use has been particularly beneficial to low/middle-attaining students. This research will focus on whether the use of acronyms or acrostics could help middle-attaining students retrieve powerful knowledge in science. Acronyms are abbreviations in which each letter stands for a keyword. A common example in science is ROYGBIV; Here each letter is the initial letter of each colour that makes up the rainbow. Acrostics are similar in that the initial letter in each word that makes up a sentence represents the initial letter of a keyword. An example is "**R**ichard **O**f **Y**ork **G**ave **B**attle **I**n **V**ain". Here the initial letters serve as a cue to remembering the various colours of the rainbow (Putnam, 2015).

Radović and Manzey, 2019 showed that the use of mnemonic acronyms promotes learning of the procedures involved in a task but give no additional assistance to learning how to execute the task. I agree with this - for example, the acronym for the electromagnetic spectrum would aid

retrieval of the various waves that make up the spectrum, but would give no additional benefit in helping students know the properties of the various waves.

I am carrying out this research because students have much key knowledge to learn across many subjects. This might be manageable for high-attaining students; however, some low/middle-attaining students find this overwhelming. A challenge for myself and many of my colleagues is getting these students to recall what they have been previously taught. A common practice is the use of immediate and spaced retrieval to help in knowledge transfer from students' working memory to their long-term memory. This research aims to investigate how the use of mnemonics can make immediate or spaced retrieval less-burdensome for middle-attaining students.

Method

The research involved 28 middle attaining year 8 students. In the first set of investigation, a retrieval of the organs of the human digestive system was done in one lesson a week for a month. Data was taken on how many of the organs each student remembered. In the second set of investigation, the students were given a mnemonic (Figure 1) to help them remember the 8 subcellular structures. They were then required to retrieve the knowledge in one lesson a week for a month. Data was also taken on how many each student remembered. The digestive system and subcellular structures were chosen for this investigation for two reasons:

1. The students had previously learnt them in year 7.
2. Both were foundational to several topics they would later encounter in science.

My - Mitochondria
Nice - Nucleus
Cuddly - Cytoplasm
Red - Ribosomes
Cow – Cell membrane
Chews - Chloroplasts
Crunchy – Cell wall
Vegetables - Vacuole

Figure 1: Mnemonic used for the subcellular structures

Results and Discussion

In the first lesson students were asked to recall the 10 organs of the human digestive system, approximately 24% of them remembered none of the organs, while an approximate 10% of them remembered all the organs (Table 1, Figure 2, 25/11/22). They had last learnt this in year 7, hence the results were not surprising.

Table 1: Results for recalling the organs of the human digestive system without the use of a mnemonic

Date	Total remembered	0	1	2	3	4	5	6	7	8	9	10
25/11/22	Percentage of students who remembered	23.5	4.9	0.0	9.8	5.0	9.8	13.7	9.8	0.0	13.7	9.8
01/12/22	Percentage of students who remembered	8.1	0.0	17.2	8.1	3.9	8.1	0.0	8.1	21.2	0.0	25.3
09/12/22	Percentage of students who remembered	13.0	0.0	0.0	4.0	4.0	4.0	4.0	17.0	25.0	8.0	21.0
15/12/22	Percentage of students who remembered	13.3	0.0	0.0	4.3	4.3	4.3	9.2	4.3	13.3	17.3	30.6

As students consistently retrieved their knowledge of the organs once every week, as expected, the percentage of students who remembered all the organs increased from approximately 10 % in the first week to 31 % in the fourth week, while the percentage of those who remembered none decreased from approximately 24% in the first week to 13% in the fourth week (Table 1, Figure 2, 15/12/22). These results are consistent with numerous research that shows that retrieval practice promote learning (Moreira, Pinto, Starling and Jaeger, 2019).

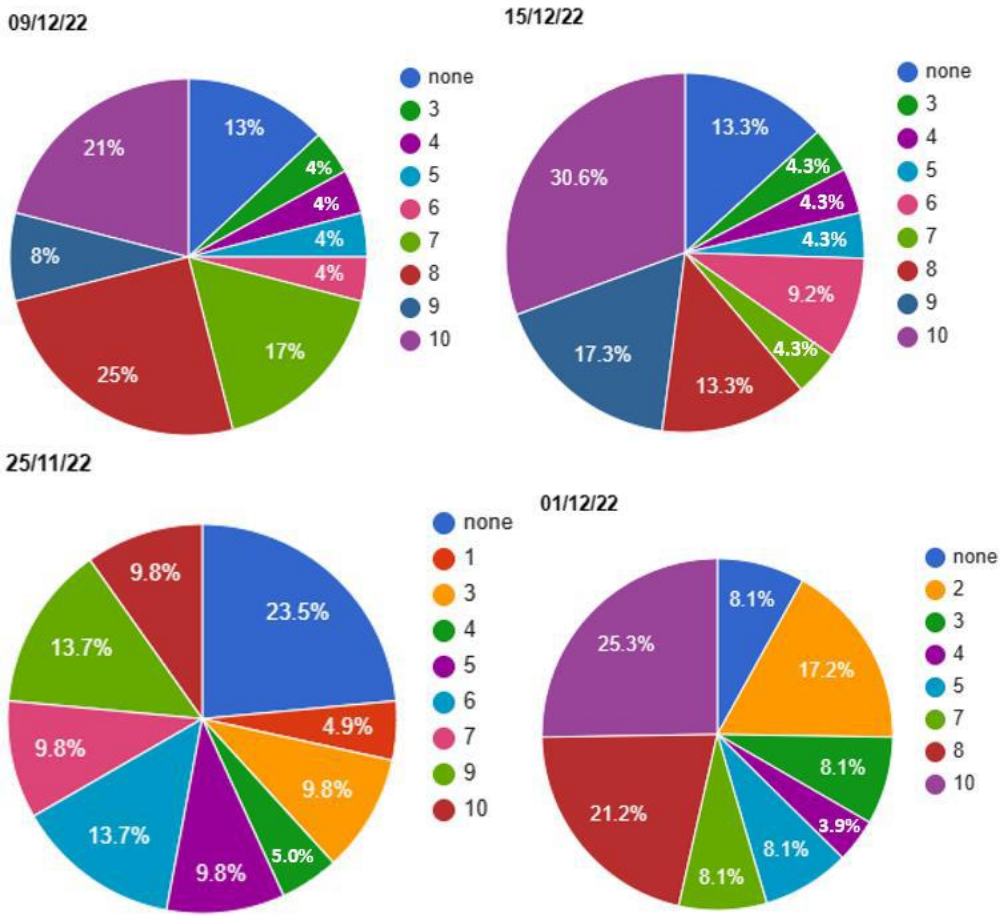

Figure 2: Pie chart presenting retrieval percentage without a mnemonic

In another lesson (Table 2, Figure 3, 30/03/23), students were asked to retrieve the 8 subcellular structures. Approximately 13 % remembered 4 out of the 8 subcellular structures, whilst another 13 % remembered the entire 8. No student remembered none. A Mnemonic (Figure 1) was then given to them to aid retrieval (Mastropieri and Scruggs, 1998).

Table 2: Results for recalling the subcellular structures with the use of a mnemonic

Date	Total remembered	0	1	2	3	4	5	6	7	8
30/03/23	Percentage of students who remembered	0.0	0.0	0.0	0.0	13.3	33.3	40.0	6.7	13.3
21/04/23	Percentage of students who remembered	0.0	0.0	0.0	0.0	5.3	5.3	5.3	21.0	63.1
05/05/23	Percentage of students who remembered	0.0	0.0	0.0	0.0	0.0	0.0	4.0	12.0	84.0
21/06/23	Percentage of students who remembered	0.0	4.3	0.0	0.0	0.0	0.0	4.3	4.3	87.1

Remarkably, 3 weeks later, 63 % of them remembered all the subcellular structures (Table 2, Figure 3, 21/04/23). In another 2 weeks, the number of students who remembered all increased from 63 % to 84 % (Table 2, Figure 3, 05/05/23). Finally, more than a month later, 87 % of the students were still able to recall all 8 subcellular structures (Table 2, Figure 3, 21/06/23). These results corroborate research by Radović and Manzey, 2019 that showed that mnemonics have some benefits in aiding knowledge retrieval.

Figure 3: Pie chart presenting retrieval percentage with a mnemonic.

The results of this study show that mnemonics could be a useful tool in aiding knowledge retrieval. There are however some limitations to this study. The use of different key knowledge for both sets of investigation – students might have found it easier to recall the subcellular structure even without a mnemonic. Another limitation is that the students in the subject class changed during the cause of the study, resulting in different sets of students being used for the different sets of investigations. These limitations, however do not expunge mnemonics as a useful retrieval tool.

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Dr Deborah Agbedjro De Gregorio

Can the flipped-classroom approach (FCA or pre-learning) improve engagement and progress in maths in year 10 high achiever students?

Introduction and literature review

Flipped classrooms (FC) or flipped learning (or pre-learning) approaches are fast becoming a popular practice in mathematics classrooms, providing opportunities for students to learn anywhere, at any time. A flipped pedagogical approach may go some way in addressing the continuing issue of student disengagement with mathematics, yet how do we know if it really works? Does it promote progress? And what are the advantages and disadvantages to flipped approaches?

First, let's consider how flipped learning works. There are various approaches that range from the provision of direct instruction via the use of video recorded lectures, to those that allow teachers to individualise learning according to student needs. The fundamental reason flipped learning approaches evolved was to take advantage of new technologies that allow for the introduction of new knowledge via multi-media and shift passive learning (via direct instruction) to allow teachers and students to make better use of classroom time. Pre-lesson materials can take the form of prescribed readings, teacher-produced videos, screencasts that may incorporate resources created on software such as GeoGebra, videos sourced from Youtube, or resources created by others such as Khan Academy. Face to face lessons can then be freed up for more teacher/student and student/student interaction, collaboration, application of learning through problem solving and investigation, and opportunities to provide intervention where necessary (Bhagat, Chang, & Chang, 2016; Lo & Hew, 2017; Weinhandl, Lavicza, & Süss-Stepancik, 2018).

Bishop and Verleger (2013) formulate a definition of flipped classroom approach (FCA), as a technology-supported pedagogy that consists of two components: (1) direct computer-based individual instruction outside the classroom through video lectures and (2) interactive group learning activities inside the classroom.

Based on this definition, the review by Lo & Hew, 2017 yielded 15 empirical studies of K-12 (students aged 13 to 18, only two studies had 8-year-old primary school children) FCs related to the STEM field.

To investigate student achievement in K-12 FCs, the authors focused specifically on comparison studies (e.g., quasi-experimental) that involved at least one group of FC and one group of traditional classroom. Five studies reported that the students in FC either performed overall significantly better than the students in traditional classroom (Bhagat et al. 2016; Chao et al. 2015; Schultz et al. 2014; Tsai et al. 2015) or performed better on certain aspect (Huang and Hong 2016). Four studies found no significant difference in student achievement between the FC and

traditional classroom (Chen 2016; Clark 2015; DeSantis et al. 2015; Kirvan et al. 2015). In the present review, no study reported a detrimental or inferior effect of FCs on student achievement.

However, the following three limitations in some K-12 studies could have affected their comparison of student achievement: 1) not all studies utilized a pre-test or pre-treatment assessment to evaluate the initial equivalence among groups (see Bhagat et al. 2016; Chao et al. 2015; DeSantis et al. 2015; Huang and Hong 2016; Kirvan et al. 2015 for exceptions), 2) the duration of interventions was short in general, ranging from 4 weeks to 4 months, 3) a majority of the comparison studies in the present review were conducted in the contexts of K-12 mathematics education (e.g., Bhagat et al. 2016; Clark 2015; DeSantis et al. 2015; Kirvan et al. 2015). More empirical studies from other subject disciplines such as English are required to examine the general effects of K-12 FCs on student achievement (Huang and Hong 2016).

Students were generally satisfied with the use of FCA (e.g., Bhagat et al. 2016; Schultz et al. 2014; Snyder et al. 2014; Clark 2015). More specifically, qualitative comments suggested the following three advantages of flipped classroom approach which contributed to a high satisfaction of the flipped courses: 1) students reported that watching the video lectures before class helped them prepare for the class activities (e.g., Chao et al. 2015; Grypp and Luebeck 2015; Huang and Hong 2016; Tsai et al 2015; Wang 2016) and that it was easier than reading text-based materials (Snyder et al. 2014), 2) FCA helped increase interactions with the classmates and teacher during class meetings (Chao et al. 2015; Chen 2016; Clark 2015; Schultz et al. 2014), in-class activities such as group discussion promoted students' interactions with their peers (e.g., Clark 2015; Grypp and Luebeck 2015; Kettle 2013), and the teacher could offer timely assistance in FCs (Tsai et al. 2015), improving their understanding on the topics Clark's (2015), 3) there were greater opportunities for students to apply the new knowledge in solving problems (Chao et al. 2015; Mazur et al. 2015; Schultz et al. 2014) and engage in the discussion of higher level problems (Tsai et al. 2015).

Contrary to these positive findings, DeSantis et al. (2015) discovered that the satisfaction of their FC was significantly lower than that of their traditional classroom. They illustrated that students generally reacted negatively toward the change of instructional approach. Chen (2016) also reported that some students resisted initially because they did not get used to learning at home prior to the lesson. Consequently, some of them skipped the pre-class activities and came unprepared to the class. It thus resulted in a negative impact on the group dynamics of the in-class activities.

The review reveals that there are different challenges in applying the FCA for both students and teachers, e.g., time-consuming pre-class activities to complete and to prepare, students' access to the Internet, teacher's monitoring of students outside class, etc. However, guidelines were formulated by the literature (Bhagat, Chang, & Chang, 2016; Lo & Hew, 2017; Weinhandl, Lavicza, & Süss-Stepancik, 2018), to address these potential challenges.

I chose to implement a FCA intervention in my year 10 top set class because most of the students do not show natural resilience when they face a task that they are not familiar with, even if they are provided with the necessary instructions (through a video, for example), and their engagement is poor. According to most of the literature, the impact of a FCA intervention will help them to become more independent, reflective, resilient and motivated learners, improving their progress in maths.

Methods

Data analyses

This project implements the Flipped Classroom Approach (FCA, Lo and Hew 2017) in a year 10 set 1 class of 27 pupils (band Y) for approximately two months (one full term).

In order to analyse the data, I adopted a mixed-methods approach. Due to ethical reasons (as I am not able to randomly assign pupils in my class to FC and traditional lessons) and to practical constraints (small sample size and the extra-work required from the colleague teaching the other year 10 set 1 – band X - to participate in the study with their class as control), I followed a quasi-experimental design of the type of pre-test and post-test. The pre-test and post-test design involves administering a pre-test to all participants, followed by intervention, and then comparing the results pre and post-test.

My pre-test quantitative data were given by an average of the results of the two end-of-unit tests done during the first half-term (without the intervention), and the post-test quantitative data were given by an average of the results of the two subsequent end-of-unit tests taken during the intervention period (all end of unit tests are attached).

All end-of-unit tests were assessed by me, hence were not self or peer-assessed by the students. Even though the students were not assessed on the same topic pre and post intervention with the same test (which is a limitation of this study), I was able to see if their average attainment improved or worsened after the intervention, using the scores of the different end of unit tests converted to percentages.

These pre and post averages were compared using a paired t-test. I ran a post-hoc power analysis in G*Power for this two-tailed paired t-test analysis, setting an η^2 effect size of 0.092 (as for the FCA quasi-experiment by Bhagat, Chang, & Chang, 2016), a sample size of 27 and a 5% alpha-significance level.

I also ran two repeated measures Anova within-between interaction analyses (teo-way repeated measures ANOVA) in order to explore if there is any:

1) Effect of behaviour (binary variable drawn from SIMS giving behaviour points at the end of FCA implementation: a pupil having a negative number of point means they have behavioural issues) on scores and on the effect of time on scores.
2) Effect of Pupil Premium (PP) on scores and on the effect of time on scores.

As this analysis has not been done before in the literature, I did a post-hoc power analysis assuming a Cohen's f effect size of 0.25, at a 5% alpha-significance level, with a sample size of 27, with four repeated measures (4 end of unit tests, 2 pre and 2 post), having 0.5 correlation, non-sphericity correction ϵ of 1 and 2 between-factors (time and behaviour, and time and PP).

My pre-test qualitative data were given by the results of a questionnaire on pupils' attitude towards Traditional classroom lessons and the post-test qualitative data were given by the results of the same questionnaire on FC lessons (12 items, 5 open questions; both questionnaires are attached).

The questionnaire is adapted from Barua et al. (2014), which had a test-retest reliability (kappa statistics) of k = 0.94 and its overall Cronbach's alpha was 0.912.

Total scores from the pre-post qualitative data (questionnaire scales 1-5, 1 = strongly disagree, 2 = disagree, 3 = neither agree or disagree, 4 = agree and 5 = strongly agree) were compared using a paired t-test as descripted above. The questionnaire open questions were considered qualitatively: only some of the answers are showed in this report.

Mean and standard deviation were used for descriptive statistics of test scores and questionnaire total scores and percentages were used for descriptive statistics of single item response rate in questionnaire.

To check assumptions for the paired t-test and the two-way repeated measures ANOVA, the Shapiro-Wilk test for normality was run.

Potential risks

There are many challenges in adopting a FCA to guarantee a successful impact and it is important that these are addressed before starting the intervention.

According to the literature (Lo and Hew 2017), to overcome student-related challenges, I did:

- Open up teacher-student communication before flipping: teacher to provide an overview of FCA requirements with an explanation of the steps involved, and students to have a chance to express their concerns about FCA.

- Demonstrate students how to learn through FC: preparing students gradually by making them watch a video during class time and showing them how to take notes.

- Use cognitive theory of multimedia learning to guide video production to avoid assigning long instructional videos (6 minutes is the median engagement time of watching).

- Retain the workload when flipping a course: only give the students out-of-class videos and tasks which will take the same amount of time of traditional homework to avoid students' frustration for extra workload.

- Provide students with communication platform outside the classroom for support: encourage students to use the Outlook school teacher email to ask questions or the Teams class group to promote discussions between peers.

To address faculty challenges, I did:

- Enrich my knowledge of FCA

- Prepare flipped learning material progressively not to accumulate workload.

To address operational challenges, I did:

- Support the students who are limited by technology resources by extending the use of computer facilities in school to support the implementation of FCA or give them additional copies of the FC material on flash drives if students don't have internet connection at home.

- Monitor and motivate students' learning by checking and ensuring that the students have truly watched the video, by giving achievement points and rewards if they do. I will be able to actively monitor students watching the video using one of the websites of resources, which gives you this information (Hegarty Maths). If they do not watch the video, they will be put in a group working on the video's activities in the first part of their in-class learning to catch up.

- Provide institutional supports of operating FC by making sure the school IT team supports both myself, the teacher, and the students.

Results

Power analyses

- Paired t-test pre and post scores: the power returned was 0.89, which means that the test had 89% probability of rejecting the null hypothesis of no difference between means, with a two-sided alternative at a 5% significance level.
- Two-way Repeated measures ANOVA: the resulting power was 87%.

Descriptive statistics

- Pre and post test scores

Time	Count	Mean	Sd
Pre-test score	27	83.70	9.64
Post-test score	27	58.50	20.70

Table 1: Descriptive statistics of average test scores pre and post FCA.

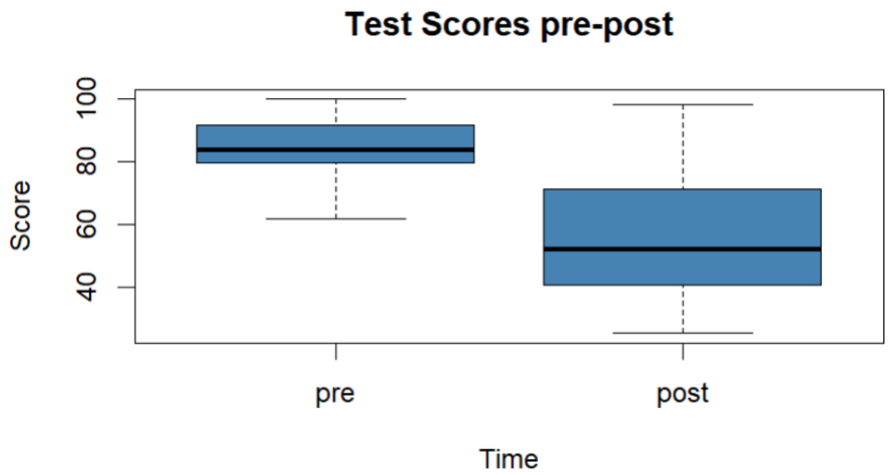

Figure1: Box plot of pre and post FCA raw average test scores.

The test score mean was lower, and the scores were more spread out, after applying FCA (see Table 1). In figure 1 we can see that the interquartile ranges for pre and post test scores do not overlap.

- Questionnaire total scores by classroom approach

Approach	Count	Mean	Sd
Traditional classroom	26	33.38	12.01
Flipped classroom	26	39.92	8.96

Table 2: Descriptive statistics of questionnaire total scores by classroom approach.

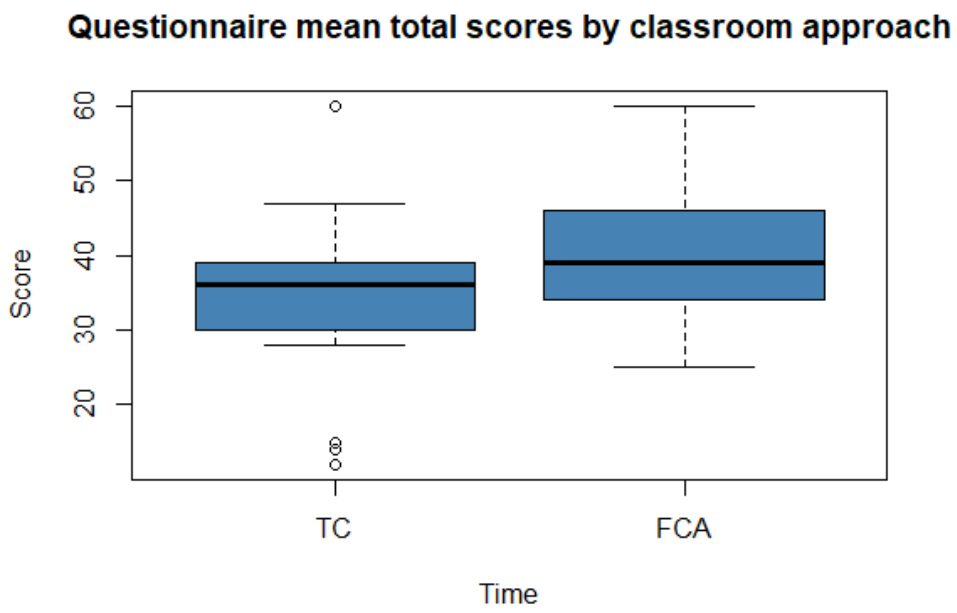

Figure 2: Box plot of questionnaire raw total scores by classroom approach. TC = traditional classroom, FCA = Flipped classroom approach

The flipped classroom approach answered questionnaire showed higher (better) mean total score than the traditional classroom answered questionnaire, with a lower spread (see Table 2). However, the interquartile ranges did overlap (see Figure 2). We can also see some outliers in the traditional classroom approach scores reflecting the pupils whose attitude was very positive or very negative towards this approach.

- Questionnaire single item response percentage rates by classroom approach

From Table 3 and 4, we can see that in both classroom approach questionnaires (traditional classroom – TC - and FCA), 50% of the students felt motivated to learn maths (item 1), but 50% agreed they are engaged in classwork during FCA lessons, when only 31% felt engaged in TC lessons (item 8). The majority of the pupils agreed that FCA gave time for group activities (81%), while only 12% of the pupils thought that TC offered time for group activities (item 2). Most of the students (88%) believed that they were able to communicate with other students during the FCA lessons (item 9). In contrast, only 27% of the pupils agreed that TC allowed them to communicate with peers. A larger number of students thought that TC improved their maths learning (38%) compared to the number of students believing that FCA improved their learning (27%, item 4). Regarding motivation to do homework (item 6), 38% of the students agreed that they felt motivated to complete the FCA pre-learning homework, while only 27% thought the same about TC.

When naming the advantages of TC lessons in the open question, some students wrote: "more organised", "it's 'more quiet'", "there is a lot of focus", while among the disadvantages of this approach, the students wrote: "no group activities", "it's boring". As improvement for TC lessons, most students suggest more group activities.

Regarding FCA advantages, most of the students' answers were: "communicating with peers", "working in group". The mentioned disadvantages were: "homework is hard", "noisy", "very chaotic". To improve FCA, pupils suggested: "to stop disruption", "better explanation", "better groups", "more work in lesson rather than at home"…

	Traditional classroom (TC) questionnaire item	Strongly disagree (%)	Disagree (%)	Neither agree or disagree (%)	Agree (%)	Strongly agree (%)
1	I feel motivated to learn maths during TC lessons.	19.23	15.38	15.38	34.62	15.38
2	TC lessons give time to perform group activities in class.	26.92	34.62	26.92	7.69	3.85
3	TC lessons will benefit me in my future education.	19.23	3.85	42.31	26.92	7.69
4	TC lessons have improved my learning of maths.	19.23	15.38	26.92	30.77	7.69
5	In TC lessons I am motivated to regularly do my homework.	26.92	15.38	30.77	15.38	11.54
6	I like watching the Hegarty Maths homework videos entirely when they are on topics already learnt in the lesson.	46.15	15.38	11.54	19.23	7.69
7	I like a traditional teacher led lesson.	19.23	3.85	38.46	26.92	11.54
8	I am engaged in classwork during TC lessons.	19.23	26.92	23.08	19.23	11.54
9	TC lessons give me the opportunity to communicate with other students.	26.92	19.23	26.92	19.23	7.69
10	TC lessons give me class time to practice problem solving.	11.54	15.38	42.31	23.08	7.69
11	I recommend TC lessons to my friends.	15.38	26.92	26.92	15.38	15.38
12	The teacher is able to expand on the topics learnt in TC lessons.	15.38	26.92	30.77	19.23	7.69

Table 3: Single item response percentage rates for traditional classroom approach by scale score (1 = strongly disagree, 2 = disagree, 3 = neither agree or disagree, 4 = agree and 5 = strongly agree). TC = traditional classroom.

	Flipped classroom approach (FCA) questionnaire item	Strongly disagree (%)	Disagree (%)	Neither agree or disagre e (%)	Agree	Strongly agree
1	I feel motivated to learn maths during FCA.	3.85	23.08	23.08	19.23	30.77

2	FC lessons give time to perform group activities in class.	0	7.69	11.54	46.15	34.62
3	FC lessons will benefit me in my future education.	3.85	15.38	50	19.23	11.54
4	FC lessons have improved my learning of maths.	15.38	11.54	46.15	23.08	3.85
5	In FC lessons I am motivated to regularly do my homework.	11.54	11.54	38.46	30.77	7.69
6	I like watching the Hegarty Maths homework videos entirely when they are on topics not yet learnt in the lesson.	30.77	19.23	23.08	7.69	19.23
7	I like a FC lesson, not traditionally teacher led.	11.54	19.23	30.77	15.38	23.08
8	I am engaged in classwork during FC lessons.	0	15.38	34.62	34.62	15.38
9	FC lessons give me the opportunity to communicate with other students.	0	3.85	7.69	30.77	57.69
10	FC lessons give me class time to practice problem solving.	3.85	3.85	46.15	34.62	11.54
11	I recommend FC lessons to my friends.	15.38	15.38	38.46	23.08	7.69
12	The teacher is able to expand on the topics learnt in FC lessons.	11.54	15.38	42.31	23.08	7.69

Table 4: Single item response percentage rates for flipped classroom approach by scale score (1 = strongly disagree, 2 = disagree, 3 = neither agree or disagree, 4 = agree and 5 = strongly agree). FCA = flipped classroom approach.

- Descriptive statistics for Two-way Repeated measures ANOVA

Behaviour	Test	n	Mean score	Sd
0	1.Geomerty	14	87.50	13.12
0	2.Probability	14	85.09	12.77
0	3.Algebra	14	57.14	27.20
0	4.R&P	14	69.14	22.87
1	1.Geometry	13	80.77	18.35
1	2.Probability	13	81.06	12.31
1	3.Algebra	13	42.31	21.51

1	4.R&P	13	64.69	18.28

Table 5: Descriptive statistics of the four consecutive test scores (two pre and two post FCA) by behavioural status (Behaviour = 1 means having behavioural issues). R&P = Ratio and proportion

Pupil premium (PP)	Test	n	Mean score	Sd
0	1.Geomerty	16	88.44	12.61
0	2.Probability	16	86.17	11.60
0	3.Algebra	16	53.98	26.55
0	4.R&P	16	70.81	21.66
1	1.Geometry	11	78.18	18.75
1	2.Probability	11	78.75	12.93
1	3.Algebra	11	44.22	23.36
1	4.R&P	11	61.45	18.27

Table 6: Descriptive statistics of the four consecutive test scores (two pre and two post FCA) by pupil premium (PP) status (PP = 1 means having PP status). R&P = Ratio and proportion

Pupils with behavioural issues had lower means than pupils without per time point (see Table 5), while pupils with PP had lower means than pupils without per time point (see Table 6).

Assumption check

- Paired t-test for pre-post FCA average test scores: The Shapiro-Wilk test null hypothesis of normality of data was not rejected (W = 0.97, p-value = 0.62).
- Paired t-test for questionnaire total scores by classroom approach: The Shapiro-Wilk test null hypothesis of normality of data was not rejected (W = 0.95, p-value = 0.20)
- Two-way repeated measures ANOVA:

Shapiro-Wilk test for normality of test scores by behaviour			
Behaviour	**Test**	**W statistic**	**p-value**
0	1.Geomerty	0.81	0.01
0	2.Probability	0.91	0.17
0	3.Algebra	0.91	0.16
0	4.R&P	0.94	0.45
1	1.Geometry	0.82	0.01
1	2.Probability	0.94	0.40
1	3.Algebra	0.84	0.02
1	4.R&P	0.92	0.24

Table 7: Shapiro-Wilk test for normality of the four consecutive test scores (two test pre and two tests post FCA) by behavioural status (Behaviour = 1 means having behavioural issues). R&P = Ratio and proportion

Shapiro-Wilk test for normality of test scores by pupil premium			
Pupil premium (PP)	**Test**	**W statistic**	**p-value**
0	1.Geomerty	0.79	<0.01
0	2.Probability	0.92	0.16
0	3.Algebra	0.88	0.04
0	4.R&P	0.94	0.33
1	1.Geometry	0.83	0.03
1	2.Probability	0.96	0.81
1	3.Algebra	0.91	0.22
1	4.R&P	0.94	0.53

Table 8: Shapiro-Wilk test for normality of the four consecutive test scores (two test pre and two tests post FCA) by PP status (Behaviour = 1 means having behavioural issues). R&P = Ratio and proportion, PP = pupil premium.

The null hypothesis of normality was only rejected for the geometry and algebra test scores within categories of behaviour (see Tables 7 and 8). This could be due to small sample size.

Paired t-test results

- The paired t-test comparing average test scores pre-post FCA returned a statistic of t = 7.7724, df = 26, with p-value <0.0001, indicating that the mean score difference of 25.22, 95% CI 18.55 to 31.89, was statistically significantly different from zero. Therefore, my year 10 higher achiever students performed better in a traditional classroom environment than in a flipped classroom environment.
- The paired t-test comparing questionnaire total scores by classroom approach returned a statistic of t = - 2.03, df = 25, with p-value = 0.05, indicating that the mean score difference between questionnaire scores about TC and scores about FCA (-6.54, 95% CI -13.17 to 0.09) was borderline statistically significantly different from zero. Thus, pupils had better attitude towards FCA compared to TC, but this difference was not statistically significant.

Two-way repeated measures ANOVA results for behaviour

Effect	**Dfn**	**Dfd**	**F-statistic**	**p-value**	**p < 0.05**	**ges**
Behaviour	1	100	4.20	0.04	*	0.04
Time	3	100	19.56	< 0.000000001	*	0.37
Behaviour : Time	3	100	0.47	0.70		0.01

Table 9: Two-way repeated measures ANOVA results. The test scores are the dependent variable, time (4 time points corresponding to the 4 consecutive end of unit tests the pupils completed in two terms, 2 pre and 2 post FCA) and behaviour are the between-subject factors. Also their interaction (Behaviour : Time) is considered. Dfn = F statistic degrees of freedom in the numerator, Dfd = F statistic degrees of freedom in the denominator, ges = generalized effect size (amount of variability due to the within subject factor, which is ID, variable identifying pupils).

Two-way repeated measures ANOVA results for Pupil premium (PP) status

Effect	Dfn	Dfd	F-statistic	p-value	p < 0.05	ges
PP	1	100	6.13	0.02	*	0.06
Time	3	100	18.93	< 0.000000001	*	0.36
PP : Time	3	100	0.03	0.99		< 0.01

Table 9: Two-way repeated measures ANOVA results. The test scores are the dependent variable, time (4 time points corresponding to the 4 consecutive end of unit tests the pupils completed in two terms, 2 pre and 2 post FCA) and PP are the between-subject factors. Also their interaction (PP : Time) is considered. Dfn = F statistic degrees of freedom in the numerator, Dfd = F statistic degrees of freedom in the denominator, ges = generalized effect size (amount of variability due to the within subject factor, which is ID, variable identifying pupils).

There was strong evidence against the null hypothesis that the test score were not different between time points in both analyses: F(3, 100) = 19.56 for behaviour, p < 0.0001, η^2 = 0.37; and F(3, 100) = 18.93 for PP, p < 0.0001, η^2 = 0.36 (see Tables 8 and 9).

Behaviour had a borderline statistically significant (F(1,100) = 4.20, p = 0.04, η^2 = 0.04) effect on scores, with pupils having behaviour issues scoring less than pupils without, independently from the FCA intervention (see Table 8).

There was no evidence for an interaction (p = 0.70) between effects of behaviour and time (see Table 8).

PP had a statistically significant effect on scores (F(1,100) = 6.13, p = 0.02, η^2 = 0.02), with pupils having PP scoring less than pupils without regardless of the FCA intervention, with a poor effect size η^2 = 0.02 (see Table 9).

There was no evidence for an interaction (p = 0.99) between effects of PP and time (see Table 9).

Discussion and conclusion

In the present study, there was no evidence that FCA improves progress in maths in my year 10 high achiever pupils. Instead, FCA worsened the students' end of unit test results compared to traditional classroom. There was no evidence that behaviour and pupil premium status modified the effect of the intervention on the test scores. However, students had more positive attitudes towards FCA compared to TC, but this difference was not statistically significant.

This result contrasts with the literature on FCA, and might be due to the limitations of the study:

- Small sample size to detect an effect of behaviour modifying the effect of the intervention on scores.
- The topics of the tests were too different from each other, and it is known that, for example, the unit on algebra (straight lines) is always more challenging for students than other units.

- The teacher was unexperienced in behaviour management to conduct group activity (I am an early career teacher in my first year as a qualified teacher), as pupils have complained about in the questionnaire.
- The pupils did not take advantage of the afternoon sessions offered in case of no understanding of the topic.
- Year 10 students are younger than some of the student cohorts recruited in other FCA studies.

To conclude, implementing FCA in a year 10 class requires strong behaviour management skills to make sure pupils are engaged in classwork and learn. Teachers need to thoroughly prepare the FCA sessions considering all possible misconceptions arising from students' pre-learning at home.

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Lo and Hew Research and Practice in Technology Enhanced Learning (2017) 12:4 Page 21 of 22

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