Literacy in science: exploring barriers to literacy in secondary school science and the impact of an in-class intervention.

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A Research & Development Project

Submitted for the MSc in Learning & Teaching 2022

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Literacy in science: exploring barriers to literacy in secondary school science and the impact of an in-class intervention

Abstract

This practitioner research project investigated key stage three students' perception towards literacy in science lessons, the barriers towards literacy and the strategies that can be implemented to improve literacy standards.

Pupils in two year 9 classes, one a high attaining set and the other a SEND class, completed assessments investigating their attitudes towards literacy and questions to quantitively assess their current working level, small semi-structured interviews were also conducted to obtain qualitative data and to allow students to discuss their ideas and opinions with greater freedom. A control group with students of similar attainment was utilise to strengthen any findings of this study. Pupils participated in a six-week intervention to target specific aspects of their literacy skills set, including explicit teaching of subject specific vocabulary and the use of vocabulary books, as well as engaging the students in frequent active reading tasks and dedicating time to enhancing their written work. Post intervention data collection followed the same mix-methods approach of interviews, assessments and evidence of students' classwork to identified improvements.

The findings of this small-scale research project are very positive, examples of students work show a marked improvement in the quality and quantity of their written work through greater use and understanding of key terminology and greater depth in their explanations. Pupils reading fluency also increased significantly with a

14.2% increase in their reading ages compared to the control groups 4.5%. The findings of this study are promising and will allow for greater exploration as to how these techniques and strategies can be applied across the science department but also strengthen cross curricula links.

Contents

Introduction

As a science teacher my role is to facilitate students learning and discussions of the world in which they live and to share the discoveries of other scientists, whether that be investigating the properties of diverse substances in chemistry, exploring the microscopic detail of living tissues in biology or theorising about the universe in physics. Although science itself is a vast and complex wealth of sub-disciplines, there is a unifying feature that binds them together and that allows the observations and knowledge of scientists to be shared, literacy. Literacy is the means by which scientists communicate by, without which ideas cannot analysed and developed, without literacy there is no science or to quote Vygotsky (1987, p.131) “the concept is not possible without the word.”

Literacy as communication tool is vital in education, not just in traditional English lessons, but all subjects, and beyond the classroom literacy allows us to experience and interact with the world. Evidence shows the literacy levels is one of the strongest predictors for outcomes later in life (Education Endowment Fund, 2018) strengthening the importance of schools doing their upmost to support the literacy development of their pupils. In the context of science, the necessity for high literacy standards becomes even more apparent. When pupils enter the classroom, they are exposed to a plethora of new language which they are expected to know and use with confidence and fluency. In fact pupils must be able to do this in order to meet the expected standards for GCSE examinations which requires students to have a reading age of 15 years and 7 months, roughly equivalent to students chronological age, despite this, research shows the average GCSE candidate has a reading age of 5 years below this (Huff Post, 2012). This mismatch in students chronological age and reading age makes the GCSE papers wholly inaccessible to some students. However, with nearly 90% of students leaving primary school having met the required levels of reading, it would appear that pupils are at best, failing to progress, or at worst, regressing with their reading ability throughout secondary school (BBC News, 2012). While disheartening this is perhaps not surprising as evidence suggesting that children's interest in reading as well as the quantity and difficulty of the texts they read decreases each year throughout secondary school (TES, 2018).

The National Literacy Trust suggest schools "could be depriving [pupils] of the opportunity to succeed both academically and in life" (BBC News, 2012) and go further by suggesting "that the strongest factor affecting secondary pupils' science scores is their literacy levels" further emphasising the urgency of a literacy intervention to improve both academic and life outcomes (National Literacy Trust, 2018).

Regardless, the pivotal role that literacy plays in education and furthering life opportunities is undeniable, as schools it is our role to allow each pupil every opportunity to develop these skills, to set high expectations of them and to foster their love of learning. From my own perspective, literacy skills are the single biggest predictor of academic achievement in science (Schools Week, 2017) with both reading and writing ability being key functions in students becoming competent scientists. Further to this is has been reported that "literacy is key to achieving genuine social justice and that successful literacy teaching is powerful enough to overcome any disadvantage due to socio-economic status" (Schools week, 2017) which is a particularly useful and powerful statement to work towards given the context of the school this research project is conducted in.

In this school, literacy is an emerging school wide priority and therefore developing a strategy to specifically target literacy skills in science is imperative and well supported by senior leaders. Considering the potential benefits of this practitioner research the following questions were considered for the focus of the following literature review.

1. Why is literacy important in science?
2. Why do students struggle with literacy?
3. What strategies can be implemented to aid students' literacy skills?

Literature review

Throughout my teaching career I have observed that literacy is one of, if not the biggest barrier to learning and also academic success, this has been echoed by Shanahan and Shanahan, (2008). Wellington and Osborne concur and go as far to say that "every science lesson is a language lesson" (2001, p.2), highlighting the importance of language and literacy without which learning is virtually impossible. Without a reasonable level of reading and writing students cannot access the curriculum and importantly cannot communicate their findings and beliefs to their peers or teachers, within our classrooms "language is the principle means of communication" (Osborne and Dillon, 2010, p.135; Mercer et al., 2004,) with literacy being the ability to "read, comprehend and evaluate written science" (Wellington and

Osborne, 2001, p.66) something which the teacher is a facilitator of acting as the "translator between the discourse of science and the language of the pupils" (p.66).

There is a growing body of research recognising the fundamental role of developing literacy in science education (Norris and Phillips, 2003) however this drive to improve literacy standards is competing with students decline in their enthusiasm for the subject, which decreases from the start of secondary school (Osborne et al., 2003; Terry and Quinn, 2010;). Science teachers are therefore faced with the challenge of balancing the need for greater fluency and accuracy in literacy alongside re-inspiring students whose motivation for science is dwindling.

What is literacy and scientific literacy?

The importance of improving literacy in the classroom has been well documented by (Wellington and Osborne, 2001; Quigley, 2018, Driver et al., 2015), however it is of course imperative to define the term literacy in the first place. Literacy itself has previously been defined by Ofsted (2011) as the "ability to read, write, speak and listen", however this can also be expanded to include "the ability to critique and question" (Kenna et al. 2018, p.217). It is important at this point to note that literacy in the context of science is not the same as the term 'scientific literacy', although the terms sound similar and the later has been in use since the 1950's when Paul DeHart Hurd applied it to the understanding and the justification for implementing science in education (Salmon, 2007; Čipková et al. 2020). Despite this, there are very few specific agreed definitions of the term in academic writing, Salmon (2007) suggests this may be because our interpretation of scientific literacy is constantly evolving along with science itself. Although much of the literature disputes precise definition, something that is unanimously agreed upon is that scientific literacy is important, with Miller (2007) claiming it is one of the few things that both European leaders and the United States of America agree will benefit societies future and something that should have more promotion and resources in order to create a generation of "scientifically literate citizens for the rest of their lives" (Ogunkola, 2013). Many researchers have tried to expand the concept of scientific literacy over the years, starting from Paul DeHart Hurd's description of scientific literacy being a way of comprehending science and its applications (Laugksch, 2000), to Durrant's (1993, p.84) what the general public "ought to know about science" approach through to Brewer's (2008) more recent concept of being able to interpret science in the media and infer judgement about an article's validity, accuracy and bias. Scientific literacy represents the understanding of the disciple of science itself and the process of science works, a complex set of skills that can only be nurtured and enhanced by a competent backbone of literacy tools.

Although two discrete terms, literacy in science and scientific literacy are closely related, without the first we cannot have the second. Literacy as a skill underpins all aspects of teaching across the curriculum, as language is the primary mode of communicating ideas and learning. It is only through effective use of language and literacy that we can begin to develop scientific literacy, that is to explain the world in which we live through the use of scientific concepts, phenomena and methods (National Research Council, 1996; Bybee et al., 2008). The scope of this research is investigating the barriers to literacy in science and explore ways of developing this, which fundamentally feeds directly into scientific literacy and raising a generation that are capable and confident communicators of science.

Why is literacy important?

Literacy is a fundamental component for allowing us to understand the world around us, in the context of science it allows us to make informed decisions with regards to health, technology and nature and also to be critical of the media we consume (Ogunkola , 2013). Developing literacy allows individuals to increase their scientific literacy, something that is far from limited to the academics (McPhearson, 2008) and instead it is inclusive of everybody at every educational level, whether somebody intends to pursue a scientific career or whether it is a skill that allows an individual to understand a newspaper article or tv documentary. As Brewer (2008) notes, scientific literacy allows people to be sceptical of presented information, this crucially allows people to create informed decisions about their life and create reasoned judgements. Heller (2005) delves further into this by highlighting that scientific literacy is arguably more important now that it ever has been, due to the technological advancements of the 21st century and how this plays an increasingly significant role in not only employment and innovation but also in leisure activities. Ogunkola (2013) summarises Heller's findings by concluding that "high levels of scientific literacy make a citizen competitive and employable, particularly in workplaces where an employee is expected to be innovative, role of scientific literacy cannot be overemphasised" (p.270).

In terms of society, having a population with high degrees of scientific literacy is vitally important. Laughsch (2000) and Walberg (1983) have noted that countries will always have a continuing demand for scientists and engineers to sustain industry and to participate intellectually in the economy and consequently scientific literacy should be deemed as a “form of human capital” that has the potential to influence nations (Ogunkola, 2013, p271). Another argument, proposed by Shortland (1988) is that scientists depend on public support and a shared understanding about the processes, outcomes and possibilities of science. Covid-19 has demonstrated this view, where the general public have needed to have, or develop a degree of scientific literacy in order to comprehend an everchanging pandemic and come to terms with new terminology and to access the information to a level that allowed them to make considered approaches towards testing, vaccinations and treatment The Royal Society (1985) also discussed this and detailed how improved scientific literacy will help aid everyone’s personal decisions with regards to diet, smoking or medical screening, but crucially to also recognise mis-information a scientifically literate population is one who is “confident and competent to comfortably handing science” (Ogunkola, 2013).

With all this in mind and with Wenger (1998, p.105) noting that “learning to become a legitimate participant in a community involves learning how to talk” the importance of developing and subsequently enhancing students' literacy skills as a means to develop scientific literacy, remains an important role of all teachers (Osborne and Dillon, 2010). If students are to develop into confident citizens of the world, the training for this begins in the classroom, fostering and nurturing the skills of literacy.

Why do students struggle with scientific literacy?

It is well documented that global scientific literacy is disappointingly low (Miller, 1998; Miller, 2007; High level Group on Science Education, 2007) and has been estimated to be only as low as 12% of Americans qualifying as scientifically literate and 25% of the population as partially scientifically literate. Surprisingly, some economically developed European countries like Portugal and Greece were estimated to have 91% and 88% respectively of their population being scientifically literate, this highlights potential areas of future research to explore these comparators. Given the importance of scientific literacy for a well informed, economically active country, this raises many questions about identifying specific areas of difficulty for students and how schools should be teaching scientific literacy to address this intellectual imbalance.

Reading, writing and speaking is the basis for communication, without it students are unable to effectively convey their observations of the world around them, without literacy students are unable to fully participate in society and poor literacy standards are strongly correlated with less desirable life outcomes (Savolainen et al., 2008). The Education Endowment Fund, alongside Oxford University, have shown that students from disadvantaged backgrounds are significantly less likely to continue studying science beyond the age of 16 and while they appreciate that there are a multitude of factors for this, they remark that the "inextricable" (Quigley, 2018, p106) link between reading comprehension and academic success in science must be a major influence. Savolainen et al., (2008) found that Finnish school girls outperform their male counterparts in every aspect of their reading, writing and spelling assessments and for the boys "problems with reading and spelling may have affected their school motivation and led to reconstruction of their educational goals" (p208) with these issues having a "stronger depressive effect on their educational career" (Savolainen et al., 2008, p.209). Developing reading ability within schools is not simply about educational attainment, but about life prospects and alongside a multitude of other factors it can be seen as a predictor for outcomes later in life. With this in mind literacy should be considered a main priority in every school, to ensure students are given the best possible start in life and to prevent a culture of social inequality where currently one fifth of school leavers are illiterate (Murphy, 2019).

In 1971 Postman and Weingartner remarked that nearly everything we "customarily call knowledge is language" (p.103), in the context of a science classroom this simple yet apt statement underpins many of the reasons students appear to struggle with science, learning science often requires learning a new language with a wealth of abstract concepts and obscure terminology, however the literature would suggest that this language development is not always targeted correctly in the classroom.

To investigate the barriers to literacy further three several key areas shall be explored in greater detail, these being; terminology in science, reading and writing.

Terminology

If "every lesson is a language lesson" (Wellington and Osborne, 2001, p.2) then understanding vocabulary and using it correctly must be at the heart of every lesson as without the words themselves, there can be no communication and sharing of knowledge. Although we might typically consider vocabulary to be primarily associated with English and Modern Foreign Languages lessons, who are very skilled in teaching terminology Quigley (2018) and Childs et al., (2015, p2) highlight the importance of teaching vocabulary in all subjects, science in particular. Childs et al., (2015) makes a comparison between English literature and Chemistry, noting that not understanding one word or even sentence in a book hinders the understanding of the story very little, however in chemistry a similar misunderstanding can lead to a complete breakdown in learning with misconceptions forming which requires further work to readdress. The precise and fixed meaning of words in science can often lead to misunderstandings for those who lack the knowledge of scientific vocabulary, something that can make the subject feel alien to students and can be challenging for pupils to relearn. It is therefore imperative for teachers to recognise the words that are most likely to cause difficulties and to embed strategies to teach the language of science in their teaching practice. To investigate how students' scientific language can be improved Casssels and Johnstone (1985) developed a list of 95 words that they believed to be the most challenging for pupils, they concluded that many of the words students struggle with are not technical subject specific terminology, but more everyday words used in the context of science, these findings have also been echoed by Quigley (2018). Their list of challenging words included terms like 'characteristic, device, effect, estimate and relative' and while their analysis found that a large number of words were understood to a satisfactory level, they also noted a worrying pattern where many terms were interpreted to be the direct opposite of their true meaning e.g., “initial = final”. As Wellington and Osborne (2001, p.12) inferred the progression in understanding terminology was not linear with increasing student age, therefore concluding that “no one should take progression for granted” (p12) thus further emphasising the importance of consistent and continued explicit teaching of terminology throughout education. Very similar to this Pickersgill and Lock (1991) examined the use of non-technical words frequently used in the science classroom, they found similar trends that words such as ‘adjacent, factor and valid’ were poorly comprehended and like Cassels and Johnstone found, many students assumed the antonym of the word rather than its correct meaning. Interestingly they found no gender differences, which is contrary to the findings of (Savolainen et al., 2008) who found that boys performed consistently worse than girls in every measure of reading, spelling and comprehension test they conducted. Consequently they highlight the importance of science teachers dedicating specific learning time to the teaching of vocabulary. Further to this, Meyerson et al. (1991) conducted a study of American third and fifth graders and their understanding of dual meaning words used in a scientific context, their findings concurred those of Cassels and Johnstone (1985) that students need to be taught the “multiplicity of word meanings” (Meyerson et al. 1991 p, 427; Roe et al., 2013scaf). Meyerson’s study focused directly on students understanding of scientific words with dual meaning such as ‘mass, organ and matter’ and although they remark that some students used these words in completely the wrong context; mass being “something at church” (Wellington and Osborne, 2001, p13) which while humorous on one level, reaffirms the need for language to be a priority in science education.

When exploring subject specific vocabulary in science there is a degree of hierarchy in terms of the perceived ease of learning such words which teachers should consider when planning and delivering lessons. Terms such as trachea have a very precise and fixed meaning, they are naming words, where although students may not have used the term outside of the science classroom, they are words that can be easily assimilated to tangible objects. These "level 1" words such as trachea (Wellington, 2001, p20,) are often synonyms for everyday vocabulary, giving new names to already known items, or giving new scientific names to unfamiliar objects. The later may refer to laboratory equipment which students are unlikely to have previously encountered, or these level 1 words could be for parts of cell as they are not directly observable day to day. These words are considered easier for students to learn and use as they are unlikely to be mistaken or confused for other objects/processes.

Wellington's next taxonomic rank "level 2" words are process words, within this are two sub-categories processes which can be learnt by "ostensive definition" (Wellington and Osborne, 2001, p.21), that is to show the students, such as crystallisation, evaporation or combustion. The second group of process words are processes which are not directly observable like evolution, although this particular example does overlap to an extent with the level 3 concept words. Depending on a student's knowledge, those processes that are easy to demonstrate are relatively simple for students to understand and use terminology correctly, however processes that feel more abstract to students and are unobservable are generally harder to learn.

The largest category of words identified by Wellington is concept words, these often present the most difficulty for students eg. “salt”, “work”, “energy” and “power”. These examples have very simple meanings to the non-scientist and are often used without thought. However, this colloquial use of language creates a learning barrier when tasked with using these terms in the context of science, where the academic definition and the everyday meanings are often are contradictory or incomplete. These are the words that cause the most confusion for students and consequently are the ones educators should pay the most attention to in order to identify and correct misconceptions.

Wellingtons taxonomy of words can be used as a helpful tool for teachers to structure and explicitly teach vocabulary in the science classroom as Wittgenstein (1953) highlighted “there can be no such thing as a private language” (Wellington and Osborne, 2001, p23) and so for clear communication and academic attainment is it critical for students to be competent in the language of science.

Strategies for improving vocabulary

With the sheer volume of new terminology presented to students and the use of tier three words with meaning at times contrary to everyday usage, the “importance of word depth and a strong focus on word consciousness is nowhere more important than the science classroom” (Quigley, 2018, p.106). This coupled with GCSE examiners noting that one of the most common mistakes made on exam papers is the “inaccurate use of specialist terms” (Tyrer, 2018, p.117), developing strategies to reduce, or better, eliminate this problem are urgently needed. It is important for academic success as well as in life that students are able to communicate clearly, concisely and with the specific terms required in that context, its is also important that students are able to spell these words correctly. Accurate spelling conveys an image of credibility and inferred intelligence and while it can be argued that in a modern age of digital communication with spelling and grammar checkers that precise spelling may become a thing of the past. There is a wealth of resources that argue spelling always was and remains to be an important skill for students to foster, with spelling and reading being skills that enhance each other (Stone, 2021). With up to 90% of words, especially in science having origins in Latin or Greek (Ross et al., 2015) it is relatively easy to teach students the root meanings of words, this in turn allows students to predict meanings behind future unfamiliar words and enhance their analytical skills and independent learning (Moats, 2005 p21). Learning the etymological histories that root many of our English common spelling patterns is one of the greatest skills we can teach students, Quigley (2018) and Crystal (2013) strongly recommend.

One of the easiest methods to implement for improving vocabulary and spelling is by utilising spelling tests. Croft (1982) examined the validity of three measures for improving spelling, a traditional dictated word test, a proof-reading exercise to identify incorrect spellings and a multiple-choice test. Croft's research showed that dictated word spelling tests correlated the most highly with spelling accuracy although students found it easier to identify mistakes in the proof-reading activity than to produce the correct spelling themselves, with students recognising 11% more spelling inaccuracies than they are able to correct themselves. These findings near replicate those of Freyberg (1970), Brody (1944) and Moore (1937) consequently, a mixture of a proof reading and word dictation activities should be used in lessons to aid spelling ability.

Writing

Writing in science is very closely related to the use of vocabulary, although the later of course could refer to oral use of language, but this is beyond the scope of this research. At the same time, it is very difficult to separate the processes of reading and writing, however “when writing is combined with reading, students’ learning can grow exponentially” (Chamberlain and Crane, 2009, p.67). Prain (2006) identified two distinct functions of writing in science, primarily as means to communicate understanding of scientific concepts, but secondly to write in different styles for a range of audiences, with writing activities that involve synthesising information promoting deeper learning than rephrasing task (Klein, 2006). Writing in science can often command a significant proportion of lesson time (Newton et al., 1999 & Davies and Greene, 1984), however Osborne and Collins, (2000) suggest that a lot of this time is spent copying notes either from the book or board; a very passive task requiring little understanding in return for very little educational gain and one of the least effective strategies for knowledge attainment (Eggleston et al., 1976). Copying notes often leads to increased boredom and disengagement for students and although it is often viewed by teachers as an unfortunate necessity, as students need a record of the knowledge for revision and examination purposes. Of course, while students will need a log of their learning, it would be naïve to think copying text without the time to comprehend what is being put to paper could ever enact meaningful change and develop the skill of writing itself. Educators must plan for active writing in class; that being writing that is structured, purposeful and allows for reflection of the skills being targeted. By consciously teaching writing in scientific genres we allow students of all abilities to emulate 'real scientists' Rivard (2004), who spend a significant amount of time writing and reporting their findings.

One of the major differences between writing in science compared to other subjects and similarly one of the areas students struggle most with, is the style of scientific writing. In many subjects such as History and English there is a narrative, a personality or a perspective; something that is notably absent in scientific writing. Science prides itself on being an objective source of knowledge written conventionally in a passive voice, distancing itself from subjective accounts. Although students most commonly record their observations with the use of personal pronouns eg. "I poured, we added, they measured" which makes science appear "less alien" (Wellington and Osborne, 2001, p65), this comes at the cost of true academic scientific writing, something which teachers must try to readdress.

Strategies for improving writing in science

One of the main strategies for improving writing is the use of scaffolds in order to organise ideas and structure the written work, this includes writing frames with sentences starters, which with increased practice can slowly be withdrawn to foster greater independence (Wellington and Osborne, 2001). Writing frames are beneficial for multiple aspects of science education, including experiment write ups, report writing and producing explanations, the later being particularly useful for examination skills. As previously discussed the main genre and style of writing is informative or instructional and using a passive voice, however there are several opportunities within science lessons for students to develop other literacy techniques, Wellington and Osborne (2001) suggest several ways of changing the audience and the genre which can be implemented as plenary activities or as extended writing tasks. This could include writing to a younger pupil to explain a concept covered during the lesson, or creating a poem to summarise learning. Prain and Hand (1996) suggest increasing the diversity of writing opportunities in science is not only enjoyable for students but improves their understanding of key ideas. However, the use of these tasks will not promote true scientific writing styles and so this must be considered when planning learning activities with Keys (1999, p 124) remarking that it "may actively work against" many of the goals of scientific writing.

Reading

Although effortless for many, it is crucial to recognise complexity of the steps in learning to read, in order to empathise and understand how and why many students will struggle with it. To read a simple sentence, students need to be able to visually recognise and process the shapes of the letters, their position within the word, assume any background knowledge, comprehend the individual words and then sentence structure and coordinate this with the eye movements needed to read at pace. With all the steps laid out in such a way, it becomes more apparent as to why reading is one of the most researched topics in education. Developing the skill of reading is a process primarily thought of as the role of early education providers, however students must have word comprehension and also read with fluency and accuracy so they can assimilate meaning, an ever-evolving task of increasing complexity throughout education (Vellutino et al., 2004).In the context of science, many of the processes needed for comprehension such as prediction, inferring and knowing key vocabulary are replicated in reading (Fang et al., 2008; Conley, 2008) with Fang et al., (2008, p.2083) remarking that "both knowledge of science content and knowledge of reading are essential". However, despite the undisputed importance of reading many secondary school students are "underprepared to comprehend science texts" (Roberts et al., 2012, p.40) and lack the skills needed to improve, something which is only exacerbated for students with learning difficulties (Craig and Yore, 1995; Kinniburgh and Shaw, 2009).

When students begin to read, their spoken language ability is one of the biggest predictions for reading ability (Nation, et al., 2010) making it concerning that approximately one in fifteen students starts school with impaired language (Rastle, 2019), it has also been noted by (Clarke et al., 2010) that targeted oral language interventions have a direct impact on reading ability.

Given the undoubted importance of reading for academic success and as a life-skill, it might be expected to consume a significant amount of lesson time and attention from educators. It is therefore disappointing to learn from Lunzer and Gardner (1979), that students in key stage three only spend 9% of their science lessons engaged in reading, with this only increasing by 1% for older students; this would translate to students using just 5-6 minutes per lesson developing their reading proficiency. Furthermore, Lunzer and Gardner discovered that this short time was limited to burst of no more than 30 seconds. It seems inconceivable that short exposures would provide opportunities for students to stretch their reading comprehension to a meaningful level. While we might like to assume that over 40 years later this is no longer the case, it would appear that little has changed, with Wellington and Osborne (2001) echoing similar findings over 20 years later. Wellington and Osborne reference that reading is very rarely planned for in science it is instead used as an extension activity or as a punishment for disruptive students with both frequently being given textbook work which is highly unlikely to inspire students' love for science.

Science is largely considered to be a practical subject, for many students the first thing they ask on entering the classroom each day is "*are we doing a practical*", students tend to enjoy 'being scientists' and completing hands on tasks, but what students rarely appreciate is that real scientists spend a lot of time reading too (Bulman, 1985). Reading is an important skill for life, but with reference to science it will become the means by which students will, in the future, interpret the world through. Students need to develop their analysis, comprehension and critical thinking skills through text so that they can make informed and reasoned judgments about science in the news and to allow them to review information with scepticism and ask intelligent questions.

Having established a rationale for the importance of reading and briefly explored the failures to incorporate reading in the curriculum, it is vital to recognise why students find reading challenging. As previously established, students often struggle with the language presented within science, both the volume of new terminologies or the use of previously familiar words in a new situation; however, the sentence structure and use of non-scientific terminology also plays a role in the accessibility of science texts. Bulman (1985) referenced the use of connectives and qualifying words such as most, some and majority can make sentence comprehension harder and put a "barrier between the reader and the information"(p.21). Hall et al (2015) echoes concerns regarding the readability of school texts, highlighting that low local cohesion texts are harder for students to comprehend compared to higher local cohesion writing, which aids students understanding in science contexts. However, contrary to this Sutton (1992) has criticised attempts to improve the readability of secondary school textbooks, which moved towards shorter, simpler sentence structure with more pictures. Sutton likened this to comic strips suggesting that they were moving too far from real science literacy. In practice, it is hard to balance these two opinions, teachers want their students to understand the texts they are presented with, but at what point does over simplification devalue the science itself? Students will need to be pushed beyond their comfort zone and ever so slightly outside of the capability, with the support of their teacher.

Strategies for improving reading

Reading can easily become a very passive activity, both for students and their teachers, and as Wellington and Osborne (2001) noted it can even be used as a punishment which will not be conducive to making reading an enjoyable and beneficial activity. It is important for teachers to embed reading into the structure of lessons and to make it a valuable use of time. Quigley (2018) proposes six strategies for enhancing reading comprehension, these are “prediction, questioning, clarifying, summarising, inference and activating prior knowledge” (p.98), all of which can be applied within the context of science with relative ease, whether that be predicting the outcome of an experiment or summarising a key concept with the use of thinking maps. Davies and Greene (1984) comment that students need to participate in ‘*active reading’* that is reading that has a purpose, a coach to scaffold and guide students, and an element of collaboration. Examples of active reading could involve asking students to highlight specific key points in the text or to label a diagram based on their reading, any active reading task will require explicit instruction and a degree of reflection on the part of the student, directed activities related to text (DARTs) are good examples of using active reading whether as a reconstruction or analysis task, the later of which will require a higher level of thinking.

Wood et al. (1992) and Wray and Lewis (1997) have presented multiple strategies for using DARTs in lessons, from sequencing activities for giving practical work instruction to text or diagram completion tasks and process tasks to how things change by synthesising flow charts. The later of these tasks presents a significantly greater cognitive demand and so would likely require more scaffolding and modelling by the teacher for successful completion. Teachers, however, must be careful not to overestimate students reading comprehension. Wood et al. (1992) have provided a useful framework for guiding students through text in three levels, literal, interpretive and applied, with each step requiring an increase in thinking level from literal where direct closed questions are asked, to interpretive where students understanding is tested and finally to applied where students are tasked with forming judgments and comparisons. Another model for supporting students reading has been proposed by Wray and Lewis (1997), their EXIT (extending interactions with text) model provides 10 process stages directly related to an appropriate teaching strategy, an extract from this is shown in Figure 1.

The figure originally presented here cannot be made freely available via ORA because of copyright. The figure was sourced at Wray, D. and Lewis, M., 1997. Extending literacy: Children reading and writing non‐fiction1 edn. London: Routledge.

Figure 1 -Extract of table from Wray and Lewis, 1997

Further to these strategies it is important to expose students to a variety of science media, not purely textbooks written for teenagers which John Holt described as “the books you only read because you have to" (Wellington and Osborne, 2001, p.43). Instead giving students the opportunity to read from news outlets, tabloid newspapers, popular science books by authors such as Prof. Stephen Hawking, magazines, medical leaflets and environmental/political groups. This allows students to develop their critical thinking skills and to evaluate whether the information presented to them as biased, peer reviewed or sensationalised. Using extracts from these materials provides cross curricula links to media studies, health education, geography and citizenship to name a few and giving students stimuli for debates, promoting research skills and allowing for the application of scientific content in real world examples, thus also aiding students' scientific literacy.

Teacher modelling

To enable students to develop and thrive with their literacy it is vital that teachers are seen as role models for good practice, this allows for subtle reinforcement and corrections, showing students how to make their communications better. A good starting point for this is through teacher talk, regular conversational talk understandably lacks the academic vocabulary and conventions required of students in school, teachers must therefore talk like an expert, not only in terms of content but in genre and tone of their subject. In science this, means a passive voice devoid of subjective views. To talk like a scientist, teachers are likely to need to define tier two and three words frequently (Quigley, 2018) and use the SEEC model (p.139) to increase students confidence with this academic code. Teachers should use probing questions to challenge students answers and where possible try to upskill students' choice of words, instead of opinion, try justification, or hypothesis instead of idea etc. The subtle nudges towards more academic language can encourage such words to be more habitual until they are common practice.

Although commonly thought of as a tool for writing, teachers can scaffold verbal communication too, Quigley (2018) acknowledges the importance of this and recommend the “ABC feedback” approach, this requires students to “agree with, build upon or challenge” (p152) responses from their teachers or peers. This scaffold can provide a useful stepping stone for students who are less confident communicators, but also challenge those who are more competent to use academic language.

Rationale

In conclusion, after an extensive literature review investigating the importance of academic literacy, the problems students experience in school in developing their literacy and the ways in which this can be tackled, a rationale and plan for further investigation has been developed.

The research questions for this project are as follows:

1. What are students perceived barriers to literacy?
2. How effective are strategies to improve students use of language and written work in science?
3. How effective are strategies to improve students reading in science?

Methodology

Context and participants

This research was undertaken at a mixed gender 11-18 school, located in a town with extremely high levels of deprivation. The town has one of the highest child poverty rates in the country and it has been documented that by the age of five, children in the most deprived areas are on average 15 months behind affluent children in terms of their vocabulary development (reference redacted for anonymity). Residents of the town have a below average life expectancy and above average rates of unemployment. The town has a very diverse population with the majority of residents not identifying as White British. There are over 150 different languages spoken within the town and the high proportion of students speaking English as a second language; presenting unique challenges for teaching staff to negate and manage these barriers to learning.

After discussion with the Head of Science a cohort of year 9 students were selected for this study, they were chosen as they were well settled into the routines and practices of secondary school, especially after the disruption of Covid-19, but also the impending commencement of GCSE work, it was thought that if successful, this literacy intervention could potentially serve as a useful tool for bridging the expectations between key stage three and key stage four work. The sample selected for intervention consisted of students in a high attaining class and also a SEND class, a second group of the corresponding classes on the opposite year half were used as a control to create a “quasi-experiment” (Wilson, 2001, p.143) where external factors and variation between the two groups is kept to a minimum. The SEND classes both contained students with EHCPs and required support from multiple teaching assistants due to the complex needs of some of the students. The intervention classes (group 1) were chosen as my own classes and so I was able to oversee the intervention work closely, the control group (Group 2) was selected as a near direct comparison and were taught by different teachers to Group 1. It is of course, important to recognise that while the control group did not actively participate in the literacy intervention and received none of these classroom resources, their literacy skills were still being developed to an extent as per their normal class teaching. It would be ethically and professionally wrong to remove all literacy learning from the control groups science learning for six weeks (Wilson, 2001). Therefore, it would be expected to see that control groups post intervention data does show some improvement in their learning as they will have engaged in some literacy activities during normal teaching. However, this research aims to investigate significant differences between the two groups following the targeted literacy intervention for one of those groups.

Figure 2 shows similar breakdowns of demographic data across the sample, although Group 2 has a slightly higher proportion of students have special educational needs (44% vs 39%) but less speaking English as their second language (39% vs 50%), the other similarities between the two groups implies that any findings produced by this study are due largely due to the impact of this literacy intervention.

Figure 2- Demographic data for the participants

	Sex		SEND			Pupil Premium		EAL	
	Male	Female	None	In class support	EHCP	Yes	No	Yes	No
Group1 (n=44)	25	19	27	14	3	16	28	22	22
% of intervention group	**57**	**43**	**61**	**32**	**7**	**36**	**64**	**50**	**50**
Group 2 (n=41)	25	16	23	16	2	13	28	16	25
% of control group	**61**	**39**	**56**	**39**	**5**	**32**	**68**	**39**	**61**

Data Collect Methods

This research followed a mix methods approach (Hayes et al., 2007) as is common in education research (Wilson, 2009), combining quantitative data collected through questionnaires with qualitative data obtained through semi-structured interviews and evidence of students work from science lessons. This allowed for both measures of students working level and actual performance to be collected which was then complemented by the thoughts and opinions gathered through interviews. This mixed method approach aimed to capture the strengths of objectivity from quantitative data alongside the personal interpretation of qualitative data, while attempting to minimise the weakness of each (McKim, 2017 & Cohen et al., 2018). Demographic data, current working level and target level data, as well as reading ages were obtained for each group as well as samples of their classwork from exercise books. Given the challenging nature of directly measuring pupils learning, indirect measures such as changes to students reading ages, spelling test scores and qualitative assessments are used as a proxy to indicate changes to learning, in addition to the attitudes to literacy assessment that provides an insight into students' perceptions of their work (Wilson, 2009).

Questionnaire design

Students were issued with a questionnaire to assess their current attitudes towards science and literacy. The questionnaire was self-designed but built upon the suggestions of Wray and Lewis (1997), Wellington and Osborne (2001) and Quigley (2018). The first section utilises a Likert style format to understand perceptions towards science, reading, writing and the use of terminology. This format was used to ensure high compliance and reduce cognitive load on the students, this was particularly important given the SEND students involved who would have been less likely to cope with the cognitive demands of free text questions, as from experience as their class teacher students would demonstrate a fear of failure when faced with open ended questions. Further to this the language of the questionnaire was kept purposely simple to ensure it was accessible to all pupils but was also trialled, as recommended by Wilson (2009) on a separate class to ensure high levels of compliance.

Section two of the questionnaire quantitatively assessed students understanding of scientific terms such as dependent variable and correlation. The final section of the questionnaire investigated whether students could make connections between words and understand their root meaning, for example "hydro" referring to water. Sections two and three were both multiple choice questions to aid completion, particularly for lower attaining students. A copy of the questionnaire can be found in the appendix.

Interviews

Two small group semi-structured interviews were conducted within Group 1, one with students from the higher attaining class and the second with students from the SEND class. The two classes were interviewed separately as they have significantly different working levels and it was thought that students would feel more confident in a group with similar students to themselves (Abuel, 1994). During the interviews pupils were asked about what could be done to support their literacy in science, any suggestions raised were, where appropriate, fed into the intervention. This was important to give the students a sense of ownerships over the learning as Wray and Medwell (2006, p.201) remarked "learners' perceptions of literacy and its teaching can radically affect the outcomes of literacy instruction." Students' responses were recorded on a pin-controlled dictaphone and transcribed. Students were made fully aware of the reasons for the interviews and understood that they were able to withdraw their consent for this at any point. The interview questions closely related to section 1 of the written questionnaire but gave the opportunity for students to explain their reasoning behind their choices and to express their opinion on how they can be supported to develop their literacy skills. A copy of the interview questions used can be found in the appendix.

Intervention

Students in Group 1 took part in a six week in class literacy intervention with the aim to improve their overall literacy and confidence in science. Quigley (2018) recommends that to have the most meaningful impact on students literacy the main focus should be on vocabulary, this was the basis for the rationale behind the majority of the literacy intervention. A classroom display dedicated to the root meaning behind common scientific words was put up, including words that used prefixes such as "chloro, hydro, ex and therm", these displays were referred to frequently during lesson time both when explicitly teaching new vocabulary but also during reading and writing tasks, especially when encountering unfamiliar words, so pupils could decode them. Students were given vocabulary books specifically for scientific terminology where they wrote the keyword alongside its definition, this was again, an aid that students could utilise as they needed for written and verbal answers. The teaching of new vocabulary was also made more explicit during lesson time with close attention played to the root meaning of words. For example, students were given the opportunity to consider the meaning of 'photo' in the word's photosynthesis and photon; explicit teaching of language allows students to identify common patterns in English (Murphy, 2019) and deduce meanings of unfamiliar words. This use of etymology described by Boardman et al., (2008, p.15) as "additive instruction" promotes deep understanding of subject specific vocabulary. Weekly spelling tests were used as a means to assess spelling competency, not as a teaching aid, the teaching came from understanding the underpinning of how words are constructed, looking at their etymology, morphology and phonemic awareness in order to develop their decoding skills.

To further vocabulary development the “SEEC model” by Quigley (2018, p. 139) of ‘select, explain, explore and consolidate’ was followed. ‘Selecting’ the vocabulary required additional teacher preparation time to really consider which words in a particular topic students were most likely to struggle with, identifying these words and the context in which they are used. Explaining relied on careful delivery of the vocabulary, allowing for students to hear it multiple times, in different contexts and to create meaningful examples and definitions that were accessible to the students. The next stage, explore, offered opportunities for students to create mnemonics, introduce imagery and practice questions where this vocabulary was used. Finally, students consolidated their learning through frequent retrieval practice and research tasks.

Students were given as many opportunities as possible to read aloud, at least once per lesson. As noted by Quigley (2018), this allows students to become more fluent and confident with their reading ability. Additionally, in group work activities students were strongly encouraged to share reading between them and to assign specific roles to their active reading for example, having one student who was responsible for summarising information and another who reported back to the rest of the class.

As a whole school, weekly ‘Drop Everything and Read’ (DEAR) sessions have been taking place, where students engage in silent reading for 25 minutes per week, however this was furthered in science lessons to increase the student's exposure to science-based literature. Students were presented with reading extracts either from newspapers/ online articles with comprehensions questions, or as a simplified version of published scientific articles from 'New Scientist' or 'Nature'. The articles chosen were selected due to their topical appeal to the students something that (Murphy, 2019) stresses the importance of to "broaden rather than restrict students' knowledge of the world" (p.121). The length of the piece and some of the more technical information was, on occasion, scaled back to make it accessible to a younger audience, this was particularly important for the SEND class. Students were given one of these reading comprehensions at least once a week, often as a starter activity.

In order to subtly engage students more with their reading priority was given to in class activities that developed students reading without conscious thought. An example of this was prior to practical work, using a card sequencing task for students to correctly identify the method they would be following, this made students familiar with reading and following written instructions thus focusing on their language, but also strengthen their scientific literacy by understanding the scientific method and the logical reasoning behind their given method.

As the lead teacher for the classes involved in the intervention, my own delivery of lessons was scrutinised with a specific focus on how literacy is presented during lessons, a more senior member of the science department was given an observation sheet for them to guide their judgements and broken down into sections; talk, reading, writing and the class environment. Literacy observations were conducted on three occasions and any points raised from these observations were used to influence future teaching practice. A copy of the lesson observation template is included in the appendix.

Post intervention data collection

Following the in-class intervention, students from both Group 1 and Group 2 completed a similar questionnaire to the initial data collection, section one remained the same to allow for a direct comparison, and sections two and three followed the same format but with different examples of scientific vocabulary to ensure students weren't recalling answers from the original assessment (see appendix). In a similar manner the same students were invited to participate in the short interviews about their confidence in science and literacy skills, all students consented to being re-interviewed and were asked the same questions as they had been given six weeks prior, students showed high levels of compliance and engagement which allowed for more meaningful comparisons to be made pre/post intervention. Data from students latest reading age tests and examples of their work from exercise books was collected for post-intervention analysis.

Data analysis

Pre and post intervention data was anonymised and transferred into SPSS for quantitative data analysis. Descriptive statistics were ran to give the median and modal response for the questions in section one and demographic data was produced to measure the diversity of the groups. The percentage change in reading age was calculated and compared for Groups 1 and 2 to look for significant differences. Additionally, statistical tests including paired and independent T Tests were conducted using SPSS to explore any statistically significant differences between pre-post intervention results and to compare the intervention and control groups. The interviews were transcribed from their recordings and common themes identified between students using the constant comparative method (Thomas, 2017) and changes between pupils pre and post intervention comments were explored. All data was stored securely on the universities One Drive system.

Ethical considerations

Throughout this project upholding the standards and expectations entrusted to me as a teacher and a researcher was of the upmost importance. Before any data collection or intervention commenced ethical approval from the university was applied for and subsequently granted by the Central University Ethics Committee (CUREC), when applying for ethics approval examples of the intervention work to be completed, questionnaires and sample interview questions were all submitted for authorisation. The research project complied with the British Educational Research Association guidance (2018) and operated under the Modus Operandi for the MSc Learning and Teaching course. In addition to this the project was discussed in detail with the Headteacher of the school and his written approval given (see appendix), it was also discussed at length with the Head of Science, especially when considering which classes should participate in the study. The Headteacher and Head of Science were very supportive of the research being conducted.

Participants of the study were fully informed of its aims and they understood that they were able to withdraw their consent to participate without question at any time. For the students who completed the interviews this was reinforced again verbally as the interviews were audio recorded, all students agreed to take part and none withdrew their consent. All students appeared comfortable and confident throughout the interviews. Although, consideration must be given to whether students felt under any pressure to answer in a particular manner as they were responding to their class teacher who is both their educator and in this instance their researcher (Mitchell and Jolley, 2013). Although not perceived to have been the case, there is a chance that some students may have felt the need to please their teacher by responding more positively than they felt, as they may not have wanted to appear critical of their teacher or equally feel that they were not meeting expected standards with their work. With the evidence presented in the form of students' classwork it is not felt that this happened, but it is a factor to acknowledge.

Collaboration

During this project collaboration and support of other members of staff at school was vital, firstly with science department who offered their wealth of experience when considering the rationale and logistics of this study such as facilitating the pre and post intervention assessments for the control group. Beyond the scope of the Science department, the Head of English provided a great deal of support and guidance through discussions of how to approach literacy from different subject perspectives and considering for future years how this research could be potentially implemented across other departments. Her passion for literacy skills in aiding both educational and life outcomes for students alongside her years of experience teaching and supporting literacy in the context of an English lesson were invaluable, as well her whole school drive to raise the profile of reading for pleasure through drop everything and read. To further understand how to teach the language of science inspiration was sought from the modern foreign languages department to explore strategies that they employ to teach entirely new vocabulary and how they foster confidence in students reading and writing. Finally, our school librarian, must also be acknowledged for her collaboration and role in this project, for always enthusing students to love reading, for providing new and exciting reading materials for each classroom and for running the Accelerated Reader programme which generated the raw reading age data.

Findings and Discussion

Pre-intervention findings

Baseline data to assess student's literacy levels prior to the intervention was collected through use of a short questionnaire and semi-structured interviews to reveal more about students' perceptions of literacy.

From the baseline assessment it emerged that 75% of students from Group 1 (n=44) do not find science easy, although rather reassuringly 82% say that it is important that they do well in science and 52% do enjoy the subject. The latter contrary to Osborne et al., 2003 who observed enthusiasm decreasing throughout secondary school, but is however, broadly in line with Terry and Quinn (2010) who reported that 55% of students enjoyed studying science during years 9-10 which is a similar age range to the students in this study. These findings suggest that there is motivation amongst the pupils to do well and a strong intervention could prove to be a valuable tool in raising literacy standards and both the quality and enjoyment of their science education. This however, is in contrast to the control group who appear to have lower aspirations and motivations in science; only 37% consider it an important subject with less than 40% enjoying science.

Through short interviews with students their understanding and opinions of both science and literacy within science were gathered. Initially students expressed views that they generally "don't mind science", despite recognising it as an important subject, the latter being especially true of the students in the higher attaining class. However both groups did have some difficulty agreeing on the term literacy meant with suggestions of "*It's how good you are at reading and writing", "It's like how good you are at writing down your thoughts"* or "*we used to do that in primary school"* and "*Is that what we do in Mrs X's English lesson?"* the last of these comments is a student referring to a targeted English catch up group. Through the short extracts above, it is clear that none of the students have a clear view of literacy, the first pupil comes the closest by identifying two features and the second starts to suggest that literacy involves communicating findings and ideas. This confusion was perhaps echoed best by Wray and Medwell (2006, p.201) who noted that students "were not clear about why they were learning to read" or the importance of other in class activities that targeted literacy skills. Perhaps quite concerningly is the third student's response which suggests they believe literacy to be an activity only associated with primary education and in a similar nature the final student only thinks it might be what they are doing in their English intervention. None of the students recognise literacy as anything more than an "*English thing".*

Initial findings paint a fairly poor image of literacy among these students, not merely in quantitative terms of their book work and assessment scores, but also their opinions of literacy, with one student remarking that "*you don't need literacy in science, just English"* and another commenting that "*computers check spelling so you don't have to*".

From the assessment it appears that although students in the intervention group recognised the importance of science, they do not perceive they have the skillset needed to succeed with 34% agreeing that they can verbalise their answers well in science and 36% stating that they can write well. There is clearly a large scope for improvement in measurable academic improvements and students' confidence within the subject. Just 61% of students responded negatively or neutrally regarding their understanding of scientific vocabulary and only 27% of pupils agree that they can easily apply their science knowledge to the real world. Concerningly, given the impending start of GSCE work 84% of pupils are not confident in answering six-mark exam questions, although it is hoped that addressing this area of weakness early will put students in a good position by the time of their externally assessed examinations. With regards to students reading in science, only 38.6% of students find this easy and 66% of pupils self-report as having difficulties with spelling, this is perhaps not surprising given the wealth of evidence and anecdotal evidence that reading and spelling ability frequently go hand in hand (Plessas and Ladley, 1963).

The full break down of pre-intervention attitudes to literacy for Group 1 can be seen in Figure 3.

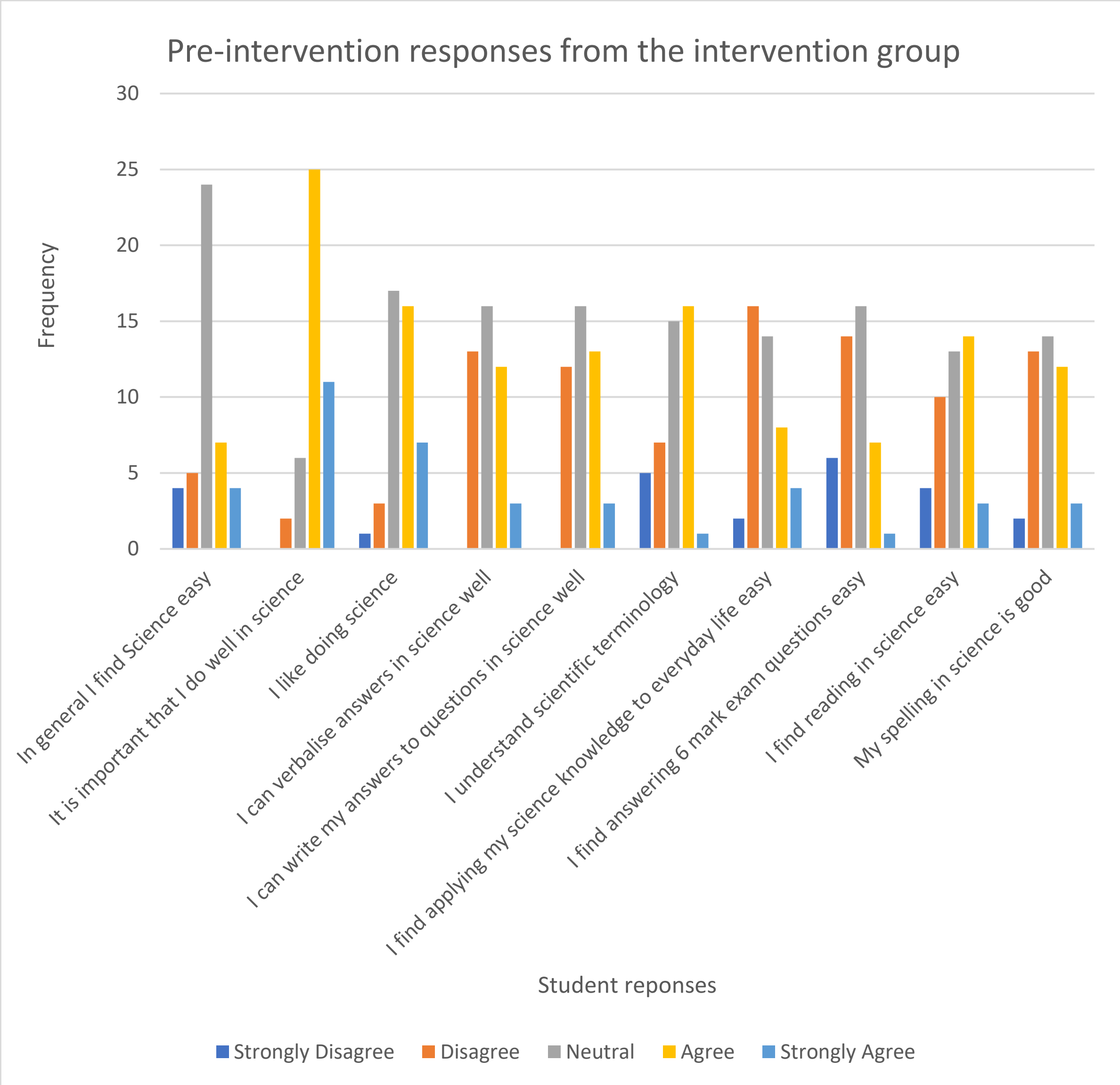


Figure 3- Graph showing the pre-intervention findings from the intervention group

Figure 4 shows a comparison between the percentage of students in the intervention and control groups who answered "*agree*" or "*strongly agree*" in the attitudes to literacy assessment. From this data it can be seen that the intervention group have a consistently better opinion of science in general, but also have a more positive perception of how they are performing in class. The intervention class recognise the important of learning science and being good scientists but also importantly they have a higher proportion of students who acknowledge their own strengths and achievements despite both classes having pupils with similar academic ability with end of year target grades averaging 3.5 for the control and 3.7 for the intervention group. In contrast, the control group appear to be starting from a lower level to begin with, with them consistently appearing less confident in their reading, writing, spelling and ability to tackle longer written exam questions. It can however be seen that for nearly every question students have favoured a neutral response above all others. There could be several reasons for this including genuinely not identifying with either end of the spectrum, or it could relate to students fear of embarrassment for either acknowledging a weakness in their literacy skills or not wanting to appear over confident in their ability, a neutral option is likely to appear to be a safer choice (Velez and Ashworth, 2007; Borgers et al., 2004).

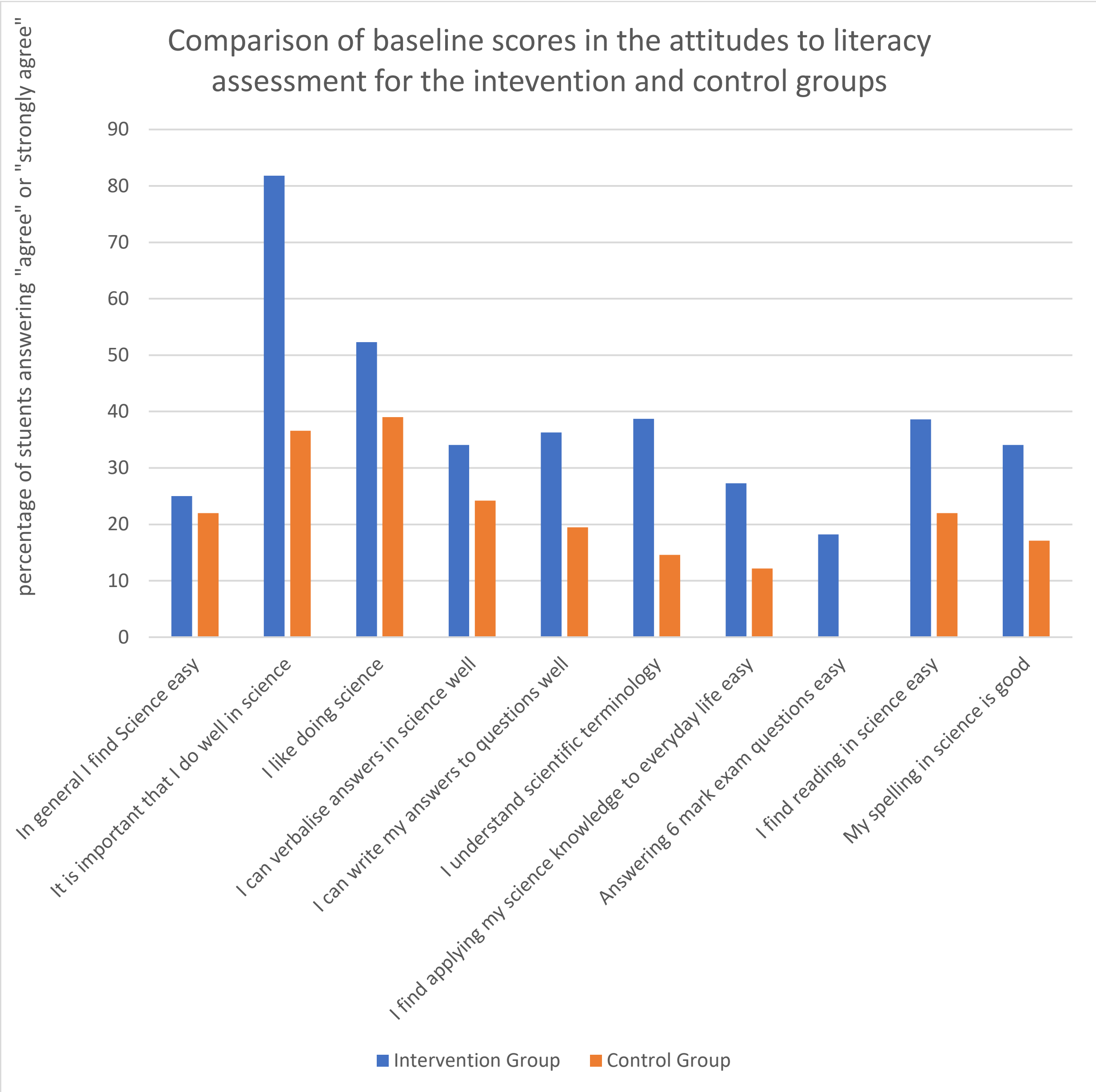


Figure 4 - Comparison of pre-intervention findings for the intervention and control groups

Writing and Subject vocabulary

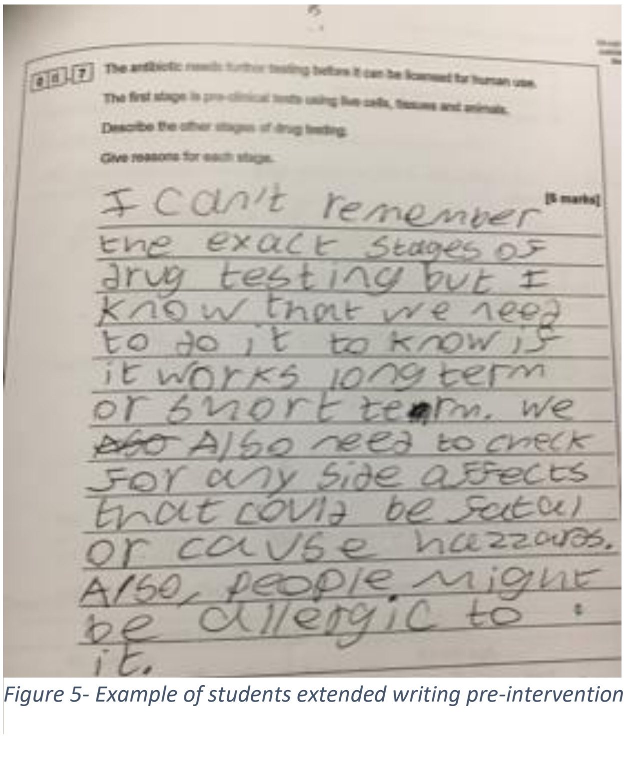
Pre intervention

The attitudes to literacy assessment revealed that 66% of students struggle with their spelling something that was evident in many of the pupils' books where both technical language and everyday words such as ‘temperature’ are commonly misspelt. In addition to this, the pre-intervention questionnaire also quantitatively assessed the students’ knowledge of key terms, the intervention group scored an average off 55% correct on this section compared to the control groups 50% with the definition of the word ‘environment’ being the easiest for all students to identify and ‘ductile’ being the most challenging. Interestingly, although anecdotal evidence and students verbal answers in class support the findings of Meyerson et al., (1991) that students find words with dual meaning the most challenging to define, this assessment tool showed that the words students struggled with the most were the specific scientific terminology, like ductile, that they are unlikely to encounter outside of the classroom. On the root meanings of words again the intervention group scored an average of 55% with the prefixes “therm” and “photo” being the most frequently correct answers; “chloro” was the hardest prefix for all students to grasp. The control group performed poorly on this aspect of the assessment with a group average of 26% correct. From these baseline literacy assessments, it would appear that prior to the intervention work commencing the control group were academically weaker, which is important to recognise and revisit when looking at significant post intervention findings.

These quantitative assessments provided a glimpse into the students working level for literacy, which when coupled with the semi-structured interviews and through examples of the students book work, aimed to give a more complete picture. From the interviews students were asked what they struggle with the most in science in terms of their literacy skills, one student noted that “*it’s never really explained, but* *sometimes I've never heard these words before, so I don't know how I'm supposed to use them".* This comment was echoed by a second student who said *"teachers don't tell you what word you're supposed to use, they just tell you when your wrong*". Both of these remarks concur the suggestions of Pickersgill and Lock (1991) who emphasised the importance of teachers devoting time to teach the language of science. These comments came from two students who are not particularly academic, through their tone, body language and remarks during the interviews, both students appeared very passive about their involvement in their education, as if it was something done to them rather than a set of skills for them to enhance. In contrast another student had a slightly different perspective when asked if teachers explain vocabulary to them, they recalled *"Not really, I think, I don't want to sound big-headed, but I think because I'm quite clever teachers just assume I will know what the new words mean, but they haven't explained it, so how would I?"* This was an interesting take on the situation, the student is academically very able and acknowledges this, yet despite recognising their own weakness in understanding vocabulary they don't raise this with their teacher as they believed their teacher to assume because they are bright that language acquisition would be effortless. These remarks further emphasis the importance of specific teaching of vocabulary for all, as regardless of attainment all students benefit from explicit instruction. From the same interview group another student recalled, *"I get marked down for not always using the right words, but I don't get it because I said the same thing, you know what I meant."* This is a common phrase to science teachers, students often don't understand the very subtle yet important distinctions between two given words in a science context, especially when we consider the alternative everyday meanings given to words that have a true and specific scientific meaning such as the difference between mass and weight. These kinds of words create confusion for students and so care must be taken to explicitly teach the language of science, so that students are effective communicators utilising a shared common language. Another student raised an interesting point when asked about whether teachers explain the meaning of words clearly in lesson, she said "*It depends, I think in biology teachers do more, because the words seem more important in biology than chemistry and physics."* When quizzed further on this idea the student elaborated saying that "*because physics is more maths based, you can get away without knowing the words, but you can't in biology".* While it is true that there is a lot of maths content in physics, the student is incorrect in thinking that language is less important in these lessons than biology. Coincidently, Farrell and Ventura (1998) investigated students word comprehension in physics and found vast discrepancies between students self-reported understanding of technical and non-technical words and their actual understanding of terms. These inconsistencies perhaps parallel the findings in this study, that students don't perceive language in physics as important compared to biology and therefore students make even less conscious effort to develop this skill. These ideas are to be shared with the Head of Physics to ensure this misconception is readdressed and acted upon.

With regards to writing, students views were a little more positive, there were remarks about writing "*just being copying from a PowerPoint*" or "*filling in* *worksheets,*" but some students did recall particular activities they had completed in science in previous academic years. This included writing a letter to Sir Isaac Newton to explain the importance of his work. One student recalled really enjoying this activity as it was "*something a bit different",* another remembered writing a story entitled '*The Race to Make a Baby'* as part of a year 7 lesson on human reproduction; they said it was fun to do these tasks as the "*stuff [scientific content] sticks in your head a bit more*!" and they wished this style of learning was incorporated more frequently. Prain and Hand (1996) highly recommend that students develop skills for writing different genres and to make the task of writing more enjoyable, especially for those who are more likely to disengage. Leading on from this students acknowledged that there were strategies they believed could help them with their use of subject specific vocabulary and their reading and writing. This included the use of vocabulary books or dictionaries, teachers making "*more effort"* to teach which words to use and more practice of written tasks to help with exam style questions. These suggestions complement the findings of Fowle (2002) whose investigation demonstrated students who used vocabulary books for second language acquisition developed great independence and confidence. Although not directly applicable to science learning as it isn't technically a second language, it is often perceived as 'the language of science' in education, consequently Fowles findings are an encouraging starting point. Students also suggested that teachers should model good work more frequently with one high attaining student remarking "*if teachers showed me how to make my writing better, not just tell me that its wrong. If I made a mistake the first time. I'll probably make the same mistake again, unless I know why."* This was a very perceptive answer from the pupil and while it seemed obvious that students would need to know what good work looks like, it would appear that this is not always done consistently across the school. Throughout the interviews it became apparent that students rarely make a conscious effort to develop their vocabulary and writing ability with some students commenting that *"spelling doesn't count in science, so it doesn't matter if you get it wrong".* This was a concern that Stone (2021) raised that with the use of computer software students perceived importance of spelling would decrease as they become more reliant on a machine to correct this for them, perhaps helping us to understand why students often don't consider their spelling ability to be an important factor in their education.

The pre-intervention data collection also revealed that 84% of pupils lack confidence when tackling six-mark exam questions, as evidenced by this students work in Figure 5 where his use of scientific language is very poor.


0 6 . 7 The antibiotic needs further testing before it can be licensed for human use.

The first stage is pre-clinical tests using live cells, tissues and animals.

Describe the other stages of drug testing.

Give reasons for each stage.

[6 marks]

I can't remember the exact stages of drug testing but I know that we need to do it to know if it works long term or short term. We ~~Aso~~ Also need to check for any side affects that could be fatal or cause hazzards. Also, people might be allergic to it.

Figure 5- Example of students extended writing pre-intervention

This student hasn't answered the question they were given and hasn't communicated any relevant information about drug testing, they haven't used key terminology, they are writing in the first person and their scientific literacy is poor, although all the words are spelt correctly, minus the error of 'affect'. The student scored one out of six for this question, it is clear that they don't know how to communicate their ideas which was confirmed by the student who said *"I find it hard to know where to start with my answers, when you have a big question and there's lots of space… I don't want to put the wrong thing*." Often with long answer questions, there is a fear of failure, students would rather write nothing at all than write something that could be wrong, something that Beery (1975) notes is even more common in high attaining students who set very high expectations of themselves. It is therefore the challenge and role of the teacher to break this barrier and put support in place by chunking and scaffolding work to overcome this fear (Chamberlain and Crane, 2009).

Post intervention

Initially to target students understanding of scientific terminology, attention was turned to the way in which language was presented to students as guided by Quigley (2018), Wellington & Osborne, (2001) and Lewis & Wray (2001), making sure that language teaching was explicit and reinforced at regular intervals. This consisted of enabling students to make connections between words through similar word structures and common root meanings. When a new word was introduced in class students were given the opportunity to, individually or in pairs, decode the word to create a working definition, such as in Figure 6.

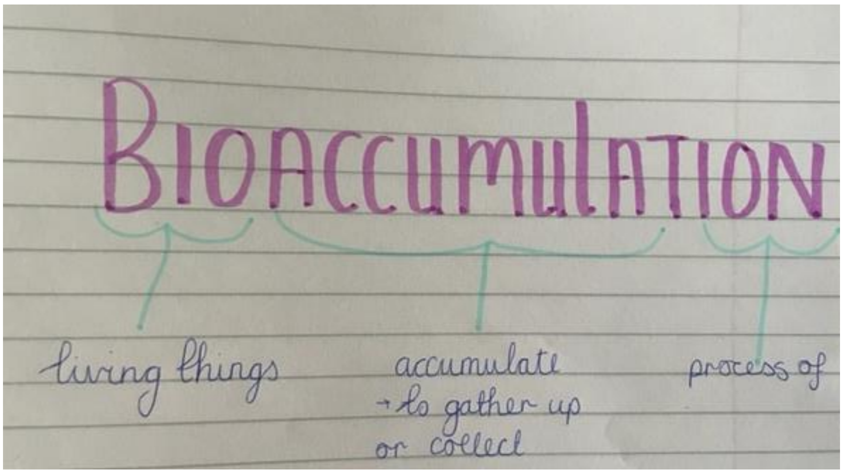


Figure 6- Example of students' learning of the root meanings of words

The word '*bioaccumulation'* was completely unfamiliar to students but they were able to successfully interpret the meaning by looking for terms they could already identify and explain. This short and simple task was used multiple times with students growing in confidence throughout, where some pupils initially required some teacher support to complete the exercise, by the end of the intervention period students were able to work more independently.

In a chemistry lesson, before introducing the new terms '*endothermic'* and '*exothermic'*, pupils were tasked with creating a list of as many words as possible that use the 'ex-'or 'en-' prefixes as shown in Figure 7. This short but effective task generated healthy competition among students to have the longest and most unique list of words, but also then prompted them to think about any common meaning between the ex and the en words. Students soon worked out that many of their 'ex' words related to giving something out and the 'en' words often corresponding to taking something in. This allowed students to then correctly define the terms endothermic and exothermic with minimal teacher input. Consequently, because students had solved the pattern before being introduced to the new scientific language they made far less confusion between the two words compared to when teaching this topic in previous years, this was further emphasised in the post-intervention questionnaire which saw students improve their understanding of the root meanings of words by 45% compared a negligible change in the control group.

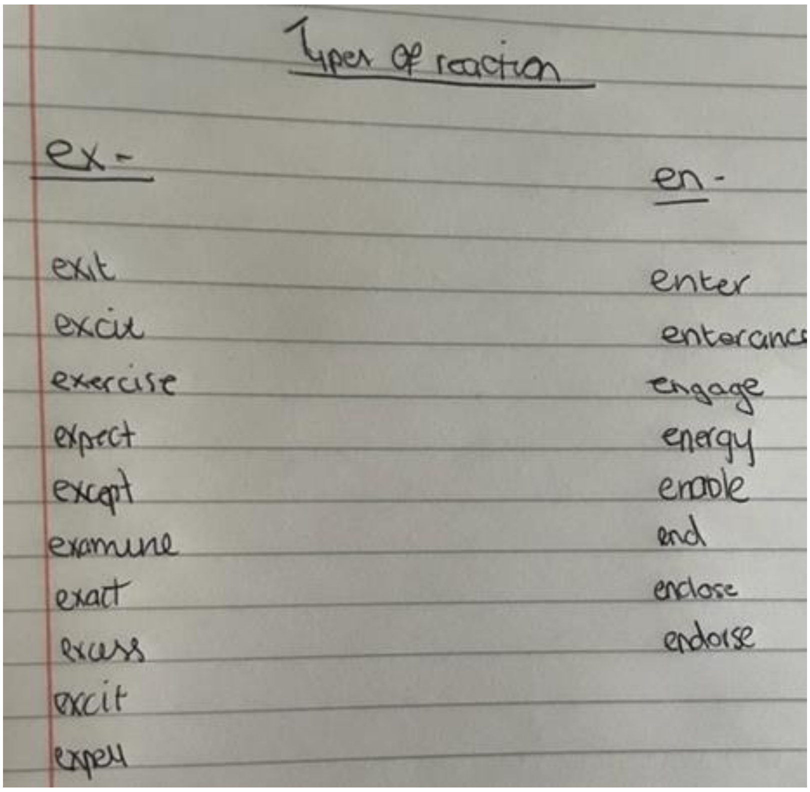


Figure 7 - students work identifying etymological connections between words

In addition, to support student's vocabulary development, key word displays were put up around the classroom to reinforce common prefixes in scientific terminology and students also created glossaries in their science vocabulary book, as recommended by Lewis and Wray (2000). Students were all issued at the start of the intervention with a small vocabulary book, similar to those used in modern language classes, each time an important scientific word was used that students it was recorded in their book.

Students noted the word alongside its definition and, for some words, a sentence where the key term was used in context, something particularly important for words like '*work'* where it can be interpreted in multiple ways depending on the circumstance. The students liked having a separate book for recording scientific language with pupils commenting that "*it was good to have something to look back on and check you used the word in the right way".* Pupils used their vocabulary books during written work, homework and when giving verbal answers in class, it boosted many student's confidence having something to hand that they could reference and proved to be a valuable tool, concurring the ideas of Lewis and Wray (2000).

Additionally, to teaching the etymology of words to students, the Frayer Model, pioneered by Dorothy Frayer in 1969 was used to explore vocabulary. The model allows students to identify; characteristics of the word being studied, antonyms, examples of the term used and it gives students the opportunity to create a definition that would be accessible but scientifically accurate for them to use. This model has been successfully utilised by Estacioa and Martinez (2017) and researched by Chamberlain and Cane (2008) for specifically targeting vocabulary in science to generate a deep and genuine understanding of words. Figure 8 is taken from group work analysing the word 'plant' at the start of a topic on ecosystems.

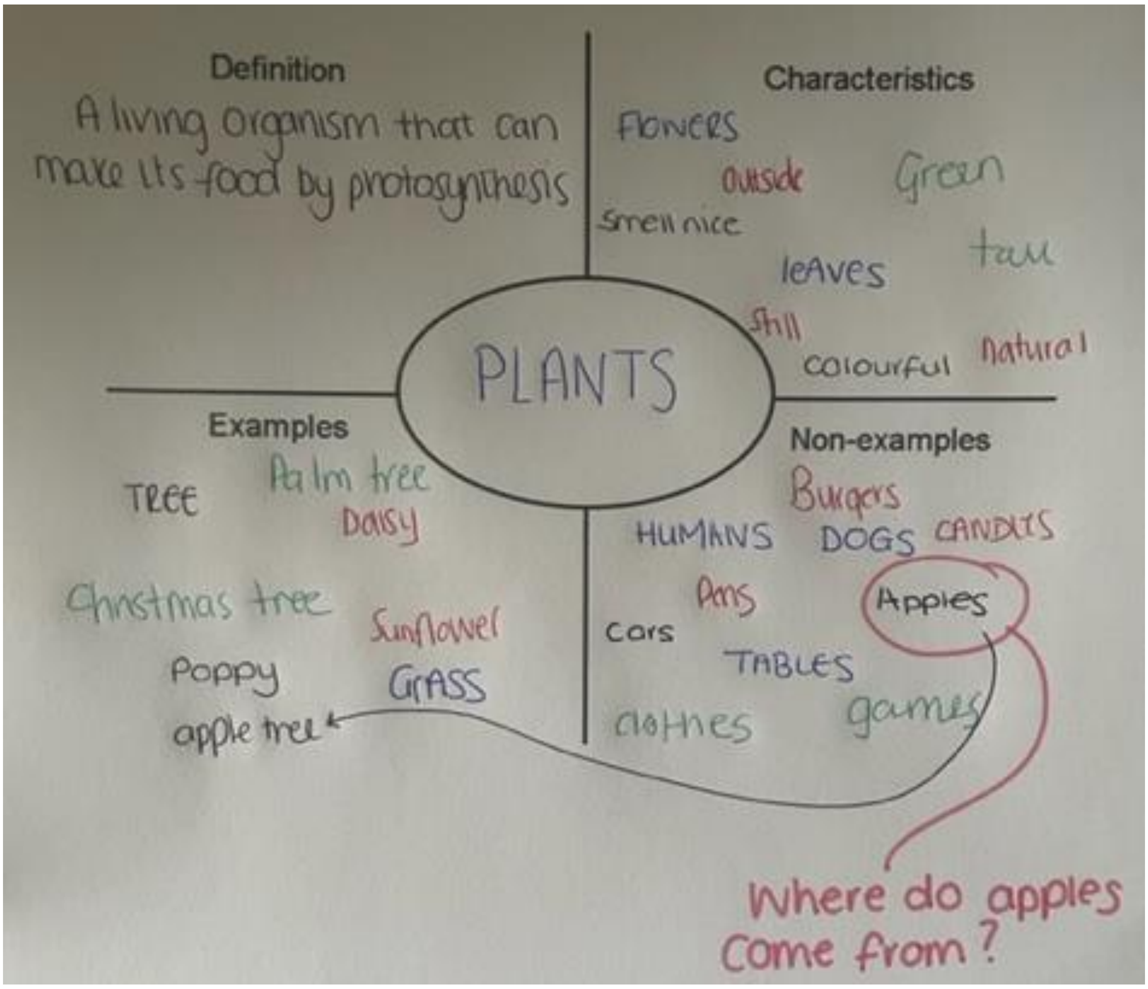


Figure 8 - Group work using the Frayer Model

Here different students have used different coloured pens to keep track of each pupil's contribution and to help when correcting any misconceptions as noted with the reference to '*apples'*. Observing pupils complete the sheet together showed which students felt more confident in the task, demonstrated by their leadership qualities, and also which students appeared to be finding the task more challenging. One student (green pen) really struggled when contributing to an agreed definition of a plant, when asked one to one about this, they revealed they didn't understand the words '*organism'* or '*photosynthesis'* that their peers had used, but didn't want to appear "*dumb*". This then gave the opportunity for these words and others to be examined in further detail as a class, to ensure all students had a common understanding. The success of using the Frayer model supports the findings of Estacio and Martinez (2017) who praise its uses for developing students critical thinking skills and Wanjiru and O'Connor (2015) who place great value on the use of graphic organisers for literacy instruction.

Throughout the intervention students completed weekly spelling tests, although conscious of the dreaded Friday spelling test notion, the aim was to create a positive record of personal achievement, rather than a class competition, which could damage students' confidence. Despite some researchers such as Trubek (2012) and the Huffpost (2016) reporting the de-emphasising of accurate spelling, it is still considered important in the research school; although given the opinions expressed by individuals in the interviews, students do not always agree. However, in the 'real world' spelling does still matter, especially in the world of work, where it has been reported that 43% of employers cite spelling errors as an immediate rejection for job applicants (Pan et al., 2021). The first weekly spelling test generated an average of 5.18 correct answers out of 10, however each week, all bar one, the students average score increased. By the final spelling test, students were averaging 6.80, a 31.27% increase, which given the short time frame of the intervention was remarkable.

After the intervention 72.7% of pupils described their understanding of scientific terminology as good, representing a 87% increase. The picture for students self-reported spelling ability is equally positive, with a post intervention score of 93.2% of students describing their spelling ability as good or very good; this represents as 173% percentage increase. It must be recognised that this figure is notably significantly higher than the students actual increase in spelling ability and therefore can be seen as a measure of the confidence and self-belief with regards to their spellings. Students feel more confident and given the short time period of the intervention, it is plausible to conclude that further quantitative gains may have continued to be seen after the intervention concluded.

As a teacher, following the in-class intervention, I could see a convincing improvement in students literacy skills, both through their written work and their reading ability. The two examples below are taken from the same student, prior to intervention and after intervention, they show a clear progression in the student's ability to communicate their scientific knowledge. The student is using more subject specific vocabulary and as part of the intervention has developed the habit of underlining where keywords have been used in order to show understanding and improve exam technique.

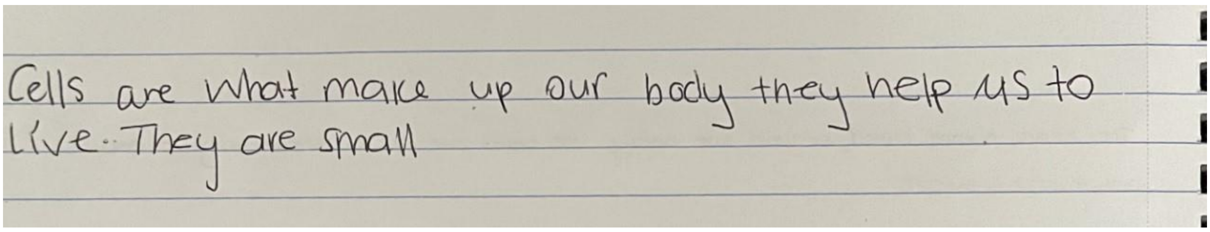


Figure 9 - Example of students written work pre-intervention

Figure 9 shows poor literacy skills, the lesson this was taken from had involved looking at the parts of a cell and understanding the role of these organelles, however these were the only two sentences the student was able to produce in the summary task at the end of the lesson. The student had not been able to recall the key vocabulary from the class or felt able to attempt to spell some of these terms, instead they panicked and wrote two very simple statements. When the student was asked about how they felt in this lesson they commented that there were "*too many new words*" and that it was "*too confusing*", this further highlighted the importance of fully imbedding literacy skills and particularly vocabulary development in every science lesson.

In Figure 10, after 6 weeks of literacy intervention the same student has made a huge leap in their work, not only are they understanding the concepts themselves in greater detail, representing better scientific literacy, but they are able to communicate this effectively too. The student has identified eight terms that they consider key to this answer, they have used each word appropriately showing their deeper understanding, their spelling is good and they have completed an extension question relating to key terminology. When asked how they felt about their work this time, the student said they felt "*quite proud*" of their writing, they attributed their success

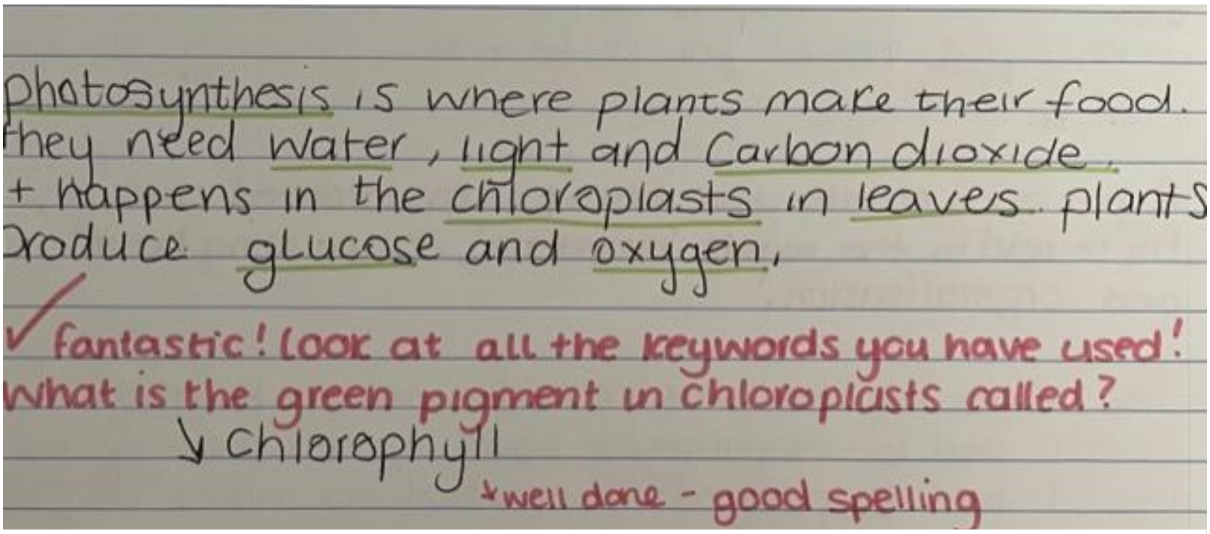


Figure 10 - Example of students work during the intervention period

down to their vocabulary book and modelling of what good writing in science looks like through student and teacher examples.

Throughout the intervention writing tasks were used to develop communication skills, but also as an engaging way of recapping information covered in the lesson, including creating and performing songs about changing states, newspaper articles on bioaccumulation and poems about energy transfers. For the SEND class this was a milestone achievement, students who had previously been too timid to answer direct questions in class stood in front of their peers and performed self-written raps on ecosystems. Students wrote their own lyrics, using their glossaries to ensure they used accurate scientific language, they payed attention to the rhythm and beat of their music to ensure the words fitted their tune and finally they confidently performed their piece. This activity developed student's teamwork skills, planning and organisation skills as well as improving their self-belief, resilience and their understanding and use of scientific language. Many pupils commented that they really enjoyed the raps and wanted to do similar tasks in the future, they ended the lesson very proud of their accomplishments.

In a biology lesson with the higher attaining class, students created poems as a summary activity for a lesson on respiration, Figure 11 is an example of an acrostic poem created by one 13-year-old girl, she has reinforced important information and the correct language to be used *"energy cannot be produced, it is released"*. This poem was produced by a student who enjoys science, but described their reading, writing and spelling as poor, having completed this piece of work and having it modelled as a good literacy example their confidence started to improve.

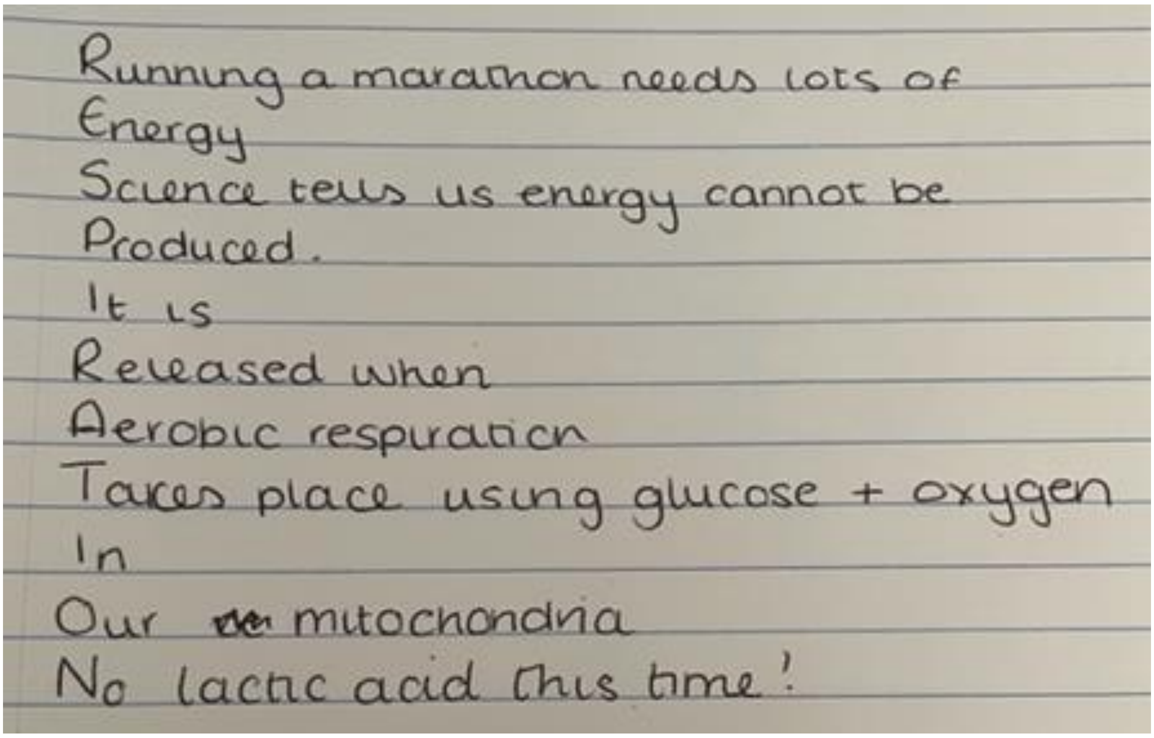
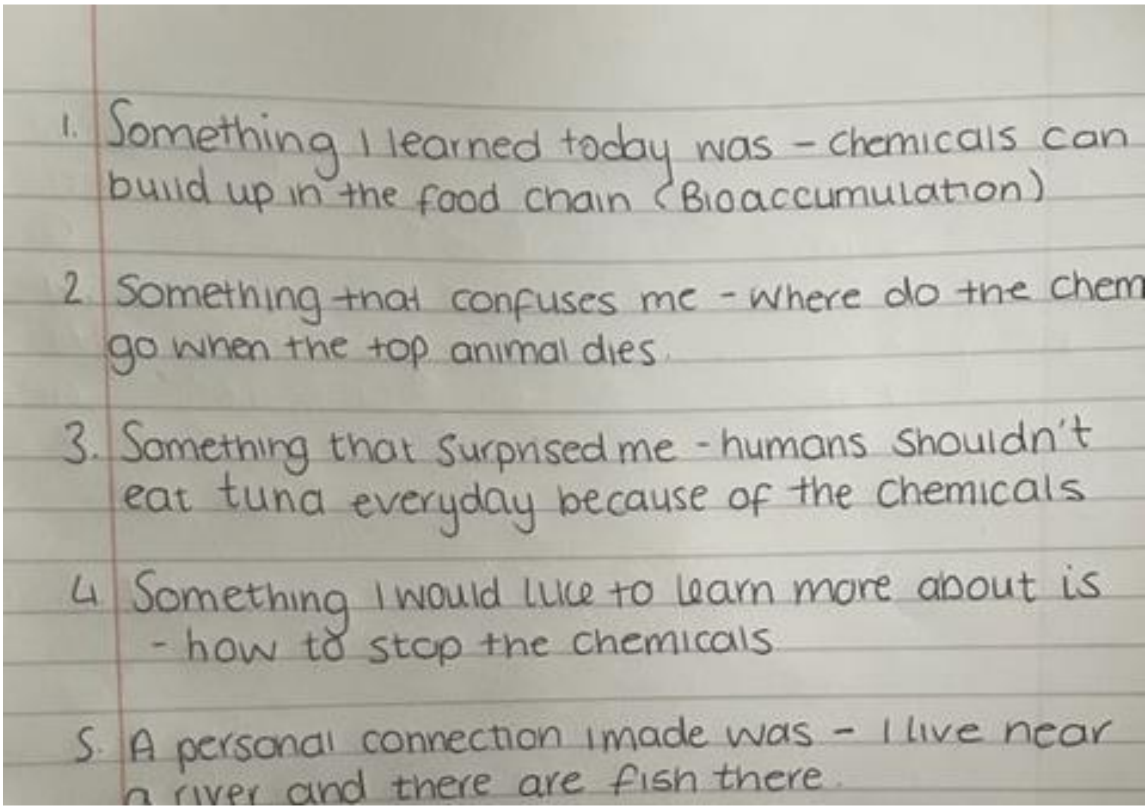


Figure 11 - Students written work post-intervention

The same student wrote a two page story about a cheese sandwiches journey through the digestive system a couple of weeks later, again this story was full of scientific language which was all correctly spelt and used appropriately. The story was light hearted and engaging in feel but completely scientifically accurate and informative, the success of this task reinforces ideas presented by Wray and Lewis' (1997) EXIT model which cited the importance of developing the skill of writing for different genres. When asking this student what strategies had allowed them to complete the work, she referenced the use of her vocabulary book and the '*help sheet'* (scaffolding) provided which encouraged greater independence and confidence. In the post intervention assessment, this particular student excelled; rating their reading, writing, spelling and use of language as very good, and when speaking to this student's English teacher they also noted an improvement in her reading and writing, suggesting that the implications of a literacy study in science has the potential to show improvements in other subjects too.

Using the "learning log activity" provided by Chamberlain and Crane (2009, p.70) students were able to subtly engage in informal writing activities in a non-intimidating manner, when the emphasis was placed on recalling, applying and inferring science students previously froze and were reluctant starters. However, by focusing on a reflective writing activity to close lessons students were more willing to participate, the task allowed students to identify their strengths which they were praised for, but also gave teachers to opportunity to acknowledge any misconceptions to be addressed in future lessons.

Figure 12 from a 14-year-old in the SEND class shows the learning log can be implemented successfully. The student has learned how to correctly use and spell a keyword from the lesson, bioaccumulation, and also considered how this knowledge can be applied to the real world, something that only 27% of students felt confident doing prior to the intervention. Although this may on paper not appear to be a significant gain, for this student the progress is tremendous, the pupil is a reluctant speaker who does not like to communicate with staff or students, he has moderate learning difficulties and dyslexia, prior to the intervention completing a few sentences was a challenge, yet now he is writing legibly with a level of fluency his teachers and mentors have not seen before.



1. Something I learned today was - chemicals can build up in the food chain (Bioaccumulation)

2. Something that confuses me - Where do the chem go when the top animal dies.

3. Something that surprised me - humans shouldn't eat tuna everyday because of the chemicals

4 Something I would like to learn more about is - how to stop the chemicals

5. A personal connection I made was - I live near a river and there are fish there.

Figure 12 - Students written work using Chamberlain and Cranes (2009) learning log

Once students had started to develop their writing technique and use of language, their final challenge was to embed these skills in exam practice questions. This was something that pupils were not confident in completing and for many was a source of anxiety. Students were presented with their exam style question in a new format so that it didn't visually appear like an exam in the hope of reducing students fear of these questions and raise completion levels (Chamberlain and Crane, 2008). From Figure 13, it can be seen that the question has been broken down into three parts, the first a simple recall, followed by a descriptive question and then finally and explanation section, this chunking, following Blooms Taxonomy aimed to make the question appear more accessible to pupils and simplify the task without minimising the educational challenge and standard expected. Students could see their 'exam question' with clear success criteria for them to work towards. Students were also provided with a checklist to help them interpret the question and ensure it was structured correctly. This included students putting a box around the command words, so they understood the type of question they were tackling and therefore the level of detail and style of answer required, secondly identifying keywords that would help them make sense of the question itself and try to focus their answer and finally students considered the points they wanted to make, which could include a short plan, before commencing writing. Figure 13 demonstrates how this tool was implemented successfully, for higher attaining students some of this scaffolding was gradually removed to increase the challenge and bring the question back closer in style and presentation to exam formatted questions.

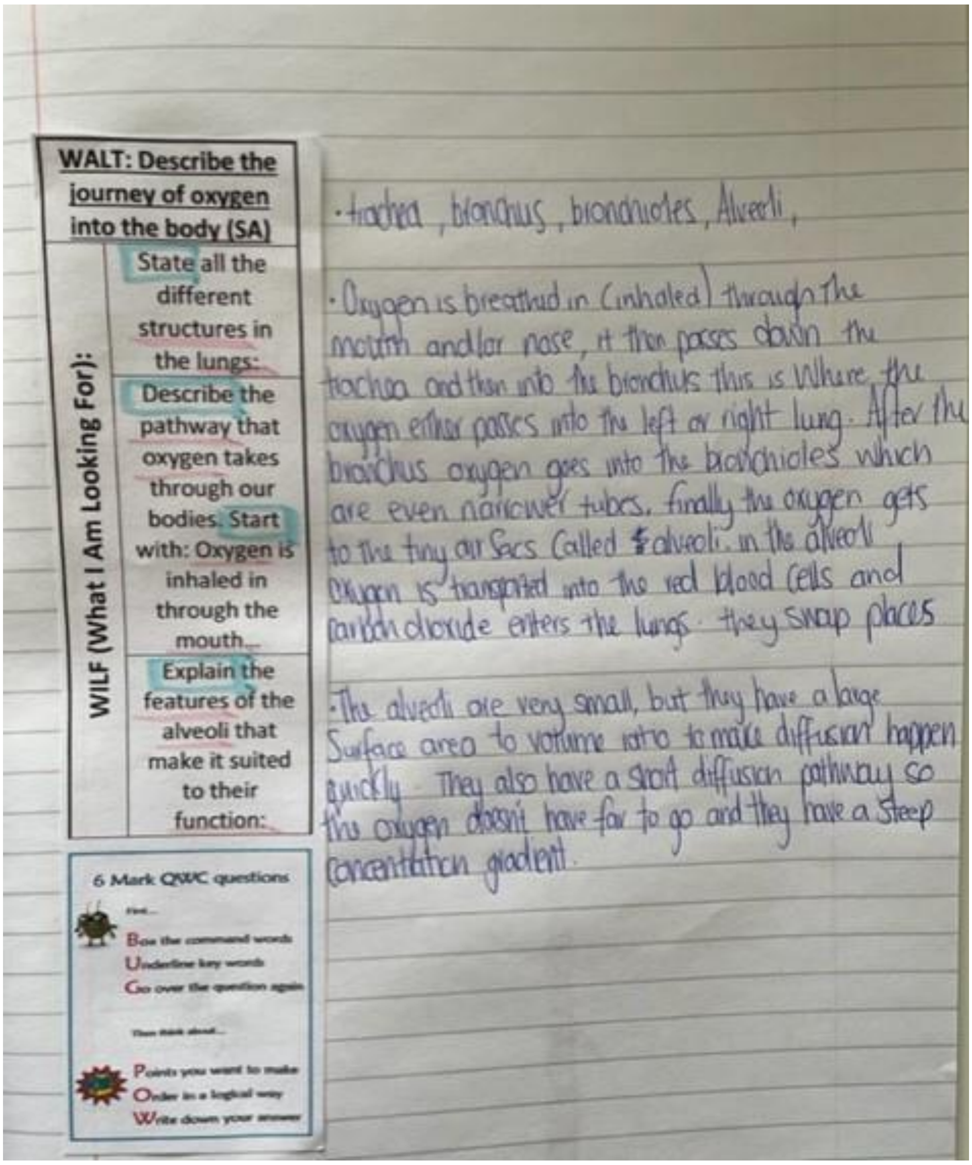


Figure 13 - Students extending writing activity during the intervention

When analysing the impact that the literacy intervention has had on students use of subject specific vocabulary and their writing ability, the post intervention assessment reveals positive news. It was found that students believed their literacy ability across all measures had increased, the most significant of these results being the percentage of students who rated their writing ability in science as good or very good which rose from 26.3% to 68.1%. Further to this, students' understanding of scientific terminology improved from 38.7% to 72.7%. This information, when coupled with the visible improvement in writing, as demonstrated in the examples presented, shows the intervention to have been successful in aiding writing in science and the use of key terminology.

To allow for an easier comparison, the table in figure 14 shows the percentage of students who answered either "agree" or "strongly agree" to the attitude towards literacy questions, for a more insightful comparison the percentage change has been calculated. Comparing these figures to the control group show a meaningful and impactful change has occurred.

Questions	**Pre intervention**		**Post intervention**		**Percentage change**	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
I can verbalise my answers to questions in science well	34.1	24.4	68.2	17.1	100	-29.9
I can write my answers to questions in science well	26.3	19.5	68.1	12.2	158.9	-37.4
I understand scientific terminology used in class	38.7	14.6	72.7	17.1	87.9	17.1
I find applying my knowledge to everyday life easy	27.3	12.2	56.8	9.8	108.1	-19.7
I find answering 6 mark exam questions easy	15.9	0	21.8	9.1	37.1	9.1
My spelling in science is good	34.1	17.1	93.2	19.5	173.3	14.0

Figure 14 - percentage of students answering "agree" or "strongly agree" in pre and post intervention questionnaires and the corresponding percentage change

These findings demonstrate a substantial improvement in all measures of students writing ability and their use of scientific language. Conversely it can be seen that Group 2, the control, have not only failed to make as much progress at the intervention group, but appear to have regressed in their writing ability and application of scientific knowledge, an alarming finding that will be shared with the class teacher to support these students after the intervention has concluded.

Finally, to note, when comparing how much students value and enjoy science, in Group 1 the number of students who find science easy increased by 45%, compared to a decrease of 17.1% in the control group, implying they are finding science increasingly more difficult. In terms of enjoyment, Group 1 saw the number of students who like science increase from 52.3% to 86.4% while Group 2 saw a drop of 10% in the same period. Simultaneously Group 1 showed 9.1% more students who agree that science is important to them, contrasted by 14.6% less students agree to this in Group 2. Group 2's decline in enthusiasm and perceived importance of science concur the suggestions of Osborne et al., (2003) and Terry and Quinn (2010;). while it would appear that the literacy intervention has reversed this to an extent. The data analysis for this is available in the appendix.

Reading

Pre-intervention

Through examination of students classwork, pre intervention assessments and semi structured interviews their attitudes and abilities to reading were explored.

From the assessment it became apparent that reading is a barrier to students' progress in science, with only 38.6% of students stating they find reading easy. Assuming that those who do not find easy are less likely to enjoy reading, presents some concerns for educators as Anderson et al., (1988) and Blunsdon et al., (2003) have both noted that students who do not enjoy reading as more likely to struggle academically. Additionally, a few common themes started to emerge from the student interviews with pupils noting they *"don't understand all the words, they don't make sense"* and *"It's hard, because sometimes I read the words but I don't get it. I'm not good at science"* additionally a couple of students remarked that even if they knew "*most of the words individually, it doesn't always make sense as a sentence*". This was an interesting point to raise that has also been recognised by Quigley (2018), highlighting that not only do science teachers need to be conscious of specific language recognition but also sentence comprehension. Many of the pupils interviewed appeared to have a fixed mindset with regards to their reading ability, believing it is something they are either inherently good or bad at and echoed thoughts that it wouldn't be something they or others had the potential to change – "*I'm just not good at reading, I never have been*", the suggestions of Lee et al., (2022) emphasise the importance of supporting a "reading-specific growth mindset" (p.15) as they identify a fixed mindset to reading as one of the major barrier for reading ability, even in students who are competent readers already. Further, to this, the comment referencing poor word comprehension is important to note, science students need to have a clear understanding of the subject specific terminology presented to them to prevent misconceptions and miscommunication, it is therefore important to, as discussed earlier, equip students with the tools needed for them to decode the language of science. When asked about strategies that could help students with their reading many of the groups responses were insightful with reference to making lessons more "*fun*" or "*interesting*" being a popular response. Pupils were able to give some examples they would like to see in lessons to engage them with reading more, including the use of word searches and crosswords as well as selecting reading materials that they perceived to be more stimulating, like space or wild animals (Lewis & Wray, 2000). It also emerged that they felt reading was given as a task to fill time or to quieten the class down if they had been too noisy, they said that reading was "*never really a proper task, just something to do in the lesson",* another student commented that in the past some teachers have relied very heavily on textbooks for students to read which meant the teacher did very little explaining of the content, consistent with the views of Wellington and Osborne (2001). Other students within the interview group nodded and agreed with this sentiment adding that "*they [the teachers] tell you to read something and assume you know it and we don't go over it again*" another interjected "*yeah, and also, some people won't even do the reading, they just sit there and wait to see if they get caught*." Two thirds of the interviewed students said they don't like reading and expressed negative feelings towards reading activities in class, echoing the findings of Tegmark et al., (2022) who recognised the lack of purposeful reading often lead to negative associations for students. It became apparent that the students' experiences of reading in science were all negative, none of them made comments that showed they believed reading served a purpose in advancing their scientific learning.

Post intervention

Students participated in many reading activities throughout the intervention that were perceived to improve students' engagement with reading, this included card sorts to determine methods for practical work, loop games where one student read a question that someone else in the room had the answer to, reading news articles, using knowledge organisers and completing puzzles such as crosswords (Lewis & Wray, 2000).

One strategy employed to aid students active reading skills involved students reading an extract and highlighting or circling every word that they were unsure of the meaning for. After doing this, pupils had to write three facts they had learned, identify two keywords in the text and finally write down one question they had after reading. The impact of this task was twofold, firstly students had to actively participate and read the text because they were required to respond to the material rather than simply say they had read it when in reality they hadn't. Secondly they needed to demonstrate high levels of comprehension by proving whether they knew each words true meaning. It is very easy for students to skim read an article, claim to know what its about and then struggle when questioned because they have no real comprehension, this aimed to prevent these outcomes. Students were then asked to share words they had identified as unfamiliar or confusing and time was dedicated to going through these words and noting any new terms in their glossaries. Sometimes students were able to answer each other's questions which was a real strength, other times they were able to deduce meanings from their work on etymology and through class displays and, on a few occasions, they required teacher help. The more this type of task was carried out, the less they relied on adult support and the more they helped each other, demonstrating their confidence as well as ability to problem solve literary terms improved.

On the recommendation of Wellington and Osborne (2001), another reading task involved reading a topical news article (example in appendix), for the SEND class within the intervention group the language was simplified to make it accessible, but without losing the content or scientific nature of the piece. At the very beginning of the intervention students were a little reluctant to engage with remarks such as "*its not an English lesson"* and "*Why are we reading in science*" being made, however these comments were from a minority of students and once the aims of the intervention had been re-explained to students their engagement improved. In the last week one of the initially more reluctant readers commented that he would "*actually quite miss reading the news each week"* and has vowed to keep it up in his own time – a promising claim!

Throughout the intervention, even if not a dedicated reading activity, students were encouraged to engage with reading as much as possible, this included reading aloud from the PowerPoint or worksheets. Although this approach perhaps seemed a little old fashioned in some ways and more a technique used in primary schools, the students appeared to thoroughly enjoy reading aloud. This was especially true of the SEND class, who after the first lessons would specifically ask if they could read, this was a pleasure to witness as at the beginning they were not a class of confident readers, with their average reading age being 9.33 years despite chronological ages of 13-14. When the SEND students' reading ages were next calculated a few weeks after the intervention lesson they showed 79% of students' reading ages had increased with a class average of a 10% positive change. Within this class one student in particular had an astounding improvement, their reading age had started at 7.10 and ended on 10.02, representing a 41.10% percentage increase. Through discussions during lesson time with the students they remarked that they found reading more enjoyable in science and it was clear that alongside a clear measurable change in reading ages for most students, their confidence in reading had also increased. Pupils had a more positive view of themselves as competent readers and were proud of their achievements (Clark and Foster, 2005).

The data in Figure 15 shows the comparison of the average reading ages of the intervention and controls groups pre and post intervention. Prior to the intervention the control group had a slightly higher average reading age than the intervention group, with the SEND class in each group having significantly lower reading ages compared to the higher attaining classes. After the intervention period the average reading ages were recalculated using the Accelerated Reader programme as part of normal working practice, the data was compared and an average percentage change was also calculated for each group. The analysis shows that as expected both groups saw an increase in the average reading ages of the students, this was consistent with the expectations that students reading ability develops throughout the school year. However, the intervention groups average reading age surpassed that of the control group at the post assessment, with more than one year of reading age value added, this represented a 14.17% increase on average for the entire intervention group, just shy of 10% more than the control class. Statistical analysis, using the levenes test for equal variance and an independent T test was conducted, the results shown in figure 16 demonstrate that students who undertook a literacy intervention had a statistically significant increase with a large effective size in their reading age t(83) = 4.481, p=<0.001, d=1.05 .

Group	Average Reading age pre intervention	Average reading age post intervention	Average % Change in reading age
Intervention	11.4	12.97	14.17
Control	11.77	12.28	4.5

Figure 15 - Change in student reading ages

	Intervention Group		Control group					
	Mean	Standard Deviation	Mean	Standard Deviation	*df*	*t*	*p*	Cohen's *d*
Average percentage change in reading age	14.17	9.74	4.50	8.56	83	4.841	<0.001	1.05

Figure 16 - Results of independent T Test for average percentage change in students reading ages in the intervention group

Observation of lessons

Using the literacy observation template (see appendix) a senior member of the department observed three lessons, two with the SEND class and one with the higher attaining class to see how literacy was being nurtured in the classroom. From all three lessons it was noted that tone of voice used was soft, empathetic and motivating and "*unwaveringly positive*" all of which are characteristics Ginnis (2008) highlights as important factors for increasing students' self-esteem. One of the lessons observed was an entire lesson focused on writing skills, this was the lesson students wrote their stories of the cheese sandwiches journey through the digestive system; the concluding piece of work in the topic of digestion. This followed a lesson where students had taken part in a very fun, yet messy, model of the digestive system activity. During the demonstration lesson, particular care had been taken when recapping scientific vocabulary and encouraging the correct use of language, using the name 'oesophagus' rather than 'gullet' for example. That lesson had been entirely practical and spoken and so this observed lesson was an opportunity for students to demonstrate their knowledge through an informative yet creative written activity.

During the lesson the senior teacher remarked at the good use of differentiated scaffolding for the students work. Pupils had a planning grid to ensure each aspect of the digestive system was covered, for the higher ability students this was simply a grid with headings, but for those requiring more support, they were given key terms to include and questions to guide their storytelling. Once each student had created a plan, they swapped with a partner who checked it and then added one extra piece of information for their partner to include. This peer assessment of work again encouraged active reading and aided communication skills with their partner. Figure 17 shows the planning stage of one students work, this pupil is a very quiet girl who does not like to make verbal conributions in class, however it is clear to see that she has fully utilised the planning document to create a clear record of all the information she needs to include; she has used accurate scientifc language and corrected her own spellings where need be. The girl's partner, an equally quiet but intelligent girl, probed for further understanding by ensuring the student refers back to the subject of the original task and questions where the components of the sandwich will be broken down. The student has responded appropriately to this feedback and this helped her pull together a well strucutred, logical and complete picture of how the digestive system works.

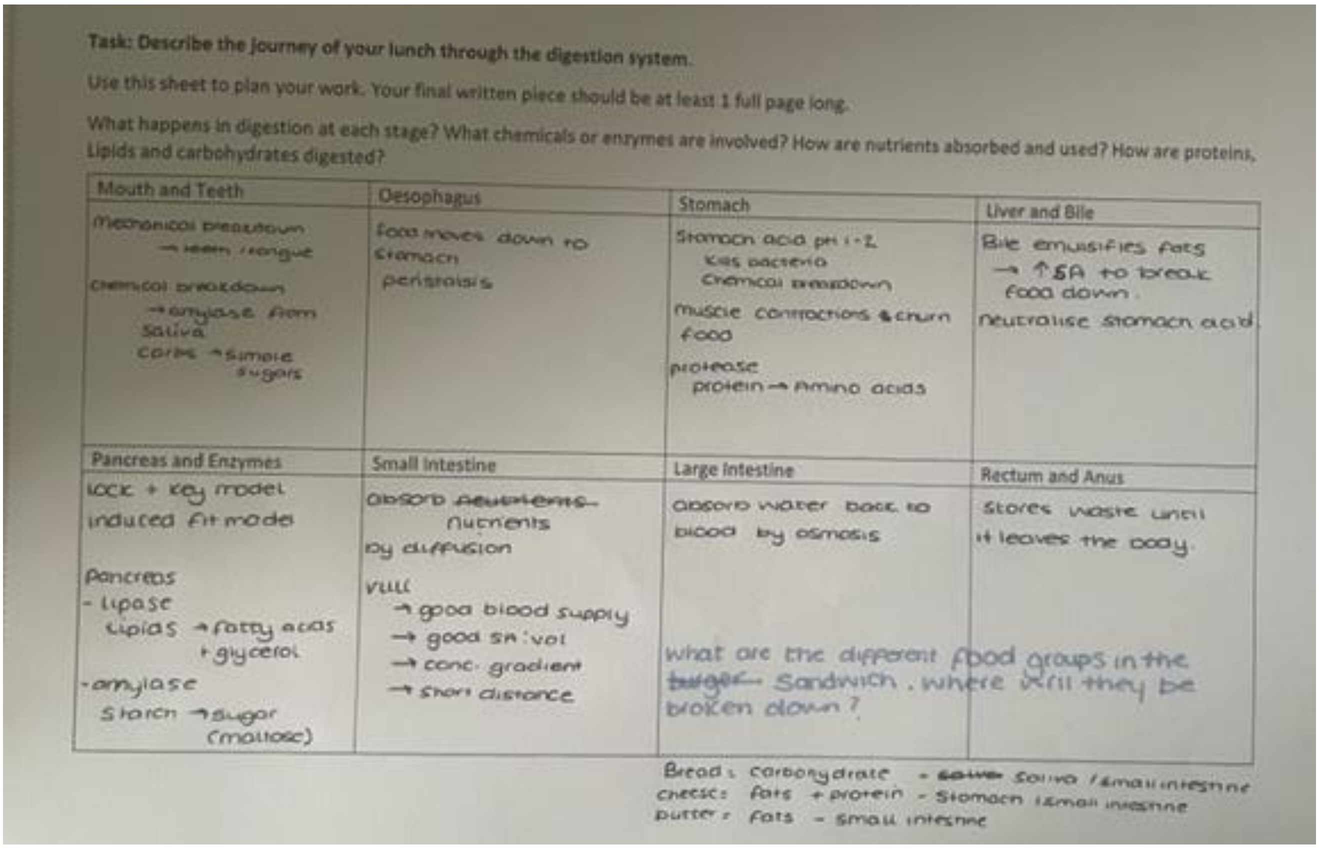


Figure 17- Example of scaffolding for extending writing task

After completing their written work students were provided with whole class feedback, modelling good work and highlighting common mistakes as this was a suggestion students had raised during the interviews, that they "*want[ed] to see what good looks like".* The following lesson, students were then handed a photocopy of somebody else in the classes work, they were anonymised and students were given a fellow student of a similar academic abilities to mark. The pupils were tasked with circling every keyword, correcting any spelling or grammatical errors and finally adding their own feedback in the form of two praises and one improvement point. These were later handed back to the original writers who had the opportunity to discuss with the teacher any questions they had about their peers' comments. Students completed the task very successfully, many commented how much they enjoyed being able to do something creative in a science lesson as it wasn't what they were used to, and even those who had been hesitant produced some excellent work. The work itself was displayed in the classroom to show recognition of their hard work but also to serve as model writing to other classes. Students writing skills showed a vast improvement to pre-intervention, prior to the intervention students would have been a lot more reluctant to engage in such an activity and would not have written the quantity or quality that they did. Students work showed an increase in the use of subject specific vocabulary, the writing also showed generally high fluency and confidence in written communication. During the lessons that were observed the senior teacher commented how "*confident and independent*" the students were in grasping new terminology and they cited their use of vocabulary books, graphic organisers and informative classroom displays as a major factor in the pupils' achievement. The success of the task made it more likely to include these extended writing opportunities in future lesson planning, it was also fed back to other members of the department to trial more with their classes after the intervention had concluded.

Limitations

Although this study has merit, it must be recognised that there are several limitations to the research. Firstly, the small sample size is smaller than originally intended, ideally this study would have been conducted across the entire year 9 cohort however this was not logistically possible due to many classes being shared by multiple teachers. This would potentially increase the likelihood of variation in the intervention being implemented and a lack of consistency and so this influenced the classes that were at disposal for this study.

While this research has shown significant improvements to students' literacy levels, especially in terms of their reading age, it must be acknowledged that there will be other factors contributing to this, many of which are beyond control (Wilson, 2007). For example, conversations were not had with the students individual English teachers to explore the impact that their teaching was having and this would be something to consider exploring further in future research. Additionally, there are a wealth of factors from outside school that will influence children's attainment such as parental engagement and the family's previous experiences of education (Desforges & Abouchaar, 2003), again these are not factors that could be mitigated and so when reviewing the claims of this study they should be viewed as likely to have been impactful to a degree.

Secondly, the impact of COVID-19 cannot be negated. This research study initially began in the academic year 2019-2020 with a larger sample size (n=270). The intervention was part complete when the first national lockdown began, pre-intervention data for the intervention and control groups had been collected and part analysed, however the move to online learning made it impossible to complete this study. All data and findings had to be destroyed as by the time pupils and teachers physically returned to the classroom too much time had passed to pick up with the research and the class were by then completing GCSE work, many of the groups also had new teachers and so continuity of the intervention was not possible. For personal circumstances I had to suspend my studies at the university for 2 years. On my return to academia my career had progressed more in favour of key stage 5 teaching, meaning I had less contact time with Key stage 3 classes which had been decided as the focus of this research, in addition, timetable constraints made the classes used for the intervention my only key stage 3 groups, and so although a small sample size, they were the only classes available for research purposes. In the near future I would like to scale up this investigation to a larger group of students across a wider range of abilities to determine whether the findings of this report are applicable to the wider key stage 3 population.

One of the main strengths of this research project was the quantity of data collected for each student in terms of their attitudes to literacy, quantitative assessments of their ability, evidence of their classwork and interview transcripts. However, due to the constraints of this project it was not possible to delve as in depth in statistical analysis as I would have liked to, for example investigating significant differences between pupil premium and non-pupil premium students or to explore any gender differences. Further statistical analysis would potentially strengthen the claims made in this study, but is something that can be pursued for professional interest at a later date.

Conclusion

This practitioner research aimed to investigate barriers to and strategies for improving pupils' literacy in secondary school science. The findings of this small-scale literacy intervention are very positive, suggesting that by embedding literacy within each lesson and dedicating specific time to nurturing these skills that significant gains can be made, both in terms of measurable academic outcomes but also students' confidence and self-esteem. The project aimed to investigate the following questions:

What are students perceived barriers to literacy in science?

Through careful evaluation of the extensive literature available in this subject as well as both the qualitative and quantitative data collected during this study, the use of discipline specific vocabulary appears to be the greatest barrier to academic success in science. Furthermore, because of this lack of terminology students are not able to articulate their observations, opinions and questions fluently as evidenced in their initially poor reading and writing ability.

Prior to the intervention pupils tended to confuse everyday language with the fixed and precise definitions of words needed in science, such as the terms 'energy and power'. However, through consistent use of student created glossaries in vocabulary books, the teaching of the etymology of scientific words, the use of graphic organisers and constant reinforcement of terminology from the teacher, students have made significant gains during a relatively short intervention period. These findings are apparent in both the quality of their work but also the number of pupils who rate their confidence understanding scientific terminology as high which rose from 38.7% to 72.1%, this is compared to the control group who only experienced at 2.5% increase during the same time period.

How effective are strategies to improve students use of language and written work in science?

One of the greatest successes of this intervention was the marked improvement in students written work and students self-reported and teacher perceived confidence in science as a whole. Many students prior to the intervention struggled to articulate themselves, often using incorrect terminology, or lacking the confidence to put pen to paper in the first place. Pupils found science "*confusing*" and were reluctant to attempt six-mark exam questions as they required a good standard of literacy which often felt "*intimidating*" to students. The use of scaffolding to structure pupils written work whether that be for extended writing projects such as 'The journey of the cheese sandwich' or a checklist for tackling longer written exam questions, proved to be very successful. Students who would frequently avoid writing tasks became engaged in the activities presented to them and showed to even enjoy some of these tasks. Again, significant improvements were seen in the intervention group compared to the control group who saw 31.8% more students who were confident in their writing ability versus a 7.5% decrease respectively.

Research question three: How effective are strategies to improve students reading in science?

During the course of this project it was pleasing to see how students reading ability developed and their confidence in reading new material improved. By subtly engaging pupils with as many reading opportunities possible throughout each lesson the task of reading itself felt less daunting to the students. Students participated in Drop Everything and Read, which is a whole school literacy strategy, but this was modified slightly to give students greater access to read scientific material, this included newspaper articles, scientific magazines and non-fiction books. Some pupils had showed initial resistance to this, but by the end of the intervention most looked forward to reading about a science news article and learning about topics beyond the scope of the curriculum. As noted by (Lewis and Wray, 2000) developing students' mindset to read for pleasure and not simply as a chore, plays a large role in improving pupils' literacy skills. There were many occasions during the intervention when students went beyond teacher expectations to engage with reading, within the SEND class they adored taking the opportunity to read aloud from PowerPoints and worksheets even without being prompted to, this also demonstrated the shift in students' mindsets and confidence as prior to the intervention the pupils would have never offered to read aloud or perform their self-written raps and songs in front of their peers. Although qualitatively there is evidence to support that the intervention has been successful in improving students reading, it is reassuring to see that quantitatively there is further evidence to support this claim, with students making on average a 14.2% percentage increase in their reading score over a six week period, compared to a 4.5% improvement in the control group.

In the near future there are plans to collaborate with the Head of English further as she begins to develop a whole school strategy for literacy across the curriculum. This research conducted within the science department will serve as an example of strategies that have had a proven impact and allow other departments to consider how the tools deployed in science can be replicated or modified for their own context. There is already a plan in place to introduce vocabulary books for subject specific language across the school, building of their success in science.

In conclusion, students' literacy skills are pivotal for their academic success in science and having the knowledge to accurately use key vocabulary is at the heart of this (Wellington and Osborne, 2001), without the understanding of the language of science pupils will struggling with their reading and writing. Being able to read and write science is an important skill for school, but also for life, without fundamental literacy skills students cannot become scientifically literate; that is to interpret and be critical of the world around them and evidence presented to them in a real world context. There is a knock-on effect that if students do not have good literacy skills, they will not become scientifically literate which then coincides with poorer socio-economic outcomes later in life. By taking steps to tackle this now it is hoped that these less desirable outcomes can be avoided, this is especially important when considering the location of this school in one of the most deprived towns in the UK with exceptionally high levels of child poverty. This research project has conclusively demonstrated that even in a time period as short as 6 weeks, significant educational gains can be made when delivering specific literacy instruction. As one student remarked she wants to succeed at school because she "*wants to break the cycle and education is the tool to bring about change."*

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Appendix

Dear Mr [redacted]

I am writing to enquire about conducting research in school this academic year. As you know, I am studying for the Master's in Learning and Teaching at Oxford University, supervised by [Redacted]. In my final research project I will explore the effectiveness of strategies in raising literacy standards in Science.

The research will take place with one year group in key stage 3 (to be decided with the HoD) I am developing ways of improving students' literacy skills through a variety of tasks, both in my lessons and with colleagues. My research focus is on students' written communication and reading, but I will also look at teachers' use of scientific terminology and how language is presented in the classroom. I have spoken to the HoD about my plan and she has agreed to collaborate and support me with me on this.

By participating in the research, the school would be contributing to a project that will *deepen our understanding of literacy in science and so contribute towards developing ways of improving attainment for other year groups in the school in the future. It also hope to share my findings with other departments at [redacted]*

I hope to conduct this research between November and February. *I would interview/ audio-record group discussions with students/ observe and take notes of current teaching practice and photocopy some students' written work as well as ask students to undertake a short literacy assessment.*

Oxford University has strict ethical procedures on conducting ethical research, consistent with current British Educational Research Association guidelines. The University also recognises, however, that my study is a piece of practitioner research, and that schools already operate with the highest ethical standards. Therefore only <u>your</u> formal consent as headteacher is necessary, and not that of individual parents or staff. However, throughout the research, students and other teachers will be able to refuse to participate in any research activities at any time.

All participants, including students, teachers and the school, would be made anonymous in all research reports. The data collected would be kept strictly confidential, available only to my supervisor and me, and only used for academic purposes. It will be kept for as long as it has academic value.

If you are happy for me to proceed with this study, please confirm that using the attached reply form. If you have any concerns or need more information about what is involved, please contact me or my supervisor. Further, if you have any questions about this ethics process at any time, please contact the chair of the department's research ethics committee, though: research.office@education.ox.ac.uk

Yours sincerely,

Name:

Literacy in Science

Class:

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
In general I find science easy					
It is important that I do well in science					
I like doing science					
I can verbalise answers in science well					
I can write my answers to questions in science well					
I understand scientific terminology used in class					
I find applying my science knowledge to everyday life easy.					
I find answering 6 mark exam questions easy					
I find reading in science easy					
My spelling in science is good					

Q1. Please circle the word that matches up to the definition

a. The variable that is measured in an investigation

Dependent variable   Independent variable   Control variable

b. The surroundings, such as air, water, soil, climate, food sources, where an organism lives

Atmosphere   environment   habitat

c. The rate of flow of electric charge

charge   current   Voltage   resistance

d. How well sets of data are linked; high _____ shows that there is a strong link between two sets of data

Correlation   discretion   regression

e. Something that is able to be stretched out a lot

Malleable   ductile   sonorous

f. The process of molecules moving from an area of high concentration to an area of low concentration

Diffusion Active transport Osmosis

Q2. Meanings behind words.

Photosynthesis, Photograph and photon all have the same 'photo' prefix. What does 'photo' refer to?

Thermal energy, thermometer and thermos flask all have the same 'Therm' prefix. What does therm refer to?

Microscope, microbe and micro-organisms all have the same 'micro' prefix. What does micro refer to?

Hydrated, hydroelectric power and hydrothermal all have the same 'hydro' prefix. What does 'hydro' refer to?

Name:

Class:

Literacy in Science

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
In general I find science easy					
It is important that I do well in science					
I like doing science					
I can verbalise answers in science well					
I can write my answers to questions in science well					
I understand scientific terminology used in class					
I find applying my science knowledge to everyday life easy.					
I find answering 6 mark exam questions easy					
I find reading in science easy					
My spelling in science is good					

Q1. Please circle the word that matches up to the definition

A .the rate at which energy is transferred or the rate at which work is done

Power current voltage

b. ratio of the potential difference across an electrical component to the current through the component

energy resistance charge

c. to organise and present data in a logical order, e.g. in a table

precise regress classify

d. a guess based on prior knowledge

formulate prove estimate

e. describes the similarities and/or differences between things, not just write about one."

Hypothesise conclude compare

Q2. Meanings behind words.

a) Antibiotics, anti-perspirant and antibodies all have the same 'anti' prefix. What does 'anti' refer to?

b) Monobrow, monorail and carbon monoxide all have the same 'mono' prefix. What does 'mono' refer to?

c) Passport, transport and support all have the same 'port suffix. What does port refer to?

d) Submarine, substandard and subduction all have the same 'sub prefix. What does 'sub refer to?

e) Hyperactive, hyperthermia and hyperventilate all have the same 'hyper prefix. What does hyper refer to?

Student interviews

Sample semi structured interview questions – to be conducted with approx. 4 students per group.

This interview is being conducted to find out more about how you learn in science and also how we can help you to improve your literacy skills.

The interview will be recorded and then typed up and your participation is completely voluntary. If at any point you want me to stop the interview, please do say.

1. What do you understand by the word ‘literacy’?
2. Why is reading and writing important in science?
3. Do you find literacy difficult in science, why/why not?
4. How do you know how to improve your written work in science lessons?
5. Do you do many extended pieces of writing in Science at the moment?
6. What do you find most difficult about reading/writing in science?
7. Do you find it easy to learn definitions?
8. Do you find glossaries helpful, why?
9. What would help you the most with reading and writing in science?
10. When you read a text/instructions in science, do you find it easy to know what is being said?
11. Do you think you are good at spelling – what helps you learn to spell the most?
12. Do you read science news articles at home/school?
13. When you get a long answer question in science, how do you feel about answering it?
14. Do teachers explain the meaning of words clearly in lessons?
15. How can teachers help you to improve your literacy skills?
16. Is there anything else you would like to comment about literacy in science lessons?

Breathing and Gas Exchange	**Particle Model**	**Waves**
1. Alveoli	1. Boiling	1. Transverse
2. Trachea	2. Evaporating	2. Longitudinal
3. Bronchus	3. Sublimation	3. Amplitude
4. Diffusion	4. Deposition	4. Wavelength
5. Concentration	5. Kinetic energy	5. Frequency
6. Aerobic	6. Condensation	6. Incidence
7. Anaerobic	7. Particle	7. Reflection
8. Respiration	8. Temperature	8. Refraction
9. Diaphragm	9. Thermometer	9. Angle
10. fermentation	10. Saturated	10. oscilloscope
Reactions	**Forces**	**Genetics and DNA**
1. Alkali	1. Acceleration	1. Alleles
2. Acid	2. Density	2. Chromosomes
3. Thermal	3. Pivot	3. Dominant
4. Concentration	4. Gravity	4. Gametes
5. Temperature	5. Moments	5. Gene
6. Equilibrium	6. Extension	6. Genotype
7. Corrosive	7. Weight	7. Heredity
8. Indicator	8. Deformation	8. Phenotype
9. Neutralisation	9. Compression	9. recessive
10. burette	10. Newton	10. variation
Earth	**Ecosystems**	**Cells**
1. Atmosphere	1. bioaccumulation	1. nucleus
2. Combustion	2. biodiversity	2. mitochondria
3. Deforestation	3. carnivore	3. ribosomes
4. Erosion	4. community	4. cytoplasm
5. Igneous	5. environment	5. cellulose
6. Metamorphic	6. herbivore	6. respiration
7. Sedimentary	7. interdependence	7. eukaryote
8. Porous	8. omnivore	8. organelle
9. Sustainability	9. predators	9. photosynthesis
10. Sediments	10. Population	10. magnification
Atoms and the periodic table	**Energy**	**Electricity**
1. Atoms	1. conduction	1. conductor
2. Elements	2. convection	2. electromagnet
3. Compounds	3. radiation	3. electron
4. Molecule	4. dissipated	4. insulator
5. Proton	5. elastic	5. neutron
6. Neutron	6. gravitational potential	6. ohms
7. Electron	7. infrared	7. resistance
8. Reactivity	8. joule	8. parallel
9. Properties	9. renewable	9. series
10. Mendeleev	10. nuclear	10. repel

The last Sumatran Rhino dies

The Sumatran rhino is now officially extinct in Malaysia, with the death of the last known specimen.

The figure originally presented here cannot be made freely available via ORA because of copyright. The figure was sourced at https://www.bbc.co.uk/news/world-asia-50531208

The 25-year-old female named Iman died on Saturday on the island of Borneo, officials say. She had cancer.

Malaysia's last male Sumatran rhino died in May this year.

The Sumatran rhino once roamed across Asia, but has now almost disappeared from the wild, with fewer than 100 animals believed to exist. The species is now critically endangered.

Iman died at 17:35 local time (09:35 GMT) on 23rd November 2019 Malaysia's officials said.

"Its death was a natural one, and the immediate cause has been categorised as shock," Sabah State Tourism, Culture and Environment Minister Christine Liew is quoted as saying.

"Iman was given the very best care and attention since her capture in March 2014 right up to the moment she passed," she added.

Sumatran rhinos have been hard hit by poaching and habitat loss, but the biggest threat facing the species today is the fragmented nature of their populations.

Efforts to breed the species in Malaysia have so far failed.

Rhino facts

- Five rhino species can be found today, two in Africa and three in Asia
- The Asian species include the Sumatran rhino, *Dicerorhinus sumatrensis*, which is the smallest living rhino species

- The animal is closely related to the woolly rhinoceros, which became extinct about 10,000 years ago
- No more than 100 Sumatran rhinos remain in the wild (some estimates put the number as low as 30), scattered on the islands of Sumatra, Indonesia

News article from: https://www.bbc.co.uk/news/world-asia-50531208

Please answer the following questions <u>in full sentences in your books</u>

1. What was the name of the rhino that passed away?
2. When and where did the rhino die?
3. What was the cause of death?
4. “The species is now critically endangered” – what does this mean?
5. What are the biggest threats to the rhino’s survival?
6. What is poaching?
7. Why is it bad for an animal to become extinct?
8. What do you think people should do to protect the rhino?

1.In general I find science easy * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
1.In general I find science easy	Strongly Disagree	Count	4	0	4
		% within Intervention	9.1%	0.0%	4.7%
	Disagree	Count	5	11	16
		% within Intervention	11.4%	26.8%	18.8%
	Neutral	Count	24	21	45
		% within Intervention	54.5%	51.2%	52.9%
	Agree	Count	7	9	16
		% within Intervention	15.9%	22.0%	18.8%
	Strongly Agree	Count	4	0	4
		% within Intervention	9.1%	0.0%	4.7%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. It is important that I do well in science * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
1. It is important that I do well in science	Disagree	Count	2	3	5
		% within Intervention	4.5%	7.3%	5.9%
	Neutral	Count	6	23	29
		% within Intervention	13.6%	56.1%	34.1%
	Agree	Count	25	13	38
		% within Intervention	56.8%	31.7%	44.7%
	Strongly Agree	Count	11	2	13
		% within Intervention	25.0%	4.9%	15.3%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. I like doing science * Intervention Crosstabulation

			Intervention		Total
			Intervention Group	Control Group	
1. I like doing science	Strongly Disagree	Count	1	0	1
		% within Intervention	2.3%	0.0%	1.2%
	Disagree	Count	3	2	5
		% within Intervention	6.8%	4.9%	5.9%
	Neutral	Count	17	23	40
		% within Intervention	38.6%	56.1%	47.1%
	Agree	Count	16	16	32
		% within Intervention	36.4%	39.0%	37.6%
	Strongly Agree	Count	7	0	7
		% within Intervention	15.9%	0.0%	8.2%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. I can verbalise answers well in science * Intervention Crosstabulation

			Intervention		Total
			Intervention Group	Control Group	
1. I can verbalise answers well in science	Disagree	Count	13	9	22
		% within Intervention	29.5%	22.0%	25.9%
	Neutral	Count	16	22	38
		% within Intervention	36.4%	53.7%	44.7%
	Agree	Count	12	9	21
		% within Intervention	27.3%	22.0%	24.7%
	Strongly Agree	Count	3	1	4
		% within Intervention	6.8%	2.4%	4.7%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. I can write my answers in science well * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
1. I can write my answers in science well	Disagree	Count	12	15	27
		% within Intervention	27.3%	36.6%	31.8%
	Neutral	Count	16	18	34
		% within Intervention	36.4%	43.9%	40.0%
	Agree	Count	13	8	21
		% within Intervention	29.5%	19.5%	24.7%
	Strongly Agree	Count	3	0	3
		% within Intervention	6.8%	0.0%	3.5%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. I understand scientific terminology used in class * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
1. I understand scientific terminology used in class	Strongly Disagree	Count	5	0	5
		% within Intervention	11.4%	0.0%	5.9%
	Disagree	Count	7	14	21
		% within Intervention	15.9%	34.1%	24.7%
	Neutral	Count	15	21	36
		% within Intervention	34.1%	51.2%	42.4%
	Agree	Count	16	6	22
		% within Intervention	36.4%	14.6%	25.9%
	Strongly Agree	Count	1	0	1
		% within Intervention	2.3%	0.0%	1.2%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. I find applying my science knowledge to everyday life easy * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
1. I find applying my science knowledge to everyday life easy	Strongly Disagree	Count	2	1	3
		% within Intervention	4.5%	2.4%	3.5%
	Disagree	Count	16	20	36
		% within Intervention	36.4%	48.8%	42.4%
	Neutral	Count	14	15	29
		% within Intervention	31.8%	36.6%	34.1%
	Agree	Count	8	4	12
		% within Intervention	18.2%	9.8%	14.1%
	Strongly Agree	Count	4	1	5
		% within Intervention	9.1%	2.4%	5.9%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. I find answering 6 mark exam questions easy * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
1. I find answering 6 mark exam questions easy	Strongly Disagree	Count	6	0	6
		% within Intervention	13.6%	0.0%	7.1%
	Disagree	Count	14	20	34
		% within Intervention	31.8%	48.8%	40.0%
	Neutral	Count	16	21	37
		% within Intervention	36.4%	51.2%	43.5%
	Agree	Count	7	0	7
		% within Intervention	15.9%	0.0%	8.2%
	32	Count	1	0	1
		% within Intervention	2.3%	0.0%	1.2%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. I find reading in science easy * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
1. I find reading in science easy	Strongly Disagree	Count	4	1	5
		% within Intervention	9.1%	2.4%	5.9%
	Disagree	Count	10	15	25
		% within Intervention	22.7%	36.6%	29.4%
	Neutral	Count	13	16	29
		% within Intervention	29.5%	39.0%	34.1%
	Agree	Count	14	9	23
		% within Intervention	31.8%	22.0%	27.1%
	Strongly Agree	Count	3	0	3
		% within Intervention	6.8%	0.0%	3.5%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

1. My spelling in science is good * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
1. My spelling in science is good	Strongly Disagree	Count	2	1	3
		% within Intervention	4.5%	2.4%	3.5%
	Disagree	Count	13	17	30
		% within Intervention	29.5%	41.5%	35.3%
	Neutral	Count	14	16	30
		% within Intervention	31.8%	39.0%	35.3%
	Agree	Count	12	5	17
		% within Intervention	27.3%	12.2%	20.0%
	Strongly Agree	Count	3	2	5
		% within Intervention	6.8%	4.9%	5.9%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2.In general I find science easy * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
2.In general I find science easy	Strongly Disagree	Count	0	1	1
		% within Intervention	0.0%	2.4%	1.2%
	Disagree	Count	3	26	29
		% within Intervention	6.8%	63.4%	34.1%
	Neutral	Count	10	12	22
		% within Intervention	22.7%	29.3%	25.9%
	Agree	Count	19	2	21
		% within Intervention	43.2%	4.9%	24.7%
	Strongly Agree	Count	12	0	12
		% within Intervention	27.3%	0.0%	14.1%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. It is important that I do well in science * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
2. It is important that I do well in science	Disagree	Count	0	6	6
		% within Intervention	0.0%	14.6%	7.1%
	Neutral	Count	4	26	30
		% within Intervention	9.1%	63.4%	35.3%
	Agree	Count	18	9	27
		% within Intervention	40.9%	22.0%	31.8%
	Strongly Agree	Count	22	0	22
		% within Intervention	50.0%	0.0%	25.9%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. I like doing science * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
2. I like doing science	Disagree	Count	1	9	10
		% within Intervention	2.3%	22.0%	11.8%
	Neutral	Count	5	28	33
		% within Intervention	11.4%	68.3%	38.8%
	Agree	Count	20	4	24
		% within Intervention	45.5%	9.8%	28.2%
	Strongly Agree	Count	18	0	18
		% within Intervention	40.9%	0.0%	21.2%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. I can verbalise answers well in science * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
2. I can verbalise answers well in science	Disagree	Count	2	7	9
		% within Intervention	4.5%	17.1%	10.6%
	Neutral	Count	12	27	39
		% within Intervention	27.3%	65.9%	45.9%
	Agree	Count	27	7	34
		% within Intervention	61.4%	17.1%	40.0%
	Strongly Agree	Count	3	0	3
		% within Intervention	6.8%	0.0%	3.5%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. I can write my answers in science well * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
2. I can write my answers in science well	Disagree	Count	1	10	11
		% within Intervention	2.3%	24.4%	12.9%
	Neutral	Count	13	26	39
		% within Intervention	29.5%	63.4%	45.9%
	Agree	Count	24	5	29
		% within Intervention	54.5%	12.2%	34.1%
	Strongly Agree	Count	6	0	6
		% within Intervention	13.6%	0.0%	7.1%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. I understand scientific terminology used in class * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
2. I understand scientific terminology used in class	Disagree	Count	1	8	9
		% within Intervention	2.3%	19.5%	10.6%
	Neutral	Count	11	26	37
		% within Intervention	25.0%	63.4%	43.5%
	Agree	Count	28	7	35
		% within Intervention	63.6%	17.1%	41.2%
	Strongly Agree	Count	4	0	4
		% within Intervention	9.1%	0.0%	4.7%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. I find applying my science knowledge to everyday life easy * Intervention Crosstabulation

			Intervention: Intervention Group	Intervention: Control Group	Total
2. I find applying my science knowledge to everyday life easy	Disagree	Count	2	13	15
		% within Intervention	4.5%	31.7%	17.6%
	Neutral	Count	17	24	41
		% within Intervention	38.6%	58.5%	48.2%
	Agree	Count	22	4	26
		% within Intervention	50.0%	9.8%	30.6%
	Strongly Agree	Count	3	0	3
		% within Intervention	6.8%	0.0%	3.5%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. I find answering 6 mark exam questions easy * Intervention Crosstabulation

			Intervention: Intervention Group	Intervention: Control Group	Total
2. I find answering 6 mark exam questions easy	Disagree	Count	2	10	12
		% within Intervention	4.5%	24.4%	14.1%
	Neutral	Count	28	27	55
		% within Intervention	63.6%	65.9%	64.7%
	Agree	Count	13	4	17
		% within Intervention	29.5%	9.8%	20.0%
	Strongly Agree	Count	1	0	1
		% within Intervention	2.3%	0.0%	1.2%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. I find my reading in science easy * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
2. I find my reading in science easy	Disagree	Count	1	16	17
		% within Intervention	2.3%	39.0%	20.0%
	Neutral	Count	0	19	19
		% within Intervention	0.0%	46.3%	22.4%
	Agree	Count	32	6	38
		% within Intervention	72.7%	14.6%	44.7%
	Strongly Agree	Count	11	0	11
		% within Intervention	25.0%	0.0%	12.9%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

2. My spelling in science is good * Intervention Crosstabulation

			Intervention		
			Intervention Group	Control Group	Total
2. My spelling in science is good	Correct	Count	1	9	10
		% within Intervention	2.3%	22.0%	11.8%
	3	Count	2	24	26
		% within Intervention	4.5%	58.5%	30.6%
	4	Count	25	8	33
		% within Intervention	56.8%	19.5%	38.8%
	5	Count	16	0	16
		% within Intervention	36.4%	0.0%	18.8%
Total		Count	44	41	85
		% within Intervention	100.0%	100.0%	100.0%

Literacy observation sheet

Subject	Teacher	Date
Class	**Lesson Context**	**Observer**

Learning through talk

Feature of good practice	Evidence
Opportunities for students to learn through talk, using a variety of strategies including drama and role play	
Students are taught the features of the types of talk they need to use	
Students have a focus for listening activities	
During group talk, students have clear ground rules	
Students have clear roles in discussion	
Students are supported in developing oral responses	

Learning from texts (reading)

Features of good practice	Evidence
Texts are appropriate in content/level of difficulty for students	
Teacher encourages students to use core reading skills eg. Skimming and scanning	
Students are supported in developing research and note making skills	
Students are encouraged to read actively eg. Highlighting and annotating	
Students are supported in developing higher order skills	
Students are encouraged to read widely and for pleasure	

Extended writing

Features of good practice	Evidence
Students know the purpose and audience for the writing	
Students are taught the main features of the text type and "what good looks like"	

Students are given support with planning and structuring their writing	
Teachers support students in developing as independent writers	
Students are encouraged to check spelling, punctuation and grammar	
Students are supported in using subject specific vocabulary effectively	
Marking consistently supports the development of literacy, with students being given opportunity to respond to comments	

Using the environment

Features of good practice	**Evidence**
The environment is literacy rich and supports development in literacy skills	