Supporting A-level science students to develop their revision strategies and exam techniques

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A Research & Development Project

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Abstract

This small-scale research and development study was designed to support of A-level chemistry students in developing effective revision strategies and exam techniques. The focus of this study was chosen in light of the lack of prior external examination experience due to the COVID-19 pandemic for the year 13 cohort (2021-22). This lack of exam experience and underperformance of students in mock examinations was a cause for concern for the science faculty and wider school leadership. A review of literature was carried out into the areas of learning strategies and students study skills, focussing on retrieval practice, self-regulation and metacognition to gauge a better understanding of the basis behind recall and application of knowledge. Using further literature practical strategies were identified for adaptation and use during the practitioner action research. Questionnaires were given to collaborating staff and A-level chemistry students to determine current practices prior to an intervention phase. A student focus group was used to delve deeper into their understanding of their perceptions of revision and exam preparation and their current experiences of exam preparation. Prior to any intervention, data showed an inconsistent picture of the delivery of revision strategies within lessons, and lack of explicit direction from teachers. Students demonstrated a mixed understanding of revision techniques with a narrow selection of passive, content-based strategies being predominantly favoured alongside mechanical use of practice exam questions. Using ideas obtained from the literature, exam board advance information, and teacher feedback, activities were designed to focus on key areas as well as being adaptable for students to use elsewhere in their exam preparation. On-going teacher feedback was collected throughout the intervention about the techniques delivered in lessons, perceptions of success and student engagement. Qualitative feedback from staff was positive and noted students throughout the intervention phase demonstrated excellent engagement using techniques introduced in sessions and increased communication with staff. Follow-up questionnaire data from students to identify changes in exam preparation habits showed an

increase in the frequency and variation of strategies being used by students across all predicted attainment grades.

1. Introduction

In light of the COVID-19 pandemic and cancellation of external examinations (2020-2021), the 2021-22 cohort of Year 13 A-level students lack the prior examination experience of previous years. The current year 13 cohort are the year group of students who were sent home due to the enforced lockdown during March 2020 and for whom their GCSE examinations were cancelled. These students were also unable to sit external AS-Level examinations in the summer 2021 due to further national cancellations of examinations arising from further lockdown measures. Although students did sit mock examinations, from these results and their performance on other assessments, it appeared to me and colleagues that they were ill equipped with the skills to effectively prepare for external examinations. Instead relying on a small number of revision strategies to prepare for assessment regardless of the subject or content of the topic in question (Chan & Bauer, 2016) . Additionally, these are also strategies that they had never put into practice under the rigor of an external examination.

The pandemic effect on the A-level cohort 2020-2022 is a picture that has been felt nationally as all students will have been in the same position having not sat any external examinations prior to summer 2022. In combination with the missed in-class teaching time due to lockdowns and recurrent staff and student absence, this added a further dimension to this year's examination series that has not been experienced before. Although exam boards published "advance information" with regards to the major content focus of exams to support teachers and learner in the preparation, this did not take into account the bigger scale impact of lost face-to-face learning (Weale, 2022. Finn et al., 2022). The research school in question is a mixed-state comprehensive in central Oxford, with a cohort that is diverse both culturally and socio-economically. The year group involved in the study experienced no remote learning in the 2020 summer term due to the cancellation of examinations, therefore had no schooling from March to September 2020. Like other students across the country, parts of their Year 12

and Year 13 study were interrupted by further lockdowns and implementation of remote learning. Due to the context of students within the school, not all have reliable access to internet and technology resources to be able to approach and engage in online learning fully during periods of remote education. So even with additional measures from the exam boards in place to help prepare students for the 2022 examination period, this was unlikely to adequately and equally support students of all abilities and demographics (Hazell, 2022. Finn at al., 2022).

Within the context of the research school, the majority of A-level chemistry students were underperforming in mock examinations. From the March mock examination period, only 25% of students were on track to achieve their minimum expected grade. This was of a particular concern for the school and for me in my role as Head of Key Stage 5 (KS5) science. Over the past few years prior to the pandemic, chemistry Alps scores within the school have increased and remained consistent, but during 2020-2021, they have shown a significant drop based on the current year groups attainment. Although this fits to the picture nationally surrounding the increase in students with top grades during non-examined years (Finn, Cinpoes & Hill, 2022) the significant drop off in our Alps score is an area of concern for the school after increased performance prior to lockdown. An Alps score is a 1-9 performance indicator score which show students' progress towards target grades in a given subject against national benchmarks (Alps Education, 2018). In the current KS5 chemistry scheme of learning, revision lessons are not a formalized component unlike the provision at key stage 3 and 4; subsequently any delivery of examination preparation strategies is variable across teaching groups and dependent on individual teachers (Parsons, 2015). This is despite a range of research evidence highlighting the effectiveness of teaching study skills to students (Fisher & Frey, 2017; Hattie et al., 1996), researched that is publicly available and digestible for non-academics through news sites (Lightfoot, 2019. Marsh, 2015.) and online forums such as The Learning Scientists (2016).

Within my role as Head of KS5 Science, I monitor the progress and attainment of students and manage interventions to help students make progress towards their individual ALPs grades. I also work with teaching staff to ensure consistent, high-quality teaching, supported by regular assessment to monitor student progression. I support staff in their professional development needs in relation to A-level teaching and work collaboratively with them on any specific area of concern or interest to help ensure the progress of their teaching groups. My role involves doing this across all A-level science subjects, biology, chemistry, physics and psychology. It was the initial intention to carry out this research and development project on a wider scale and cover all students taking at least one A-level science subject. Due to the ongoing effects of the pandemic and the intense cover demands as a result of staff absence and alternate year group remote learning, I carefully considered to focus solely on A-level chemistry rather than across all four subjects. I myself am a chemistry specialist so felt I was in a better position to provide more detailed and appropriate resources to aid revision and exam preparation in my own subject area. Discussions with my head of faculty and sixth form leadership also identified A-level chemistry as the area of greatest concern due to the drop in performance previously mentioned. Within the school we also have the support of a school science improvement lead working within the faculty who is part of the school's wider multi-academy trust network. The school itself has also been in a state of flux over the past 2 years with greater trust involvement, such as the placement of school improvement leads but also due to significant changes in leadership including interim headteachers. This has resulted, unsurprisingly, in an unsettled environment for both staff and students, with a constant flow of change in policy and procedure since September 2021. It was therefore vital to consider the appropriate scale of the project when proposing further commitments and introduction of new interventions on both staff and students. By scaling the project down from its initial proposal, it ensured it was manageable in terms of workload, and minimal interruption of normal operations for all involved.

This small-scale research and development project aimed to introduce a structured revision program. The intervention focused on the explicit delivery of revision strategies in the context of the AQA A-level chemistry specification and introducing students, more broadly, to examination techniques to enable them to maximize their marks. Before designing any such intervention, an exploration of the research literature was needed to ensure that this initiative was based, as much as possible, on evidence from research, and this will be discussed next. Through the literature review I aim to explore the implementation and use of study skills within the education sector, while also considering other key themes of retrieval practice, metacognition and self-regulation. From the literature I ultimately aimed to consolidate a range of empirically supported strategies than could be adapted and used during the intervention stage of the project.

2. Literature Review

The literature review will discuss the key ideas involved in developing revision skills and strategies for use in formal examinations, including retrieval practice, and self-regulation and meta-cognition.

2.1 Retrieval practice

One of the major focusses for my research into current literature was that centred around retrieval practice. Retrieval practice has been a big focus for the school CPD this year in relation to memory. The approach within the faculty has concentrated on retrieval in the form of using simple fact-based tasks to start lessons as a way to enable all students to engage and draw on prior learning. I wanted to explore this topic a bit deeper and see if it could be applied more widely. The basis of retrieval practice is the improvement of term learning by deepening the connections between ideas within long term memory (Endres et al., 2020; McCabe, 2010). In a piece of research discussing the link between Bloom's taxonomy and retrieval practice by Agarwal (2019), it questions the basis of Bloom's learning hierarchy as to whether fundamental recall skills need to be fully established before higher order application. When considering the context of A-level study many a teacher would argue that students need to be able to recall the basics before being able to access questions requiring skills in analysis or evaluation. Dunlosky et al. (2013) argue that if students are unable to recall key ideas, then application of those ideas with prove ever more difficult. What Agarwal is proposing however is that factual retrieval in isolation does not appear beneficial to the more complex retrieval required to succeed in final testing. For greater student performance, higher order learning processes need to match the demand of the complex level retrieval required in examinations. Following one particular route of retrieval practice could cause problems, if students end up unprepared for the type of assessment based on ineffective preparation (Panadero et al., 2017).

Agarwal does discuss that older students may benefit to a greater extent from higher order retrieval, in the context of their research this refers to American college age students. Although we could assume year 13 students may fall into the bracket of "older students" to some extent we must take into account their current circumstances. It would amiss to discount the impact of missed face-to-face learning and therefore we can presume that they are less experienced in "extracting factual information from complex materials"(Agarwal, 2019). The students in the context of this research project are likely to benefit from mixed level retrieval practice, where factual retrieval tasks are used alongside side those with a higher demand providing a variation in difficulty and a scaffolding of sorts. This style of retrieval practice was found to have a greater impact on performance of higher order questioning than fact or higher order retrieval tasks alone (Agarwal, 2019.). Careful consideration of the type of task, retrieval or otherwise dependent on the style of testing is important to consider. If A-levels were a test of recalling key facts then simple factual retrieval practice would likely be more than adequate, but we know this is not the case. Targeted retrieval improves the learning and recall of targeted content, whereas free recall aids the wider learning or various contents that can be interlinked (Endres et al., 2020.).

When we are considering learning in relation to the cognitive demand of the examination it is important to also look at the explicit assessment objectives of the specification in question. In the AQA A-level chemistry specification (2015), the assessment objectives indicate students should be able to "demonstrate", "apply", "analyse, interpret and evaluate", these objectives are also identical to those in A-level biology (AQA, 2021a), physics (AQA 2017) and psychology (AQA, 2021b). They are what we would most likely consider "higher order" skills based on Bloom taxonomy, skills that Agarwal's research indicates are better prepared for by application style retrieval style tasks. For example, within the research it is discussed the use of questioning via a multiple-choice format, which requires participants to make decision between answers. The style of the question determines whether they just have to recall a fact

from the comprehension passage or apply information from the passage to determine the answer. Conversely Willingham (2009) states that “fact learning must precede skill”. In opposition to the conclusions by Agarwal, Willingham’s ideas suggest that the knowledge learning of facts must be done first to allow for the development of higher order skills and interlinking of knowledge. Claiming a secure background knowledge can aid memory of new information but also free up working memory to create links and think critically. Students often fixate on knowledge retention without any focus on subject specific skills (Oakes & Griffin, 2016) , so are unlikely to be able to link fundamental factual knowledge with wider application and deeper connection without guidance. The benefits of retrieval style practice are lost when prior understanding is lacking (Fiechter & Benjamin, 2018).

Fiechter and Benjamin (2018) discuss a scaffolded approach to retrieval practice, although in the context of language learning in adults they identify some interesting points. They identify that “diminishing-cues” retrieval practice could be particularly effective in difficult learning environments where standard retrieval is not. They however do not elaborate on what a “difficult” learning environment is, it could be attested that some individual students within the research school will have unfavourable learning environments at home due to their family’s circumstances. Scaffolding retrieval style tasks may therefore prove to be more useful on an individual basis or to those with significantly below expected attainment, where standard retrieval practice would not be accessible. Rogers (2010) discusses the “big jump” that occurs between a modelled problem and then being expected to complete a whole question. Suggesting that partially completed problems allow students to retrieve smaller facets of information at a time, building to a bigger and more complete picture of a series of practices. There is however caution to be taken with too many similar repetitions of the same types of problems, resulting in mechanical problem solving (Oakes & Griffin, 2016) which leads to a fluency and false confidence similar to that that comes from repeated rereading (Karpicke et al., 2009).

There are seemingly, however, indirect effects of the different types of retrieval practice to consider which link with other key areas of interest when considering revision and exam preparation, that of student efficacy and metacognition. With active or free recall style retrieval, if a student's answer is "generally" correct and coherent, they believe it to be good despite gaps in knowledge (Endres et al., 2020). This gives the student a feeling of success and increased feeling of self-efficacy however due to the holistic nature of the task feedback is less specific and therefore metacognitive gains are lower. Targeted retrieval requires a direct and specific answer, this makes it easier for students to identify gaps in knowledge independently increasing metacognition. Repeated failure of targeted retrieval-based tasks could result in student disengagement due to a sense of not being able (Brown et al., 2014), however alternative theory state that a student's perceived lack of knowledge can create interest (Endres et al., 2020). This study by Endres et al. (2020) is based on university level students where there is likely to be a greater ability to identify learning in failure, based on greater experience of learning and examinations more so than that of school age students. Brown et al. (2014) also highlights the importance of struggling and its ability to strengthen connections in the long-term memory. The concept of struggling feels alien and counterintuitive to a lot of students, that knowledge is deepen in these moments of difficulty. This is furthermore supported in the work by Agarwal (2019) where an increase knowledge retention and ability to apply knowledge was demonstrated, based on using challenging processes to retrieve knowledge. Self-efficacy has also been seen to benefit from students being able to design their own assessment criteria from modelled examples of work, this can then be used to self-assess (Panadero et al., 2017). This strategy gives students a deeper understanding of the marking criteria resulting in greater success and attainment. Self-efficacy is well evidenced as an indicator of student performance (Oakes & Griffin, 2016; Panadero et al., 2017).

2.2 Self-Regulation and Metacognition

Self-regulation can be promoted via strategies such as self-assessment, as shown in the meta-analysis by Panadero, Jonsson and Botella (2017). By self-assessment they are referring to students assessing their own work not the "signalling of perceived understanding" using checklists or traffic-lighting systems. Self-assessment via a variety of strategies including determination of the strengths and weaknesses within answers, comparison against a mark scheme and modelled examples aids learning. Through a diversification in the strategies students employ, they begin recognise how to close the gap, not only in their learning but in self-regulation, by giving them ownership in the exam preparation (McCabe, 2010; Panadero et al., 2017). Self-regulation is the ability for students to maximise their learning through their behaviour (Hunter & Lloyd, 2018). This could include students be able to manage their time, their learning environment, and their effort. If we are able to build these into the learning, they experience in their education environment (i.e., school) they are more likely to be successful at these skills in other contexts (Feudel & Dietz, 2017; Panadero et al., 2017).

Self-regulated learning has a vital link with metacognition in terms of being important for students in their ability to self-evaluate and monitor their own progress towards goals. If we are able to improve students' accuracy in metacognition, they will also be more able to choose appropriate strategies to support their learning (McCabe, 2010). The incorporation of advance information (AQA, 2022) adds a greater need for student self-regulation. Students being able to determine for themselves what to study and focus their time and effort on, mastery of the main focus topics or elements of the whole course (Kornell & Bjork, 2007). If students lack metacognitive skills, they will continue to pursue the use of strategies even when they know it's not helpful (Karpicke et al., 2009). Teachers are not exempt from their role of disseminating information when it comes to self-regulation, students need to know how to use the resources they are given or guided to create (Chen et al., 2017).

2.3 Study Skills and Revision Strategies

In terms of students' study skills and exam preparation, students are often reluctant to change their current patterns of study behaviour. Feudel and Dietz (2017) investigated this in relation to the reluctant uptake of a mathematics support programme for university level students. They identified several key reasons that students are reluctant to engage in new support strategies; not aware of current automatised way of working, do not know how to combat difficulties, lack of understanding of what resources to use, do not see benefit of effort (if they believe it has worked before). The final statement is interesting in the context of university students who have prior experience of exams, for a typical A-level student who would have previously sat GCSEs they might have a similar viewpoint. Often students do not see the need to change study habits from GCSE to A-level, with the changing difficulty in exams, they believe the same methods will be successful (Dunlosky et al., 2013; Oakes & Griffin, 2016). These methods are often not the most effective strategies to strengthen learning and often inconsistent with research evidence for example, rereading (McCabe, 2010; Morehead et al., 2015). Teaching staff also believe students use ineffective strategies in relation to the way they are being assessed (Hunter & Lloyd, 2018), yet may be ill-equipped to support students effectively. Integration of support mechanisms into the course is needed to engage students, students who engage see the positive effect of the strategies they had been taught (Chen et al., 2017; Feudel & Dietz, 2017).

It is vital not to ignore the role of teachers, tutors and professors in the dissemination of knowledge around learning strategies and how best to use techniques to practice and harness knowledge. Staff buy-in is essential in the success of support programmes and interleaving into the curriculum helps embed techniques as useful practice (Feudel & Dietz, 2017). It is often the case that staff feel ill-prepared to deliver knowledge around revision or exam techniques (Dunlosky et al., 2013). This is either due to a lack of specialised training or stuck using ineffective strategies such as rereading (Hunter & Lloyd, 2018). The research around

study strategies used by faculties at a university level by Hunter and Lloyd (2018) may not be truly representative of the use of strategies used by teachers within secondary education due to the differences in assessment styles and frequency of assessment. It is also worth taking into account the difference in the student cohort size, and the difficulty of delivering study skills to larger groups within a university setting may be a contributing factor to lack of variety in the resources provided by teaching staff. One aspect that is highlighted by this research is the lack of specific training for staff in supporting students with exam preparation, this is also likely true of teachers across all ages of education(Dunlosky et al., 2013). Conversely, work by Morehead, Rhodes and DeLozier (2015) found that educators could identify effective study skills but also held views that were "inconsistent with research". Claiming that although teachers held a wider knowledge of effective learning strategies this was only moderately more than the knowledge held by students. Teachers' lack of knowledge on current research and literature is evidenced by educators referring to differentiation to accommodate students' "learning styles". Learning styles is a topic the is highly debated and with limited supporting evidence (Coffield et al., 2004; Hunter & Lloyd, 2018; Willingham, 2009). The research indicates no interaction between being taught in a "style" and test performance, additionally the lack of reliable way of identifying an individual's learning style is a difficult starting point to then claim any benefit in the process (Hunter & Lloyd, 2017).

2.4 Supporting students during the build up to the exam period

The concept of spaced practice involves starting preparation as early as possible giving students ample opportunity to review, and revisit over a given period of time, followed by repetition of this process (The Learning Scientists, 2016). For students this prospect may feel intimidating but by breaking revision down in this way should help it feel more manageable

and allow for better understanding. Spacing relative to mass studying or cramming is more effective in facilitating the retention of knowledge (Agarwal, 2019; Morehead et al., 2015).

Retrieval practice is a useful and valuable method, not just as a revision skill but a learning skill overall. The practice however does not need to be delivered in one singular format, it can be varied in delivery but also in structure from factual recall to higher order application and analysis. Retrieval through formulaic quizzing cements the belief that testing is only useful for determining the accuracy of response (Morehead et al., 2015). "[Students] don't see testing as a learning event" (Kornell & Bjork, 2007). This is furthermore evidence on why teachers understanding the empirical evidence behind strategies is important so students can be presented with a rationale. Students need also not work alone in their revision, although sometimes it is beneficial to remove distraction. Peer work when retrieving information or self-testing, encourages discussion and discourse that further supports and deepens the learning process (Goodbourn, 2009).

The availability of advance information for these exams provides a benefit in making students aware of what is being tested (Agarwal 2019). We also know that the examination series Summer 2022 has been more generously graded to "provide a safety net for students who may have been impacted by the pandemic" (Ofqual, 2022). I think it wouldn't be too bold to say that all students, in some way, have been impacted by the pandemic, but perhaps lower ability learners and those from disadvantaged backgrounds more so (Hazell, 2022., Finn et al, 2022). The generosity in grade boundaries may favour those at the bottom-end of the grade scale to prevent them from leaving with a "U" grade. Public knowledge of lower grade boundaries could lure students into a false sense of security that grades will be easier to obtain, and less preparation is needed. Other subjects were provided with support through the means of optional content, adaptations of coursework requirements and additional

materials such as equation sheets (Ofqual, 2002), however none of these additional measures were applicable to A-level chemistry.

The advance information provided by the exam boards gave a list of topics which were identified as a "major focus" from each of the three papers, these topics were also listed in rank order from highest to lowest marks (AQA, 2022). While this all sounds promising, the front page of the document offered some additional information and advice which could be seen to contradict the "support" element of the advance information. The "information" section states the topics not listed "may appear in multiple-choice, low-tariff questions or via synopticity" (AQA, 2022). To break this statement down, 30 marks of paper 3 are made up of multiple-choice questions, this accounts for 10% of the overall A-level grade students are awarded (AQA, 2015). Unindicated content therefore made up a minimum of 10% of the total marks. Furthermore, no definition was given to what constituted a low-tariff question. Within the "advice" section, they advised students and teachers consider how they might focus their revision on non-listed parts of the specification. In a crude sense the provision of advance information act to support students' self-regulation by giving them focus areas for the exam preparation, with the warning of anything could be tested, so don't forget to revise it all.

It is important to be realistic in that student and teacher engagement is key to the success of any intervention and this is most likely to be achieved with a variety of mechanisms to support revision and exam preparation. Variation in revision strategies is important not due to differences in students learning style, but because variabilities in strategy usage results in variable encoding which allows for more elaborative and effective memory retrieval (Hunter & Lloyd, 2017). "Retrieval practice alone is not enough to ensure success for our students" (Jones, 2019). Moving staff and students away from passive strategies such as rereading, restudying and unfocussed highlighting by offering engaging alternatives (Agarwal, 2019; Fiechter & Benjamin, 2018; Hunter & Lloyd, 2018; Jones, 2019). Provision of a varied

intervention programme to engage all those involved in empirically supported, active learning strategies, such as alternative methods of retrieval practice will result in more effective revision in preparation for external examinations (Hunter & Lloyd, 2018; Oakes & Griffin, 2016). A selection of strategies identified from the literature I intended to adapt for the intervention phase are set out below. Some of these are adaptations of strategies students were already engaged in, this was purposeful as to not overload them with new ideas, but also teaching them how to adapt and make current strategies more effective (Chen et al., 2017).

2.5 Intervention strategies

"Without consistent and effective use of learning strategies, the review process prior to assessment can be unmanageable" (Rooney, 2009).

The idea of diminishing cues retrieval is something I felt could be utilised to support our learners who were significantly under achieving and had been for some time. The idea of scaffolding retrieval of knowledge, by "fading" examples, such as removing steps while modelling (Fiechter & Benjamin, 2018; Rogers, 2018), could be a useful strategy to try during the intervention stage. This would be easily applicable to topics such as amount of substance where multi-stage equations are common, but also processes that involve following a set of rules such as redox equations and shapes of molecules.

Mathematical skills make up a 20% proportion of the marks in A-level chemistry, in the work by Feudel and Dietz (2017) they identify key strategies of their mathematics study skills programme. Several of which in part could be transferrable and adaptable for use within this project such as identifying the meaning of units and symbols and verbalisation of calculation stages. Nilson (2013) discusses aiding mathematical and multistage problem solving by writing an "error-analysis" when a problem in incorrect or incomplete, to explain what went

wrong at each stage. Verbalising of the problem-solving process is also something that could be beneficial when practicing multiple choice style questions. Comprehension of the possible answers when approached with a complex question with multiple potential solutions, promotes and awareness of reasoning and application of concepts (Nilson, 2013). Nilson (2013) refers to these as “fuzzy problems” in the context of mathematical questioning, although not all the multiple-choice questions in an A level chemistry exam require maths skills, the problem-solving skills are transferable.

Roadmaps is a technique that is ideal for sequencing style concepts (Jones, 2019) such as required practical. Advance information specifically highlighted four of the twelve required practicals assessed as part of the A-level chemistry course (AQA, 2022). Practical skills contribute 15% of the A-level chemistry examination and are interleaved throughout all the exam papers (AQA, 2015 and 2022). The road-mapping strategy incorporates retrieval practice in a way may not be immediately obvious to teachers and students, drawing on long-term memory to consider the individual stages and sequencing of steps within a practical. Additionally, the use of “signposts” to indicate key focus points for example; specialist equipment, data analysis, common errors. It can also be used longer term for spaced practice and laying out of a topic from start to finish.

Jones (2019) also advocated the use of “Roll and Retrieve learning grids”, a 6x6 grid where each square contains a different topic or question. Students use the rolling of a dice to select the square to work on, creating an element of random selection and enforced interleaving of topics. The random arrangement of topics allows for this interleaving of different content areas, which is ideal especially for those who may be reluctant or unsure of how to incorporate interleaving into their revision. Interleaving is not something that comes naturally to learners, it is common for people to put aside content they believe they have already learned and do not revisit it (Kornell & Bjork, 2007). The concept of interleaving involves

students switching between topics to allow them to recognise similarities and differences between them (The Learning Scientists). These learning grids are also an effective way to incorporate retrieval by way of students working on a question or recalling knowledge on a given topic. Flipping between different topics and styles of questions is ideal for exam preparation, aiding students' ability to discriminate between them within the context of an exam (Brown et al., 2014).

Flashcards are a technique that gets a mixed review within the literature as its effectiveness is dependent on use. Flashcards are popular amongst students but often just as an activity of recopying notes and re-reading (Jones, 2019). If used as a quizzing tool can be very effective, however accurate self-testing is something students find difficult (Kornell & Bjork, 2007). There is contradictory advice within education research about how to effectively use of flashcards, with some suggestion of a Leitner Box approach - sorting cards into categories based on confidence level. This is complex as it requires students to have the metacognitive skills to fully grasp what they do and do not know. This approach then encourages students to spend the majority of their study time on the content they remember less (Oakes & Griffin, 2016). This is in opposition to the approach of keep the information you think you know within the same pack, not minimising time on a particular area. This technique ensures constant revisiting via a spaced method, retrieval and recall, which deepens the connections to that content and strengthens learning (Kornell & Bjork, 2007; Morehead et al., 2015). What is clear is, whatever approach is taken when using flashcards, it needs to be "active" like self-testing, not simply rereading or copying notes previously made.

Similarly, to flashcards, mind maps get a similar mixed review from the literature which stems from how they are used. Jones (2019) takes the idea of a mind map and reforms it into a thinking and linking grid, making connections and exploring links between concepts. This can be done effectively by students working in pairs to encourage deeper discussion of the links

being created. It also allows students of different abilities to support each other in more complex of tenuous links. By varying the use of mind maps we can make them more effective (Goodbourn, 2009). A way to make familiar techniques such as mind maps into more effective learning strategies is to involve students in their creation rather than them just being provided. Students involved in the creation of resources, active participation, is part of the learning process (Jones, 2019). There is also a level of difficulty in creating a resource from scratch rather than just using a resource that has been given to you. The process of creating a study material has benefits in its own right by requiring greater memory retrieval (McCabe, 2010). Being able to ask questions of the process being carried out, researching and finding answers to be able to form the connections within the grid or map also supports The Learning Scientists (2016) strategy of elaboration. Connections between ideas are fundamental for understanding and embedding knowledge into long-term memory, more so in the light of advance information and the "synopticity" of examinations.

Dual coding in combination with other strategies provides a scaffolding for students which can build confidence and self-efficacy (Fiechter & Benjamin, 2018; Jones, 2019). The use of multimodalities has shown to simulate different areas of working memory (McCabe, 2010) as long as it is used in a way that does not induce cognitive overload, for example static media over animations. The revision of practical techniques lends itself well to incorporate of images, especially those that involve unusual specialist equipment. Other topics such as transition metals and reactions of aqueous ions, where there is seemingly lots of factual information to be learnt also lends itself to dual coding due to the extensive colour range of the reactions and also practical observations that need to be recalled. Being able to explain what the visuals mean and what they represent is key to its success as a revision strategy aiding students in being able to draw from memory (The Learning Scientists).

After each exam series the exam boards release an examiner's report which provides a useful insight to common errors and problem areas from the exams. These usually include improvements to be made to generic exam skills, such as crossing out work not to be marked to avoid contradicting supplementary answers and wasting time by repeating the question within the answer. The feedback also gives more subject specific advice highlighting shortcomings in skills specific to chemistry such as balancing equations and charges, and positions of curly arrows within organic mechanisms. These reports furthermore offer guidance on specification topics that students found difficulty with and were not well known, for example in 2019 the paper 1 report flagged aqueous chemistry, mass spectrometry, shapes of molecules and practical techniques as areas of concern (AQA, 2019). The reports on examinations then proceed to go into detailed analysis of each question, highlighting patterns of strengths and weaknesses throughout the paper. As teachers these reports help inform our understanding of how each paper is being assessed so can be an invaluable resource in terms of preparing students. The wealth of information from the examiner's reports pre-pandemic, were used as "pre-exam session", that aims build student confidence on insider exam knowledge of where marks can be lost or gained through each paper.

It was important in the intervention phase of this research project that teachers felt confident, supported and well-informed about the strategies they were delivering. Literature suggests problems lie in the teaching of how to study and learn rather than in the exams themselves (Burns & Sinfield, 2004; Hunter & Lloyd, 2018). This in turn provides students with a secure understanding of revision strategies that gives them the support and increased confidence they need to succeed (Jones, 2020). Current practice of staff was essential to establish as teachers are the "front line in dissemination of information about studying"(Morehead et al., 2015).

3. Methodology

For this research project I carried out practitioner action research initiated by the needs of the school and science faculty, working in collaboration with the chemistry teaching team to implement a small-scale manageable intervention, the findings of which will hopefully inform future practices and processes. Through this action research I aim to collect data to allow me to discuss the following questions in relation to the chemistry teaching staff and year 13 A-level chemistry students within my school:

RQ1) What is the current teaching practice of revision strategies and exam techniques amongst A-level chemistry teachers?

RQ2) What do students' exam preparation habits look like? (Pre-intervention)

RQ3) What effect does explicit teaching of revision strategies and exam techniques have on students' exam preparation habits?

RQ4) Is there any correlation between student predicted grades and the variation or types of strategies they use?

Research question 1 will be answered using data from the teacher questionnaire and the discussions from the student focus group in relation to their experiences in lessons prior to any interventions. Research question 2 will be answered using the student questionnaire data obtained prior to any intervention as well as the qualitative data from the student focus group to identify specific details and nuances in student habits. The data obtained from the student questionnaires pre- and post-intervention will be used in combination to investigate research question 4. Research question 3 will be answered using data collected during intervention from the individual teacher feedback and the responses to the student questionnaire on their use of revision strategies post-intervention and post-exams. The next section will explore the

methodology behind each data collection method used as part of the practitioner action research.

3.1 Student Focus Groups

From the student focus groups I intended to obtain qualitative data on the current exam preparation of students, specifically looking to establish their views on not only what types of strategies they are using but in their opinion what they feel is effective and not effective in preparation for assessments. I also wanted to use this discussion to determine what types of strategies are explicitly taught by teachers in their chemistry lessons. This was to enable me to draw a comparison between what the teachers feel they deliver and what is observed by the students themselves. Within the discussion I was also interested in whether students were able to differentiate between what is meant by "revision strategies" and "exam technique". Exam technique itself could be said to more closely with skills associated with self-regulation, prioritizing questions within the exam and managing time. Whereas revision strategies is focused on how they learn the knowledge needed to answer questions. As the questions I asked delved into their use of both I was interested to know if the associated different skills with each of these areas as we would expect.

The data obtained from the focus group interviews was a small snapshot of student ideas and opinions in relation to current practice, the effectiveness of that practice and their in-class experience. The aim was to use the data from this discussion to understand, evaluate and assess current practice as well as aid in the development of the intervention. I chose to carry out the focus group prior to students being sent the questionnaire as I didn't want the students to be influenced to name strategies listed in the questionnaire. The unknown nature of the questions asked during the focus group meant students had to consider their exam preparation practices in the moment. This allowed for natural responses to the questions,

rather than feeling there were things they “should” be saying based on those strategies identified in the questionnaire.

The research benefit of collecting qualitative data through a focus group rather than interviews is not only more time efficient but also allows for the gathering of more collective ideas rather than individual views (Cohen et al., 2018). Students volunteered to take part, and so it brought together students with different approaches, allowing for different viewpoints to be discussed and challenged. By using a focus group as a research tool, it allowed for a deep exploration into students’ views and ideas where they could elaborate in-depth in a way that cannot be obtained by a survey. By using a questionnaire on students’ strategies alongside a focus group it gave a further insight into the data obtained from both methods. The discussion itself took a semi-structured form, with a list of questions (Table 1), however the manner of questioning was informal, and students were encouraged to ask for clarification. The ability to re-word questions was important to ensure understanding as for some of the students involved, English is an additional language. A structured clinical interview style with no flexibility to further elaborate on questions would have not been appropriate. By using two groups of students, I aimed to ensure as much similarity in wording and sequence of questions to enable increased comparability of responses as well as “complete” data from both groups (Cohen et al., 2018) . All the audio recording from the focus group was transcribed and imported into NVivo for analysis. The transcript data was then coded and categorized based on the ideas and comments that arose during the interview and the questions being asked.

Table 1.

Student Focus Group Questions
How many hours of independent work do you do for chemistry outside of class?
What sort of environment are you studying in outside of lessons?
How do you focus yourself on independent work?
During that time what sort of strategies do you use in preparation for assessments?
How do you know the strategies you are using are effective?
Have you tried any strategies that you don't find effective?
Are there study strategies you have been shown/taught during class you find useful?
Are there study strategies you have been shown/taught during class that you don't find useful?
During class are you given the rationale for the use of particular strategies and how they might aid exam preparation?
What types of strategies are you encouraged to do outside of lessons?
What types of exam skills have you been taught during lessons?
What is the difference between an exam technique and a revision strategy?
Are there any exam techniques you have been taught that you find effective?

The year 13 A-level chemistry cohort involved in the research and development project consisted of 24 students across two teaching groups. Students were asked to volunteer to take part in an initial focus group prior to any formal intervention. Two focus groups were interviewed, containing a total of 7 students who volunteered to be part of the discussion (3 in one group and 4 in the other). This was a slightly lower number than I initially intended to be involved but due to recurrent student absence, I wanted to minimize disruption to any class time, and add further commitments to the students. Initially I would have liked to recruit a slightly larger number of students to have a more even spread of student abilities (discussed below) but also to bring more voices into the discussion to further the amount of data that could be analyzed. Cohen (2018) discussed the disproportionate views that can be deducted by having too small a group, whereas a slightly bigger group can support helpful discourse. To recruit students, they were shown a PowerPoint slide laying out the background behind the research project, they were told that the discussion would be audio recorded and transcribed. They were informed their responses could be used in the write up of the research, however they would remain anonymous. They were also informed no information would be being passed on to their class teachers, this was further repeated verbally before any discussion

took place. For the focus group interviews, I chose to recruit one group of students from each teaching group as the two classes have one common and one different teacher. Students who had volunteered to take part in the interview were then given a participant information sheet and consent form prior to any discussion and audio recording. As students self-selected themselves to participate in the focus group, there was a limited spread of student abilities and attainment within the two groups, and the participating students achieved between a C and E grade in the most recent mock examinations. All students were falling below minimum expected grades at the time of discussion. No students who were on track to achieving their target grade or above a grade C volunteered to be part of the focus group, this could potentially be due them feeling that wouldn't benefit from the discussion as they may feel more secure in their use of strategies than those making less progress. The meta-analysis by Hattie, Biggs and Purdie (1996), suggests that middle ability students that are also underachieving students are more likely to seek study skills support and go on to benefit from it.

The students who participated in the focus groups have been studying in the same chemistry class for at least 2 years in person and remotely, some share other subject classes or have been in the same teaching groups lower down the school. Positive relationships could be identified within the group, but students were not afraid to give alternative responses to others already voiced or to challenge each other. They also used each other to clarify questions and develop their responses with little input from myself as the interviewer. It is also important however to consider further aspects of peer dynamics that can be present in a group research situation. Students within the groups could be influenced by what would being said by others, feeling that they needed to conform to the opinion of the majority or those students who may appear to be more popular or more able in the context of the subject. In the topic of revision there may also be a perceived idea as to what "they should" be doing

and feeling the need to give the socially desirable response in the presence of their peers but also a member of subject staff.

Although I am not the course teacher for any of the current year 13 A-level chemistry students, I do deliver an additional content review session on a weekly basis to both classes. I have also taught all students in previous years. Therefore, it is important to note the power dynamics in the students' focus groups. The majority of the students in year 13 know me well having taught them for a number of years previously so are aware of my involvement in education research and are comfortable to be honest and relaxed in their responses either verbally or written. Within my role as key stage leader for A-level sciences, students are aware of my responsibility in terms of monitoring their attainment and progress and liaising with their teachers on a regular basis. I often have individual conversations around assessment data and progress with students, and these conversations can be both positive and difficult, occasionally making further contact with pastoral tutors, the sixth form team and home where necessary. So having an awareness that my position could have caused them to be cautious in voicing their views on the teaching they experience and its perceived effectiveness. I endeavored to reduce this issue by being friendly and relaxed in my mannerism and tone when going through the details of the research with them and allowing them to ask any questions they had. I allowed students to lead the discussion and control the flow of conversation between them. I am fortunate to have a good rapport with students within the chemistry cohort and this trust is demonstrated by individuals coming to me for subject support even though I am not their class teacher. Student who took part in the focus group and questionnaire showed interest in the research I was doing, and many were involved in my research for my part 2 assignment.

3.2 Teacher Questionnaire

The pre-intervention teacher questionnaire aimed to establish the current practice within the A-level Chemistry teaching team. Looking into whether individual members of the teaching team were delivering any explicit teaching in relation to revision or exam preparation, and if so, which strategies or techniques in particular. Through the questionnaire (Table 2) I also hoped to determine if teachers gave a rationale behind the strategies they suggested. Data was collected via an online form distributed via an email link, so participants were able to complete the questionnaire within their own time around their teaching commitments. The three staff involved in teaching A-level chemistry were provided with research information and consent forms during a faculty meeting, where I was able to explain the context of the questionnaire. All three members of the chemistry teaching team showed an interest in the research and encouraging willingness to be involved. Goodbourn (2009) identifies that a positive and supportive atmosphere that allows teachers to engage in learning is a key feature that is vital in supporting students to develop their own learning skills.

During the meeting preceding the completion of the questionnaire I was able to highlight the anonymity of their responses and that no observations would be made of their practice in relation to their answers. Due to the narrowed focus of solely A-level chemistry rather than across the four A-level science subjects, I only provided the questionnaire to those teachers involved in the teaching of year 13 chemistry classes. I chose to do a questionnaire rather than interviews in this context as I wanted teachers to be able to respond individually with as much or as little detail as they liked. To also reduce any potential influence from the answers of other participants in a group interview setting, especially within the context of three teachers with varying experience. Due to time and workload commitments individual interviews were not a viable option. I analyzed the data obtained from the teachers' questionnaire in NVivo using the same coding categories used for the student focus group to allow for comparison between teacher and student views.

Table 2.

Teacher questionnaire questions
Do you explicitly teach revision/learning strategies during lessons? If so, which strategies have you taught during year 13 chemistry lessons in the past year? Do you explicitly teach exam skills/techniques during lessons? If so which skills/techniques have you taught during year 13 chemistry lessons in the past year? Do you give a rationale or background information on why a particular strategy or skill is being taught? What skills do you feel are most important for students in your subject to achieve success in examinations?

Although I am one of the chemistry teaching team, my Head of KS5 Science role means I am constantly liaising with the other members of the team regarding the teaching of the course, ongoing assessment data and student progress. Therefore, it is further important to consider that there may be an unconscious pressure to give a positive answer in terms of the initial questionnaire and the feedback to the interventions. Being a member of the close-knit team, discussions about the current scheme of learning and adaptations throughout the year are not uncommon and we have a positive working relationship. As a result, I believe the staff participating in the project would be give truthful and honest responses to questions asked. Although I oversee the A-level chemistry course teaching I am not the direct line manager of any of the teachers involved in the project.

3.3 Student Questionnaire

All A-level chemistry students (24) were issued an online questionnaire via Microsoft teams on revision strategies being used at school and at home prior to any intervention. All students were familiar with Microsoft teams, and it had been used regularly by all subjects to communicate with students about homework and other notices. Some students were less engaged with Microsoft teams so were also sent a link to the questionnaire via email explaining the context. Due to the school network running through Office 365 linking

students' accounts to the online survey, their names appeared automatically alongside their responses, all names were removed and replaced with numbers before any viewing or analysis of the data. The research question intended to be answered by the questionnaire is "What do students' exam preparation habits look like? (pre-intervention)". The questionnaire was split into two parts "in school" and "at home" to further identify if there are any differences between the strategies students were using in the two different environments, and the frequency of strategy usage on a "always, sometimes, never" scale. Students were also asked to enter their predicted grade before reviewing the questions, this was to allow for potential correlation in the data analysis between frequency or variation of strategies used and grades predicted. This depended on students having an accurate awareness of what their predicted grades were prior to the exam season. The questionnaire (Appendix 1) was adapted from the revision questionnaire task used in The A-level Mindset (Oakes & Griffin, 2016). This questionnaire was chosen due to applicability in the context of revision habits of A-level students in particular, the language used is clear and accessible. In the research by Oakes and Griffin (2016) this questionnaire is used a starting point for students' analysis of their own practice, in this way it acts as a strategy in itself, causing students to engage metacognitive regulation of their own exam preparation habits. This questionnaire used a 3-point Likert scale with the categories "Never", "Sometimes" and "Always". I chose to use the same descriptor at each point as the original questionnaire to reduce the potential errors in interpretation of numbers across a larger point scale. I also wanted to keep the data as simple as possible to determine the most frequently used strategies by the cohort of students, as techniques they used occasionally or ones, they felt they used all the time or not at all. This simplified scale also reduced the nuances in the interpretation of terms such as "a little" or "a lot" (Champagne, 2014, as cited in Cohen et al. 2018). There is an argument however, that similar misinterpretation of the term "always" could also be a point of error, and so that needs to be accounted for in the analysis of the data. Due to the limitation in the set-up of Microsoft forms

students were unable to select two options within a category, for example, “Reading through notes, in school; sometimes, at home; never”. The questionnaire required students to select an option for the use of each technique at school, and then repeat for the strategies again considering their usage at home. This was not ideal as it lengthened the questionnaire with a repetition of the statements, which could result in respondent fatigue (Champagne, 2014, as cited in Cohen et al. 2018). For that reason, I chose not to add any additional strategies into the original list and reduce the wording in the descriptions where possible. I made certain however to ensure the list still include those strategies mentioned by teachers in their questionnaire responses and those techniques highlighted by students during the focus groups, without it being too long and reducing the strain and time commitment for the students when responding. It was also imperative to name strategies or describe them using language which students would be familiar with, this ensured it was accessible to all students as much as possible and to reduce possible areas of misunderstanding. This is a problem that is difficult to address in using questionnaires in research where misunderstandings cannot be address directly during completion by individuals and well as the clarification on specific terms such as what we might understand by “always” in the Likert scale. In the context of this questionnaire, closed questions were used and a prescribed scale of responses were given to allow for quick coding and analysis of data. This also gave a clear deliberate focus to be able to formulate an answer to the research questions being addressed. Open questions would have provided more scope for students to add any additional techniques they were using but would have added further strain on the students as respondents and could have resulted in less accurate responses further down in the questionnaire (Cohen et al., 2018).

One of the problems that arises with questionnaires can be response rate, especially where there is a follow up comparison. After the last exam most students were not checking emails or in school so encouragement to complete the follow up questionnaire was more difficult that preceding the intervention while classes were happening as normal. A positive aspect of

students choosing to participate in the research is they have made the conscious choice to be involved and contribute. Students repeated an identical questionnaire post intervention. This was to investigate whether their exam preparation strategies had changed, in either style or number after the explicit teaching of these skills during the revision period. The format and statements used were the same to ensure ease of comparison across the responses. Due to anonymity, I was unable to match student responses from before and after the intervention stage however by still asking students to enter predicted grades I can draw correlations between changes in exam preparation habits and predicted attainment. Based on the original questionnaire (Oakes & Griffin, 2016) I was able to group the strategies into categories "content", "skills" and "feedback", this allows further analysis as to the types of strategies being used by different ability learners, in different learning environments, pre and post intervention. There was consideration of grouping categories into the broader groups of "active" and "passive" techniques as done by Hunter and Lloyd (2018) however the nature of some of the strategies such as mind-maps and flashcards did not lend themselves to categorization in this way. Both these techniques for example could be classed as active or passive depending on their usage, therefore by categorizing them so broadly would have inferred a learning process than may not be an accurate representation of its use. I chose not to do any statistical testing on the student questionnaire data due to the small sample size of students and due to using narrow 3-point Likert scale. The number of students predicted a certain grade also results in even smaller sample size groups (between one and six students) which would not be appropriate to attempt to draw statistical significance from.

3.4 Interventions and Teacher Feedback

Students were given a revision schedule to provide structured sessions from the start of their given "study leave" period. Usually, study leave would involve all students studying

independently outside of the school environment prior to exam except for ad hoc revision sessions run on a subject-by-subject basis, usually the day before the exam. Often these sessions are a “drop-in” for students to arrive with questions or topics they want to recap rather than a structured lesson. It was important to provide a clear structure and routine to support students with their exam preparation. Short term intense revision can pose problems in terms of student self-regulation, under time pressure, students tend to give priority to easier more manageable items of revision (Kornell & Bjork, 2007). A clear and organised plan however reduces procrastination and wasted time (Muteti et al., 2021).

The majority of these sessions fell within their normal timetabled lesson slots as to avoid clashes with any sessions being held by other subjects. I worked closely with our school science improvement lead from our school’s trust to help devise a schedule that worked around student exams and staff timetables that ensured staff were not being asked to take on additional workload and students had the best opportunity to receive maximum pre-exam support. Due to the two teaching groups running at different times in the timetable we decided to open up all sessions to all students studying A-level chemistry to widen their opportunities to be involved in sessions. This also allowed us the ability to repeat sessions for students who were absent either due to illness or exams for other subjects taking place at the same time as scheduled sessions. Unfortunately, due to the late implementation of the intervention as a result of ongoing school closures and high demand of staff to cover lessons in the previous term, clashes with exams and other sessions were unavoidable, and student absence also meant not all students took part in all sessions. This resulted in not all students experiencing the same level of intervention with regards to revision strategies and exam preparation. By teachers involved offering repetition of sessions it meant a compromise between have a lower number of unique strategies that could be delivered but ensuring all students getting the same input of information.

Using the advance information provided by the exam board and pre-pandemic examiner's reports, I worked with the class teachers and our improvement lead to identify key topics to design strategies around. We chose to focus on examiner's reports pre-2020 to ensure we had feedback on the examinations where a typical cohort of students sat the exams, rather than smaller re-sit cohorts from 2020-2021, which would be less reflective of the national picture. The collaborating teachers also contributed their knowledge of problem areas they had identified in final set of mock exams most recently completed by the students. Topics identified included: required practical, transition metals, reactions of aqueous ions, bonding and intermolecular forces and shapes of molecules.

A more general area of concern was that of mathematical skills, including; rearranging equations, conversion of units, rounding and significant figures. All the sessions were carefully designed to take into account multiple elements from the literature, the majority of sessions had a main topic focus (Table 3). Topics were chosen based on the advance information provided by the exam board, low scoring topics from 2017-2019 examiner's reports, alongside class teachers recommendations.

Each session contained one or more strategies to implement, and each had a clear rationale and link to how it would benefit students in terms of their exam preparation. All sessions involved a retrieval style task, whether through simple definition recall, or exam style questions. Any task or practice question was given a time limit to help build this in student routines and self-regulation of their own independent work. Based on the exam board's advice to consider "synopticity" and revision of non-high tariff content (AQA, 2022), I ensured there was as much linking and interleaving of topics as possible. This was something I felt was very important also based on the research of drawing on long-term memory of content from all over the course to make stronger more concrete links between ideas, and aid more effective retrieval of these ideas. Further details of these sessions can be seen in table 3.

Table 3

Session Focus	Learning Strategies
Transition metals (Topic identified from advance information and mock exam feedback)	Key terms retrieval activity -students then created their own for a different topic. Timed exam questions follow up with teacher modelled answers. Links map (Appendix 2 and 3)- students annotated map in pairs Colour matching to equations based on transition metal reactions
Bonding (Topic identified from advance information and 2018 examiner's report)	Identification of bonding types, intermolecular forces between molecules. Modelled examples of the problem-solving process followed by examples for students to complete. Examples of varying difficulty. Spaced gaps for timed exam questions, students self-marked using mark scheme, guided by teachers.
Shapes of molecules (Topic interlinks previous and future sessions, and identified by 2019 examiner's report)	Step-by-step guided example using set rule to work out molecule shapes. Scaffolded examples removing individual rules from view. Students required to draw diagrams and gained marks for correct components of the diagrams, accurate drawing, bond angles, and shape name. Progressive difficulty in examples. "Fuzzy problems "multiple choice, students required to give reasons for options not being correct.
Reactions of Aqueous ions (Topic identified from multiple links to advance information major focus and 2018 and 2019 examiner's report)	Visual mapping of changes in reactions (Appendix 4) Paired flashcard quizzing on interlinked topics Creating exam questions based on mark scheme- working backwards
Mathematical Skills (Topic identified from advance information and 2017-19 examiner's reports)	Conversion of units using data from diagrams- including non-chemistry-based scenarios. Significant figures using data from diagrams and exam style questions. Rearranging of equations for different subjects, talking through and verbalizing rearranging process
Required Practical (Topic identified from advance information and 2017-19 examiner's reports)	Road mapping exercise based on required practical 2. • Improvements to methods/sources of error • Results tables • Drawing and interpreting graphs • Calculating uncertainty • Analysis of data

Although exam technique in relation to content was woven throughout the sessions, there were specific sessions held prior to each exam on maximizing marks. These were designed using the insights provided by pre-pandemic examiner's reports (2017-2019) and included further details from the "Instructions for examiners" section found at the front of mark schemes which according to AQA "should be known by students" (AQA, 2018). These sessions also focused on common exam errors, content specific feedback from previous questions that matched the advance information major focus areas as well any shortcomings in mathematical and practical questions.

The overarching idea of exam preparation intervention was to introduce a balance of new strategies and demonstration of more effective use of current strategies, that would be easy for students to take away and use without supervision (Dunlosky et al., 2013).During the intervention period, the teachers collaborating on the project completed an ongoing feedback log after each session they delivered. This qualitative data was based on their opinions and observations of student engagement in the session. Data was collected via a shared excel workbook, where teachers could identify what they felt worked well during the session and identifying areas for further improvement and development. The simple nature of a "What went well", "even better if" feedback system aimed to make the format of providing feedback easy and quick for collaborating staff to complete. This encouraged feedback to be provided as we moved through the intervention, rather than waiting to feedback on all sessions at the end. Feeding back at the end of the intervention on the nuances of each session would have likely resulted in inaccuracies and difficulty remembering the successes and point of development for each revision session. Data from the teacher feedback was categorized into strategy specific and student engagement and behavior. This data could then be used to triangulate with the findings from the student post-intervention questionnaire about whether the sessions were useful and accessible to students.

4. Findings and Discussion

RQ1) What is the current teaching practice of revision strategies and exam techniques amongst A-level chemistry teachers?

Of the chemistry teachers involved in the project, two of the three believed they had explicitly taught revision skills as part of their lessons in the past academic year. Both of these teachers mentioned the creation of mind-maps specifically in relation to organic chemistry, one teacher referred to using checklists, but there was no further elaboration on how either of these techniques were used once created or provided. Another mentioned the use of past exam practice questions in three stages of completion, in a review type approach where students completed the question using their retrieved knowledge, then reviewed using their textbook or notes to add to their answer, then final marking using a mark scheme. The same teacher mentioned using a similar technique for revision, by getting students to actively recall everything they could remember about a topic, consolidation and review of content using textbooks, then a skills-based practice followed by a feedback stage via self-marking. This is an example that links well with the ideas of practice laid down by Oakes and Griffin (2016) but also in the use of a retrieval activity (even if both staff and students don't recognise it as such), aiding the development of metacognition, students recognising gaps in their knowledge through the use of mark schemes.

Several students within the focus groups described similar strategies within their independent practice of completing questions, reviewing and adding to them before marking. Interestingly no student recognised that they may have been taught to use this strategy in class, and the questionnaire also showed that they more often engaged in timed questions and using mark schemes at home than in school. This links well to research findings where teachers in studies

claim to disseminate information on useful strategies, but students seem to disagree that the techniques they use did not come from teachers but are improvised (Kornell & Bjork, 2007; Morehead et al., 2015)

In comparison with teachers' feedback on the explicit teaching of revision strategies, students from the focus group also showed a variation in their responses to the teaching of revision strategies they experienced. Three students referred to flashcards and mind maps being explicitly taught, but prior to A-level study. Two students were unable to identify any revision strategies they had been explicitly taught how to use during the past 2 years. One referenced active recall, which interestingly wasn't a term used by any of the teaching staff in their questionnaires. It could be inferred that this is the technique teacher 2 was elaborating on. Variation and inconsistency in what is delivered by teachers in the learning environment is something that is echoed in the literature (Morehead et al., 2015).

I also asked students within the focus group if there were any revision strategies, they used in class that they found particularly effective. Interestingly they named different strategies to those given in response to question about strategies "explicitly taught" in lessons. It would appear from this that techniques that are being used as "activities" in class are not explicitly taught or emphasised as a way to prepare for assessment. From the qualitative data obtained it is not possible to say whether the lack of explicit instruction is intentional or potentially just not observed by students. Group work was a common theme around for one of the focus groups and what they found useful for revision within the context of the lesson, being able to figure out questions with friends and competition between groups. One student stated about group activities "the energy's […] better, it's like you're all helping each other". Conversely the same group of students found group work with regards to peer teaching or re-teaching of topics not useful, this was also echoed by individuals in the second group. The second focus group only identified exam questions as a useful in class revision activity. This group however

did identify some very specific practices they didn't find useful, one student described an activity of "binge learning content" followed by a quiz like game. This type of technique being ineffective is echoed by Morehead et al. (2015), where mass studying is less effective at facilitating retention compared to spaced practice. It also supports the claim that students often believe the purpose of testing or quizzing is just about getting the correct answers, when the process of retrieval is key (Morehead et al., 2015). A quiz tagged on to mass studying however is probably not effective way to retrieve deeper encoded knowledge. Another student talked about their dislike for quizzes on prior content from year 12, what I can easily identify as a retrieval style quiz, based on the current faculty practice. The split of responses between the two groups could lead to the conclusion that the students within the groups were responding similarly or in line with others within the same discussion. I feel there is an interesting point to draw on that both students and teachers separate what we might think of as learning activities in class and revision strategies. Revision strategies are those that build and deepen knowledge to aid retrieval of information in an exam, but in effect no different to the strategies employed in lessons to introduce and revisit the knowledge in the first place. By educating students of the science behind these learning strategies, we can enable students to engage these techniques more fully outside of lessons and aid their long-term learning of concepts and ideas (Dunlosky et al., 2013).

In the case of exam technique, two of the three teachers felt they explicitly teach exam technique during lessons. Modelling of answering exam questions was mentioned by both, specifically in relation to multi-stage calculations and breaking down key terms within the question. One referred specifically to multi-stage calculations and long answer questions, explicitly showing where marks are gained and awarded by the examiner. The other teacher wrote in detail about supporting students who struggle with timing issues and identifying questions that were "easy-wins" where success and confidence can be gained early (Rooney & Dubowe, 2010). Some students were unsure about specific exam techniques they had been

taught or unable to identify anything they recognised as an exam technique. Those that were mentioned by students echoed and built on the responses by staff, the examples given included; breaking down the exam questions, defining keywords and looking at where marks are gained within an answer. Students also gave responses that linked closely with the ideas around self-regulation and metacognition, such as estimating time required for certain questions and reviewing the paper to find questions related to topic where they felt more confident (Endres et al., 2020).

From the teacher questionnaire, all teachers felt they gave students a rationale behind why they were using a particular revision strategy or exam technique. The benefits of specific strategies such as retrieval practice, are often more obvious to teachers than they are to students, so teachers may not go into the details and shout out the benefits (Karpicke et al., 2009). Students were asked in the focus group whether they were given a rationale behind the techniques and strategies they were being advised to use, the response across both groups was variable. Several students were unsure whether they were given rationales or not and stated that in their responses, one student felt most of the time they weren't given an explanation unless asked for. Overall, all students felt they were given some reasoning, some of the time. This is potentially understandable that it may be a factor that gets overlooked by teachers when we consider the amount of content that needs to be covered by teaching staff and the workload demands. Dunlosky et al (2013), also consider that teachers and schools are ultimately focussed on delivering content to ensure complete coverage of the specification.

The responses from both the teacher questionnaire and the student focus groups would appear to mirror the variation and inconsistency in delivery of revision strategies and exam techniques referred to in the studies by Dunlosky et al. (2013), Hunter and Lloyd (2018) and Morehead et al. (2015). From the student focus group and teacher questionnaire there is some consensus that some exam preparation (revision strategies and/or exam technique)

even though variable is being delivered in the research school. This includes different styles of retrieval practice, elements of review and recap, and some use of modelling and exam style questioning.

RQ2) What do students' exam preparation habits look like? (Pre-intervention)

Initially the responses from the student focus group with regards to how much time they commit to the chemistry exam preparation and their learning environment will be considered. All students involved in the focus group discussions stated that they worked on chemistry for between one and two hours a day. Two students specifically mentioned they would spend more time on other subjects during exam season where those examinations were earlier in the calendar. This aligns with the work by Kornell and Bjork (2007) which highlights that students will tend towards focussing their attention on "whatever's due soonest", especially those with lower metacognitive regulation. These students are also less likely to have a formalised plan for their exam preparation. Procrastination around revision is more common in students who have poor planning and lack of structure in their exam preparation (Muteti et al., 2021).

In relation to learning environment, in school, the library or at home where the three key environments mentioned. Although several students mentioned studying in their bedrooms, they did refer to preparation of their environment as a dedicated workspace, others preferred to use rooms not use for "leisure". This was intended to minimise distraction, five out of the six students mentioned putting their phone away, turning it off, or silencing notifications, to further reduce distraction. No other distractions were mentioned in addition to mobile phones. Five students specifically referred to working in cycles, giving themselves a set working and break time rotation. It is not clear from the questions asked whether students moved between topics during these cycles of working. Something as simple as putting away

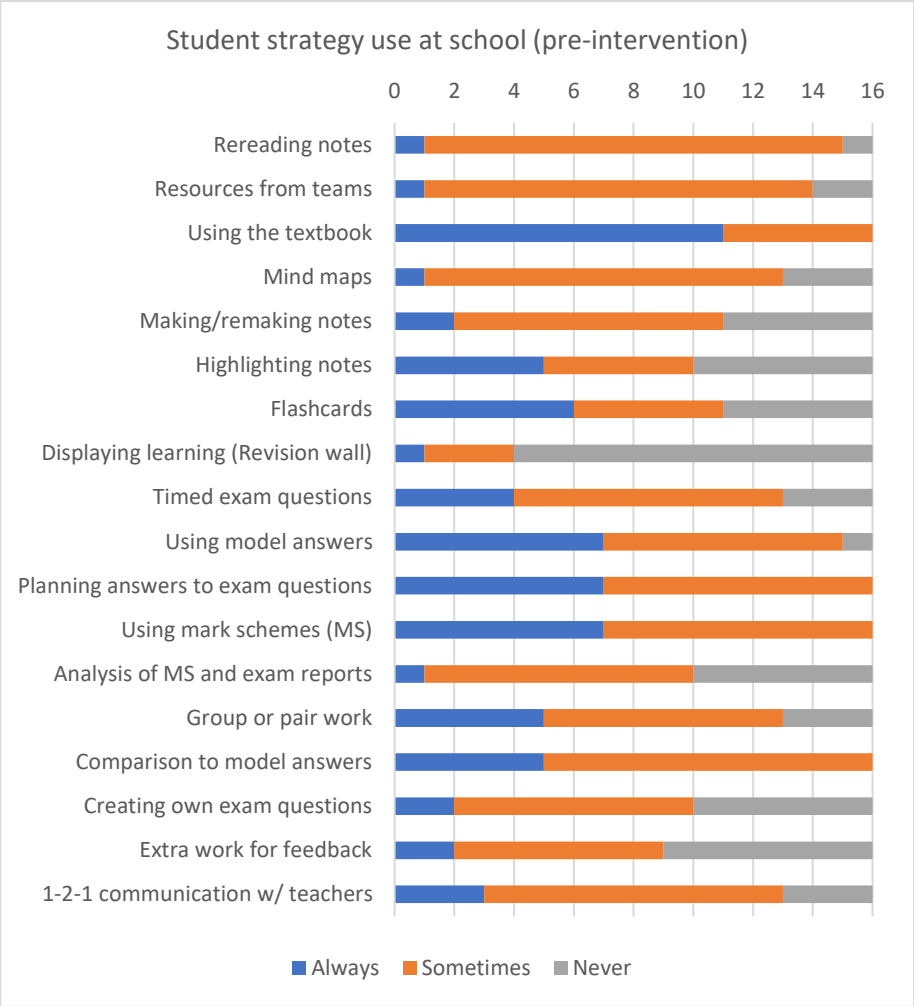
a phone is evidence of self-regulation, the conscious minimising of distraction, this is positive as learning is improved when it is given full undivided attention (Hunter & Lloyd, 2017).

It appears from the discussions all the students were showing some self-regulatory skills in terms of setting up an ideal working environment and minimising distractions. The strategies they actively engaged during these periods of work could be classed as limited in variation and effectiveness. Three students mentioned using their preparation time to make resources, mind maps and flashcards rather than specifically use them. No student within the focus group felt able to explain how they might use a set of flashcards or a mind map beyond rereading or displaying it "somewhere where I see it every day". Completion of past papers and past exam questions were a common answer across the two groups and a much more functional and active revision strategy (Hunter & Lloyd, 2018; Rooney & Dubowe, 2010). Select individuals referred using a mark scheme or YouTube videos to review answers or using their textbook to fill in gaps. No student could elaborate on why they used a mark scheme other than to check the answer, there were no specific references to identifying where individual marks were gained, despite it being mentioned as a strategy using in class. This is reflective of the conclusions made by Morehead (2015) where student belief in the sole benefit of testing as the determining the accuracy of a response.

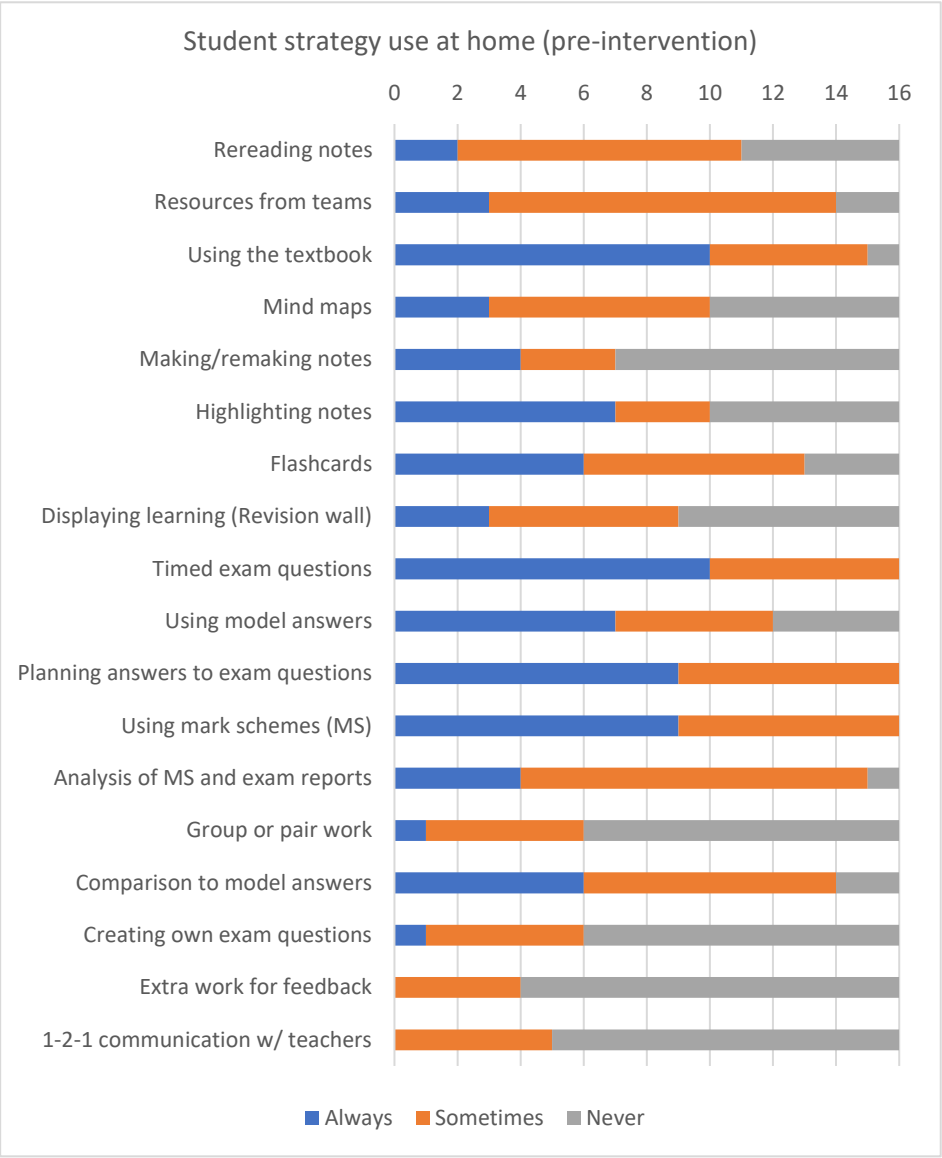
From the pre-intervention student questionnaire about what strategies (Appendix 1) they used at school and at home, initially it appeared that there was very little difference between what students were using in the different environments. On closer inspection it appeared students were more likely to choose "Always" or "Never" rather than "Sometimes" when considering their use of a strategy at home. This potentially indicates they were more likely to try alternatives in the context of school (see Graph 1 and 2). That may be due to encouragement to use a range of techniques within the classroom by teachers or their peers using different strategies in group environments. It could also indicate that when working

independently students are more likely to stick to the strategies, they either feel more confident with or that they believe work for them. The only strategies that showed an increase in "sometimes" being used at home were flashcards, analysis of mark schemes and exam reports and displaying learning. Displaying learning, a technique more applicable to at home study anyway, sticking notes and mind maps on the wall was mentioned within the student focus group. It could also link to a greater or lesser self-regulation amongst students, that they might be more or less inclined to work independently in their home environment.

Graph 1



Graph 2



The data (graph 1 and 2) shows that strategies that would be classed as content-based strategies such as rereading, reviewing resources from teams (such as lesson PowerPoints) and mind maps are the most popular amongst the students. Similar strategies such as reading the textbook, mind-maps and making notes were also mentioned by students within the focus groups. This is despite several of the students then going on to name these as ineffective strategies, two students specifically identified mind maps and two, flashcards as strategies they felt were ineffective. This question proved insightful during the focus group as to students' use of these techniques; "I feel like I don't fit all the information in [mind maps]",

"so much information on something so small", suggesting a tendency to rewrite notes. "Flashcards they don't work for me, I feel like I just write so much, maybe I'm just doing flashcards wrong", this statement in particular was really interesting and supports some of the issues within literature that suggests that students stick to the same strategies even though they know it's not working (Feudel & Dietz, 2017). Jones (2019) refers to the common use of flashcards being students recopying notes then proceeding to just reread the flashcards. The literature suggests that rereading gives students a confidence in their ability because the fluency in what they are reading increases with every reread (Karpicke et al., 2009). This fluency gives a false sense of learning and students' assessment of the own ability is often greater than it is shown by testing. This confidence and fluency is maybe why students continue to rely on strategies like rereading and remaking notes in a different format even when they doubt its effectiveness.

Already highlighted is the popular use of textbooks both in school and at home. Within the focus group discussion students referred to using the textbook in several ways including reading, checking or reviewing answers to questions, or answering questions from within the textbook itself. It is therefore important to consider that "using the textbook" is more than just reading it, for some students at least. One student gave a very thoughtful response when communicating their thoughts on textbooks as a resource, "all the questions are super cookie cutter. You'll never get an easy question like that in an exam, so it's kind of useless because it makes you feel confident", they go on to describe exam questions being in different in style and that if you solely used the textbook, you would be unprepared for the difficulty of the exam. This idea supports the view of Agarwal (2019) and Panadero et al. (2017) that retrieval practice needs to reflect the style and demand of the examination. This response showed a student with clear metacognitive thought processes; however, the questionnaire data suggests that other students do not have the same awareness around use of the course textbook.

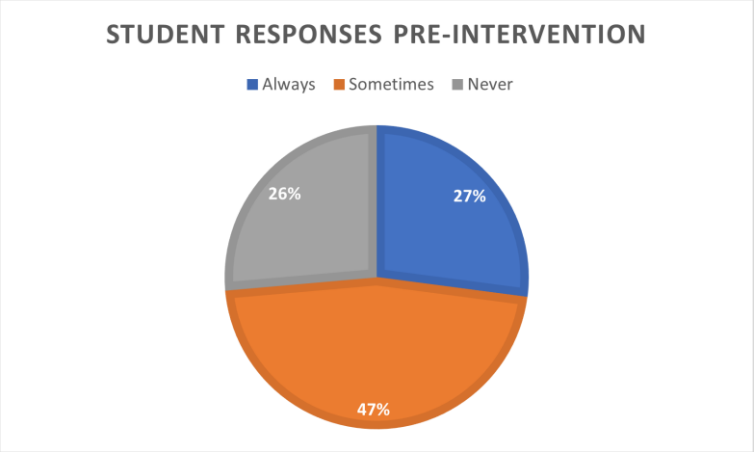
Overall, a total of 16 students completed the questionnaire so it would appear the majority of students within this cohort are trying a range of techniques maybe not as regularly as we would like but they are certainly not stuck on just "passive" strategies. This is clearly evidenced by the number of students engaging with past exam questions, model answers and mark schemes at both school and home.

RQ3) What effect does explicit teaching of revision strategies and exam techniques have on students' exam preparation habits?

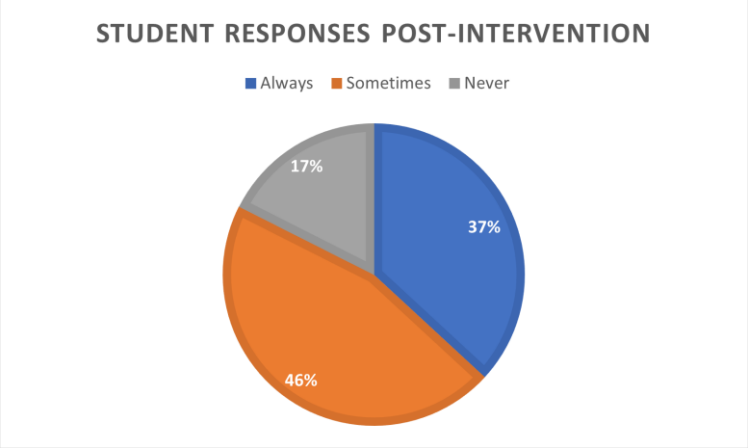
All students who took the initial questionnaire completed the follow up questionnaire which was really positive for being able to compare their use of strategies before and after. The graphs (Graph 3 and 4) below show a shift in revision habits post-intervention. With a 10% increase in responses of "always", and a 7% decrease in students selecting that they never use a particular strategy. This is encouraging as it indicates a shift towards students being willing to try different approaches to their exam preparation and commit more fully to using others. It is important to note that it would potentially be expecting this shift towards more frequent strategy usage, due to the closer proximity of the exams post-intervention. We would not necessarily expect to see an increase in the range of strategies being used especially based on the literature suggesting students stick to the same preparation methods out of habit (Feudel & Dietz, 2017; Karpicke et al., 2009). From this data we are unable to see if students are explicitly doing more revision in terms of time spent as was not being investigated. This was not included in the questionnaire as it is considered more important to have effective use of time rather than simply more time spent on using their strategies (Chen et al., 2017; Oakes & Griffin, 2016). What we can see is an increase in the more consistent usage of a wider range of strategies which may not have happened without some teacher input. The literature reviewed suggests that students are unlikely to alter their study habits

without support and guidance (Dunlosky et al., 2013). Teachers involved in the project worked hard to encourage students to trial and test new ideas, and all sessions purposefully indicated other topic areas where strategies could be used by students at home.

Graph 3



Graph 4



The questionnaire data post-intervention (Appendix 5) shows an increase in “always” and “sometimes” responses across the majority of strategies at school and at home, the increase at home from before to after is not necessarily unexpected as students spend more time at home during the exam period. One category that did see a small but surprising increase was one-to-one communication with teachers post-intervention, at home. This reflects my own experience and the experience of teaching staff during the intervention, where we were in receipt of emails from students outside of sessions requesting support and advice. This

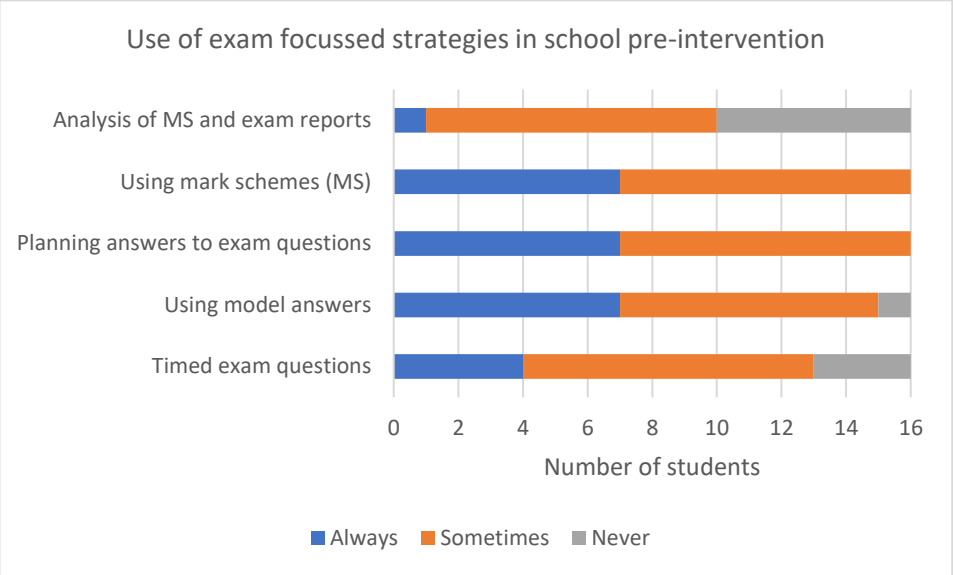
increase in engagement outside of lessons, in terms of communication with staff was an unexpected but positive outcome of the research. Students were reaching out for one-to-one support, not just for resources or exam style questions but for strategies for them to use. Individuals emailing to ask for clarification of mark scheme points, and for techniques to support specific areas of study; “Do you have any ideas that could help me remember the reactions of group 7 with H_2SO_4?”, “How could I revise the all the different information we need to know for required practicals?”. There was also a greater number of students attending “drop-in” style sessions, sessions which in throughout the academic year and drop-ins during mock exam periods had been predominately empty. After the first “maximizing marks” exam technique session held prior to paper 1, there were multiple requests for similar sessions to be added into the timetable before paper 2 and 3 which were not originally accounted for. This was really positive feedback and indicated that students found them a valuable use of their time.

The session feedback from teachers commented on the “interesting and focussed conversations” between students during collaborative tasks. They noticed that students were not only helping each other and building on each other’s ideas, but noticeably critiquing and correcting with reference to resources like mark schemes and examiner’s reports. When there was a range of strategies being trialled in the sessions it was noted that students were least focussed on the past exam questions. Teachers commented that they felt this might be because exam questions were the most familiar part of the session, that students were overconfident doing something they had met lots of times before. The teacher who delivered the shapes of molecules session, commented on the effectiveness of the scaffolded examples and the removal of steps. Students gained confidence through the modelling process and but removing small steps at a time they were able to more easily identify any missing parts to their answers. “With the first few [examples] being the same, they we able to consolidate the ideas”. Teachers appreciated the explicit rationales behind the strategies and having these

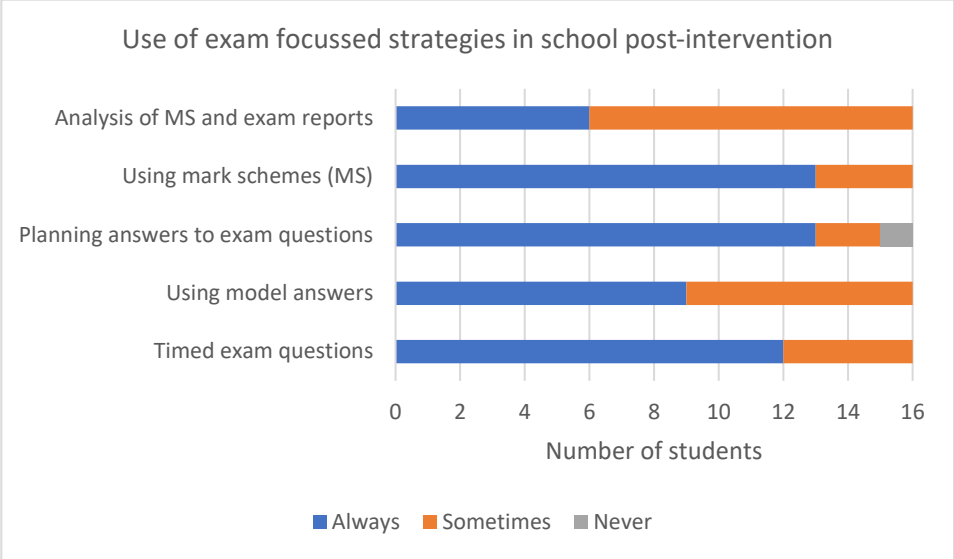
built into the session meant it was easy to give these explanations to students and get students buy-in to try something different. They also felt the clear links between year 12 and 13 content and the overlap of topics was a useful thing to highlight, and 2 teachers independently mentioned they would be keen to do more of this within their lessons.

The comparison of questionnaire results pre- and post-intervention indicated an overall increase in the use of strategies across the board regardless of the effectiveness (appendix 5). This is not ideal but within our intervention there was no conscious choice to deter them away from particular techniques or discuss the lack of evidence behind some revision strategies. One area of the data that stood out was the increase in "always" (decrease in "never") response when it came to skills-based strategies such as using exam questions, mark schemes, model answers and examiner's reports in school. These strategies are predominately skill-based techniques practicing the application of knowledge and exam focussed feedback skills. I was really surprised that these responses remained more similar when considering strategies use at home (see appendix 6) but showed a bigger shift within school (graph 5 and 6). Highlighting the increased use and engagement of these techniques within lessons, despite teachers' feedback that the felt that students were less focussed on the exam questions. There is a possibility that completion of the first questionnaire provided students with an insight to the range of techniques they were currently using (or not). Chen et al. (2017) found that students showed an increase in self-reflection resulted in a wider variety of resource usage. The questionnaire could have therefore inadvertently acted as a prompt to strategies they could be using.

Graph 5



Graph 6



Of the 24 students on the A-level chemistry course, only 1 student attended zero sessions, this student did not attend drop-ins for any other subjects either. Another student had an individual conversation with me that she didn't feel the sessions were benefitting her and she would prefer to revise independently at home. Overall, teachers were pleasantly surprised by the initial response to the program as there was concern that giving them a timetable during their study leave may not be preferable. Students were very positive and overwhelmingly grateful, thanking their class teachers for putting on the classes for them. This was a hugely

positive outcome for the intervention, “students’ overestimation in their abilities”, feel that they don’t need to engage with support strategies (Feudel & Dietz, 2017). Turnout to the sessions was good despite running during the exam period, attendance to the sessions is discussed further in the limitations section.

One of the most interesting bits of teacher feedback I received was about the teaching of revision skills. The member of staff spoke to me about their consideration that until this point it hadn’t really occurred to them, that they hadn’t be taught revision skills themselves in school and had never been educated on how to teach them in the classroom. This lack of training on revision strategies and exam technique was a frequent theme through the literature (Hunter & Lloyd, 2018; Morehead et al., 2015). It is no surprise that teachers feel like they have to stick to the same reliable or even ineffective techniques, when they haven’t been taught otherwise. A statement from a student during the focus group mirrors that thought “(you) don’t get really given the scientific reasonings sometimes you ask the questions and makes you realise the teacher doesn’t know themselves it’s sometimes like they just have to do it”.

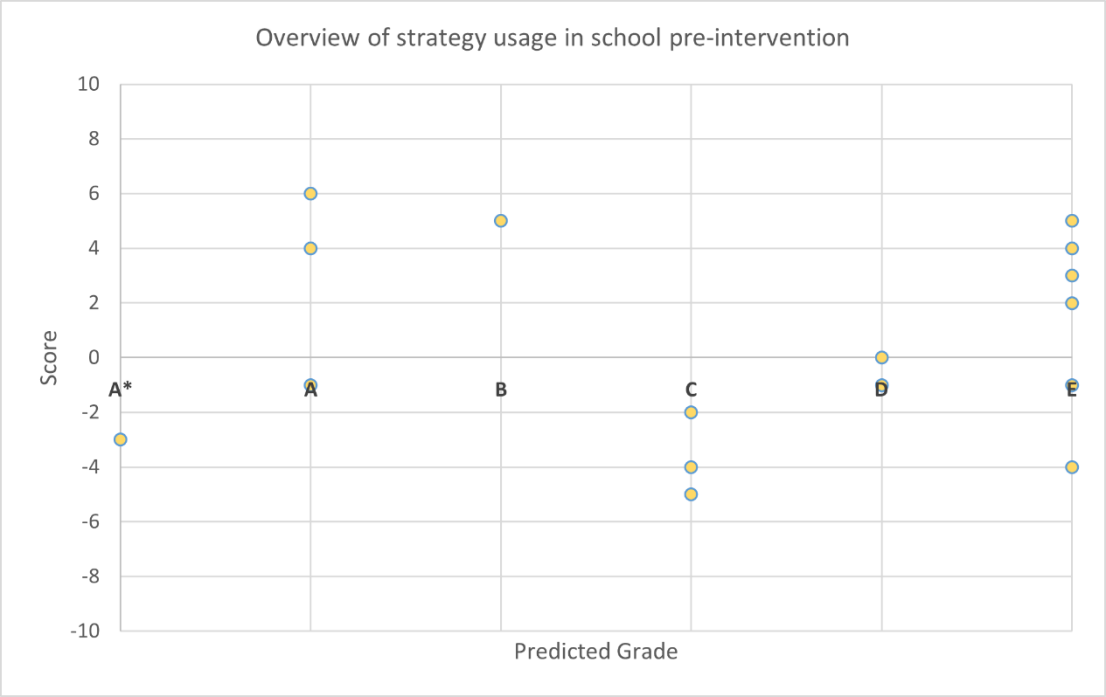
RQ4) Is there any correlation between student predicted grades and the variation or types of strategies they use?

When looking at the use of strategies alongside student predicted grades there are some areas to consider between variation of strategies being used at home and in school. This questionnaire data was converted to be numerical for ease of processing. The option “never” generated a -1 score, “sometimes” = 0, always = +1. This score was then able to be plotted against student grade. Each point on the graph represents a student (some points are overlapped due to students with the same grade with the same score these are indicated by an asterisk* on graphs 7-10). The grade represents the students predicted grade based on the

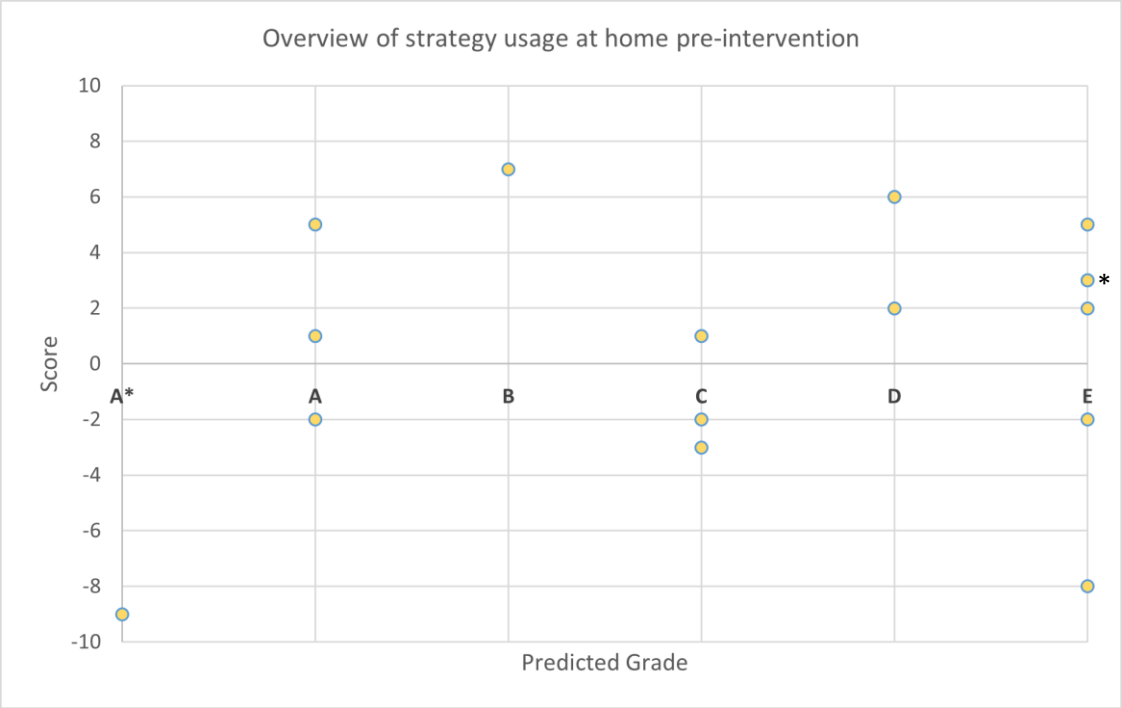
prior attainment, the higher that score the greater breadth of strategies being used more regularly and a lower score indicates most strategies not being used or used very infrequently.

First, I will discuss the data in graphs 7 and 8. As can be seen in the graphs the student predicted the top grade of an A* engaged in the lowest variation of strategies in school had even lower engagement out of school. All students predicted an A also dropped in their overall net score when comparing use of strategies in school to at home. The drop in strategy use from our A* and A grade students is an interesting insight into potentially them utilising in school contact time to prepare for exams and outside of school using more limited range of strategies that work for them as individuals. This is reflective of the work by Chen et al. (2017), where they discussed higher ability students engaging in less revision strategies than their peers due to better understanding of the notes, they take the first time by being more actively engaged in class. Students with the lowest predicted grades of an E also show an overall drop in net score. The biggest rise in strategy engagement outside of school comes from those in the middle grades B-D. It could be inferred from this data that our students with the lowest predicted attainment struggle to engage in revision and exam preparation outside of school without the support of teachers and peers or have less confidence and self-regulation in how to prepare for exams.

Graph 7

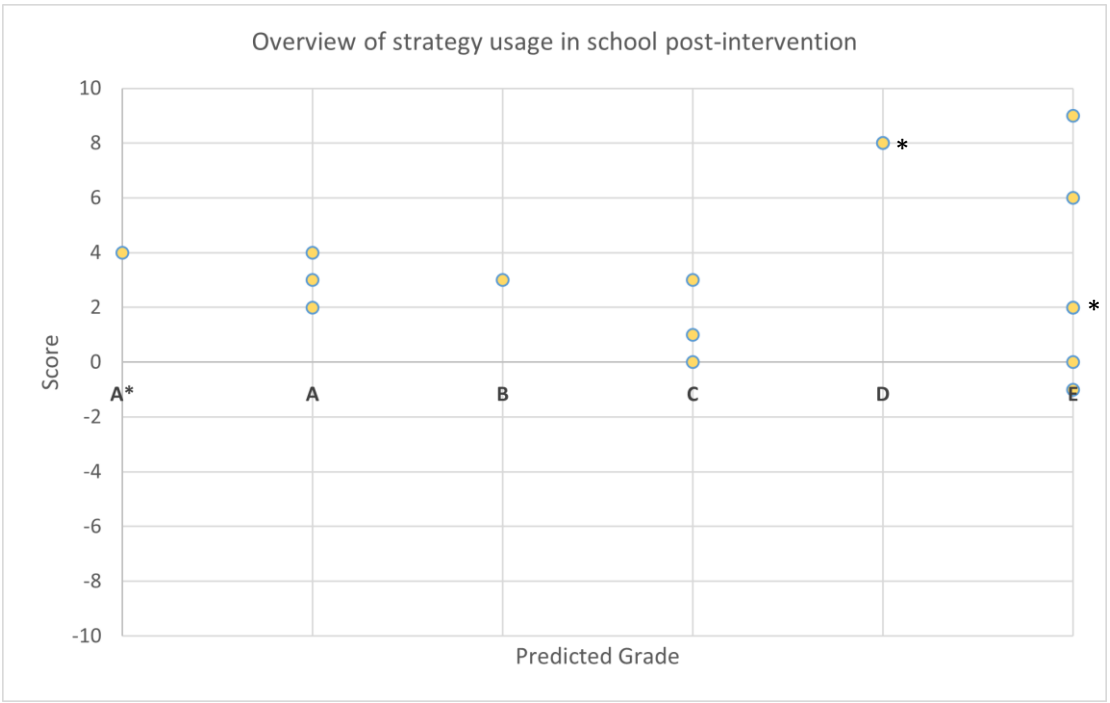


Graph 8

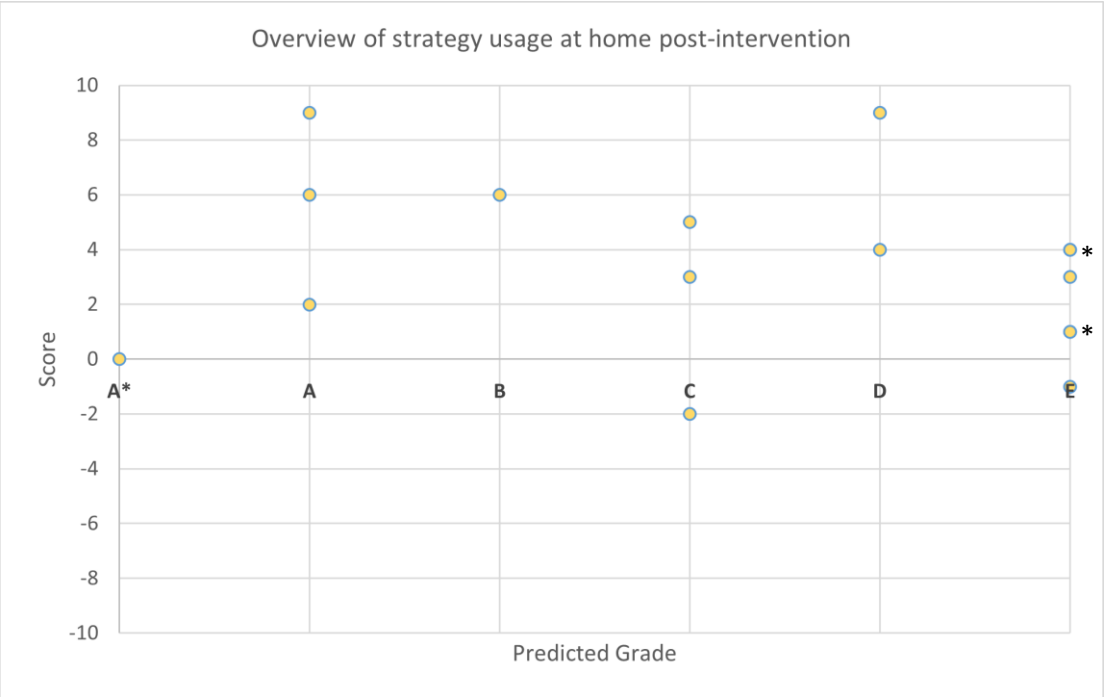


Graphs 9 and 10 display the shift in variation and frequency of strategy usage against student predicted grades post-intervention. A comparison between graphs 7 and 9 (in school, pre- and post-intervention) show that within school our A* student made the biggest increase in terms of breadth and frequency of strategies. Students predicted grades C to E also show an overall increasing trend in the range and more frequent use of strategies. This increasing trend in also reflected in the questionnaire data from students' strategy usage at home. In this case all students except the student predicted a B grade had an increased score for a wider range and more consistent use for revision strategies at home post-intervention. As discussed previously, when looking at the overall picture an increase in exam preparation at home would be expected during the exam season, however the shift in the number of strategies being used correlates with the increased use of strategies being delivered through the intervention. Students need reminders of what resources and techniques are available to them (Chen et al., 2017). Effective instruction of how to use the resources and techniques allows students to use them effectively without supervision (Dunlosky et al., 2013).

Graph 9



Graph 10

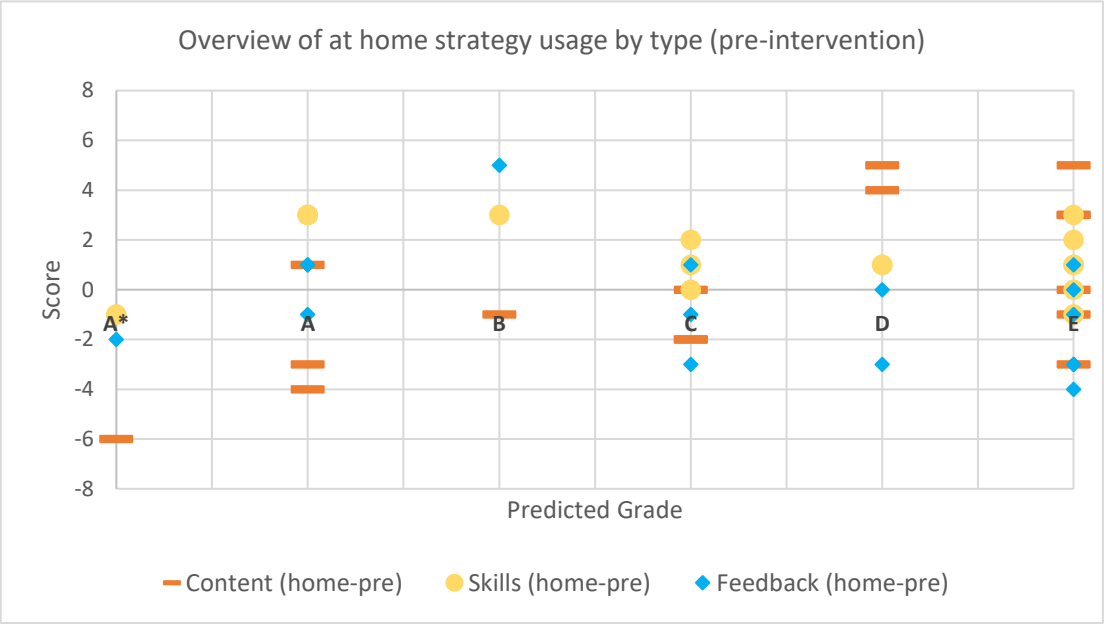


When considering the changes in students exam preparation post-intervention there are some interesting differences still between their indicated practice at school and at home. For example, our A* grade student still scores much lower at home than a school, possible indication that although there are engaging in the revision sessions, at home they have settled on using a specific set of techniques. The student does however show a sizeable increase in score at home pre- and post-intervention. Students across the range of predicted attainments also show a greater score variation at home than at school, this could be due to the direct instruction and encouragement to trial techniques at school and the greater freedom chose the range of techniques to practice on at home.

One of the aspects I wanted consider within the data was the use of different types of strategies (indicated in Appendix 1) in correlation with students predicted attainment. For this discussion point I decided to only consider the responses in relation to student strategy usage at home, to give an insight into students' independent exam preparation rather than that guided by the sessions in school. This was to see if students with a higher or lower

predicted attainment grade favoured a particular type of technique within their exam preparation (content, skill or feedback). Graph 11 shows the net score relating the strategy variation and frequency grouped by strategy type prior to any intervention. It can be observed that the usage of content techniques shows a slight trend, where students with higher predicted attainment score lower in terms of the number and frequency of content-based strategies they use. There is a general pattern that can be seen from A*-D grades with an increase in the content strategy score in particular. The students with predicted E grades show more variation across all three types of techniques. The other pattern to note within this data set is that the majority of students with attainment predictions from A*- B score higher on skills and feedback techniques. This indicates that a wider range of skill and feedback strategies are used more frequently by these students than content-based strategies. Students predicted C grades show a slight increase in the use of skills-based strategies than feedback.

Graph 11

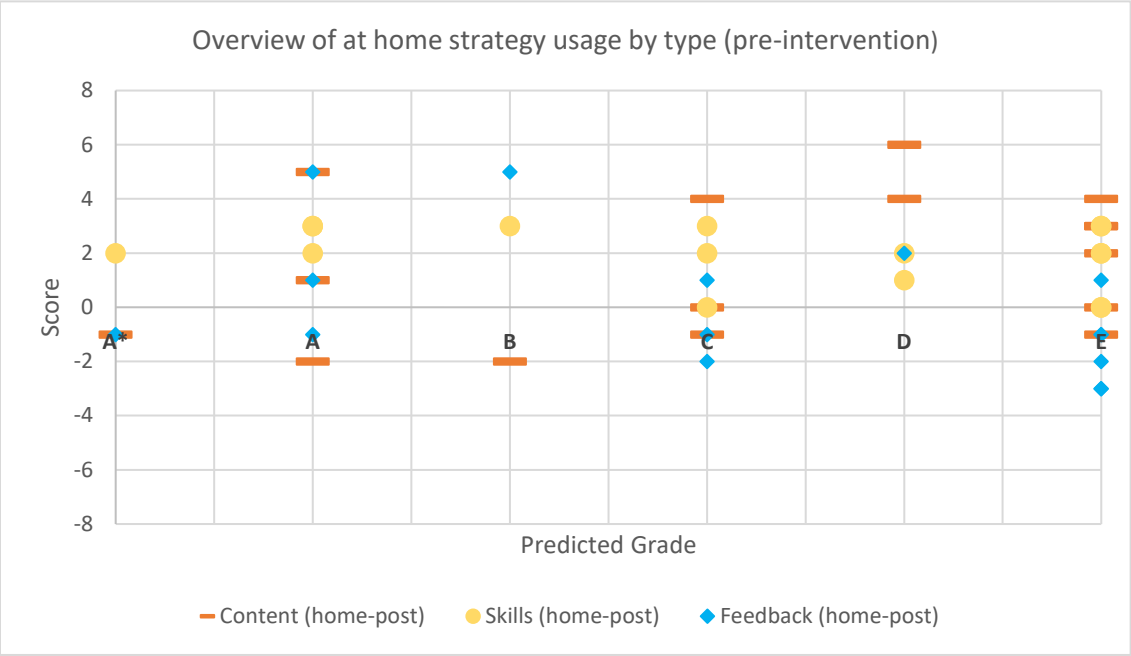


Although not all students from the year 13 chemistry cohort engaged in the student questionnaire these results provide an insight that reflects some if the findings within the

literature. Students who consistently engage in what we would define as higher order strategies (skill and feedback techniques) outperform those who primarily use lower order strategies (content) such as rereading (Muteti et al., 2021; Oakes & Griffin, 2016). The literature also suggests that lower ability students favour passive strategies (Chan & Bauer, 2016), based on the data collected I am unable to confirm whether those students with lower predicted attainment would also fall into the band of "lower ability" based on their prior attainment from key stage 4. Students within the E grade predictions in particular could be vastly underperforming rather than fall into a category of lower ability, which could account for the wider range of scores across the three strategy categories.

Post intervention variation in types of strategies used (Graph 12), shows fewer clear correlations to students predicted attainment. There are some increases and decreases of content techniques across students at all grade levels. With some of our higher predicted attainment students showing the biggest increase in this area. This very slight change from pre to post intervention with some small increase and decrease for individual students is similar for skills and feedback-based techniques with most students maintaining their scores in relation to skills-based strategies. There is more of noticeable overall increase in the feedback strategies scores across a range of students at different grade levels including A, C, D and E, indicating a greater use or greater engagement with feedback-based strategies. This furthermore supports the findings looking at the overall data and teacher feedback about student email communication post-intervention. What cannot be determined from the graphs used is if the strategies students were using within the categories changed, for instance a decrease in the use of textbooks, but an increase of the use of flashcards within the content category. Although I have looked at this change in habit use more generally in the realm of RQ3, individual changes of this nature would have required analysis of each individual student's data and was not within the scope of the research questions.

Graph 12



It is however important to note the variation between students predicted the same grades pre- and post-intervention. Although small changes to habits can be identified overall there seems to be no clear correlation between frequency or variation in strategy use and predicted grade.

5. Research Limitations

The major limitation in this practitioner action research was the timing within the school year, ideally this project would have begun after the first set of mock exams in November 2021, allowing for reflective cycles and multiple spaced interventions. This would have better supported the literature with regards to spacing and its benefits for building long term memory (Agarwal, 2019; McCabe, 2010; Morehead et al., 2015),while also better supporting the students in their exam preparation. The circumstances of the changes faced by the school while still feeling the impacts or the pandemic and the need to balance the demands of the research against teacher workload meant starting earlier unfortunately this was not feasible this academic year. Additionally, the original proposal for the project was to include all of the A-level science courses, which would have provided a wider pool of data from which to draw conclusions. Although disappointing to have to compromise on the initial idea this was necessary for the circumstances stated previously. Another addition to the original ethical approval could have been made to allow for comparison of students' actual A-level grade with their mock exam grades, however only historical data was included in the for use within the research. The late release date for A-level results would have added a significant pressure to an additional analysis step in the final stages of writing.

One of the limitations of the student questionnaire was asking students to identify their frequency of using particular revision strategies in school or at home, a better phrasing of "outside of school" may have been more appropriate as not all students revise at home. It is possible the students were able to reason that "at home" could also be considered to mean somewhere other than the school environment. In class and outside of class may have also be potential better differentiation better guided and independent revision. Furthermore, the questionnaire basis was chosen prior to intervention planning, not all strategies were then used as examples during the sessions. If the questionnaire had been written based on the

strategies students would be undertaking during the revision sessions this would have been more useful in terms of seeing a more direct impact of the revision sessions in promoting specific strategies rather than just encouraging a greater range or type.

Oakes and Griffin (2016) recommend randomization of the strategies within the questionnaire to reduce grouping of strategies by the type of technique they are (i.e., content, skill or feedback). The software used to format and disseminate the questionnaire did not allow for randomization. This means the strategies remained grouped and in the same order for “in school” and “at home”. Not all the strategies listed were also applicable to “at home” use, such as “handing in extra work” and “one-to-one discussions with teachers”. Students did however complete these sections and there some interesting points of discussion around increases in both of these categories post-intervention and links to teacher feedback.

A biggest limitation I found in terms of obtained data was the use of a teacher questionnaire rather than interview. Without the face-to face discussion I wasn’t able to delve deeper into teachers’ responses and encourage them to give more detail and gain insight as to why they chose to deliver certain strategies. I also neglected to ask about techniques they felt were effective and ineffective for student exam preparation, thus would have been an interesting triangulation with student responses and data from the literature. There was a significant amount of variation between the responses of the three members of teaching staff from a couple of words to long paragraphs, which made comparison difficult.

During the intervention phase itself student absence due to exams in other subjects meant occasionally students missed out on a particular session so did not experience the full range of devised interventions. Although students were able to access resources remotely and the ability to access learning and interact with other students and teachers via Microsoft teams is beneficial, it is not able to replace the in-class experience (Jones, 2019). As a teaching team we did endeavor to hold repeats of sessions to allow for student catch-up wherever possible.

Attendance is an issue not just in the context of this project but as part of a bigger picture that we as teachers have limited control over. It results in gaps in student knowledge but adds to the workload of teachers not just in catching students up but in tackling misconceptions and misunderstandings (Jones, 2019). The intervention itself was also not as evenly spaced as we might have envisaged it to be due to the spacing between chemistry exams with paper 2 and 3 being held within 4 days of each other.

6. Conclusions and Implications

The research findings suggest that there is a wide range of variation when it comes to exam preparation. This variation is reflected in the data obtained from both teachers regarding their own practice and from students about their in-class experience. Overall, the students within the cohort showed a wider range of strategies being used than expected prior to intervention. The focus group gave an interesting insight to how some of these strategies might be being used. The responses from students indicated findings aligned with literature that students are not always aware of effective strategies or how to properly use strategies to be of maximum benefit to them (Karpicke et al., 2009; McCabe, 2010; Morehead et al., 2015). The questionnaire data post-intervention demonstrates increase in the frequency of revision strategies being used by students but also the variety of strategies of which they are engaging in. Overall, this trend was true at school and at home. It was noted that as the exam period draws ever closer, we would naturally hope to see an increase in the amount of revision undertaken by students, however the shift in techniques used as a part of the exam preparation is perhaps not a typical change. The experience of the revision programme itself was positive for the staff involved and they were encouraged by the active engagement and participation by students. The consistent attendance throughout the sessions and noticeably increased interactions with staff outside of lessons was a welcome change from the indifferent nature of the year group previously experienced. As a result of the inconclusive nature of the findings of RQ4, it is important as teachers we don't assume based on attainment students know what's effective or have a range of useful strategies to draw upon. Within lessons we should encourage all students to trial and test strategies regardless of ability or current attainment.

From the discussions within the student focus group and teacher questionnaire responses in particular, I believe there is an interesting point to draw on that both students and teachers

separate what we might thing of a learning activities in class and revision strategies. Overlooking the intertwined nature between the two, learning strategies are in effect revision strategies just used in a different context. One for the immediate use and processing of information within the lesson and the other used with focus of achieving exam success. The ongoing consideration for me in my role as part of the science leadership team is how we can enable students to engage these techniques more fully outside of lessons might aid their long-term learning of concepts and ideas. Rather that discounting them as something that only a teacher can facilitate in the classroom. In the context of teachers, I believe the answer lies in education and continued professional development.

It is clear from this project and the literature the need to equip teachers with knowledge behind what they are delivering and awareness of the specific benefits of strategies. Empowering teachers to feel confident within the classroom to give students suggestions where techniques can be applied to other areas of the course. As well as being able to suggest useful and effective strategies based on empirical evidence rather than the reiteration of the same ideas; mind maps and flashcards (Dunlosky et al., 2013). When teachers do choose to demonstrate techniques like mind maps and flashcards ensuring they know how to guide students in the most effective ways to use these resources, rather than as notes in a different format. The ongoing aim as a result of this project is to provide wider faculty training, supporting individuals to become in-house experts that can share good practice and be observed. Teachers leading the cascade of knowledge to other teachers (Goodbourn, 2009). By doing this, it will ensure that effective teaching of revision strategies is happening at all levels, reducing the need of KS5 staff to address misconceptions in revision strategies and exam technique. Just implementing these changes at KS5 would potentially disadvantages students who by that point are more likely to be committed to using ineffective methods and more reluctant to change (Feudel & Dietz, 2017). Teachers are time poor so guidance on what

is effective and how to use it is vital to long term, constituent implementation (Dunlosky et al., 2013).

On a specific level there is changes to be made in how we teach students to use mark schemes rather than just an explicit list of what is correct content. Identifying the nuances within them the “must contain” terminology and phrases, and conversely terminology and phrases that examiners will “ignore” and will not be counted. The use of levelled marking criteria for longer answer questions and the ability for students to correctly identify “errors carried forward” in their own calculation, rather than the focus solely being whether it is right or wrong. This should enable students to see the value and learning opportunities in testing (Morehead et al., 2015). Alongside this both teachers and students engaging in the use of examiner’s reports, this is not currently common practice within our science faculty and is a point of discussion moving forward as a result of this project. It is likely that this will initial take the form of key stage leads such as myself, disseminating key headlines from the examiner’s reports to the class teachers to be deliverable and accessible to students.

Embedding strategies and techniques as a standard component of the A-level chemistry course is already in progress. Ongoing embedded practice can improve student engagement and skills long term, rather than short term implementation of interventions (Feudel & Dietz, 2017). Adaptation of resources from the intervention phase are going into the permanent scheme of work for current year 13 (2022-23) and future year groups. During the project all intervention sessions and resources were sourced or created by myself individually which not feasible long term, for all strategies to all be developed by one person. By building on the work of the intervention as a starting point, teachers involved in the project are keen to develop further resources. This kick-starts a group of teachers who are engaged and keen to learn and develop their expertise in this area. As a result of the findings from this study there will include some aspect of including why certain techniques are more effective that others,

this should allow students to have greater regulation over their study habits by being able to choose techniques that are more beneficial and make better use of their time (McCabe, 2010).

By ensuring revision strategies and exam techniques are an inbuilt part of the curriculum, also brings me reassurance as Head of KS5 science, that the teachers are delivering this knowledge, and not avoiding it. It also takes away any uncertainty about what is being cascaded to students in lessons, when students claim to not have been taught how to revise, we will know they have. It is however important to remember that there will always be variability in students acting on instruction (Morehead et al., 2015), as with all elements of teaching, student engagement is key. Students are engaged when teachers are. I am hopeful that the outcomes of this project will allow for implementation of some of the ideas across the other A-level sciences courses within the next academic year.

Although on a small scale, within this research we can still see hints of trends that reflect the wider picture of students' attitudes to exam preparation. Students' over confidence and commitment to using strategies they know are not helpful (Karpicke et al., 2009; McCabe, 2010). Students "illusions of competence" affects how they choose to study (Karpicke et al., 2009). There is a bigger picture of developing students' metacognitive awareness and improving self-regulation. There are already encouraging discussions in progress with the Deputy Head of Sixth Form to look at a collaboration to develop these skills in our students. By investing time and energy into developing these skills within our students they will be able to prepare more effectively for examinations in all of their subjects not just sciences.

"Practise should not be a punishment. When you invest time and creativity to make practice fun, people will be motivated to participate, not out of sheer enjoyment but also because you are communicating an important message: this is something positive that is worth our time" (Lemov (2012) as cited in Oakes and Griffin, 2016)

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8. Appendices

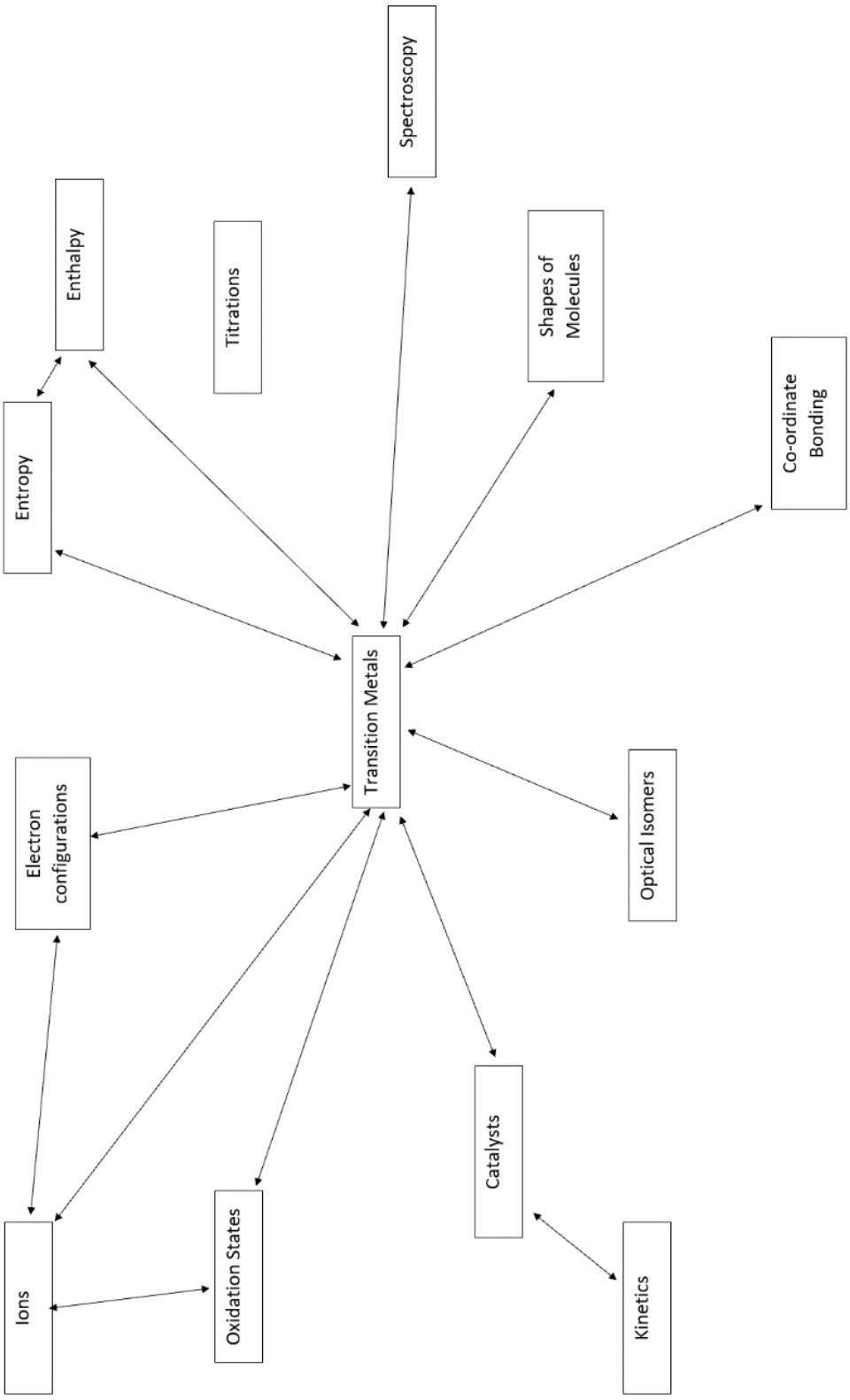
Appendix 1: Student Questionnaire

(C)- Content Technique (S)- Skill Technique (F)- Feedback Technique

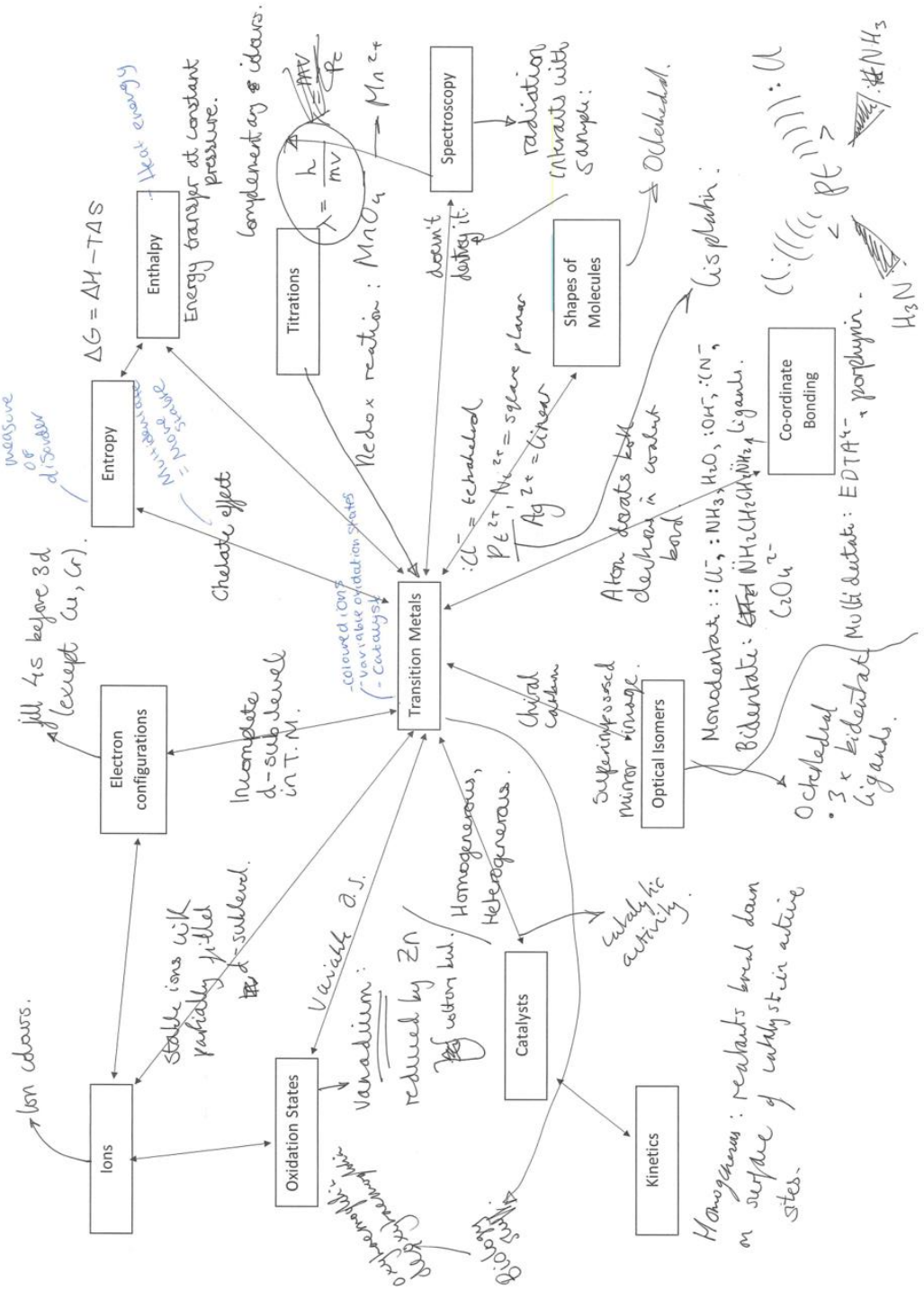
	In school:			**At home:**		
	Always	**Sometimes**	**Never**	**Always**	**Sometimes**	**Never**
Reading through class notes (C)						
Using class resources from Microsoft Teams (C)						
Using the course textbook (C)						
Mind-maps/Spider diagrams (C)						
Making/remaking class notes (C)						
Highlighting and colour coding notes (C)						
Making/Reading Flash cards (C)						
Using a revision wall to display your learning (C)						
Writing exam answers under timed conditions (S)						
Reading and analysing model answers (S)						
Using past exam questions and planning answers (S)						
Marking your own work using a mark scheme (F)						
Analysis of mark schemes and examiners reports (F)						
Working in groups with other students (F)						
Comparing model answers against your own (F)						
Creating your own exam questions (F)						

Handing in extra working for marking/feedback (F)						
One-to-one discussions with teachers (F)						

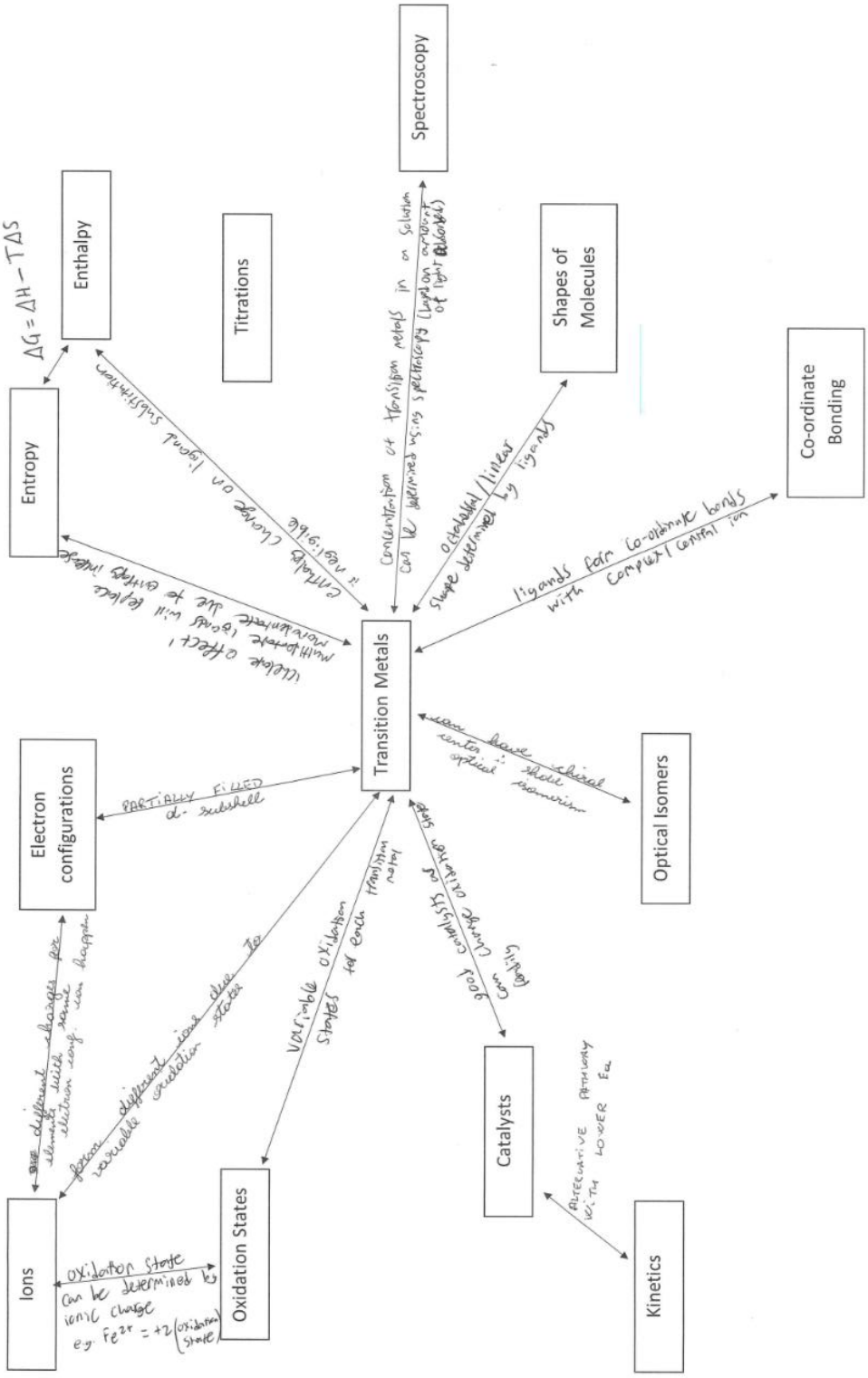
Appendix 2: Transition Metals Concepts Link Map



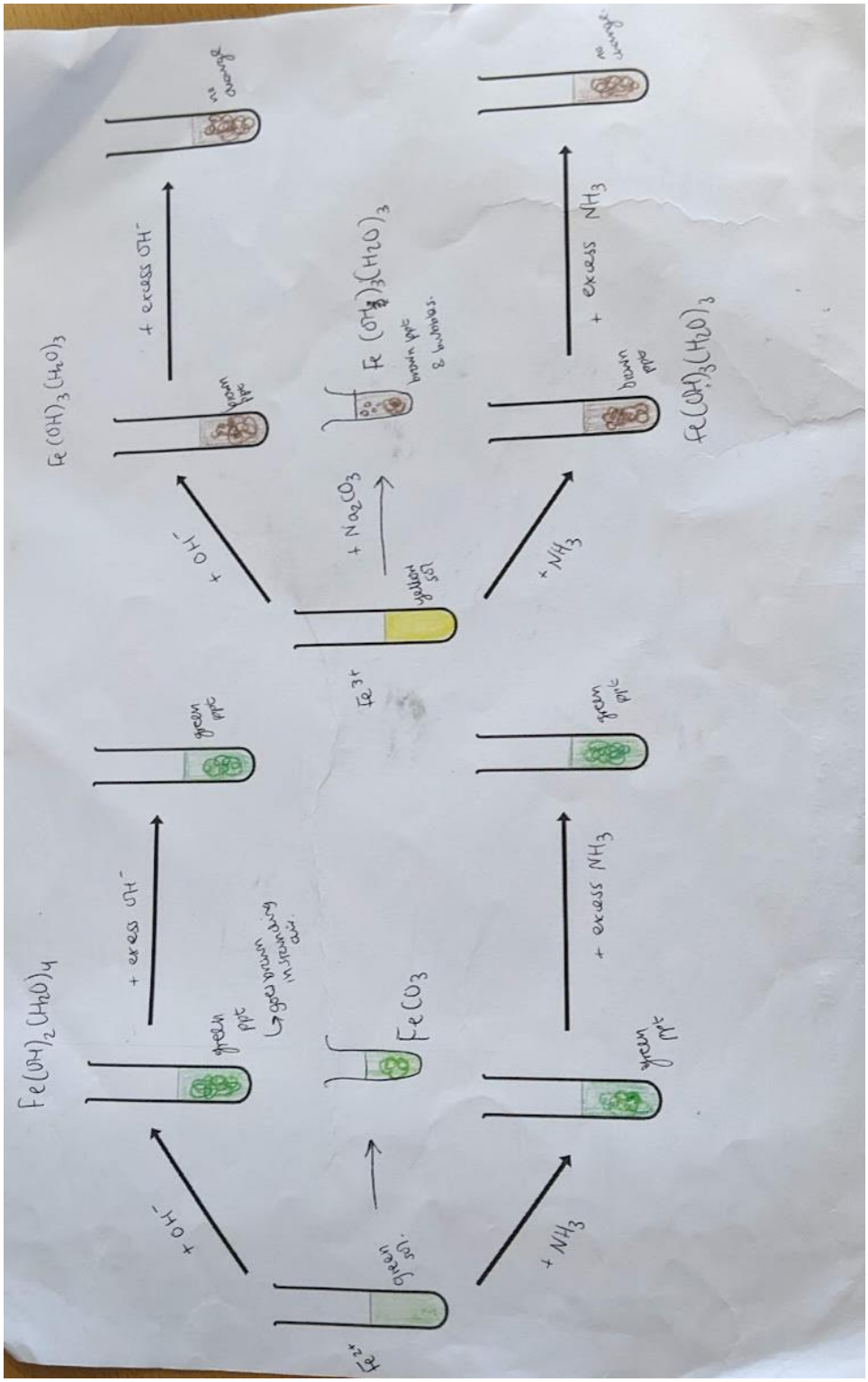
Appendix 3: Student Work Example Transition Metal Concepts Link Map



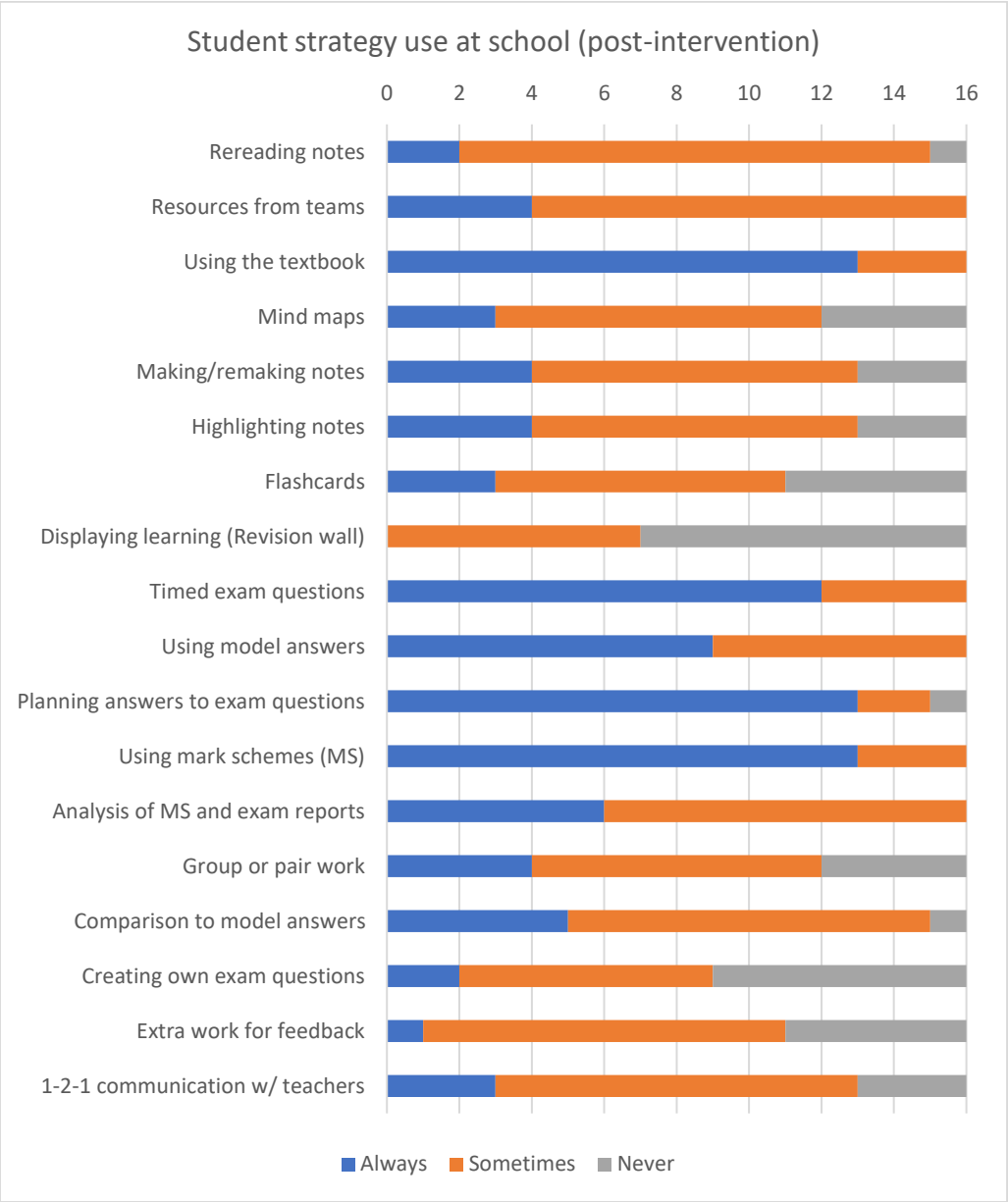
(Appendix 5 continued)



Appendix 4: Student Work Example: Reactions of Aqueous Ions Dual-coding



Appendix 5: Post-intervention strategy overview graphs



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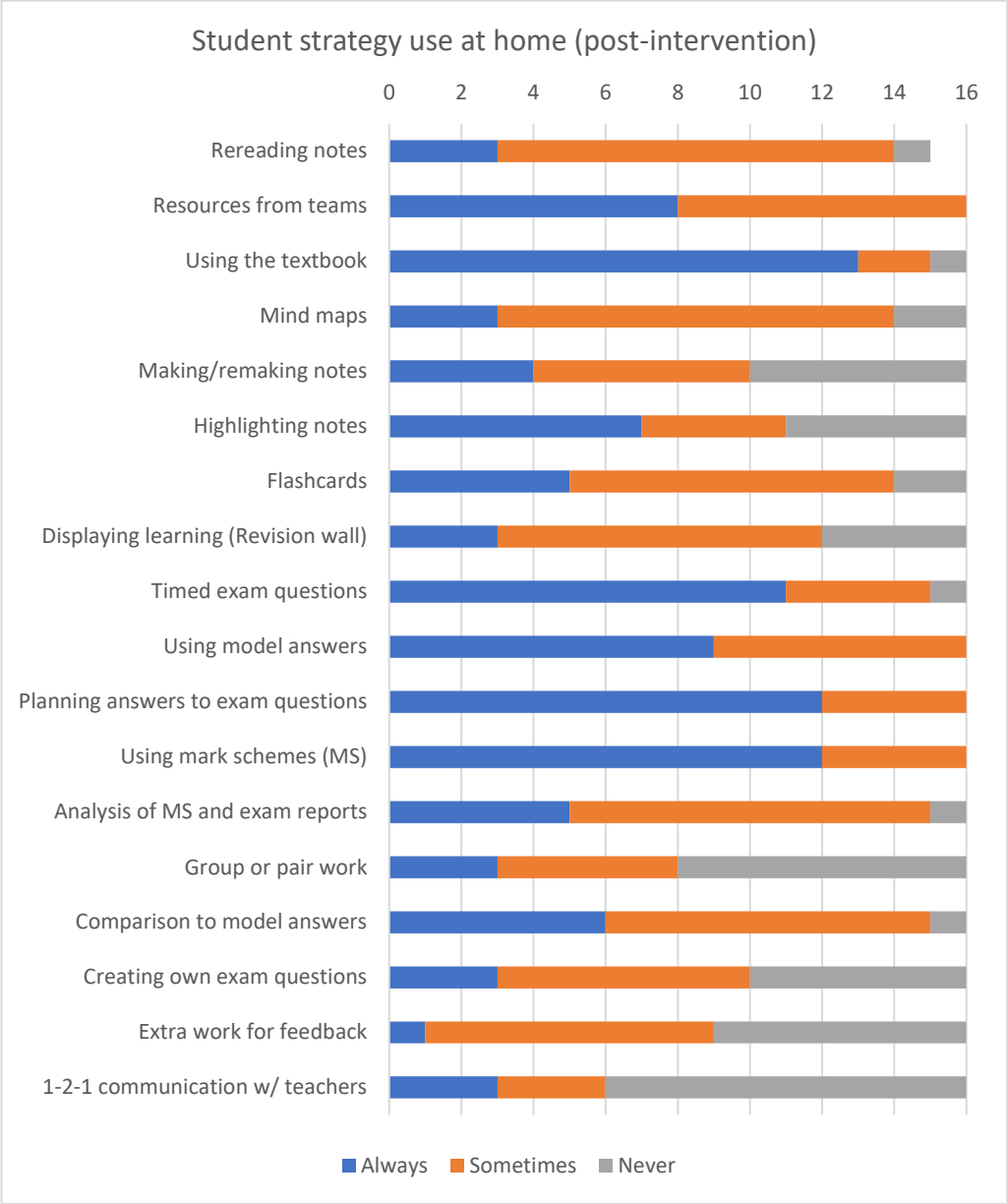

Appendix 6: Graphs for use of exam focussed strategies at home pre- and post-intervention