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Investigating the Effect of Using Modern Language Vocabulary Teaching Strategies on the Recall and Application of Scientific Vocabulary with a Year 7 Class: A Case Study Proposal

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Abstract

Vocabulary is essential to understanding and participating in scientific discourse and is therefore integral to learning science. Science teaching, however, has a notable lack of explicit vocabulary teaching. Scientific teaching may benefit from using the vocabulary teaching strategies that can often be observed in modern language teaching. Strategies observed in the modern language classroom have been adapted for scientific vocabulary teaching in this case study proposal. Improvements in the recall and application of scientific vocabulary following the intervention would suggest that the strategies are beneficial to scientific learning. Such results would encourage further research that could investigate whether the strategies could help to close the attainment gap that exists between the socially advantaged and disadvantaged. Further research would be shaped by considering students' perceptions of vocabulary learning.

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Introduction

Vocabulary in Education

The importance of vocabulary in education is highlighted by Alex Quigley (2018) in his book *Closing the Vocabulary Gap,* which offers a comprehensive review of the literature surrounding teaching vocabulary in the classroom. Quigley (2018) suggests that addressing the vocabulary gap that exists between the socially advantaged and disadvantaged can help to tackle social inequalities in the classroom and, therefore, in society in general. He argues that a broad vocabulary offers a vital academic tool for success and gives students the confidence to communicate beyond the school gates.

Quigley (2018) also connects vocabulary to school success, which may not be surprising when considering the increasing demands of academic vocabulary brought about by bigger and harder qualifications at every key stage. He references evidence that shows vocabulary is a significant factor to students achieving A*-C grades in mathematics, English language and English literature.

Science as a Second Language

The observations I have collected in science classrooms at secondary schools in the UK suggest that science education may tend to overlook the importance of vocabulary learning given that there appears to be a lack of vocabulary teaching. These observations have been noted despite hearing several teachers explain that learning science can be like learning a foreign language. This concept has been of particular interest because of my experience of studying Spanish alongside science throughout my education, as well as my experience teaching English as a foreign language. The suggestion that science can be compared to learning another language is reflected in the literature.

Cohen (2012) suggests that science has its own language where students are introduced to completely novel words or novel uses of familiar words. Tong et al. (2014) further contributes to this argument by highlighting various studies that suggest the technical vocabulary of science helps to distinguish scientific language from every everyday language, and that native English speakers recognise scientific discourse as a different type of language. She concludes that students therefore must be taught scientific language to engage in scientific discourse.

Based on these observations and experiences, I concluded that vocabulary teaching in science may benefit from implementing the strategies used in the modern language classroom. I have therefore collected observations of vocabulary teaching in modern languages and will suggest in this proposal how the strategies could be implemented in teaching science and why they may be of benefit.

To my knowledge there is little literature that discusses using modern language vocabulary teaching strategies in science, however the importance of vocabulary teaching in science, and education in general, has been widely discussed. In the review of the literature, I will therefore discuss the literature surrounding the importance of vocabulary in science education, which supports the need to explore increasing vocabulary teaching in science. Following the review of the literature, I will outline the strategies proposed for the intervention and then discuss how the study may lead to further research.

Vocabulary in Science

Vocabulary is essential to discipline-specific learning in science education (Brown & Concannon, 2016). Vocabulary represents the building blocks to scientific language and conceptual elements of scientific literacy (Brown & Concannon, 2016; Young, 2005). The technical vocabulary and concepts of science impact students' understanding of texts and instruction, and potentially prohibit equitable access to higher level tasks and processes (Kennedy, Rodgers, Romig, Mathews, & Peeples, 2018). Townsend, Brock, & Morrison (2018) highlights that discipline-specific science words carry critical meaning in science language and result in heavy cognitive load as students grapple with science texts. In addition to understanding scientific texts, vocabulary is needed to link one content area to another and grasp the 'bigger picture' (Cohen, 2012). Kennedy et al. (2018) provides evidence from various studies supporting the importance of vocabulary in science education that shows that vocabulary knowledge is associated with increased achievement and that vocabulary deficits often serve as a barrier to learning in science.

Townsend et al. (2018) explains that scientific language can be challenging because it is technical and abstract. It is abstract because it represents phenomena that cannot be observed, and technical because concepts and processes are defined with precision. The conciseness and precision of scientific language facilitates learning from one another and builds knowledge for those who are familiar with the language of science. On the contrary, the same features of scientific language put up barriers to those who are not familiar with the language of science given that individual words and phrases bear the weight of scientific concepts. Therefore, developing scientific vocabulary is necessary to engage in scientific discourse. This point is also argued by Townsend et al. (2018) who references studies that suggest deeper scientific knowledge, which can be represented by scientific vocabulary, feeds into richer participation in scientific discourse communities. Brown & Concannon (2016) explain that, in addition to being able to engage in scientific discourse, students' ability to use scientific vocabulary is important as it aligns with what is required in science occupations.

The literature discussed demonstrates that vocabulary is known to be an integral part of science learning. However, my observations of science teaching have revealed little emphasis on teaching vocabulary, especially when compared to the modern language classroom. This observation seems to be strongly supported by the literature. Tong et al. (2014) highlights research that suggests that science teaching has underutilised language-based activities. Quigley (2018) agrees with this point by arguing that explicit vocabulary teaching is a rare activity and vocabulary is too often 'caught, not taught'. Cohen (2012) also highlights this as a problem and explains that whilst some students can pick up vocabulary incidentally, those who start off with a lower initial vocabulary ability cannot do this as effectively.

As suggested above, science learning in general may benefit from explicit vocabulary teaching. Indeed, Young (2005) argues that vocabulary strategies and explicit instruction is the job of every teacher, not just the English teacher. This view is shared by Feez & Quinn (2017) who argue that teachers must help children bridge the gap between everyday language and scientific language, of which specialised vocabulary is a distinctive feature. Explicit vocabulary teaching is essential because mere exposure does not lead to inferring correct meaning of words (Cohen, 2012). Brown & Concannon (2016) present multiple studies to demonstrate that explicit vocabulary teaching improves student comprehension and improves academic achievement.

In the context of this case-study proposal, it is possible that the cornerstone argument (that there is a lack of explicit vocabulary teaching in science) for carrying out the research could be limited because some of the key studies are not UK-based. Both the Tong et al. (2014) and Cohen (2012) studies are US-based, with many references from Canadian and American studies, therefore they may not be relevant references for this UK-based study. However, I would suggest that a lack of explicit vocabulary teaching in science may be a common issue to science teaching in the UK and the US given that their findings reflect the observations I have collected in UK schools. This suggestion is reinforced by the comprehensive review of the literature concerning a lack of explicit vocabulary teaching in education in general by Quigley (2018) that is UK based and references evidence from both the UK and US.

Perceptions About Learning Vocabulary

Another factor that may contribute to the success of vocabulary learning could be considering students' perspectives about vocabulary knowledge and learning. Brown & Concannon (2016) argue that a necessary component of effective science teaching considers students' perceptions of vocabulary knowledge and learning in order to promote more self-sufficient, independent learners.

Brown and Concannon (2016) aimed to address gaps that they identified in the literature concerning student perceptions of vocabulary knowledge. Their study was carried out with a group of 41 American eighth-grade students and data was collected with relation to the topics "types of energy" and "energy transformation". They found that literacy strategies have a powerful role in learning and that there is a relationship between students' perceptions of vocabulary knowledge and content achievement. Content achievement was measured using a content knowledge test that covered disciplinary core ideas identified by the K-12 Science Education Frameworks and evaluated by the American Association for the Advancement of Science (AAAS) project 2061 Assessment website. The study also found that the strategies strongly supported students' understanding of many science terminologies and the students outperformed a national data set. The national data set was the result of the AAAS project 2061 website that tested items with a sample population of approximately 1000 middle-level students.

The thorough analysis of the results instils confidence in the credibility of the findings. Inferential statistics showed that, following the intervention, there were significant increases in students' perceptions of their ability to explain new terminologies. Inferential statistics were also used to show

the students significantly outperformed the national data set in all but one of eight items in the content test. The relationship between students' perceptions of vocabulary knowledge and content achievement is evident as a high percentage of students had high confidence in their ability to explain many terms, and this was subsequently reflected by a high percentage of correct answers to the related items in the content test.

It is important to consider the one test item (about elastic energy and compression) that found no significant improvement in achievement, although there was still an increase. Despite not finding a significant improvement, a high percentage of students had high confidence in their ability to explain the related key terms. These results cast doubt on the relationship between students' perceptions of vocabulary knowledge and content achievement.

The perceptions of vocabulary test only assessed students' perceptions of knowledge and did not evaluate the accuracy of students' perceptions. I would suggest that evaluating the accuracy of students' perceptions (perhaps by using a multiple-choice test of definitions) may have helped to understand the cause of the anomalous result, as it may have revealed that students were overconfident using some of the terms related to elastic energy and compression. On the other hand, it may have revealed that students' perceptions were indeed accurate, therefore the lack of a significant increase in achievement could indicate that there was another factor that affected the results for the test item, like challenging wording of the question or conceptual difficulty. Identifying the cause of the anomalous result by evaluating accuracy of students' perceptions would help to better understand the connection between students' perceptions of vocabulary knowledge and content achievement.

Despite the element of doubt caused by the anomalous results for the test item, I would judge that the results of the study provide good evidence to show a relationship between students' perceptions of vocabulary knowledge and content achievement. There was indeed considerable consistency between increased content achievement (for the other seven test items) and confidence to explain the related key terms, although I acknowledge the conclusions drawn may be more reliable if there was an increase in the number of test items and related key terms that were studied.

Whilst Brown and Concannon (2016) argue their study is the first study to examine the interplay between students' beliefs about knowledge, assessment of knowledge and a classroom culture that values students' beliefs about literacy strategies, they also acknowledge that the study was carried

out on a select few learning objectives. They suggest more research is needed to understand the relationship between perceptions of vocabulary knowledge, reading comprehension and content achievement.

Considering students' beliefs about their vocabulary and the vocabulary teaching strategies could be useful to this case study as it may reveal whether students believe their vocabulary knowledge has improved during the intervention, and whether they attribute any improvements to the teaching strategies. This would be interesting to consider as it would help to shape future teaching and could contribute to the development of further investigation.

Research Questions

The literature indicates that learning scientific vocabulary is fundamental to understanding scientific literature and participating in scientific discourse. My own experiences have provoked the idea that scientific teaching could benefit from implementing some techniques used in the modern language classroom, especially when it comes to learning vocabulary. Observations collected in the modern language classroom have revealed techniques that could be amended to teach scientific vocabulary. Some of the techniques may already be utilised in the science classroom and the literature has provided guidance for adapting the techniques to vocabulary teaching in the context of the science classroom.

In addition to investigating the effects of the techniques on the learning of scientific vocabulary, it is important to consider students' perceptions about vocabulary knowledge and their learning in relation to the strategies. The following three research questions are therefore being proposed:

1. Do the vocabulary teaching strategies improve the recall of scientific vocabulary?
2. Do the vocabulary teaching strategies improve the application of scientific vocabulary?
3. Do students believe the vocabulary teaching strategies are beneficial to vocabulary learning?

Methodology

Context

The study is proposed to take place in a 11-18 academy in Essex. The proposed case is a mixed-sex, mixed-ability Year 7 class of 30 pupils. The study would cover four, one-hour lessons with relation to the "space" topic, a topic in the school's science curriculum based on the AQA Activate 1 book syllabus. The space topic consists of four lessons and the AQA syllabus places the space topic alongside the Earth's structure topic, which consists of six lessons. The two topics together combine to make the "Earth Unit", and the end of unit test is composed of questions from both topics.

Case Study Rationale

Feez & Quinn (2017) argue that bridging the gap between spoken language in everyday life and the reading and writing of scientific text is particularly beneficial to students in middle years of schooling (in Australia) because this is the period that students begin to master the specialised reading and writing needed to learn and display the distinctive knowledge of science. Based on this suggestion, the Year 7 class would be a good target age for the study to investigate. Teaching vocabulary with this age range ties into the thinking behind teaching vocabulary in the modern language classrooms that I have observed at my placement school (the proposed school for the study). The language teachers explained that vocabulary is explicitly taught to Year 7 and Year 8 only, and once students have mastered the basics of the language, they are encouraged to begin to learn new vocabulary independently.

The selection of one class to study indicates that the investigation should be carried out in the form of a case study given that the object of the study is a specific, unique, bounded system, which Stake (2000) highlights is a useful epistemological rationale for case studies.

This proposal aims to provide insight into the usefulness of using explicit vocabulary teaching in my science lessons. This topic will be explored in greater depth by also considering the students' perceptions of vocabulary knowledge before and after the intervention. Given that the goal of the study is to greater understand the mechanisms and impact of explicit vocabulary teaching, and that the selected class can be argued to be typical of other KS3 classes in my school, the study matches Stake's description of an instrumental case study.

Ethics

The research will be carried out in line with the school ethical guidelines and the British Educational Research Association's guidelines for educational research (2018). The Head of Science and the usual classroom teacher have been informed of the methodology of the intervention. The participants will be given an outline of the intervention, the data collection methodology will be explained, and participants will be assured that data will be kept anonymous. The permission of all participants and their responsible adults will be requested. The Faculty Ethics Form has been approved and signed by the Subject Lecturer.

Teaching Rationale

I have observed a variety of activities in modern language classes that could be helpful in teaching scientific vocabulary. Some of these activities have been adapted to make them more suitable for science lessons and are outlined in Table 1. The rationale of the strategies and the proposed key terms will be discussed below.

Lesson	Class Hangman	Cloze Exercise	Frayer Model	Odd One Out	Drawing	Bingo
The Night Sky	✔	✔	✔			
The Solar System	✔	✔	✔			
Day and Night				✔	✔	
The Moon			✔		✔	✔

Table 1: Details of the vocabulary teaching strategies to be implemented in the space topic

Selection of Key Terms

The space topic in the AQA Activate 1 book highlights 25 key terms. The list of key terms has been reduced to 17 key terms in keeping with Quigley's (2018) SEEC (Select, Explain, Explore, Consolidate) model. The SEEC model explains that in selecting keys terms, teachers must determine which terms are most important to the topic and which terms are unlikely to be part of a child's knowledge. The key terms highlighted by the Activate 1 book that I have judged to already be part of a child's knowledge, like Earth, have therefore been omitted from the intervention. Omitting such

words means that more time can be dedicated to focusing on the words that students are likely to be less familiar with and may need more help to understand.

Hangman

Hangman is an exercise that I observed being used in modern language teaching to help explore how to spell unfamiliar words. The game was led by the teacher and the students guessed the letters to the key term. It is possible for the students to use hangman in pairs to practise spelling, and it would be necessary to provide correct spellings of key vocabulary before carrying out the activity. Because of time constraints in the teaching sequence, I propose to only use the activity with the whole class to introduce the spelling of key terms. For example, hangman will be used in the intervention to introduce the key term *asteroid* in The Solar System lesson.

Cloze Exercises

Cloze exercises are used to let children practise using their new vocabulary knowledge and are also used to present unfamiliar words, whereby students are encouraged to work out the meaning of the term based on the context. The authors of the Best Evidence Science Teaching website (BEST, 2019) suggest that defining key terms like *galaxy*, *Solar System* and the *Universe* can be challenging for students. They highlight a study of 199 college students in the US (aged 17-19) that were found to commonly provide incomplete definitions of the terms. Therefore, a focused cloze, designed by the BEST team, will be used in The Night Sky lesson to challenge students to correctly use the key terms *galaxy* and *Universe*.

Bingo

Bingo proved to be useful in the observations collected in the modern language classrooms where it was used to test students understanding of multiple key terms. Students choose six key terms from a large list of key terms. The students cross off the word when the definition is read out by the teacher. Given that the bingo activity can cover a wide range of vocabulary, it is a useful revision tool. Therefore, bingo will be used at the end of the unit in the final lesson and could also be used in a revision lesson.

Drawing

From my own experience in language learning, drawing images helped me to associate the target word with the object itself, rather than the translation. Drawing can help students internalise words by creating a mental image and interest (Young, 2005). When required to provide the meaning of a word, the student remembers the drawing and makes the connection (Cohen, 2012). Drawing will be implemented in the intervention by asking a volunteer to draw a key term, secretly provided by the teacher (*orbit* for example), on the whiteboard. The students in the class can think about what the drawing represents and then try to guess the key term.

Hangman, cloze exercises, bingo and drawings are activities that are not absent from the science classroom. However, they are activities that appear to be used more frequently in modern language teaching than in science, and I have therefore planned to incorporate these activities more frequently than I have typically observed in Key Stage 3 science classrooms.

Odd One Out

The "odd one out" activity is an activity that I have observed only in language lessons. Students are presented with three or four similar sounding or similar looking words and are asked to identify which is the odd one out, and explain why. Similar exercises called word pairs and word triplets are presented by Quigley (2018) who explains that these types of strategies help students to connect words and make more considered word choices in their own talk or writing. An example of the activity can be seen in Figure 1 from the Day and Night lesson. In this activity, students' understanding of the key terms *light year* and *light minute* is challenged. Misunderstandings will be highlighted if students are not able to identify that *light years*, *light minutes* and metres are units of distance whereas minutes are units of time.

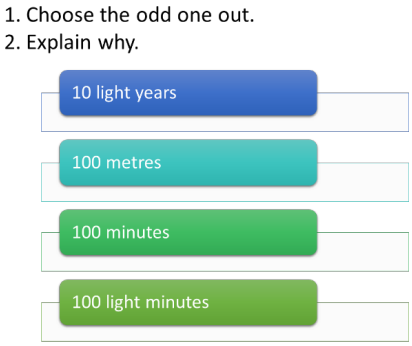

Figure 1: Example of the odd one out activity used in The Day and Night lesson

Graphic Organiser: Frayer model

Whilst I have not observed the use of graphic organisers with language learning, graphic organisers appear to be a good way of providing students with multiple exposures and contexts to key terms, as often occurs in the language classroom. Indeed, Quigley (2018) explains that graphic organisers can get children thinking about the words they encounter in different ways. Quigley (2018) suggests that the Frayer model is a useful type of graphic organiser that can lead to deeper understanding of words. I would also judge that the Frayer model is an attractive model as it requires input and ownership from the students. The Frayer model, which can be seen in Figure 2, contains a key term in a central square surrounded by four boxes for students to complete with information. Quigley (2018) suggests completing the Frayer model with a student friendly definition, an example of the word, non-examples of the word and an illustration of the concept.

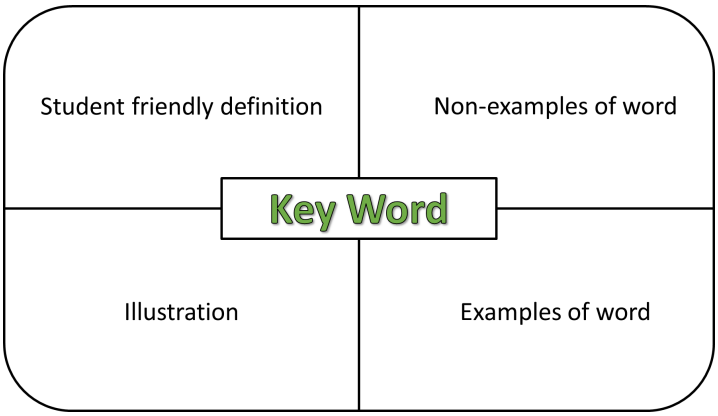

Figure 2: An example of the Frayer model

A key feature that is appealing in the graphic organiser is the use of illustration. As already described, Young (2005) and Cohen (2012) highlight the importance of drawings in vocabulary instruction. Cohen (2012) provides further evidence that demonstrates the powerful role of drawings by outlining the findings of a study. In this study, 142 American undergraduates were split into three groups to learn 50 words. One group received only the definitions of the words, another group received the definitions and an example of the word used in a sentence, and the final group received definitions, the words in context as well as a simple picture to illustrate the meaning of the word. The group with all three scored highest on vocabulary outcome measures.

Based on this finding, I propose to include a definition of the word, the word in a sentence, additional examples and an illustration of the word in the Frayer model to be used in the intervention. Whilst Quigley (2018) suggests using non-examples of key terms, I propose to use additional examples because I would judge that it may provide a more appropriate learning opportunity for science learning, especially when considering the space topic. For example, Figure 3 shows the use of the Frayer model with the key term *galaxy*. Although I acknowledge that non-examples, such as the *Universe*, could deepen the conceptual understanding of the key-term *galaxy*, I would judge that students would learn more from thinking about what an example of a *galaxy* would be given that they may not know. For example, they may not be familiar with The Andromeda Galaxy and the Milky Way *galaxies*.

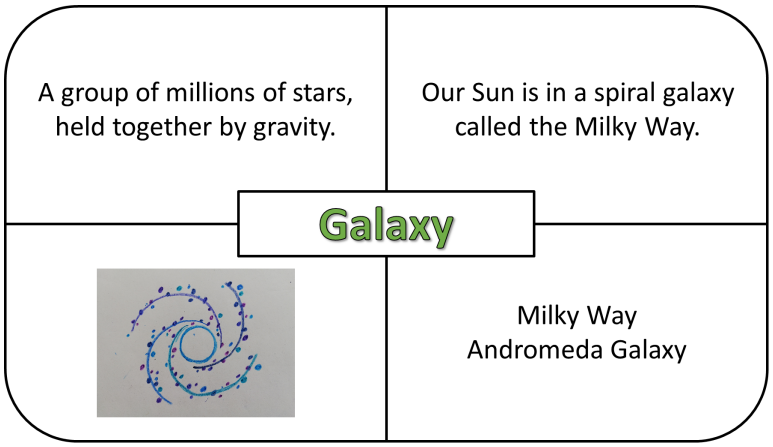

Figure 3: A demonstration of how the Frayer model can be used for the key term *galaxy*

Word of the Week

I have observed words of the week in several language classrooms. Quigley (2018) describes a similar concept called a word wall which is a collection of words that are developmentally appropriate. Word walls can help to create an accessible, word rich environment and provide a "conversational scaffold" (Quigley, 2018; Brown & Concannon, 2016). Brown and Concannon (2016) provide evidence of the benefits of word walls by highlighting a study that showed there was a significant increase in the percentage of eighth-grade students in the US scoring at the proficient level in science after the implementation of a word wall, over a year. Although it is not clear what is meant by a proficient level, and the strategy was implemented over a year (which is much longer than the time available in this small-scale study), I would judge that using a similar technique is worth trying given the widespread use in modern languages.

I plan to present a word of the week before the teaching sequence with a term that will be highlighted as unfamiliar to the students by the Rate Your Word strategy (which will be described below in Data Collection). The constant exposure to the term in the classroom may generate interest and could improve spelling accuracy. A term that is likely to be novel to students in the space topic is *heliocentric model*, and therefore is the most likely candidate for word of the week.

Data Collection

The proposed methods for data collection, which are outlined in Table 2, will be described and justified with relation to the literature below.

Research Questions	Data Collection Methods	Data Analysis Methods
Do the vocabulary teaching strategies improve the recall of scientific vocabulary?	Spelling tests Multiple choice tests	Descriptive statistics Descriptive statistics
Do the vocabulary teaching strategies improve the application of scientific vocabulary?	Definitions test End of unit test	Descriptive statistics Descriptive statistics
Do students believe the vocabulary teaching strategies are beneficial to vocabulary learning?	Rate Your Words strategy Questionnaire One-to-one interviews	Descriptive statistics Descriptive statistics Inductive coding

Table 2: An outline of the data collection and data analysis methods

Assessing Vocabulary Recall

The recall of the selected 17 key terms will be investigated using pre- and post-intervention spelling tests that will be taken by the whole class. Spelling tests have been used to measure students' academic proficiency by Townsend et al. (2018) who uses the Academic Vocabulary Spelling Inventory, which includes a traditional spelling test. An increase in the number of correctly spelled answers could be an indicator that the recall of vocabulary has improved.

A further way to test the recall of vocabulary will be to use a test that contains multiple choice questions that require students to choose the correct definition to the key term presented. The whole class will again take pre- and post-intervention tests. The average of the number of correct matches achieved by the class will be used to show if there are improvements in the recall of the key terms.

Each term could be analysed to see if there are significant improvements relating to spelling or being correctly matched to its definition. Improvements in either test for a specific term could indicate that a certain strategy is effective in teaching vocabulary. For example, a large increase in the percentage of students who choose the correct definition for *light year* may indicate that the odd one out activity is an effective strategy, given that *light year* is a term that connected with the odd one out strategy in the intervention.

Assessing Vocabulary Application

The application of vocabulary will be assessed by asking students to define the key terms using their own words. It may be necessary to ask students to only define five key terms so that the amount of testing does not become overbearing. Reducing the number of questions will also help to manage time effectively in the study. It will still be possible to generate a good representation of students' application of the key terms because each student can be given a different set of key words to define. The test will be given pre- and post-intervention and improvements in the application of key terms can be analysed by comparing the overall percentage of words that are correctly defined.

The end of unit test will also be used to examine how effectively students are able to apply their vocabulary knowledge. End of unit tests are applied at the end of every teaching unit so there will be no change to the students' typical studying routine. Given that the end of unit test is split almost equally between the two topics, it would be possible to collect two sets of data from the one test, a set of results for the Earth's structure topic and another for the space topic. Higher achievement in the space topic compared to the Earth's structure topic may indicate improved application of vocabulary resulting in increases in achievement.

Assessing Students Perceptions

The "Rate Your Word" strategy as described by Young (2005) will be used to assess student perceptions about the key terms. Students will be asked to choose the option that best describes their confidence using each of the 17 key terms, according to the following options:

- Never heard of it
- Heard of it, but can't use it
- I might be able to use it
- I know it and can use it confidently

The options are in line with the principles of Edgar Dale's 'Four stages of word knowledge" model, described by Quigley (2018).

The strategy will be administered pre- and post-intervention. The number of students who choose each option in the pre-test will be compared to that of the post-test to see if there any general increases in confidence using the key terms. The strategy may produce a set of results like that modelled in Figure 4. This hypothetical graph suggests an increase in confidence using the key terms following the intervention as there is an increase in the number of terms that students indicate they believe they can use.

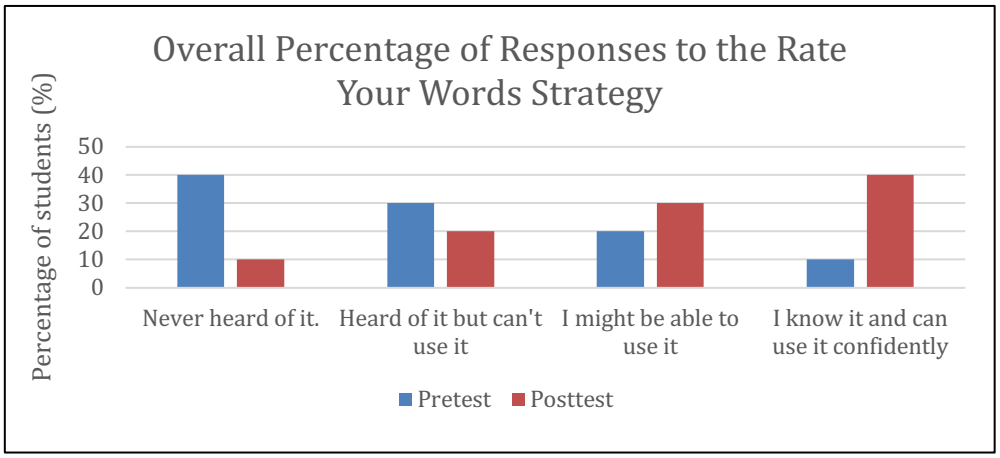

Figure 4: Hypothetical graph that is a model of the responses that may be produced by the Rate Your Words strategy

Brown & Concannon (2016) use a similar strategy to demonstrate perceptions of vocabulary knowledge and ability to explain specific terminology. They compared the percentages of students who chose the option "I know and can explain terminology" between the pre-test and post-test to analyse if there are changes in perceptions about vocabulary for each term.

Following the work of Brown and Concannon (2016), the results of the two tests will also be used to investigate the effects of the strategies for each term. The percentage of students who believe they can confidently use each key term can be displayed in a bar chart as modelled by Figure 5. The graph shows there is an increase in the number of students who believe they can confidently use most of the key terms. The hypothetical graph shows notable increases with the key terms *axis*, *dwarf planet* and *phases of the moon* for example. Such results may reveal that certain strategies are particularly effective in helping students learn vocabulary.

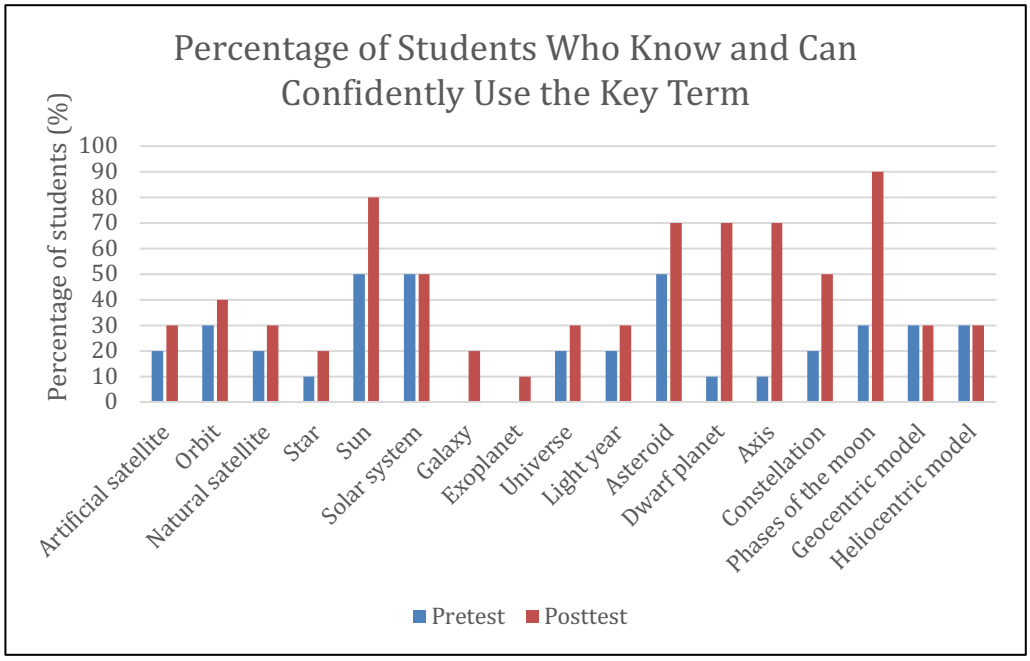

Figure 5: Hypothetical graph showing the percentage students that believe they know and can confidently use each key term

It is important to note that the use of the self-evaluating Rate Your Words strategy may also help vocabulary learning. Brown and Concannon (2016) argue that this strategy allows students to evaluate and reflect on the content and promotes deeper levels of self-regulatory learning. Young (2005) agrees with this suggestion by explaining that the strategy helps promote students' metacognitive ability.

Questionnaire

A questionnaire will build on the findings from the Rate Your Word strategy to explore students' beliefs about whether the intervention strategies are beneficial to their vocabulary learning. The questions are adapted from the questionnaire used by Brown and Concannon (2016). The students will be asked to choose whether they agree, disagree or are undecided/uncertain with a series of questions related to their perceptions about vocabulary knowledge.

Answers to the questions will reveal whether students believe they understand and can use the vocabulary, whether they believe the vocabulary teaching strategies helped them to learn vocabulary and whether learning the vocabulary helped them to understand the space topic. As suggested by Bell

and Waters (2018), the percentages of students choosing each option can be presented in the form of a bar chart to illustrate the range of responses received.

One-to-One Interviews

The final method of data collection will add to knowledge of students' perceptions about the strategies by investigating why students found the strategies effective, or not. I propose to conduct structured one-to-one interviews where students will be asked to explain why they chose their answers to the questions in the questionnaire. One-to-one interviews will be useful in this small-scale research project because Denscombe (2017) explains that it is easier to transcribe a recorded interview when the talk involves only one interviewee. Being able to transcribe will be useful because students are likely to provide a variety of answers that may be difficult to record by taking notes. For example, students may explain that they did not enjoy the activities used to learn vocabulary in the space topic because they felt they were too boring, too challenging, they didn't like the presentation, or they took too long. On the contrary, they may have enjoyed the activities because they were unusual or exciting. It is difficult to predict what students' views will be, and so transcribing the interviews will enable the answers to be inductively coded and subsequently analysed.

Inductive coding will be used to indicate the key themes that emerge from interviews. For example, should students explain that they thought the activities helped them learn vocabulary because they are "unusual", "different" or "not the kind of activities normally done in science", these descriptions could be categorised as "novel". Other categories may include "being fun" and "challenging". The key themes could then be used to compare what aspects the students view as important in vocabulary learning strategies. For example, 90 per cent of students may explain that they enjoy the intervention strategies because they are challenging, however 50 per cent of students may indicate that they felt the Frayer model did not help learn vocabulary because it is boring. Understanding the factors that students attribute to the success (or not) of the intervention strategies will help to understand why the strategies are successful (or not) and how each strategy, or the collective strategies, can be improved.

The purpose of the interview and methods of data collection, including the use of recording equipment, will be explained to the whole class. The students and their responsible adults will be asked to grant permission for their participation if selected. I propose that the interviews will be carried out with five randomly selected students. This figure has been decided based on the time and resources available and is in keeping with the advice relating a pragmatic approach to sample size by

Denscombe (2017). A random selection will be achieved using a random number generator whereby students are allocated a number based on the alphabetic order of their surnames. Selecting students at random would provide a good representation of the class's views. Should students decline to participate, it would be sensible to then ask for volunteers. Using volunteers (that are more likely to be only the most enthusiastic and high-attaining students) would mean the sample would become more exploratory than representative but may still illuminate some interesting perceptions about the vocabulary teaching strategies (Denscombe, 2017).

Discussion

Implications for Future Research in the Context of Improved Vocabulary Learning

The literature around vocabulary in science indicates that vocabulary plays a key role in understanding scientific discourse, can help people to participate in scientific discourse and that vocabulary teaching may benefit students academically. Following the proposed intervention, it is possible that evidence from the vocabulary recall and application tests indicate an increase in scientific vocabulary learning. Positive results in these tests would contribute to the suggestion that vocabulary is instrumental in learning science, as can be seen in the literature. A study by Townsend et al. (2018) shows that engaging in vocabulary learning results in increases in spelling accuracy and gains in the production of discipline-specific science words. Further academic benefits are found by Brown & Concannon (2016) whose study shows that the test population of 41 eighth-grade students in the US outperformed a national data set on a content knowledge test, related to the topic of study, following the implementation of vocabulary and reading strategies.

A key factor in the potential success of the intervention may be in large part thanks to the use of the Frayer model. The features of the model (student-friendly definition, example of the word in a sentence and illustration) have been suggested to aid in vocabulary learning (Cohen, 2012; Young, 2005). Successful outcomes will be in keeping with evidence from the study by Reed, Jemison, Sidler-Folsom, & Weber, (2019) that investigated the benefits of using graphic organisers. The study found that graphic organisers significantly improve science performance, which was measured using the Discovery Education Assessment of science concept knowledge.

Positive results in the recall and application of the vocabulary may coincide with a feeling of increased confidence revealed by the Rate Your Words strategy. A correlation between confidence using the key terms and academic success could be expected when considering the study by Brown & Concannon (2016) that showed students' perceived confidence with using specific vocabulary was connected with content achievement.

The perceptions relating to whether students feel they can recall and apply the 17 key terms will be revealed by the questionnaire as well as the Rate Your Words strategy. The questionnaire will also show whether students feel as though the intervention strategies collectively benefit their vocabulary learning and whether each individual strategy aids vocabulary learning. It could be possible that the results reveal links between perceptions about particular strategies and vocabulary learning. For example, if the questionnaire reveals that a large percentage of students agree that cloze exercises help in learning vocabulary, you could expect that there is an overall increase in the percentage of students who can correctly match the terms used with the cloze strategies (like *galaxy* and *Universe*) to the correct definitions.

Should the intervention produce a set of evidence, as speculated above, that indicates that the intervention strategies support the recall and application of vocabulary, the evidence collected about perceptions of vocabulary learning will become pivotal in shaping the future research questions. The investigation into perceptions of vocabulary learning by Brown & Concannon (2016) showed that students believed that drawing pictures, watching videos, taking notes and completing a pre-test helped them to learn vocabulary. Based on their research, this case study may reveal the strategies that students believe are most beneficial to vocabulary learning, and this may be strengthened by evidence of improved vocabulary in the tests and exam. Producing such a set of results would stimulate the need for further investigation into the strategies, which could take place in the form of an action research study that would focus on those strategies that the students, or the data, identify as being most beneficial.

Further investigation into the benefits of the strategies may also involve looking at whether the strategies help to reduce the vocabulary gap that exists between the advantaged and disadvantaged. Failures in achievement are associated with a limited vocabulary and these failures are inextricably linked to a child's postcode, as well as socioeconomic status and educational attainment of their parents (Quigley, 2018). Should the strategies prove beneficial to learning science, it may be

interesting to begin to investigate the strategies effects on reducing the vocabulary gap and reducing the attainment gap in the context of science learning.

Possible Limitations of the Study

It is possible that the results of the intervention play out as described as above, and it is also possible that the intervention reveals interesting and unexpected outcomes. Both scenarios will drive future research. Unexpected outcomes, whilst difficult to predict, may be the result of limitations of the case study. The limitations and possible improvements will be discussed with relation to future research.

I would speculate that the main limitations of the study may be the result of the time restrictions imposed by the context of the study. One example could be that the focus of the study, vocabulary learning, may be too specific. It could be beneficial to investigate the effects of a broader range of literacy strategies. It could be argued that the intervention lacks opportunity for reading for example.

Reading

Reading is a key component of literacy instruction which has been suggested to be essential to science learning. Tong et al. (2014) provides a comprehensive explanation of the importance of reading to science instruction, including that reading becomes a window into the acquisition of scientific knowledge, the reading process complements scientific reading and that reading is associated with students' ability to succeed in high stakes assessments. Tong et al. (2014) describes the results of multiple studies that support the importance of reading including an example that showed reading was found to be a statistically significant predictor that accounted for 25 per cent of the student-level variation in science achievement among 198 schools in a large urban district in the US. Another example showed that explicit reading instruction lead to the same amount of gains for students with initially lower literacy skills as students with stronger literacy skills, therefore closing the attainment gap.

The importance of reading is reflected in the modern language classroom where reading is commonly observed. The time constraints of the context of the study means it has not been possible to include the investigation into the benefits of reading instruction. Further research may provide better opportunity to also investigate how reading instruction alongside the vocabulary teaching strategies might benefit vocabulary learning in science.

Multiple Exposure to Key Terms

Another aspect that is difficult to address given the time constraints is multiple exposures to the key terms. Townsend et al. (2018) highlights a variety of studies to demonstrate that exposure to words in multiple contexts and multiple opportunities to practice and personalise word meanings are important to vocabulary teaching in general, and in science. In the context of English as a foreign language learning, Wessels (2013) argues that multiple exposures through rich and varied activities provides effective vocabulary instruction. This reflects the vocabulary teaching I have observed in the modern language classroom where repeated exposure and practice using new vocabulary is notable. Whilst I would judge that the strategies in the intervention are varied, the demanding curriculum means there is a lot of information to cover in a short period of time and this results in a lack of opportunity to expose students to the words multiple times in multiple contexts, especially in the context of this small-scale study.

Imagery

A strategy that is also worth highlighting and that may be interesting to explore in the intervention is using imagery. Imagery is sometimes used in modern language teaching. One approach to imagery described by Cohen (2012) is called the "keyword" method. Cohen explains that this method involves forming an interactive mental image of the new word and connecting it to a word that shares a similar element. For example, the Spanish word *carta* means letter and students are encouraged to remember this in the modern language classroom by picturing somebody placing a letter in a cart. An example where this could be used in science could be for the word apex, one could visualise an ape at the top of a mountain to remember that apex means the highest point. Cohen references a study that indicates the keyword method leads to substantial increases in life science content acquisition for middle school students with mild disabilities. One drawback of trying to implement this technique is that it is a highly creative strategy and would demand a lot of time to plan effective interactive mental images. I have found it impossible to think of any good examples for the key terms in the space topic.

If a further study allowed additional time, which could be used to increase the number lessons or teach a larger topic, then it could be possible to implement the strategies mentioned above alongside those of the intervention. Increasing the number of strategies used may increase the chance of improving vocabulary learning in science.

Selection of Key Terms

The selection of the key terms also has a role to play in the success of the intervention. The SEEC model was followed when selecting the key terms, but it is possible that some unexpectedly challenging words may have been overlooked. Whilst the key term *Sun* has been considered in the planning of this intervention, it serves as a good example of a word that could easily be overlooked. One may expect that students can accurately define the *Sun*, however Best Evidence Science Teaching points out that students hold misconceptions relating to the *Sun*. They highlight evidence that suggests only half of 10-11-year olds realise that the *Sun* is a star, three-quarters describe the *Sun* as a huge ball of fire and misunderstanding is persistent as only 55 per cent of adults identify the *Sun* as a star. The surprising complexity of the key term *Sun* serves as an example that some of the terms omitted from this study perhaps merit further attention.

On the other hand, it could be possible that the intervention would benefit from a further reduction in the number of key terms. It could be possible to reduce the shortlist based on the findings of the Rate Your Words strategy. A term could be removed from the key terms list if it receives at least 90 per cent of responses that indicate students believe they can already confidently use the term. Such feedback would suggest that it is unnecessary to focus on the words that students have already mastered. This would mean that more time can be dedicated to the most challenging key terms and could be more beneficial to improving vocabulary knowledge.

The sensation that the selection of the key words may require more consideration is further developed by Quigley (2018) who explains a three-tier hierarchy of words that was developed by Isabel Beck. Tier 1 words are the basic words of everyday talk that are learned implicitly like ‘people’ and ‘good’. Tier 2 words are valuable words that appear across the academic curriculum and are recommended to be taught explicitly as they are essential to cracking academic code. Tier 2 words include ‘investigate’ and ‘enquire’. Tier 3 words are subject specific vocabulary and Quigley (2018) suggests that textbooks highlight such words and organise them in a glossary. Therefore, the key terms used in this intervention are all Tier 3 words. Quigley (2018) suggests that Tier 2 words can help to make sense of the Tier 3 words. The three-tier hierarchy does provoke the idea that it could be worthwhile including Tier 2 words as targets for explicit vocabulary teaching in further research.

Ineffective Strategies

Another possible outcome of the study may be that the strategies used in the intervention prove to be ineffective. A lack of progress in vocabulary learning indicated by the tests would suggest the strategies are ineffective. Such results would likely be correlated with students' perceptions that they cannot use the key terms, as suggested by the findings of Brown & Concannon (2016) that show perceptions about vocabulary knowledge are linked with achievement. In these circumstances, it may be expected that students reveal they do not value the strategies in the questionnaire, and one-to-one interviews may reveal why the students believe the strategies are ineffective.

Implications for Future Practice

Taking into consideration the observations of vocabulary teaching in the modern language classroom and literature around vocabulary teaching in science, I am convinced that my future teaching will benefit from paying closer attention to vocabulary and exploring various vocabulary teaching strategies. Deeper ownership of science vocabulary can allow for more powerful learning experiences and I am convinced that students learning will benefit from explicit vocabulary teaching (Townsend, 2018).

I am confident that all students will benefit from explicit vocabulary teaching and hope it can also make a difference to students who start off already disadvantaged in their vocabulary knowledge. Quigley (2018) suggests that vocabulary instruction can close the vocabulary gap, which may contribute to progressing social justice. This can be evidenced by a study referenced by Quigley (2018) that shows students with reading difficulties who were exposed to explicit vocabulary teaching benefitted three times as much as those who were not. Not only could vocabulary teaching help to close the vocabulary and attainment gaps, vocabulary teaching can help students to participate in scientific discourse, which strikes me as one of the principle aims of science education (Cohen, 2012).

Whilst I am more cognisant of the academic benefits of the vocabulary strategies described in this proposal, I also have the impression that many of the strategies are fun and challenging given that students in the modern language classroom appear to enjoy the activities. The results of the questionnaire will reveal whether students tend to enjoy such activities in the context of the science classroom, and interviews may reveal whether students find the strategies fun.

Additionally, I am optimistic that the study will provide learning opportunities for the students and teacher alike, especially when confronted with unexpected challenges. One example, revealed during a pilot study of using the Frayer model, was when I noticed that sometimes students created images that illustrated misunderstandings. When asked to draw an illustration of a *galaxy*, a student drew an illustration of the *Solar System*. This could be concerning because perhaps creating their own illustrations reinforced a misunderstanding rather than facilitating learning.

Whilst it is possible that using an illustration reinforced a misconception in this example, it did provide an opportunity to address the misconception. The student was required to draw an illustration of the *Solar System* when completing another Frayer model. The student compared his illustration of the *Solar System* to that of the *galaxy*. He could see that the drawings were the same despite the key terms being different, and so changed his illustration of a *galaxy* when he could see where he went wrong. If the student had not been able to understand which drawing was incorrect, other students could have helped to improve his illustration by explaining their own illustrations in their Frayer model.

The key implications that the research proposal has produced for my future practice are that I will look to explore vocabulary teaching strategies and collect feedback from students in order to find out which strategies are most effective in helping to learn vocabulary. I am particularly interested in further exploring the Frayer model as it combines a variety of strategies to help learn vocabulary. The findings by Reed et al. (2019) that graphic organisers result in improved science content knowledge further strengthen my desire to explore using the Frayer model, in addition to a compelling argument presented by a student who declared “I like using this, can we do another one?” during a pilot study.

Conclusion

Collecting observations in the science classroom and modern language classroom have indicated that there is opportunity to increase vocabulary learning in science teaching, especially considering the suggestion by various teachers that learning science is like learning another language. The literature concerning the importance of vocabulary teaching in science teaching appears to support such observations. Vocabulary teaching strategies frequently used in the modern language classroom can be adapted to meet the needs of vocabulary learning in the science classroom, and indeed many of

the observed strategies have already been suggested to benefit vocabulary learning in the science classroom, including cloze and odd one out exercises.

This proposal aims to investigate how replicating some of the strategies used in the modern language classroom can provide benefits to vocabulary learning in the science classroom. A further proposed point of investigation is to consider students perceptions about vocabulary learning, which will reveal the strategies that students feel are most beneficial to vocabulary learning, and has the added benefit of aiding vocabulary learning by improving students' metacognitive ability and encouraging independent learning (Brown & Concannon, 2016; Young, 2005).

The findings of the study will lead to further enquiry into the use of vocabulary teaching strategies. It may be the case that the intervention results in improved vocabulary learning. Such results would encourage further research into how the strategies could be effective in reducing the attainment gap in the context of the science classroom. On the contrary, results may expose some of the limitations of the proposal, in which case it would be worth considering how it could be possible to increase exposure to new vocabulary, how to incorporate other useful strategies observed in language teaching, or how to improve the shortlist of key words to maximise the benefits of the strategies.

References

Bell, J. & Waters, S. (2018). *Doing your research project: A guide for first-time researchers* (7th ed.). London: Open University Press, McGraw-Hill Education.

Best Evidence Science Teaching [BEST] (2019). The night sky, stars and galaxies. Retrieved from https://www.stem.org.uk/best/physics/big-idea-earth-space

British Educational Research Association (2018). *Ethical Guidelines for Educational Research, fourth edition.* Retrieved from https://www.bera.ac.uk/publication/ethical-guidelines-for-educational-research-2018-online

Brown, P. L., & Concannon, J. P. (2016). Students' perceptions of vocabulary knowledge and learning in a middle school science classroom. *International Journal of Science Education, 38*(3), 391–408. doi: 10.1080/09500693.2016.1143571

Cohen, M. T. (2012). The Importance of Vocabulary for Science Learning. *Kappa Delta Pi Record, 48*(2), 72–77. doi: 10.1080/00228958.2012.680372

Denscombe, M. (2017). *The good research guide: For small-scale social research projects* (6th ed.). London: Open University Press, McGraw-Hill Education.

Feez, S., & Quinn, F. (2017). Teaching the distinctive language of science: An integrated and scaffolded approach for pre-service teachers. *Teaching and Teacher Education, 65,* 192–204. Retrieved from https://doi.org/10.1016/j.tate.2017.03.019

Kennedy, M. J., Rodgers, W. J., Romig, J. E., Mathews, H. M., & Peeples, K. N. (2018). Introducing the Content Acquisition Podcast Professional Development Process: Supporting Vocabulary Instruction for Inclusive Middle School Science Teachers. *Teacher Education and Special Education, 41*(2), 140–157. Retrieved from https://doi.org/10.1177/0888406417745655

Quigley, A. (2018). *Closing the vocabulary gap.* London: Routledge.

Reed, D. K., Jemison, E., Sidler-Folsom, J., & Weber, A. (2019). Electronic Graphic Organizers for Learning Science Vocabulary and Concepts: The Effects of Online Synchronous Discussion. *The Journal of Experimental Education, 87*(4), 552–574. https://doi.org/10.1080/00220973.2018.1496061

Stake, R.E. (2000). Case Studies. In N.K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 435-454). London: SAGE.

Tong, F., Irby, B. J., Lara-Alecio, R., Guerrero, C., Fan, Y., & Huerta, M. (2014). A Randomized Study of a Literacy-Integrated Science Intervention for Low-Socio-economic Status Middle School Students: Findings from first-year implementation. *International Journal of Science Education, 36*(12), 2083–2109. doi: 10.1080/09500693.2014.883107

Townsend, D., Brock, C., & Morrison, J. D. (2018). Engaging in vocabulary learning in science: the promise of multimodal instruction. *International Journal of Science Education, 40*(3), 328–347. doi: 10.1080/09500693.2017.1420267

Wessels, S. (2013). Science as a Second Language: Integrating science and vocabulary instruction for English language learners. *Science and Children, 51*(1), 50–53 https://digitalcommons.unl.edu/teachlearnfacpub/143/

Young, E. (2005). The Language of Science, The Language of Students: Bridging the Gap with Engaged Learning Vocabulary Strategies. *Science Activities, 42*(2), 12–17. doi: 10.3200/SATS.42.2.12-17

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