The Comprehension of Expository Science Texts

Among Year 6 Students

A thesis

submitted in partial fulfilment

of the requirements for the degree

of

Master of Education

at

The University of Waikato

by

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THE UNIVERSITY OF

WAIKATO

Te Whare Wānanga o Waikato

2012

Abstract

This study examined the influence of instruction in text feature knowledge and metacognitive strategies on the comprehension of expository text among Year 6 students. Over a period of 8 weeks, twelve Year 6 students read a series of 10 expository science texts with diagrams. An Intervention Group comprised of six students received instructional lessons that emphasised recognition of text features, integration of information across text features and identifying a navigational pathway. A Control Group, of a further six students, read the same material however, they did not receive instruction relating to metacognitive strategies and text features. Comprehension of each text was measured by multiple choice questions, pre and post knowledge assessment, and written response. Metacognitive awareness was measured pre and post intervention using a modified Metacognitive Strategy Index (MSI) (Schmitt, 1990). The study took a mixed methods approach. Qualitative data was analysed by thematic analysis. Quantitative data presents descriptive statistics that indicate differences between and within Intervention and Control Groups. Findings indicate that students benefit from explicit instruction in metacognitive strategies and text feature knowledge.

Acknowledgements

My sincere thanks to my supervisor, Dr. David Whitehead. Your encouragement throughout this journey has been phenomenal. Your expert knowledge, guidance and high expectations have both inspired and motivated me.

My thanks to the University of Waikato for awarding me a Masters Research Scholarship that enabled me to complete my studies without the additional financial strain that study often brings.

I could never have completed this study without the steadfast support of my husband Mike. You are the simply the best. Thank you for your listening ear, your encouragement and the endless opportunities you gave me to study. Thanks for believing in me.

To my beautiful daughters Willow and Perri, your own educational journeys are just beginning. You will make me proud in whatever you do; I look forward to celebrating your successes with you.

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Introduction

1.1 Context

Instructional content at primary school is heavily loaded with narrative texts (Duke, 2000). However, as students progress beyond primary school, they are increasingly required to engage with expository texts. By high school, learning in content areas (particularly science) demands the ability to remember, understand and build knowledge from expository texts, which often include diagrams. Insufficient exposure to, and instruction in how to read expository texts and diagrams at primary school limits opportunities for success at secondary school and beyond (Martin & Duke, 2011). Instruction in comprehending expository texts and diagrams at primary school is therefore, an important contributor to future academic success (Meyer & Ray, 2011). For this reason, expository texts and diagrams need to be given greater emphasis as instructional content at the primary school level.

Expository texts, particularly those containing diagrams, do not present with a consistent structure in the way narrative texts do. The dynamic nature of expository texts and diagrams demands different processing strategies of reader. Narrative text is typically presented and read in a linear fashion. By comparison, expository texts that include diagrams, may contain aspects that are presented in linear format (such as the main text), and other aspects that are non-linear (such as placement of inset text boxes and pictures, labelled diagrams and enlargements). The presence of diagrams and their related captions, labels and subtitles present a challenge to readers. In particular, the navigation of non-linear structures, typical of expository text with diagrams, is problematic for readers who have had little exposure to this type of text. Reading expository texts that include diagrams requires cognitive effort and decision making by readers. From their varied multi-modal presentation, students must reconstruct content, and make the necessary links and connections that allow them to organise text features and create meaning.

This ability to connect information from varied sources and reconstruct meaning is an essential skill if students are to meet the multi-literacy demands of our era. In a multi-modal environment, students are having to process non-linear information, and identify connections across varied text feature modes from which they can gain meaning. Instruction in text and diagram interpretation supports and exercises cognitive and metacognitive strategies that can be applied in today's varied and demanding literacy environments.

Students with cultural and literate capital associated with the reading of expository texts, leave primary school as proficient readers (Tunmer, Nicholson, Greaney, Prochnow, Chapman, & Arrow, 2008). They are advantaged by their ability to transfer foundational skills and strategies to a range of text structures. When presented with expository passages, that include text and diagram features, these proficient readers are more likely to have the attentional capacity to make reasonable attempts to navigate and comprehend these texts. Students already struggling to master reading skills find themselves faced with another unattainable hurdle. This inability to gain meaning from expository structures impacts negatively on their success in content areas. The Matthew Effect (Stanovich, 1986) then compromises their learning of content area knowledge. Consistent with the Matthew Effect, an inability to access these texts also reduces exposure to content area knowledge, opportunities to build prior knowledge and vocabulary. Reading expository texts offers students an insight into their world. An inability to access text results in limited exposure to content knowledge. A lack of instruction in comprehending expository texts is likely to exacerbate the already present Matthew Effect for those students who lack the cultural and literate capital of their peers.

1.2 Purpose

This study aims to establish whether instruction in expository text and diagram would support students in their comprehension of this potentially complex text type. This purpose is pragmatically important because it is linked to the *New Zealand Curriculum* (2007) and *National Standards* (Ministry of Education, 2009). Using language, symbols and text is one of five Key Competencies identified in the *New Zealand Curriculum* (Ministry of Education, 2007). The Key Competencies are described as "capabilities for living and life-long learning" (Ministry of Education, 2007, p. 12). "Working with and making meaning of" (Ministry of Education, 2007, p. 12) texts and diagrams is recognised within this document as a significant skill that has application across all learning areas. Additionally, the recently introduced *National Standards* (Ministry of Education ,

2009) assert that by Years 5 and 6 students will be able to "integrate pieces of information in order to answer questions" and that they will work with texts that "often include illustrations, photographs, text boxes, diagrams, maps, charts, and graphs that clarify or extend the text and may require some interpretation" (p.30). Similarly, at Level 3, the *New Zealand Science Curriculum* requires students to "Engage with a range of science texts and begin to question the purposes for which these texts are constructed" (Ministry of Education, 2007, Science Level 3). Establishing an effective method of instruction in comprehending expository science text and diagram has widespread benefits across key areas of the *New Zealand Curriculum*.

Research indicates that the comprehension skills of students in New Zealand have shown little improvement in recent years, despite an improvement in decoding ability (National Education Monitoring Project [NEMP], 2009). NEMP (2009) recommends that students "need guidance and encouragement to help them to focus on developing good comprehension" (p. 1). This same report also asserts that comprehension skills are likely to develop more rapidly if instruction is integrated across the curriculum as opposed to being the sole domain of language teaching and learning.

A key component of the instruction required to meet these national goals, outlined in the *New Zealand Curriculum* (Ministry of Education, 2007) and *National Standards* (Ministry of Education, 2009), involves expository text structures. Expository texts are varied in their structure and purpose. It has been well-established that explicit teaching of text structure is beneficial to the comprehension skills of readers (Meyer, Brandt & Bluth, 1980; Meyer & Poon, 2001; Pressley & Wharton-McDonald, 2006; Williams, Hall, Lauer, Stafford, DeSisto & deCani, 2005). Diagrams are a specific component of text structure. These are used extensively for communicating information and adding to written commentary. This component is, in particular, a convention of science texts (McTigue & Flowers, 2011; Vavra, Janjic-Watrich, Loerke, Phillips, Norris & Macnab, 2011).

A programme of instruction that supports the acquisition of strategies and the metacognition required to process expository texts and diagrams should be beneficial to students reading all literacies. For example, beyond print based texts, students are increasingly engaged with online texts. Leu, Coiro, Castek, Hartman, Henry & Reinking (2008) describe the need for readers to "navigate their own paths...through the online texts they read" (p. 323). Students reading online texts must synthesis information across multiple sources to construct meaning (Leu et al., 2008). The skills students learn through instruction in expository text and diagram are transferable to the more complex content of web-based reading. Metacognitive awareness developed through such instruction may provide scaffolding to support students across a range of new literacies.

1.3 Research Focus

The aim of the current research is to identify the effects of an instructional reading programme, designed to teach text and diagram interpretation strategies, on the comprehension of expository science text and diagram among Year 6 students. One of the factors challenging students' ability to comprehend science texts is their ability to interpret graphic information (Smolkin, McTigue & Donovan, 2008). However, teaching students how to make these interpretations does not appear to be a priority. Pressley & Wharton-McDonald (2006) report that minimal teaching time is spent on explicit instruction in expository comprehension strategies in elementary class levels. Not only are expository texts marginalised, the evidence suggests that teachers rarely guide students through the complexities of diagrams (Smolkin & Donovan, 2001; Williams et al., 2005), missing valuable instructional opportunities that might enable students to integrate and fully comprehend the information being presented. Indeed, one of the factors challenging students' ability to comprehend science texts is their ability to interpret graphic information, (McTigue & Flowers, 2011).

Images and diagrams are significant features of expository science texts. They are intended to assist readers comprehend often complex content. Diagrams convey information that may otherwise require long and detailed written passages. They assist readers to generate visual mental images of objects or events that may otherwise be considered abstract and difficult to understand (McTigue & Flowers, 2011). It should not be assumed that readers interpret diagrams as they were intended. Students have difficulty reading diagrams and images, (Pinto & Ametller, 2002). Indeed, evidence suggests that many primary school students consider diagrams in science texts to be of little importance (McTigue & Flowers, 2011). This misunderstanding of purpose inhibits students from accessing important content and can misconstrue the intended meaning. A lack of instruction in diagram interpretation may hinder student learning in content areas (Pinto & Ametller, 2002; Wheeler & Hill, 1990).

1.4 Approach

Few studies have examined the impact of an instructional programme in diagram interpretation on the reading comprehension of expository science texts. In this study, the impact on reading comprehension of teaching diagram interpretation to an intervention group was compared with a control group that received no explicit instruction in diagram interpretation strategies.

Students in both the intervention and control group read a series of expository science texts as their instructional Guided Reading approach text over a period of six weeks. Each group received two lessons per week. The instructional group received instruction in strategies to support the comprehension of these complex expository texts. These strategies included accessing prior knowledge, recognising a range of text features and their purpose, identifying a navigation pathway for reading the text, scanning between text and diagram, and imaging.

Assessment measures collected data pertaining to pre and post knowledge, comprehension for each passage, and metacognition.

1.5 Outline

Chapter Two critically reviews current literature surrounding reading comprehension. This chapter deals with trends associated with expository text instruction and, the use and interpretation of diagrams as a feature of expository texts. Metacognition and self-efficacy are reviewed with consideration toward their influence over expository text comprehension.

Chapter Three describes the methodology used for the instructional programme, including the sequence of lessons and details of instructional material. It also details the mixed-method, quantitative and qualitative data gathering procedures.

Chapter Four reports the findings of the study by providing quantitative and qualitative results separately. Quantitative results include a statistical analysis of the intervention programme, while observations, interviews and transcripts detail qualitative results.

Chapter Five provides a discussion of the findings, a note on the limitations of the study and suggestions for future research.

Chapter Two

Literature Review

2.1 Introduction

This current study is concerned with the reading of expository science texts with diagrams by Year 6 students. The aim of the study is to identify whether specific instruction in interpreting text and diagram in combination is beneficial to the students' comprehension of expository science texts. It is hypothesised that instruction will assist students in their reading and comprehension of this text type. As instruction progresses it is expected that students will develop metacognitive skills that assist them to navigate these multi-modal texts.

The following review of current literature was undertaken to identify and describe current research concerning comprehension of expository science texts and diagrams. The review begins with a brief summary of reading comprehension. Next, classifications of expository texts are considered and the use of expository text in the primary classroom is explored. The review then specifically considers literature concerning the characteristics and teaching of expository science texts, in order to inform, design and deliver the current study this section of the review considers the following questions:

- What are the characteristics of science texts and diagrams?
- How do skilled readers read expository science texts and diagrams?
- How can instruction in reading text and diagram develop skilled readers?
- What theory explains the processing of visual and verbal modalities?

Finally, this review considers the roles of metacognition and self-efficacy as contributors to student success in comprehending expository texts in content areas such as science.

2.2 Reading Comprehension

Reading is a complex act requiring a synthesis of skills and strategies that engage both lower and higher order thinking. At its foundation, reading requires an understanding of sounds, letters, clusters and words. This knowledge is applied to decode text. However, an ability to decode does not automatically transfer to an ability to comprehend (Pressley, 2006; Pressley & Gaskins, 2006; Wiley, Griffin & Thiede, 2005; Woolley, 2010).

Reading comprehension is greater than knowledge of words and their construction (McNamara, Ozuru & Floyd, 2011; Oakhill, Cain & Bryant, 2003). Reading comprehension begins before reading. Pressley (2006) describes the evaluation, connections and predictions good readers make before reading. The skilled reader evaluates a text in terms of its usefulness in meeting their purpose for reading. The skilled reader also evaluates the structure of the text. Prior knowledge is accessed by the reader at this time and continues to be a point of reference throughout the reading.

2.2.1 Prior knowledge.

Prior knowledge is an integral feature of reading comprehension. It provides a reader with the world knowledge that supports "the generation of inferences required to understand the text" (Pressley, 2006, p. 54). According to Context Availability Theory (Kieras, 1978) a readers' ability to connect content to their prior knowledge is influential to understanding rather than the imaginal potential of words. Schwanenflugel & Stowe (1989) contend that readers process both concrete and abstract words faster when they are presented in a supportive context. Connections made between text and prior knowledge support the creation of new knowledge (Anderson & Bower, 1973). The skilled reader is able to make these connections across all levels of discourse (Pressley, 2006). To this extent, prior knowledge is a key reference point for text comprehension. As these connections are made, prior knowledge may be questioned, supported, challenged and elaborated during reading. As comprehension develops, so too does prior knowledge – one strengthens and enhances the other (Fielding & Pearson, 1994).

Pressley (2006) describes prior knowledge as supporting readers to make "bridging inferences" (p. 54). These bridging inferences "provide coherence between the sentence currently being read and the text read up until this point" (p. 54). While Pressley (2006) draws substantially from research in the field of narrative texts, he acknowledges they apply also to expository texts. When considering expository texts and diagrams, bridging inferences play an important role in supporting the reader to construct coherence between and across text structures.

There is a consensus developing among researchers that the process of reading comprehension differs across text types (Duke & Martin, 2008). Wiley, Ash, Sanchez & Jaeger (2011) contend that adult readers do not make bridging inferences to the same extent when reading expository science texts. They point to this as a key differential between the processing of narrative and expository texts. Similarly, Best, Floyd & McNamara (2008) found that prior knowledge was a key determiner of third grade students' comprehension of expository texts. By comparison, prior knowledge did not carry the same influence over comprehension of narrative texts.

2.2.2 Teaching reading comprehension.

Since Dorothy Durkin's (1978-1979) landmark study of comprehension instruction, the need to teach comprehension strategies has been recognised through extensive research (Collins Block & Duffy, 2008; Meyer & Ray, 2011; Pressley, 2002; Pressley 2006; Wiley et al., 2011). However, Pressley (2002) laments the lack of application of comprehension strategy training in the classroom. During the 30 years since Durkin's contribution, research has been concerned with what comprehension strategies to teach, when to teach them and how best to do this. Collins Block & Duffy (2008) identify nine key comprehension strategies that research has shown to be successful. These are: predicting, monitoring, questioning, imaging, looking-back, rereading and fixing it, inferring, identifying main ideas, summarising and drawing conclusions; evaluating, and synthesising. Additionally Collins Block & Duffy (2008) point out that teaching comprehension is "more a matter of being strategic than of knowing individual strategies" p. 29. The challenge to the classroom programme of instruction is to create authentic learning environments and to provide explanation and feedback to students that enable students to apply the range of comprehension strategies strategically. Hattie & Timperley (2007) state that "...when feedback is combined with effective instruction in classrooms, it can be very powerful in enhancing learning" (p. 104).

Pressley (2002) presents an argument for teaching multiple strategies. Citing naturalistic research examples Pressley consistently observed students being taught a repertoire of comprehension strategies. This teaching approach is more in keeping with replicating, endorsing and encouraging the behaviours of skilled readers who utilise and coordinate multiple strategies as they read (Pressley, 2002).

Instruction in comprehension strategies has shown improved comprehension in readers. Indeed, studies have argued that many struggling readers fail to develop these strategies to comprehend without explicit teacher instruction (Collins Block & Duffy, 2008; Dymock, 2005; Martin & Duke, 2011; Pressley, 2006).

Research continues to refine and clarify which comprehension strategies should be taught, when they should be taught, and which teaching methods are most effective. There is widespread agreement that explicit instruction in comprehension strategies is highly beneficial to emerging readers, particularly in relation to expository texts (Collins Block & Duffy, 2008; Martin & Duke, 2011; Meyer & Ray, 2011; Pressley, 2006; Wiley et al., 2011).

2.3 Expository Text

Reading comprehension strategies are essential when reading and comprehending expository texts. Comprehension of this text type is a necessary skill for learning and functioning in this era of multi-literacies, as students move into secondary and tertiary education they interact predominantly with expository texts. Web page design provides a similar platform where multiple text features work together and require the reader to synthesise information across these features. Prain & Waldrip (2006) assert that to meet the demands of science literacy in later years "...students in the middle years of schooling need to learn about the multi-modal nature of the representation of scientific inquiry..." (p. 1845). It would, therefore, seem reasonable to expect that the primary years would provide some foundation learning concerning expository text comprehension. Research shows this is not the case. For example, Duke (2000) identified the scarcity of expository texts in first grade. Her study of experiences offered to first grade students across 20 different classrooms found expository texts sorely lacking, with a mean of just 3.6 minutes per day spent with expository texts. This limited exposure does little to prepare students for the curriculum demands ahead of them (Prain & Waldrip, 2006; Williams, Hall, Lauer, Stafford, DeSisto & de Cani, 2005). Wiley et al., (2011) point to the transition from learning to read, to reading to learn, which takes place at late primary school level as a key time when students need to be taught to comprehend expository science text and to apply strategies with automaticity as they do with narrative text.

In part, the strategies used by readers of expository texts differ from those used when reading narrative texts, because expository texts differ significantly from narrative texts in many ways. Expository texts frequently contain content that the reader has had minimal exposure to (Pressley, 2006; Williams et al., 2005) and often include content-specific vocabulary that may also be unfamiliar (this is particularly evident in science texts). Expository texts also differ in structure. Where narrative generally presents as a sequential problem-resolution structure, expository texts can present in a range of structures. Dymock (2005) categorises expository texts as descriptive structures and sequential structures. Each of the two categories has specific sub-structures within them. Descriptive structures focus on attributes, these include lists, web structures along with compare and contrast matrix structures. "Sequential structures present a series of events that progress over time" (Dymock, 2005, p. 180), such as the string pattern. Similar structure lists can be found in the work of other researchers (Armbruster, Anderson & Ostertag, 1987; Meyer & Freedle, 1984).

To further complicate matters for the reader, a single expository text may present more than one structure. This is certainly the case when diagrams are included as part of the text package – as is frequently the case with expository science texts.

Further complications stem from researchers, and practitioners alike, using different terminology when talking about this text type. The terms non-fiction, expository text and informational text are all used to label these text types. Williams (2009) attempts to address the issue of terminology, by proposing a useful framework for non-fiction that focuses on text function and content. Williams' (2009) framework proposes three structural formats for non-fiction work. The first being *non-fiction narrative*, this includes non-fiction texts that may present information in a storybook style, biographies, historical diaries and blogs. The second structural format is *expository text*, this incorporates procedural books, encyclopaedias (including digital and web based), informational books and websites, nature identification-type books, posters, brochures, maps, web-based discussion boards. These are "fact-based texts that are designed to inform or describe" (Williams, 2009, p. 253). The third structural format Williams (2009) proposes is *hybrid structures*. Examples include cross-format books (such as The Magic School Bus series), magazines, newspapers, fact-based simulation computer/web based games.

Similar frameworks have been presented by other researchers (eg., Duke & Bennett-Armistead, 2003; Pappas, 2006). Importantly, Williams (2009) presents a framework that considers the multi-modal nature of literacy today. He places digital, web-based and interactive modalities alongside conventional books and print-based media.

Whitehead (personal communication) provides a cognitive perspective on the classification of expository text. He notes that recount and procedure differentially evoke episodic thinking, description and report prompt readers and writers to think conceptually and explanation, argument and discussion differentially evoke critical thinking. This classification does not negate the potential of readers and writers to simultaneously engage in other types of thinking (creative, caring and reflective).

2.3.1 Characteristics of expository science text and diagrams.

Diagrams are a significant feature of expository science texts. Diagram is a generic term used to describe text features that take many forms for example tables, labelled photos/pictures/stylised drawings, compare and contrast sequences, text boxes and so on. Ainsworth (2006) refers to diagrams as representations, while Pozzer-Ardenghi & Roth (2010) name them inscriptions. A single page may contain one or more diagrams. These may be presented in a range of structures. These mixed modes provide challenges to the reader who must determine their function, purpose and relation to the text.

Research identifies that diagrams serve several functions within these texts (Carifio & Perla, 2009; McTigue & Croix, 2010; Waldrip, Prain & Carolan, 2006). One function is to provide clarification of ideas presented in the written text. In this capacity, diagrams are particularly helpful in providing the reader with a visual representation to assist them understand more abstract text content (Ainsworth & Loizou, 2003). A second function is to convey information that may be too complicated to deliver in written form. Similarly, diagrams frequently carry additional information over and above what is conveyed in written form. Diagrams can assist as organisational tools. Diagrams are frequently used to more easily communicate spatial relationships. Diagrams serve a range of functions that support and enhance written content.

In reviewing the literature at the time, Levie & Lentz (1982) identified four key support functions, (or roles) diagrams have in science texts. The first was an attention guiding function. Here Levie & Lentz (1982) describe how diagrams compel readers to attend more fully to printed material, particularly the image. Secondly they note diagrams have an affective function. Levie and Lentz (1982) supported the notion that diagrams heighten interest in material, in turn motivating engagement with text. The third role was a cognitive function. Levie & Lentz (1982) asserted that diagrams enhance both comprehension and recall for information presented. This is assisted by the diagram and text providing multiple modes for mental representation and recall. The fourth and final function for diagrams was a compensatory role. As a compensatory function they claim that diagrams support the learning of poor readers in the science content area.

More recently, Ainsworth (2006) summarises the functions of diagrams within text as having three key functions. First, they serve a complementary function, in which diagrams provide additional information. Second, diagrams have a constraining function, where the diagram facilitates the interpretation of other material. Thirdly, diagrams support a construction function, where the integration across different diagram and text representations builds deeper understanding.

It is evident that diagrams that accompany expository science texts serve several functions. The skilled reader utilises these functions to gain meaning from the text. Instruction is required to ensure students are aware of, and are able to utilise, these functions (McTigue & Flowers, 2011; Pinto & Ametller, 2002). Indeed, McTigue & Flowers (2011) demonstrated that many primary school students consider diagrams in science tests to be of little importance. Their study illustrates that a lack of understanding of the functions of diagrams may lead students to largely ignore this component of text. Explicit instruction that targets the functions of diagrams is necessary for students to gain full meaning from expository science texts and diagrams (Ainsworth, 2006; McTigue & Flowers, 2011; Pinto & Ametller, 2002).

2.3.2 How skilled readers read expository science texts and diagrams.

Skilled readers are able to navigate multi modal text, make connections between modes and to synthesise information. Research tells us that the ability to make connections between text and diagram is supported by page design (Holsanova, Holmberg & Holmqvist, 2008).

Research concerning diagram design considers design variables including frequency of diagrams within a text passage, semiotics, text-diagram integration and page layout. One such study conducted by Holsanova et al., (2008) considered the impact page layout has on text-diagram integration. The study utilised eye tracking measures to better understand reader interactions with text and information graphics. In a study of 31 adult participants they sought to answer the question; "How can we make it cognitively easier for readers to integrate information from different sources" (p. 2). Holsanova et al., (2008) found integration of text and graphics occurs best with an integrated format, where the physical distance between text and graphic was small. In a separated format readers were more likely to consider the two as self contained and not connect the two, (or ignore one completely). Deeper processing (that Holsanova et al., identified through sustained attention) was evidenced with texts that were serial in their layout. That is, they provided the reader with a clear path to navigate the combination of text and diagram.

In their research, Holsanova et al., (2008) used attention as a measure of interest, and the assumption made that this corresponded to deeper processing and comprehension. The researchers employed no direct measure of comprehension. As no direct measure of comprehension was used it is difficult to ascertain the level of synthesis readers made across text and diagram. Schwonke, Berthold & Renkl (2009) found that adults in their study were unaware of the deeper understanding integration of information across text and diagram can construct. This may also have been the case with participants in the Holsanova et al (2008) study; however, measures were not made of this aspect of comprehension. Reflecting on the three functions Ainsworth (2006) identifies (detailed earlier) it may be that the sustained attention Holsanova et al., (2008) observed was a result of the first two functions (complementary and constraining), and perhaps not a result of a construction function.

A further research thread explores the premise that skilled readers of expository texts strengthen their comprehension of science text and diagram by constructing mental images that support synthesis of text and diagram modes. Leutner, Leopold & Sumfleth (2009) investigated whether drawing images, mentally imaging or both imaging and drawing had positive effects on comprehension of science text among tenth grade students.

Leutner et al., (2009) found that mental imaging produced optimal results. In addition, they found that the positive effect of this mental imagery was lost when combined with producing a drawn picture. Leutner et al., (2009) conclude that the production of diagrams increases the cognitive load upon the reader, leading to decreased comprehension results. By comparison, mental imaging demands less cognitive load, resulting in increased comprehension.

Leutner et al., (2009) present no evidence that prior learning concerning diagram representations of science text had taken place with the student participants. It could be questioned whether such instruction would have provided students with a better understanding of how their visual images could be transformed into graphic representations consistent with/complimentary to the science text they read. That is, it cannot be ruled out that students did not have the knowledge required to produce diagrammatic images of science content. A mental image is far more complex than paper based representations. Students mental images would consist of nested concepts beyond the parameters of the text itself. The text utilised by Leutner et al., (2009) contained abstract content concerning water molecules. Extending the study with a second text representative of a more concrete subject may have resulted in increased ability to produce diagrams as students would likely be more familiar with diagrammatic representations of this kind.

2.4 Dual Coding Theory

Dual Coding Theory (Paivio, 1986) provides a theoretical foundation upon which to understand how readers process and interpret text. Dual Coding Theory (DCT) suggests two cognitive systems for storing information – verbal language and visual mental imagery. Processing takes place within and between these two systems. Coding in the verbal language system includes both the spoken word and written word (which is encoded verbally through self talk at time of reading).

An important feature within DCT is the distinction between abstract words and concrete words. The theory asserts that concrete words can be encoded twice, once through a verbal code and again through an imagery (nonverbal) code (Ashcroft, 2006; Sadoski, Goetz & Rodriguez, 2000), as opposed to abstract words that are more difficult to encode in an imagery code. The ability to access both verbal and nonverbal codes strengthens related cognitive processes.

Dual Coding Theory suggests three levels of processing; representational, associative and referential, (Sadoski et al., 2000), allowing for knowledge, meaning and memory to be represented and processed within and between codes (Sadoski, 2005). Concrete language assists the referential level of processing, activating both verbal and visual codes, thus stronger cognitive connections are made (Sadoski et al., 2000).

From a DCT perspective, the inclusion of diagrams in science texts supports the reader to better understand the often complex and abstract concepts that are presented by providing visual and verbal referents.

2.5 Self-Explanation and Diagram Comprehension

A further research thread suggests skilled readers increase their level of self-explanation when reading diagrams (e.g., Ainsworth & Loizou, 2003). In their study of adult participants, Ainsworth & Loizou (2003) found that diagrams promoted more self-explanation than text alone. This resulted in superior comprehension over participants reading text alone.

Ainsworth & Loizou (2003) observed that while "text students spoke more than diagram students" (p. 679) this talk was predominantly paraphrasing the material read, diagram students engaged in more self-explanation dialogue. This interaction with diagrams suggested the diagram students were engaged in deeper thinking and synthesis of material. This was reflected particularly in scores on "more difficult knowledge inference questions (78.3% for diagrams compared to 46.6% in the text)" (p. 678). These results suggest that this metacognitive strategy utilises the construction function (described earlier, see Ainsworth, 2006) of diagrams as the reader integrates information to build deeper understanding.

Students studying diagrams may also have benefitted from increased mental imagery. In addition, the verbal and visual modes may have assisted diagram students in their recall of information. Studying diagrams may have caused students to spend greater time attending to the diagram, benefitting recall and comprehension. Ainsworth & Loizou (2003) did not measure such aspects.

Ainsworth & Loizou (2003) suggest that a further advantage is that diagrams are less cognitively demanding as they provide opportunity for "computational offloading" (p. 670). While this may be the case for the skilled reader, research suggests this does not hold true for emerging readers. Hannas & Hyona (1999) document that while high ability students are able to be strategic in their reading of science text and diagram, low-ability students were not advantaged by the use of diagrams.

2.6 How Can Instruction in Reading Text and Diagram Develop Skilled Readers?

Diagrams are an underutilised feature of science texts and many students do not understand the purpose of diagrams that accompany text (Hannas & Hyona, 1999; Kelley & Clausen-Grace, 2010; McTigue & Croix, 2010; McTigue & Flowers, 2011; Smolkin, McTigue & Donovan, 2008). For example, McTigue & Croix (2010) interviewed 30 elementary and middle school students about their practices when presented with a text passage that includes diagrams. Qualitative data gathered from these interviews confirmed that students tended to ignore graphics, considering them simply a visual representation of text that they "skip over" (p18) as they read. Indeed some were grateful for the presence of diagrams, viewing them as space fillers that reduce the amount of text they were required to read. Although a useful finding, McTigue & Croix (2010) may have furthered their understanding of students' interaction with diagrams had they utilised an eye-tracking protocol. This would have provided quantitative support for student statements gained through interview, or perhaps have identified misconceptions students may hold surrounding their reading behaviours. McTigue & Croix (2010) would then have had the opportunity to develop this analysis further by providing some instruction that aimed to develop an understanding of the importance of diagrams. A further eye-tracking protocol may have shown that following instruction students spent the same or more time attending to diagrams as they read such multi modal texts. This tendency of ignoring diagrams reflects earlier findings of Hannas & Hyona (1999). Their research found that elementary students reading science texts spent just 6% of their total reading time attending to the graphics.

Together, these studies suggest that little has changed with student perceptions of diagrams over the intervening decade. They also suggest that interpreting diagrams is not an innate act of reading. Rather, instruction in some form may be required to enable interaction between a reader and diagram to reach its potential.

2.7 Page Design and the Comprehension of Expository Texts

Holsanova, Holmberg & Holmqvist (2008) were able to show that page layout has an impact on the attention of skilled readers. Findings of the kind Holsanova et al., (2008) present with adult skilled readers, suggest that primary school students would also require support as they navigate and integrate information presented in this multi-modal format. Some guidance concerning text construction, selection and instructional emphasis can be gained from these findings. Students are likely to find reading such texts less taxing when text and diagrams are presented in a serial layout. Instruction that supports the student to recognise layout features and a navigation path may support them developing this skilled reader attribute. The placement of text and related diagram in close proximity on the page is more likely to guide students to recognise a relationship between the two. Instruction that supports students in recognising relationships between text and diagram, and in identifying placement cues that indicate this relationship, is likely to assist in developing an ability to recognise a navigational path through such a text. However, it cannot be assumed that this translates to deep understanding through synthesis across sources (Ainsworth, 2006; Schwonke et al., 2009)

McTigue & Slough (2010) endorse the need for a coherent structure and clear integration of verbal and visual information. In considering design elements that support student reading of science texts McTigue & Slough (2010) also identify as important; "the concreteness of text, the voice of the author and selective use of visual information" (p. 213). McTigue & Slough (2010) contend that a well-constructed text and diagram passage may offer some support, in the absence of teacher instruction, assisting the reader to navigate and integrate information.

Consideration of such design features is particularly important when selecting suitable texts for students. The New Zealand primary school teaching context does not provide textbook material in the area of science. While the *New Zealand Curriculum* (Ministry of Education, 2007) provides a framework of learning and key content in science, individual schools and teachers select related reading material from a range of sources (NZ School Journal series, Connected Journals, trade books, web pages and commercially produced classroom teaching handbooks). Significant variance in design can be expected of material with such a wide range of sources. However, textbooks may provide only marginally reduced variance. In a review of four, sixth grade science texts in the state of Texas, Slough, McTigue, Kim & Jennings (2010) found considerable variance of graphical representation. While some of the diagrams presented in the textbooks were accessible for students others did not reflect the design principles discussed above. Indeed Slough et al., (2010) identified that one third of the diagrams across the four texts "were not connected to the text spatially or semantically" (p. 301), one third served no purpose - they were simply "decorative". This would suggest that writers of such textbooks are not utilising the research that is available concerning design of diagrams (Slough et al., 2010). With this in mind, teachers need to be discerning about their text selection in this area, whether they are using textbooks, trade books, web pages or other material.

The design of diagrams may well influence the readers' ability to interpret and synthesise information as these studies suggest. As Waldrip, Prain & Carolan (2006) identify, the scope of diagram design is immense. While reviewing the literature, little evidence has been found regarding whether we should also be concerned with an optimum progression for teaching and learning with diagrams. McTigue & Slough (2010) suggest that diagrams should be selected based on which best suits the information intended. Similarly Waldrip et al., (2006) state that students need to develop an understanding of the different modes that are used to best deliver information for different purposes. Students should not be limited in the range of diagram formats they are exposed to (Waldrip et al., 2006). Learning the skills required to interpret the information presented is essential (Ainsworth, 2006; Schlag & Ploetzner, 2011; Schwonke, 2009). Diagram selection and optimum design do not stand alone, they still demand a reader who knows how to access, process and synthesise such a text. The studies of skilled readers reviewed here suggest that processing and synthesis are achieved by recognising text features and identifying a clear pathway to navigate this text.

2.8 Learning to Read Diagrams.

Schlag & Ploetzner (2011) acknowledge the difficulties many students have processing text and diagram passages. They designed and trialled a learning strategy aimed at increasing student learning from such texts. The learning strategy was a six-step process as follows:

> 1. *Get a general overview*
> 2. *Underline relevant terms in the text*
> 3. *Mark relevant elements in the picture*
> 4. *Use the underlined terms to label element in the picture*
> 5. *Summarize in your own words*
> 6. *Draw a summarising sketch.*
>
> (Schlag & Ploetzner, 2011, p. 927)

This learning strategy addresses many of the actions research shows skilled readers use when reading expository text with diagrams. By following these steps students are guided to identify a navigational path, identify key aspects of both text and diagram, to integrate information and to synthesise between the two. The study aimed at systematising the learner into processing and integrating text and diagram. Students were asked to follow the steps (provided in an age appropriate version) as they read. Pre and post testing assessed the effectiveness of the learning strategy.

While results showed students who employed the strategy gained better results in post-testing, there is little evidence that students gained an understanding of diagrams and their purpose. Neither did this study identify any self-regulated application of this learning strategy beyond the directed study. While students were instructed to use this learning strategy there is no evidence that they learned the strategy. No social context was provided through which students may be able to develop the metacognitive thinking that may support learning in this area, (such as self-explanation).

Kelley & Clausen-Grace (2010) present an alternative reading strategy for use when reading expository science texts at the primary school level. Capitalising on the already well-established practice of; previewing guided reading texts by talking about illustrations, activating prior knowledge, making predictions and setting a purpose for reading endorsed by the likes of Clay (1991). Kelley & Clausen-Grace (2010) demonstrate the effectiveness of transposing these strategies onto the reading of expository texts and diagrams, using the text feature walk strategy.

The text feature walk strategy develops students' ability to organise information across a range of text features. Emphasis is placed on developing an understanding of the range and purpose of text features. In previewing the text students identify the text feature type and purpose, during this process a plan for navigating the text is developed, ensuring that all text features are attended to.

It was found that students implementing the text feature walk generated "more meaningful predictions and deeper comprehension of text" (Kelley & Clausen-Grace, 2010, p. 194). In addition, the discussion that took place in the social context of guided reading was "integral to the success of the text feature walk" (p. 194).

A key strength of this strategy is the ease with which it may be incorporated into existing guided reading programmes. The strategy utilises existing practices associated with previewing text during guided reading lessons. The text feature walk provides a practical application reflective of page layout findings of Holsanova et al., (2008) discussed earlier in this chapter.

2.9 How Does Metacognition Support Reading Comprehension?

Metacognition is defined as cognition about cognition (Flavell, 1979). To be metacognitive, an individual demonstrates a self-awareness of their cognitive abilities, limitations and processes. This self-awareness allows an individual to identify and select strategies for learning as and when appropriate to the task. It is the "active control over the cognitive processes engaged in learning" (Livingston, 1997, p. 1).

Much research concerning metacognition has taken place since Flavell's early work in the 1970s. We now understand that metacognition can be taught (Baker, 2008; Pressley & Gaskins, 2006; Schraw, 1998). "Virtually all recommendations coming out of the research on fostering cognitive and metacognitive reading strategies emphasise the importance of beginning with teacher-led instruction, followed by a gradual release of responsibility to the students themselves" (Baker, 2008, p. 75). Lai (2011) describes successful research featuring instructional settings that involved collaborative groupings, peer interaction, cooperative learning, or small group learning. The conditions described "promote group discussions about the use of reading strategies" (p. 25). Guided Reading (Ministry of Education, 2005) provides a teaching and learning environment that supports this type of interaction.

Both Houtveen & van de Grift (2007) & Schraw (1998) encourage explicit instruction in metacognitive strategies. Such instruction would include "how to use strategies, when to use them, and why they are beneficial" (Lai, 2011, p. 23). Houtveen & van de Grift (2007) demonstrated the positive long-term effect of metacognitive strategy instruction. Students in their treatment group continued to outperform control students when revisited a year later. Pressley & Gaskins (2006) observed effective instruction that explicitly taught metacognitive strategies and ensured that students were regularly prompted to use these strategies. The learning environment ensured that students regularly had an opportunity to practice and strengthen the skills. Similarly Veenman, Van Hout-

Wolters & Afflerbach (2006) believe that ongoing practice and maintenance of metacognitive strategies is fundamental to metacognitive automaticity.

Metacognition instruction is beneficial to both good readers and poor readers (Baker, 2008; de Jager, Janse, & Reezigt, 2005; Pressley & Gaskin, 2006; Veenman et al., 2006). Metacognitive knowledge provides the reader with the means to monitor their own comprehension by identifying errors (from lower order errors of decoding, through to higher order errors of understanding) and having the ability to select and employ correction strategies (Baker, 2008; de Jager et al., 2005). Good readers are metacognitively active before, during and after reading (Pressley & Gaskins, 2006).

2.9.1 Metacognitive instruction to support comprehension of expository science texts.

Metacognitive skills are domain general. Schraw (1998) describes them as multi-dimensional, they are utilised by the learner across learning areas. As such, instruction should provide learners with opportunities to develop, practice and apply these skills across content areas. Veenman et al., (2006) endorse the role of "embedded metacognitive instruction" (p. 9) in content areas (such as science). Similarly, Michalsky, Mevarech & Haibi, (2009) claim that embedded metacognitive instruction may support learners as they develop scientific literacy. Michalsky et al., (2009) studied 4th grade students' science literacy and the effects of metacognitive instruction at different phases of reading (before, during and after reading). Students receiving metacognitive instruction out-performed those in the control group who received no instruction. These results support the premise that "mere exposure to scientific texts is insufficient and that explicit instruction is required to train students to self-regulate their learning" (Michalsky et al., 2009, p. 372). The question of timing of metacognitive instruction during a lesson has been raised by Michalsky et al., (2009). Performance results of the three intervention groups ranked: After Reading, Before Reading and During Reading. It may be that the cognitive load during reading contributed to the lower gains by the During Reading group. This is a further consideration to take into account when designing lessons that include metacognitive instruction.

The current study aims to provide students with opportunities to develop, practice and apply metacognitive strategies when reading expository science text and diagram. The study is consistent with the premise that a collaborative instructional environment supports student learning of metacognitive strategies. It is expected that with explicit instruction the multidimensional element of metacognition will lend itself to learners transferring strategies across a range of diagram formats. It is hypothesised this instruction and these conditions, will enable students to achieve a deeper understanding of information presented in both text and diagram. The lessons detailed in the next chapter are designed to release responsibility to students as they develop maturity of metacognitive thinking, resulting in an efficacious belief that will enable them to transfer their learning across a range of expository texts and diagrams.

2.10 Self-Efficacy

Bandura (1994) defines self-efficacy as "peoples beliefs about their capabilities to produce levels of performance that exercise influence over events that affect their lives" (p. 71). Self-efficacy is influential in determining student academic success (Zimmerman, 2000). An efficacious belief brings confidence, commitment and heightened interest in activities (Bandura, 1994).

Developing a sense of self-efficacy toward comprehending expository text and diagrams would likely result in benefits for the learner. It is this belief that allows students to adapt strategies to varied texts and to approach the text with a belief that they will gain meaning. Students who reach high school without having opportunities to build this efficacious belief may be less likely to achieve the level of comprehension and engagement required of them in content based reading (such as expository science texts).

Bandura (1994) asserts that "the most effective way of creating a strong sense of efficacy is through mastery experiences" (p. 72). Further strengthening of self-efficacy is gained in social context. Bandura (1994) describes the benefits of "seeing people similar to oneself succeed by sustained effort raises observers' beliefs that they too possess the capabilities to master comparable activities" (p. 72). In the classroom, opportunities to experience mastery can be provided through lessons that scaffold support and lead to a release of responsibility. Guided Reading provides a learning context through which such mastery lessons can be taught. Guided Reading also provides the social context that Bandura (1994) identifies as providing observations of others succeeding with learning.

2.11 The Current Study

Studies of primary school students reading expository science text and diagram appear to fall into two categories. The first being a single task where students read and respond. Variances occur with the material, the diagrammatic content or the instruction. The second involves interview and observation. Few studies involve interventions that teach strategies and seek to measure the improvement in skill level and metacognitive awareness of students reading expository science text and diagram. The only study found that presented a learning strategy was Schlag & Ploetzner (2011). They too had been unable to locate studies that focussed on learning strategies for such text, "there are presently no comprehensive learning strategies which facilitate learning from text-picture combinations" (p. 922). This study will add to research concerning the comprehension of expository science text by examining the impact on reading comprehension of teaching text and diagram interpretation among Year Six students. The study used a mixed methods approach to explore the following research question: *What is the impact on the comprehension of expository science text when students are taught strategies to interpret text diagrams?*

Strategies included accessing prior knowledge, recognising a range of text features and their purpose, identifying a navigation pathway, scanning between text and diagram, and imaging. A unique aspect of this study is the authentic classroom environment in which the programme was taught, providing an ecologically valid context for learning.

Chapter Three describes the methodology used for the instructional programme, including the sequence of lessons and details of instructional material. Chapter Three also details about the mixed method, quantitative and qualitative data gathering procedures.

Chapter Three

Method

3.1 Overview of the Study

Students were taught to recognise information in expository science texts can be carried in two different forms – text and diagram. Students were taught strategies to navigate these complex expository texts, and to integrate information between text and diagram, which included; recognising a range of text features, understanding how to navigate the range of text features, and scanning between text and diagram to develop comprehension of material presented.

3.2 Participants and Setting

The twelve Year 6 students who participated in this study were drawn from a large, decile 5[1] urban primary school in the Auckland region. The students were all from the same Year 6 class. The class composition was mixed in gender representation (11 boys and 15 girls), with ages ranging from 9.8 years – 10.8 years as at 1 January 2012. The Year 6 class was multicultural in representation; 61% European, 8% Maori, 4% Pacifica, 12% Indian, 11% South African, 4% Chinese. This demographic is representative of the school community. Selection of students was determined by their reading age. Students were working at their chronological age for reading, (that is 10 - 11years range). Students with specific learning needs were excluded, as were exceptional readers.

Within the Year 6 class the reading programme operated with students grouped according to their reading age, determined predominantly by Running Records administered using PROBE (Parkin, Parkin & Pool, 2002). Refer to Table 1.

[1] Decile rankings are a measure used to determine funding for Primary, Intermediate and Secondary schools in New Zealand. "Decile 1 schools are the 10% of schools with the highest proportion of students from low socio-economic communities, whereas decile 10 schools are the 10% of schools with the lowest proportion of these students" (Ministry Of Education, 2011).

Table 1

Class Reading Profile

Sex	< 9 years	9-10 years	10-11 years	>11 years
Male	3	0	4	4
Female	2	4	6	3
Total	5	4	10	7

During the course of a normal instructional reading programme these groups complete a range of reading related tasks, including Guided Reading. Guided Reading is typically small group instruction. During Guided Reading students are guided purposefully through a text (Ministry of Education, 2005). Teaching instructs and supports students in the use of appropriate reading processes and comprehension strategies. Guided Reading is a core component of instructional reading programmes throughout New Zealand Primary Schools (Ministry of Education, 2005). Guided Reading sessions were used to teach the intervention programme. Guided reading lessons provided a social context and opportunity for peer interaction that allowed students to observe others successes. This is consistent with Bandura's (1994) premise that such observations contribute to the development of self-efficacy.

3.3 Measures

The study took place over eight weeks of the first term of the 2012 school year. Each group received one or two instructional lessons a week. Lessons were 40-50 minutes duration. Usual programme interruptions determined lesson frequency. Such interruptions included school camp and a cycle safety programme.

Prior knowledge for each topic was assessed immediately before students read each passage. Students were each supplied with a blank sheet of paper and were given three minutes to write down as much as they could about the topic. The researcher and an independent rater coded the prior-knowledge sheets. One point was given for each accurate statement related to the topic. Inter-rater reliability was established to be 90%, and any disagreements were resolved through discussion. Prior knowledge was then used as a springboard into the text.

Students were directed to metacognitive strategies to apply this prior knowledge to new learning.

The design of comprehension questions was informed by both levels of thinking and levels of discourse taxonomy. The revised Bloom's Taxonomy (Anderson & Krathwohl, 2001) was used to design questions that differentially evoked different types of thinking. Also taken into consideration were the levels of discourse across the text that the student needed to sample in order to find an answer to the question. Figure 1 illustrates the interrelation of these parts. A relationship exists between the continuums, that is, between levels of thinking and levels of discourse. For example, comprehension question items that involve cognition tasks, that require evaluating and creating, are more likely connected with discourse levels across and beyond the whole text. Items requiring remembering are more likely accessing text at the sentence level.

The ability of students to answer questions at different levels of thinking and different levels of discourse is dependent on their prior knowledge; this was addressed in detail in Chapter 2. Prior knowledge was recognised as being influential across all types of questioning identified in Figure 1.

Levels of Thinking

Question design based on Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001)

Remembering	Understanding	Applying	Analysing	Evaluating	Creating

Levels of Discourse

Question design based on levels of discourse (verbal)

Sentence level	Paragraph level	Whole text	Beyond text

Question design based on levels of discourse (multi-media)

Sentence level

Paragraph level

Whole text combined with diagram/picture/photograph

Questions design based of levels of discourse (visual)

← Diagram / picture / photograph →

Question design based on readers:

Direct recall of information from text or diagram	Understanding vocabulary in context	Ability to identify sequence Ability to identify compare & contrast structures Ability to identify cause & effect structures	Ability to synthesise across both text and diagram

Figure 1. Levels of cognition across comprehension questions.

Each instructional lesson concluded with a series of comprehension questions. The questions (see Appendix C for detailed lesson guideline) were designed to measure students' ability to access and understand information in text and diagrams. Consistent with the multiple taxonomy described in Figure 1, multiple-choice comprehension questions were designed to address the various dimensions of expository text comprehension. Questions were consistent with the levels of thinking dimension as follows:

Locating information. These questions were direct recall/location of content. A question was asked for each text feature (main text, labelled picture, comparison sequence etc.).

Understanding vocabulary. There was one vocabulary question in each test.

Compare and contrast. One question asked students to compare or contrast. These questions required students to analyse information, to consider relationships to text content and/or prior knowledge.

Recognising sequence. One question required students to consider chronological sequence of an event or action.

Integration. A final evaluative/synthesis question was designed to have students integrate information from both text and diagram(s). This question required a short answer. Each of the evaluative/synthesis questions started with *'Picture this...'* This prompt was designed to allow the question to summarise the key theme of the passage, while at the same time prompting students to visualise the given scenario. This use of visualisation process allowed students the opportunity to integrate prior knowledge with text and diagram content. The question then required them to either describe or explain a given scenario, event or feature related to the passage. Responses to the *'Picture this'* question were scored by numeric count according to the number of accurate ideas reported.

Questions were also consistent with the levels of discourse dimension as follows:

- Questions whose answers could be sourced directly from text.
- Questions whose answers could be sourced directly from diagram.
- Questions whose answers required a synthesis from information in both text and diagram.
- Questions whose answers required accessing readers prior knowledge, that is, not from either text or diagram, but, never-the-less evoked by the text and diagrams.

An example of the multiple-choice and *'Picture this'* questions is available in Appendix D.

Students had access to the text as they answered the multiple-choice questions. However, the text was not available as they answered the final synthesis question (outlined below). This aspect of the study provided the researcher with data concerning students' ability to skim and scan the text and diagrams for information and further data concerning synthesis and understanding gained without the ability to access text.

3.3.1 Interview questions.

The questions and prompts, presented in Figure 2, are indicative of those used during the study. They draw from examples presented by McTigue & Flowers, 2011; Kelley & Clausen-Grace, 2010; and Duke & Bennett-Armistead, 2003. The selection is wide and they were not all employed during every session. Although listed here as a complete group, the researcher's role was to identify which questions and prompts were required to best support students in their learning. This is particularly the case with those employed at the 'during reading' phase. Observation and monitoring by the researcher was essential during reading, to be ready to offer the appropriate support at the appropriate time. It was important not to interrupt the flow during reading and to allow adequate 'wait time' to enable students to process and select strategies with growing independence.

Pre and post reading questions and prompts were used to initiate collaborative discussion where students worked together to build meaning by articulating their responses within the group. This social context reflects conditions that support the development of metacognitive awareness and self efficacy (Bandura, 1994). During reading, prompts were individually suited to the needs of the reader as a response to their immediate reading need. In this way, the researcher was sensitive to the needs of the individual.

Consistent with Baker (2008) and Kelley & Clausen-Grace (2010) this study aimed to develop automaticity of self monitoring through repeated modelling and a gradual release of responsibility. Questions and prompts maintained focus on developing comprehension through understanding text and diagram features. They were used to scaffold the students to use the questions and prompts themselves as they gained independence and responsibility was relinquished to them.

Reading Phase	Questions and Prompts
Before Reading	What do you already know about __________? What do you notice about the reading? What text features do you recognise? Which text feature(s) are the most important? Why? How do we read a passage/diagram like this? Where do we begin? Where do we go next? Have you already gained some knowledge from this text walk? What do you expect to learn from the text? From the diagram? Which do you think is most important? What vocabulary can you see that may make reading tricky?
During Reading	What have you read so far? What do you understand about what you have read so far? Where are you going to read next? What do you need clarified? Are you making pictures in your head to help you understand the ideas in the text and/or diagram(s)?
After Reading	What did you learn from the main text? What did you learn from the diagram(s)? Did the text and diagram(s) support one another? In what way? Which was more important – the text or the diagram(s)? Why? Did you make pictures in your head as you read? How did that help you to understand? What did you learn? What did you already know that was confirmed by your reading? Did you find your eyes scanning between text and diagram(s)? What did you do if the text did not make sense? What did you do if the diagram(s) did not make sense?

Figure 2. Examples of questions and prompts.

3.3.2 Measures of metacognition.

The Metacomprehension Strategy Index (MSI) (Schmitt, 1990) was used as a measure of one aspect of reading-related metacognition. This index, consisting of 25 multiple-choice questions, was used to measure this aspect of metacognition both pre and post intervention. The items on the MSI gather information concerning students' strategic reading processes during the three phases of reading (that is; before, during and after reading). The MSI measures student awareness of metacomprehension behaviours across the following key strategies: "a) predicting and verifying, b) previewing, c) purpose setting, d) self questioning, e) drawing from background knowledge, and f) summarising and applying fix-up strategies." (Schmitt, 1990, p. 455). Lonberger (1998) and Schmitt, (1988) report the MSI as a reliable measure of metacognition.

In its original form, the MSI was intended to measure strategies specific to narrative text. To better align with the purpose of this study, changes were made to the wording of the MSI. These changes ensured questions evoked answers specific to strategies used while engaging with expository texts. This change is consistent with Schmitt (1990) who notes that the MSI can be adapted for use with expository texts. The key strategies identified above (a-f) are also necessary for reading expository texts. As the MSI was not used as a standardised measure, adjustments were made to the measure to better align it with the purpose of this study. Changes made were in line with recommendations made by Schmitt (1990). The following example illustrates the manner in which items from the MSI were altered:

Question 8, original with narrative emphasis:

Before I begin reading, it's a good idea to:

A. Think of what I already know about the things I see in pictures
B. See how many pages are in the story
C. Choose the best part of the story to read again
D. Read the story aloud to someone

Question 8, adjusted to align with expository text:

Before I begin reading, it's a good idea to:

A. Think of what I already know about the things I see in the illustrations and diagrams
B. See how many pages are in the article
C. Choose the best part of the article to read again
D. Read the article aloud to someone

The adaptations made to the MSI were sensitive to the purpose of this research. All questions were then designed to direct student thinking toward the strategies used when reading expository texts. Of the 25 questions, seven specifically mention diagrams, of those items, three possess answers that involve diagrams.

As the MSI was not used as a standardised measure, some wording was changed to make the measure more easily understandable to the cohort that was the focus of this study. For example:

Original instruction:

In each set of four, choose the one statement, which tells a good thing to do to help you understand a story better *before* you read it.

Updated instruction:

Decide whether A, B, C or D would help you the most ***before*** **you read** an article or non-fiction text.

The researcher administered the MSI, to students individually. The 25 items that compose the MSI were presented on individual cards. Before questioning began, the researcher explained to students that the 25 questions were presented on different colours; that the yellow cards would ask about what they did before reading, the green would ask what they did during reading and the blue cards would ask questions about what they did after reading. The colour coding was used to reinforce the phase of reading that the question related to. The repetitive nature of the lead question for each item was such that students may easily ignore the significance of the phase in question. It was intended that the colour coding would act as an additional trigger to emphasise before, during or after reading.

Cards were presented individually, with the researcher reading aloud the question and possible answers. The card was left on the table to allow the student to re-read before responding. The researcher noted the response on the MSI interview-tracking sheet (Appendix A) and then proceeded with the next card. Reading aloud by the researcher, controls for one confounding variable, differences in reading ability. The procedure of reading aloud and making the question card available for re-reading reduced the possible negative impact of reading ability and listening comprehension ability across the cohort.

In addition to the MSI, a further three interview questions (sourced from McTigue & Flowers, 2011) were employed (see Appendix B). These questions focussed directly on understanding students diagram knowledge. In contrast to the multiple-choice format of the MSI, these additional questions required students to form short answer responses.

It was recognised that multiple-choice questions may restrict thought and opportunities to demonstrate knowledge beyond the tight structure of the question format. These additional questions provided an opportunity for students to articulate their knowledge, and understanding of strategies related to text and diagram passages. They offered insight that was more individualised and provided for student voice.

The questions concerning diagram knowledge were asked directly following the MSI interview.

3.4 Materials

The study utilised 10 expository passages (Table 2), each with a corresponding diagram component. The passages contained between 117 and 174 words and were rated at a Flesch-Kincaid[2] Grade Level of between 4.2 and 6.9 (giving them a reading age of between 9 and 11 ½ years). The wide grade level range was a result of the content specific vocabulary typical of science texts. This technical language influences a higher score because of the lower frequency of some of the specialised terms. Each lesson had a vocabulary component built into it to address and minimise the impact of this technical language.

Passage topics were selected to be consistent with content demands of the *New Zealand Science Curriculum* (Ministry of Education, 2007) at Level 3. Passages were grouped according to their science content. This enabled students to build on their prior knowledge over a series of readings. All passages in the instructional lessons dealt with *The Living World* strand. Lessons 1-4 focussed on Reptiles with four readings sourced from Jackson, (2008). Whales was the focus of lessons 5-7 with three readings sourced from Morgan (2010). The final three lessons were about Insects, these readings were adapted from Else, (2003).

Students worked with a variety of diagram structures over the sequence of 10 lessons (Table 2). Each passage featured a main body of text and two or three

[2] The Flesch-Kincaid Grade Level Readability Test rates texts on a United States school grade level. It considers both sentence length and syllables per word.

supporting diagrams. Passages were sequenced to build upon student knowledge and familiarity with diagram forms. Initial passages featured realistic pictures, supported with single sentence labels and a single additional photo with supporting caption of one or two sentences. Successive lessons introduced students to enlargements, sequential diagrams, comparison diagrams, insert text boxes and cut-away diagrams.

Table 2

Expository Science Passages

Passage Title	**Grade Level**	**Corresponding Reading Age**	**Word Count**	**Diagram Type**
		Scientific Content: Reptiles		
Super Lizards	5.9	10 ½ years	164	Realistic picture with labels Inset photo with caption.
Deadly Hunters	6.2	11 years	117	Realistic picture with labels Inset photo with caption.
Perfect Poisoners	5.8	10 ½ years	162	Realistic picture with labels Inset photo with caption.
Scuttle and Scurry	4.2	9 years	136	Realistic picture with labels Inset photo with caption. Enlargement
		Scientific Content: Whales		
The Whale Family	5.5	10 ½ years	138	Realistic picture with labels and a caption Inset photo with caption. Inset text box
Senses	5.4	10 ½ years	149	Realistic picture with labels Enlargement Inset text box Sequential diagram
Watery World	5.8	10 ½ years	173	Realistic picture with labels and a caption Inset photo with caption Inset text box
		Scientific Content: Insects		
Insect Flight	5.0	10 years	174	Comparison series Sequential diagram Inset text box
Insect Senses	6.9	11 ½ years	162	Realistic picture with labels Enlargement 2x comparison series
A Complete Change	6.6	11 ½ years	162	Comparison series Sequential diagram

In summary, students encountered eight realistic pictures with labels, six insert photos with caption, three enlargements, four inserted text boxes, three sequential diagrams, and four comparison series. Each passage also featured a title and one or more subtitles. Table 3 details these text features and their purpose within the text.

Table 3

Text Features

Name of text feature	Purpose of text feature
Title	Briefly tells the reader what information they can expect to learn about
Headings and subtitles	Help the reader identify the main idea for that section of text
Pictures and captions	Illustrate an important object or idea from the text
Labelled pictures	Allow readers to see detailed depictions of an object from the text with labels that teach the important components
Inset photos	Support ideas presented in the text. Support the reader to visualise and interpret written information
Inset text box	Add additional information related to the text. Sometimes offer an illustration of an idea that has been presented or offer a related snapshot of information
Sequential diagram	Allow the reader to see how an event described occurs over time (this may be a short or long time frame). These diagrams break an event into stages, they must to interpreted in a defined order. Support the reader to visualise and interpret written information
Comparison series	Illustrate a comparison between objects from the text. These diagrams do not need to be read sequentially. Support the reader to visualise and interpret written information
Enlargement	Allows readers to see close-up detail of an object from the text

The range of text features students met was consistent with McTigue & Slough (2010) and Waldrip et al., (2006) who both endorse the need for students to develop an understanding of the different modes that are used to best deliver information for different purposes.

3.5 Subjects

A stratified sampling method was employed to ensure the experimental and control groups within the class population were each sampled purposefully and randomly. This approach ensured both groups were represented in the sample in the same proportions as they were in the class population. This approach also reduced sampling error. The class population was divided into layers based on sex and reading ability. A systematic sample drawn from each layer until two matched groups were formed comprising students who were working within six-months - above or below - of their chronological age for reading. Students with specific learning needs were excluded, as were exceptional readers.

3.6 The Intervention Programme

The study was conducted over the course of 8 weeks, with instruction taking place two times per week during the class's designated 50-minute reading block. Participants in the instructional group received 40-50 minutes instruction during weeks two through seven of the study. They read a new text and diagram passage during each instructional session and completed an assessment immediately following instruction. The control group received equivalent instructional time, reading passages and testing. The control group were not instructed in methods of integrating diagram and text for comprehension. Weeks 1 and 8 were reserved for pre and post testing of both the instructional and the control group. The researcher provided instruction to both the instructional (intervention) group and the control group.

Before the start of the study, 12 students were identified reading at their chronological age. These students were given a letter explaining the study and a parental consent form, which gave parents the option of not including their child in the study. All students agreed to participate in the study.

During the first week, all participating students completed initial assessments, which were administered by the researcher. Students were withdrawn individually from the classroom for assessment measures to be administered. Measures were administered in the same order across all participants. The sequence of measures was as follows:

Modified Metacomprehension Strategy Index

Measure of Students Diagram Knowledge

3.6.1 The role of the teacher.

Initially the teacher had a lead role in introducing students to text features, their purpose and how to navigate these more complex expository text structures. Initial lessons were utilised to develop these skills and text awareness. Texts were grouped in a manner that built on student knowledge by introducing new structures sequentially and repeating text features. This sequencing was designed to reinforce the purpose of each feature and develop automaticity in the recognition of text features and their purpose. Building knowledge of text features in this way gave students confidence as they recognised familiar text features over the course of successive lessons. As students developed their understanding of the passages it was predicted they would be able to evaluate structure, content and decide on navigation with developing independence. This release of responsibility is an essential part of developing student metacognition. As has been identified earlier, content-specific vocabulary is a feature of expository science texts. This aspect of the passages required ongoing teacher support and could not be scaffolded for in the same manner as text features were. However, it was predicted that as students gained confidence working with these texts they would be more relaxed about attempting to use strategies such as reading around the word to gain meaning for new vocabulary. Continual teacher support was maintained in this area, supplementing the high content-vocabulary.

Students were instructed in strategies to help them navigate the text and diagram passages. According to Anderson & Bower (1973); Fielding & Pearson (1994); and Pressley (2006), accessing prior knowledge is an important metacognitive strategy that enables students to make decisions about their reading behaviour and to process text beyond the word level. Students began each lesson by recording prior knowledge concerning the topic of the reading. Accessing prior knowledge was designed to assist in establishing a purpose for reading as students identified questions they had concerning the topic. Following accessing of prior knowledge, each lesson continued with a text feature walk. During this phase students were taught to scan the page and identify key text features. This aspect of instruction reflects the text feature walk strategy utilised by Kelley & Clausen Grace (2010). During the text feature walk students were encouraged to discuss features of the text and make predictions about their purpose. Students were asked to identify the sequence in which they would read the text features. Students were then encouraged to read the main text, followed by the diagrams. Scanning between text and diagram to confirm meaning was encouraged.

In this study, feedback to students before, during and after reading was used to assist students in learning to navigate, read and interpret expository science texts. Purposeful, instructional dialogue between teacher and student is a key feature of the Guided Reading approach. In large part, this dialogue focuses on extending learning through feedback (Ministry of Education, 2005). Feedback reflected the Hattie & Timperley (2007) model by addressing three key questions: 'Where am I going?', 'How am I going?' and 'Where to next?' These three key questions were articulated as follows:

- Learning intentions linked to the skills, strategies and knowledge required to navigate and comprehend expository science texts with diagrams were shared at the beginning of each lesson.
- During the lesson, feedback was linked to the learning intentions.
- Opportunities were given for dialogue surrounding students' actions during reading including tracking their successes and identify key areas for next learning steps.
- As new texts and diagrams were introduced with each lesson, students had the opportunity to plan their reading of the text and practice metacognitive strategies.
- Lessons were designed to develop a concepts, strategies and knowledge over a series of lessons. This enabled students to build on prior knowledge and to practice skills required of a reader of expository science text.
- As lessons progressed students applied their newly acquired reading strategies to a wider range of diagrams.

3.7 Data Analysis

3.7.1 Analysis of quantitative measures.

The Wilcoxon Signed Rank test was used to analyze scores from the same children on two different occasions. These were a pre-test and post-test of knowledge relevant to the texts used for each lesson and second, an analysis of pre-test and post-test of MSI sub-test results. This non-parametric alternative to the repeated t-test was used because the research methodology involved a matched subject design involving a random sample and because the test statistic does not make the normal assumption about the population from which the sample was drawn, that is, that the sample conformed to a normal population distribution. Although less 'fussy' than parametric statistics, the Wilcoxon Signed Rank test was regarded as a useful statistic. This was due to the very small sample and because the data set would not meet the stringent assumptions of parametric tests.

Additionally, the Mann-Whitney U test was used as an alternative to the t-test for independent samples. Again, parametric test assumptions were circumvented because scores from the two tests were converted to ranks, so the actual distribution of scores did not matter. It was used to test for differences between the Intervention group and the Control group.

3.7.2 Analysis of qualitative measures.

According to Parsons & Brown (2002), "Data analysis is the process of systematically organizing and presenting the findings in ways that facilitate the understanding of these data" (p. 55). To facilitate the readers' understanding of the data collected in this study, the data gained from the researcher's reflective journal, the participants' reflective journals and the interview were analysed qualitatively while the data gained from the survey, the pre-test and the post-test were analysed quantitatively. Mixed methods research was also adopted, the results of the qualitative and quantitative data being used to help each other explain, refine, clarify, or extend each other's results.

Thematic analysis, a widely used method in qualitative analysis, "…is a method for identifying, analysing and reporting patterns (themes) within data. It minimally organizes and describes your data set in (rich) detail" (Boyatzis, 1998, cited in Braun & Clark, 2006, p. 79). "It involves the searching across a data set—be that a number of interviews or focus groups, or a range of texts—to find repeated patterns of meaning" (Braun & Clark, 2006, p. 86). "A rigorous thematic approach can produce an insightful analysis that answers particular research questions" (Braun & Clark, 2006, p. 97). Thematic analysis was adopted in this research to analyse the data gained from the researcher's reflective journal, the participants' reflective journals and the interviews. According to Braun & Clark

(2006), there are six phases of thematic analysis: 1) familiarizing oneself with the data; 2) generating initial codes; 3) searching for themes; 4) reviewing themes; 5) defining and naming themes; 6) producing the report.

Accordingly, the analysis of the reflective journals and interviews in this research underwent these six phases. In the first phase, the interviews were transcribed, the reflective journals read and re-read, and initial ideas noted down. In the second phase, interesting features of the data were coded in a systematic fashion across the entire data set; the data relevant to each code were then collated. In the third phase, codes were collated into potential themes and all data relevant to each potential theme were gathered. In the fourth phase, it was checked whether the themes worked in relation to the coded extracts and the entire data set; then a thematic map of the analysis was generated. In the fifth phase, the specifics of each theme were refined and the clear definitions and names for each theme were generated. The sixth phase was the final opportunity for analysis and so efforts were made to select compelling extract examples, do the final analysis of selected extracts, relate the analysis to the research questions and literature, and produce a report of the analysis.

3.8 Outline of Chapter 4

Chapter 4 presents descriptive statistics that indicate differences between the intervention and control group, followed by comparative and inferential statistics to further describe those differences. This is followed by qualitative data obtained through observations and interviews. Finally links are made between the two data types to triangulate and provide an overarching view of the results.

Chapter Four

Results

This study sought to examine the separate and combined impact of teaching both diagram interpretation and graphic representation on the comprehension of Year 6 students reading of expository science texts. The study used a mixed methods approach to explore the following research question: What is the impact on the comprehension of expository science text when students are taught strategies to interpret text diagrams?

Strategies included; accessing prior knowledge, recognising a range of text features and their purpose, identifying a navigation pathway, scanning between text and diagram, and imaging.

The first section of this chapter reports results from a quantitative analysis, gathered through multiple-choice questions, written response to reading and the Metacognitive Strategy Index (MSI) (Schmitt, 1990). The second section of this chapter presents results from a qualitative analysis of data drawing on data gathered through observations, interviews and transcripts. Taken together, these results are explained in the final Discussion chapter.

4.1 Quantitative Data

Table 4

Wilcoxon Within Group Analysis of Intervention and Control Group Scores for Metacognitive Strategy Index Subtests

	Significance of difference between pre and post MSI scores		Difference between pre and post MSI mean scores	
MSI Subtest	Intervention Group	Control Group	Intervention Group	Control Group
1. Summarizing and fix-up	0.16	0.66	1.33	-0.17
2. Previewing	0.32	0.16	0.00	0.33
3. Background knowledge	0.04*	0.11	3.17	1.83
4. Self-questioning	0.07	0.79	2.00	-0.17
5. Purpose setting	0.01*	0.07	1.17	1.00
6. Predicting and verifying	0.05*	0.89	2.67	0.17

* .05 level of significance

The Wilcoxon test reported in Table 4 revealed that the Intervention group recorded three significant differences in their MSI subtest mean scores. The areas of significant difference were background knowledge, purpose setting, and predicting and verifying. In addition, near significance was reached by the Intervention Group (IG) in the subtest of self-questioning. In comparison, no significant differences were found between pre and post MSI mean scores in the Control Group (CG).

Table 5

Wilcoxon Within Group Analysis of Intervention and Control Group Scores for Text Knowledge

		Significance of difference between pre and post knowledge*		Difference between pre and post knowledge mean scores	
Lesson	Text	Intervention Group	Control Group	Intervention Group	Control Group
1	Super Lizards	0.66	0.17	0.83	-1.34
2	Deadly Hunters	0.08	0.68	2.50	0.50
3	Perfect Poisoners	0.02*	0.11	-1.67	-1.00
4	Scuttle and Scurry	0.22	0.25	-0.67	-1.84
5	The Whale Family	0.02*	0.34	8.17	3.40
6	Senses	0.01*	0.58	6.33	0.60
7	Watery World	0.01*	0.07	8.00	1.50
8	Insect Flight	0.01*	0.03*	8.34	4.50
9	Insect Senses	0.04*	0.30	8.60	1.67
10	A Complete Change	0.01*	0.03*	11.40	3.67

* .05 level of significance

The Wilcoxon test reported in Table 5 reveals that the IG recorded seven significant differences in their pre and post knowledge mean scores. The texts that produced significant differences in pre and post knowledge were *Perfect Poisoners*, The *Whale Family*, *Senses*, *Watery World*, *Insect Flight*, *Insect Senses*, and *A Complete Change*. Significant differences in pre and post knowledge are evident from lessons 3, 5, 6, 7, 8, 9, 10. In comparison, the CG only demonstrated significant difference in their pre and post knowledge scores for two texts; *Insect Flight* and *A Complete Change*. These texts were lessons eight and ten of the programme.

The IG showed little knowledge growth with the text *Scuttle and Scurry*. This text had the lowest readability count of all the texts used.

Table 6

Mann-Whitney U Test Between Group Analysis of Intervention and Control Group MSI Post-Test Scores

	Post Test Mean Scores			
MSI Subtest	Intervention Group	Control Group	Mann-Whitney U	Asymp. Sig.* Scores
Summarizing and fix-up	3.33	1.83	5.00	0.03*
Previewing	1.67	1.33	1.20	0.27
Background knowledge	4.83	3.67	11.0	0.24
Self-questioning	2.33	0.83	4.50	0.03*
Purpose setting	2.10	1.67	14.0	0.50
Predicting and verifying	4.83	2.30	3.50	0.02*

* Significant at .05 level

The Mann-Whitney U test reported in Table 6, revealed that between groups the IG MSI post test mean scores across all subtests were higher than those of the CG. The Mann-Whitney U test reports significant post test mean scores between IG and CG for the MSI subtests of summarizing and fix up, self questioning, and predicting and verifying.

Table 7

Mann-Whitney U Test Between Group Analysis of Intervention and Control Group Multiple Choice Test Scores

		Multiple Choice Mean Scores			
Lesson	Text	Intervention Group	Control Group	Mann-Whitney U	Asymp. Sig.* Scores
1	Super Lizards	7.58	5.42	1.09	0.31
2	Deadly Hunters	6.08	6.92	4.33	0.70
3	Perfect Poisoners	7.42	5.58	1.05	0.39
4	Scuttle and Scurry	8.08	4.92	1.73	0.08
5	The Whale Family	2.67	5.60	1.68	0.09
6	Senses	4.17	8.20	2.10	0.04*
7	Watery World	5.75	6.30	0.28	0.81
8	Insect Flight	6.50	4.50	1.50	0.13
9	Insect Senses	5.50	5.70	0.24	0.81
10	A Complete Change	5.60	5.40	0.12	0.91

* Significant at .05 level

The Mann-Whitney U test reported in Table 7 revealed that there were variable results between IG and CG multiple choice test scores. The IG scored a particularly low mean score for the text, *Senses*. This text scored a level of significance in favour of the CG. Students had access to the text as they answered the multiple-choice questions, so there was opportunity for them to revisit text and diagram to source answers. Only one significance difference was reported, this was at lesson 6.

Table 8

Mann-Whitney U Test Between Group Analysis of Intervention and Control Group 'Picture This' Test Scores

		'Picture this' Mean Scores			
Lesson	Text	Intervention Group	Control Group	Mann-Whitney U	Asymp. Sig.* Scores
1	Super Lizards	6.17	6.83	0.34	0.73
2	Deadly Hunters	5.25	7.75	1.30	0.20
3	Perfect Poisoners	7.42	5.58	0.92	0.36
4	Scuttle and Scurry	8.50	4.50	2.04	0.04*
5	The Whale Family	6.00	6.00	0.00	1.00
6	Senses	7.42	4.30	1.62	0.11
7	Watery World	6.58	5.30	0.65	0.52
8	Insect Flight	6.30	4.70	0.95	0.34
9	Insect Senses	7.42	4.30	1.62	0.07
10	A Complete Change	7.90	3.10	2.54	0.01*

* Significant at .05 level

The Mann-Whitney U test reported in Table 8 illustrates that the intervention group were able to produce a greater number of accurate responses in 7 out of 10 ‘Picture this’ responses. The CG scored higher in two texts (*Super Lizards* and *Deadly Hunters*), these were lessons 1 and 2 respectively, while both groups scored equivalently for *The Whale Family*. IG ‘Picture this’ mean scores reached levels of significance for two expository passages – *Scuttle and Scurry*, and *A Complete Change*.

4.2 Qualitative Thematic Analysis

What follows is a thematic analysis that draws on all data gathered using interview, observation, and survey procedures outlined in the previous chapter. The themes to emerge from an analysis of the data were; confidence and independence, connectedness, changes in the quality of learning dialogue, transfer and application, and imaging as support for comprehension.

4.2.1 Confidence and independence.

Data indicated that individual confidence in reading and comprehending expository science texts increased over the course of 10 lessons. Students in the intervention group demonstrated increased engagement in the instructional activities in line with this growth of confidence.

Initially, students reported feeling overwhelmed by the text and diagram passages, considering them too difficult for their perceived reading ability. Reflecting on their learning, students variously described feeling “freaked out” (Student G) by initial reading passages. “I was thinking this is older kids stuff” (Student H). “I was like, I’m not gonna do this” (Student E).

Over the course of the intervention, students became confident in identifying pathways for navigating these complex texts. Student H describes her actions in previewing text at completion of intervention programme: “I scan it every time, as soon as I get it I scan it, I start scanning.”

There was considerable group discussion prior to reading, concerning the order in which they would read the text and diagrams. This discussion was a valuable instructional component as students debated the reading pathway they deemed most effective. Indeed by the final few lessons when there was an expected release of responsibility to the students, they continued to seek an opportunity during the lesson to describe their reading pathway – “You haven’t asked us how we are going to read it" (Student A). Understanding the procedure built confidence among the group.

Students gained confidence from knowing what they can 'get' from diagrams. They had a heightened expectation that they could gain additional information, explanation and meaning from the diagrams. With this expectation came heightened engagement and a sense of wonder at what they had previously neglected. One sign of this confidence was that students in the IG were actively seeking out the next reading session. The researcher was frequently questioned as to when the next session would be. This student confidence, displayed through anticipation, was an indication that students were engaged in meaningful learning that targeted their needs.

By comparison, the CG of students did not demonstrate similar levels of confidence and independence. Regular exposure to this text type over the course of 10 lessons did build some skills. However, there was reduced group discussion and interaction during instructional lessons. Unlike the IG, who demonstrated high levels of motivation and engagement, lessons with the CG were sometimes met with groans.

4.2.2 Connectedness.

Students' improved their ability to make connections to prior knowledge (of both the content knowledge and their growing prior knowledge of diagram types) supported their comprehension of expository science texts.

IG students were prompted to make connections to their prior knowledge by generating ideas before and after reading. As with other aspects of the intervention programme, discussion was a key point at which students would reflect on these connections. Reflective statements from the students during the lesson such as "I never knew...", "Did you know...", "I always thought...", were prevalent during intervention group discussion. Not only were these students sharing these connections, they were eagerly showing one another which part of the text or diagram the information had been gleaned. This behaviour reinforced the content value of both text and diagram. These instances also gave rise to teaching opportunities that further explored 'making connections' as a metacognitive activity during reading. The instructional dialogue focused on making incorrect connections, making connections limited to the reader's experiences and changing understandings as new information is presented.

Students in the IG engaged in metacognitive thinking to identify connections between text and diagram features. They became confident in rereading text and/or diagram for clarification and they would look back at what they had read or scan ahead to a diagram, to clarify meaning in text. Students were now approaching these texts very differently to the linear narrative structure they had predominantly worked with. IG students had an expectation that they would gain meaning by using their comprehension to synthesise text and diagram content.

The sequentially structured lessons allowed students to build their knowledge and confidence across the range of diagram types. As the series of lessons progressed, students gained control from recognising diagrams and connecting them to those met in previous readings. Indeed, there was often a sense of excitement as students recognised diagram structures/formats they had met in previous lessons. This growing familiarity supported confidence and text comprehension. Data supports the conclusion that students in the IG understood the design, purpose and place of the diagram, making accessing and connecting information easier. These students had a greater expectation and awareness of what new meaning and/or clarification diagrams may bring to the text, as is illustrated in the following exchange:

A: "There's a picture, a big picture of one part of it."

Researcher: "So what did we call that big picture?"

A: "It's the zoom thing."

Researcher: " A, can you show them the picture you're talking about?"

A: "The big eyeball."

K: "Oh! Like...it... with that gecko thing..." *(referring to enlargement in previous reading "Scuttle & Scurry")*

A: "Zoom, zoom... An enlargement!"

While the CG followed the same programme structure of recording prior and post knowledge, qualitative data suggests they did not display the post knowledge gains evident across the IG. The CG were not prompted, as the IG were, to make connections with this knowledge as they read.

Importantly there was little evidence that this group were making connections across text and diagram features within a reading other than when a comprehension question required them to do so.

Student C provides an example of the inability of the CG to make connections between text and diagram as he reads *A Complete Change,* text 10 in the series of lessons. The key content of this text was insect metamorphosis.

C *(during reading)*: "Metamorphosis – that's cool! Mrs de Jonge, I found a cool word – metamorphosis" *(points to metamorphosis written as part of a caption).*

Researcher: "Is it only there?"

C: "Yeah" *(In fact, metamorphosis appears in both text and diagram and is explained in both visual and verbal forms as it is key content vocabulary).*

Researcher: "What does it mean?"

C: "I don't know" Laughs.

Goes to get dictionary. Looks up word in dictionary.

While looking up the word in the dictionary was one means of finding out the words meaning, it was also available to C through the text and illustrated in the various diagrams presented on the page. At no point did C connect that he could gain meaning from the text and diagrams. Interestingly, C shared the word with others in the group who had also read the text, none of them indicated they had come across the word and they too asked, what it meant. While the CG were able to access information specifically targeted in multi choice questions, there was little indication that they were making these connections through the text and diagrams as they read. This group did not make connections within or between readings, rather readings stood in isolation.

4.2.3 Changes in quality of learning dialogue.

Learning dialogue, as evidenced through group discussion, became more specific to the instructional content of the intervention. Application of content specific vocabulary demonstrated students' heightened knowledge of the intricacies and peculiarities of the expository science text and diagrams.

Over the course of the intervention programme students acquired vocabulary specific to the diagrams they engaged with. IG students used this vocabulary frequently during lessons as part of related discussions. As such, it became a part of their vernacular.

There was prolific peer interaction and support between students in the IG. As the intervention progressed, they began to comment on one another's strategy application or discussion input. The tone of this discussion was encouraging and complimentary. There was a high level of support shown between students in the IG.

No such use of diagram-specific vocabulary was evident amongst the CG. Not only had they not had the opportunity to acquire this vocabulary in an instructional environment (as the IG received), they appeared to have no prior knowledge of such vocabulary, as no application was evident.

4.2.4 Transfer and application.

IG students were introduced to a range of learning strategies including accessing prior knowledge, recognising a range of text features and their purpose, identifying a navigation pathway, scanning between text and diagram, and imaging. Students in the IG reported that their learning experiences within the instructional setting were beneficial to their wider reading practices. They felt that they now had a greater awareness of how texts work and that they were no longer intimidated by the layout and design of text.

Students reported that they now chose more challenging recreational texts. G (at post intervention interview): "I've started to read other books with more pages." J: "Yeah I read everything now, I used to just read the main text."
H: "My mum buys magazines, now I read all the little bits, they're amazing what you can read – I used to not like reading, I just looked at the pictures."

There were no reports or evidence that this transfer of strategies was also occurring within the CG.

4.2.5 Imaging as support for comprehension.

Reading is not exclusively verbal, readers also image. The positive effect of imagery instruction on the IG was evident in student motivation, understanding of (and between) text and diagram, and recall of information (instant and delayed recall).

IG students reported that imaging was motivational. J: "They help me um... go through the book, 'cause usually if I just like read the words then like if I'm just reading words usually I'll probably forget and I'm like... oh yeah I'm bored ... but then picturing I'm like I wanna learn more, I wanna learn more... so I keep on reading."

As this example illustrates, imaging brought the information to life, helping the information become more than words on the page. Imaging as they read, assisted students in making meaning. Having made this connection between image and meaning students were motivated to read more.

Imaging supported students to make meaning from the text and diagrams. Students E describe the benefits of imaging upon their understanding of text: E: "It's like... ummm... trying to clarify what it looks like."

Imaging as they read enabled these students to clarify their understanding of the text, an important aspect of comprehension. Some of the more abstract concepts were able to be understood as students used the diagrams and illustrations to support them to create accurate images. Content specific vocabulary was more readily understood with a pictorial reference that prompted the student to create an accurate mental image. Students in the intervention group described this as becoming an important function during their reading.

Furthermore, IG students reported referencing between text and diagram to create accurate mental images. Student J described finding connections between text and diagram as "adding on" to an image to create meaning.

Student H reported a similar action:

H: "I would picture it and the whole way through it... I've got the full picture and I've added more stuff in my head"

This 'adding on' clearly involved students actively making connections between a range of text features in order to 'add on' to their image to create meaning. In doing so, intervention group students were creating a personalised sequence of information through cumulative imaging, to bring clarity to their comprehension.

Intervention group students indicated that imaging was a useful tool for recall. While discussing a sequential diagram in the text *A Complete Change* the researcher prompted students to recall a previous text that had also featured a sequential diagram.

Researcher: "Can you think of another page we had that had a sequential diagram?"

J: "Whale Senses. It told you umm at first the ...umm whale makes a clicking noise that shoots through the air, bounces back off something and it's continuous the clicking and it comes back to the whale."

Researcher: "When you were recalling that sequence of what happens did you have the diagram in your mind?"

J: nods.

There was evidence that IG students developed in their ability to create and apply imaging as a comprehension skill over the course of the lessons. The following three snapshots from student G illustrate this development.

Lesson 1

Researcher: "Do you have a picture in your head?"

G: "No...I don't think so."

Lesson 3

G: "I hate this part" *(indicates the 'Picture this' question)*

Researcher: "Why?"

G: "I have to think"

Post intervention interview:

G: "When I make a picture in my head I analyse it, then I do a lot of thinking and then I get it. I also see if I had this picture before."

This development was further evidenced through the IG growing ability to respond to the *'Picture this'* questions. These questions were designed to allow the question to summarise the key theme of the passage, while at the same time prompting students to visualise the given scenario. This use of visualisation process allowed students the opportunity to integrate prior knowledge with text and diagram content. The question then required them to either describe or explain a given scenario, event or feature related to the passage. As the lessons progressed IG students were able to respond to these questions with growing depth and detail. The CG did not demonstrate similar levels of depth and detail in their responses to *'Picture this'* questions.

4.2.6 Summary of qualitative findings.

IG students demonstrated development across a range of identified themes; confidence and engagement, connectedness, quality of learning dialogue, transfer and application, and imaging as support for comprehension. The combined effect of these areas of development, was the emergence of an efficacious system. Growing levels of self-efficacy were evident across the IG. Students demonstrated a self-belief that they could read these texts and they carried an expectation that meaning would be gained.

Student H illustrates her self-belief: "I knew I would be able to figure it out... I'm picturing it totally in my head like every book I read I picture."

Teacher: "Did you use to do that?"

H: " Umm... not...I did, but not in every book, now I do it in every single book."

Considered together these results suggest improved levels of self-efficacy among the IG.

4.3 Post script.

Once the study was complete, and consistent with the terms of ethical committee recommendations, the balance of the Year 6 class received instruction in line with the IG programme. To ensure the CG were not marginalised in any way, lessons were taught that revisited the text and diagram passages and attended to building text feature knowledge that had been omitted from earlier lessons.

4.4 Outline of Chapter 5

Chapter 5 presents a discussion of the results presented here. Qualitative results will be used to help interpret quantitative findings. This form of triangulation will assist in confirming or reconsidering the data. The results will be further considered by reference to the literature review. Alignments and variations to existing research will be noted.

The focus of the discussion will also be on the extent to which the results answer the research question: What is the impact on comprehension of expository science text when students are taught strategies to interpret text and diagrams? The chapter concludes by considering the limitations of the study and further research suggestions.

Chapter Five

Discussion

In this study, explicit instruction in strategies designed to assist students read expository text and diagrams was combined with instruction to develop metacognitive awareness. The study adopted a mixed methods approach. Quantitative data provided measures of specific aspects of metacognition and, pre and post knowledge, while qualitative measures provided valuable insight into student actions and attitudes toward these text types.

This study expands our local and international understanding of the comprehension of expository science texts and diagrams. A strength of the study was its New Zealand context, participants were Year 6 students at an urban New Zealand primary school. A further strength of this study was that it entailed a series of instructional lessons that provided scaffolding for the reader. This enables reinforcement, practice and independence to develop. Other studies reviewed had involved read and respond lessons (e.g., Schlag & Ploetzner, 2011), interviews and or observations (McTigue & Flowers, 2010). Another strength of this study was its ecological validity. The lessons were taught within the structure of a normal school day in the classroom environment with all the usual interruptions that entails. The programme was part of the usual classroom programme of work as such; it was in keeping with the demands of the wider curriculum.

With respect to the demands of the *New Zealand Curriculum*, (Ministry of Education, 2007) these results are interesting. They provide support for a model of instruction that can be accommodated within the programme demands of the New Zealand educational setting, meeting the demands of the *New Zealand Curriculum* (Ministry of Education, 2007) and *National Standards* (Ministry of Education, 2009). Thus any New Zealand teacher can incorporate this type of instruction within their instructional programme.

Gains in metacognitive strategy were evident across the Intervention Group (IG). These metacognitive gains were likely due to the programme of instruction which included metacognitive instruction. As with successful teaching programmes described by Pressley & Gaskin (2006), students in the IG benefitted from the regular opportunity to practice and strengthen these metacognitive skills. While not receiving explicit metacognitive instruction, the Control Group (CG) were directed to record their prior knowledge before reading as the IG did. This repeated exposure and instructional value transferred by teacher expectation may have been a contributing factor in the CG's strongest measure of significant difference between pre and post Metacognitive Strategy Index (MSI) scores, purpose setting.

It is interesting to note that IG students demonstrated significant gained between pre and post knowledge in the metacognition subtests of background knowledge, purpose setting and predicting and verifying. Further, the Mann-Whitney U test between group analysis of IG and CG MSI posttest scores, recorded differences in the sub tests of summarising and fix up strategies, self questioning and predicting and verifying. Across these two measures, the IG significantly outperformed the CG in five of the six metacognition subtests.

It is assumed this metacognitive awareness was influential to IG levels of self-efficacy. Intervention group student behaviours were consistent with the findings of Bandura (1994) who describes self-efficacy as "peoples beliefs about their capabilities to produce levels of performance" (p. 71). Beliefs about capabilities are built on metacognitive behaviours of an individual such as self-awareness of their cognitive abilities, limitations and processes. The findings of this study suggest that the development of efficacious behaviour observed among the IG over the course of lessons was founded in the development of metacognitive awareness, illustrated in IG gains in MSI testing.

While the IG scored zero difference between pre and post MSI mean scores for the subtest of previewing, this is a result of a high baseline in the pre test. The MSI pre test indicated students came to the test with a high level of metacognitive strategy understanding in the area of previewing text. Previewing is a cornerstone of the Guided Reading programmes students have participated in throughout their primary school years. It is reasonable to expect this area of metacognition would have been well established by these earlier reading experiences. While the MSI measures six subtests of metacognitive strategy, the number of questions for each subtest varies. The previewing subtest presents only two questions (the smallest measure of the six subtests). This small sample of questions may also have contributed to the zero difference between pre and post test MSI scores of the IG.

IG students were introduced to a range of learning strategies including accessing prior knowledge, recognising a range of text features and their purpose, identifying a navigation pathway, scanning between text and diagram, and imaging. This study found that explicit teaching of strategies to support comprehension of expository science text and diagrams, had benefits across the wider context of reading.

Qualitative data indicated that students in the IG felt their experiences within the instructional setting were beneficial to their wider reading practices. They reported that they now had a greater awareness of how texts work and that they were no longer intimidated by the layout and design of text. This is likely due to the metacognitive emphasis of the instructional programme. Students were taught to apply strategies across a range of text and diagram models. Adding to recommendations of Waldrip et al., (2006) and McTigue & Slough (2010), the findings of this study further illustrate that students need not be limited in the range of diagram formats they are exposed to. Providing a programme that develops student understanding of diagrams within text, and metacognitive strategies to utilise when reading these passages, enables students to apply these strategies over wider text and diagrams contexts. Consistent with the findings of Schraw (1998) students demonstrated an ability to utilise metacognitive strategies across learning areas.

A key feature of this study was the progression of lessons. These lessons were designed to scaffold student learning, to reinforce diagram features and develop automaticity in the recognition of diagram features and their purpose. Data demonstrates that the IG benefitted from this scaffolded programme. There was an indication that strategies developed cumulatively over the duration of the lessons. By lesson three the IG demonstrated significant differences in pre and post knowledge, they followed this with significant differences in lessons 5 through 10. Even as texts became more difficult and the range of diagrams expanded, the IG continued to demonstrate significant differences between pre and post knowledge. These results were reflected in the increasing confidence and enthusiasm the IG brought to their instructional lessons.

All students demonstrated ability to search back through the reading passages to source answers for the multiple choice questions. As students had access to the text during this time they were able to skim and scan the text in order to respond with accuracy. For this reason there was little margin between IG and CG multiple choice scores. By comparison, the *'Picture this'* responses of the IG strengthened over the duration of the instructional programme. *'Picture this'* questions were designed to evoke imagery. IG students demonstrated increased ability to synthesise information across multiple sources with prior knowledge and to utilise imaging to construct meaning. Not only were IG students utilising imaging within a single text, they also reported making connections between texts. The findings of this study suggest the IG became more adept at utilising visual processing in cohesion with verbal. IG group responses to *'Picture this'* tasks were strengthened by their ability to access both visual and verbal codes. These findings support the explanation provided by Dual Coding Theory (Paivio, 1986) that the ability to access both verbal and nonverbal codes strengthens cognitive processes.

Taken together, multiple choice and *'Picture this'* data present information about student depth of understanding. The multiple choice demonstrates that students who are not hindered by reading difficulties can access and isolate information from expository science text and diagrams when directly instructed to do so. However, this does not translate into synthesis, deep understanding and imagery that supports recall and application of learning. In the classroom context teachers should not relate accuracy in sourcing information to deep understanding that enables students to utilise and apply the new knowledge.

A key component of this instructional programme was the previewing of text and identifying a navigational pathway for reading. Many researchers (Holsanova et al., 2008; McTigue & Slough, 2010) have suggested that for skilled adult readers and children alike, text layout influences comprehension. The findings of this study endorse the importance of developing strategic awareness of text layout before reading. It was evident that identifying and planning a navigational pathway at the before reading phase contributed to student success and self-efficacy. Strategies such as the text feature walk (Kelly & Clausen-Grace, 2010) are easily integrated into guided reading lessons and are influential over student success.

5.1 Limitations

Although the results of this study provide evidence that an instructional programme targeting expository science texts may benefit student comprehension of these texts, the results need to be considered alongside potential limitations of the study. The first consideration is the small sample size. The IG and CG were comprised of just six students each. While this group size is consistent with group sizes expected within the guided reading context, any exceptional data within this small sample size quickly influences the analysis of quantitative data. The study groups' participants were all identified as reading at their chronological age, these students brought with them reading capital. As the CG demonstrated, repeated exposure was influential to gains to some degree.

A more robust selection process may have better aligned the two groups. During the teaching weeks standardised tests administered at the school, identified two students in the CG functioning well above their age in measures of reading comprehension and vocabulary knowledge. A more robust selection process across a larger sample may have excluded these students from the study.

A further area providing potential limitations was that of the grading of pre and post knowledge assessments. This aspect proved problematic. Students were awarded one point for each accurate statement connected to the text topic. However, no distinction was made between the depths of knowledge demonstrated. Therefore, one point could be scored for a simple statement such as "Whales live in the sea" while a more sophisticated statement such as "Whales use echolocation to track prey" would earn an equivalent one point. With this in mind, a more detailed grading of pre and post knowledge measures may have provided results that more accurately describe student knowledge.

5.2 Recommendations for future research

There is currently a lack of research information concerning instructional strategies for teaching expository text and diagram interpretation to primary students. It is recognised that these skills are important for future learning in content areas however, expository text continues to be marginalised in the primary school setting. Further research that seeks to define best practice in instruction in expository text and diagram would have benefits for students and teachers alike.

Research is necessary to determine which strategies lead to the greatest learning outcomes for the majority of students. Hannas & Hyona (1999) documented that low-ability students were not advantaged by diagrams in the same way that high ability students were. Perhaps low ability students require a more scaffolded approach to develop the strategies to read and comprehend these complex texts. Further research that utilises a scaffolded programme of instruction (such as this current study) to teach low ability students may challenge the findings of Hannas & Hyona (1999).

The variety of diagram design and purpose in expository science text is very broad. This study found success in introducing students to a wide range of diagrams on the premise that students would utilise their metacognitive skills to support comprehension of these varying modes, a view supported by McTigue & Slough (2010) and Waldrip et al., (2006). No previous research was located that identified an optimum progression for introducing diagrams to students. Further research that considered the complexity of different diagram types would be of interest. Research findings concerning optimum progression may assist teachers select texts and diagrams appropriate to their students. This would also assist in refining the scaffolding of this knowledge.

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Appendices

Appendix A. Metacomprehension Strategy Index

META COMPREHENSION STRATEGY INDEX

Adapted from Schmitt, M.C. (1990). For use with an article or non-fiction text.

Directions (To be read aloud): Think about what kinds of things you can do to better understand an article or non-fiction text before you read it, while you are reading it and after you have read it.

As I read each statement, decide whether A, B, C or D would help you the most. You may reread the questions as you decide on your answer. There are no right answers. It is just what you think would help the most. Circle the letter of the statement you choose.

I. Decide whether A, B, C or D would help you the most ***before*** **you read** an article or non-fiction text.

1. Before I begin reading, it's a good idea to:
    - A. See how many pages are in the article
    - B. Look up all of the big words in the dictionary
    - C. Make some guesses about what I think I will learn from the article
    - D. Think about what I have learned so far in the article

2. Before I begin reading, it's a good idea to:
    - A. Look at the illustrations and diagrams to see what the article is about
    - B. Decide how long it will take me to read the article
    - C. Sound out the words I don't know
    - D. Check to see if the article is making sense

3. Before I begin reading, it's a good idea to:
    - A. Ask someone to read the article to me
    - B. Read the title to see what the article is about
    - C. Check to see if most of the words have long or short vowels in them
    - D. Check to see if the illustrations and diagrams are in order and make sense

4. Before I begin reading, it's a good idea to:
    - A. Check to see that no pages are missing
    - B. Make a list of words I'm not sure about
    - C. Use the title, illustrations and diagrams to help me make guesses about what this article is about
    - D. Read the last sentence so I will know how the article ends

5. Before I begin reading, it's a good idea to:
    A. Decide on why I am going to read the article
    B. Use the difficult words to help me make guesses about what that article will be about
    C. Reread some parts to see if I can figure out what is being said if things aren't making sense
    D. Ask for help with the difficult words

6. Before I begin reading, it's a good idea to:
    A. Retell all of the main points that have happened so far
    B. Ask myself questions that I would like to have answered in the article
    C. Think about the meanings of the words that have more than one meaning
    D. Look through the article to find all of the words with three or more syllables

7. Before I begin reading, it's a good idea to:
    A. Check to see if I have read this article before
    B. Use my questions and guesses as a reason for reading the article
    C. Make sure I can pronounce all of the words before I start
    D. Think of a better title for the article

8. Before I begin reading, it's a good idea to:
    A. Think of what I already know about the things I see in the illustrations and diagrams
    B. See how many pages are in the article
    C. Choose the best part of the article to read again
    D. Read the article aloud to someone

9. Before I begin reading, it's a good idea to:
    A. Practice reading the article aloud
    B. Retell all the main points to make sure I can remember the article
    C. Think of people like those in that article and what their lives might be like
    D. Decide if I have enough time to read the article

10. Before I begin reading, it's a good idea to:
    A. Check to see if I am understanding the article so far
    B. Check to see if the words have more than one meaning
    C. Think about what I already know about the topic
    D. List all of the important details

II. Decide whether A, B, C or D would help you the most ***while* you are reading** an article or non-fiction text.

11. While reading, it's a good idea to:
    - A. Read the article slowly so that I will not miss any important parts
    - B. Read the title to see what the article is about
    - C. Check to see if the illustrations and diagrams have anything missing
    - D. Check to see if the article is making sense by seeing if I can tell what I've understood so far

12. While reading, it's a good idea to:
    - A. Stop to retell the main points to see if I am understanding what has happened so far
    - B. Read the article quickly so that I can find out what it is about
    - C. Read only the beginning and the end of the article to find out what it is about
    - D. Skip the parts that are too difficult for me

13. While reading, it's a good idea to:
    - A. Look up all of the big words in the dictionary
    - B. Put the book away and find another one if things aren't making sense
    - C. Keep thinking about the title and the illustrations and diagrams to help me decide what is being explained
    - D. Keep track of how many pages I have left to read

14. While reading, it's a good idea to:
    - A. Keep track of how long it is taking me to read the article
    - B. Check to see if I can answer any of the questions I asked before I started reading
    - C. Read the title to see what the article is going to be about
    - D. Add the missing details to the illustrations and diagrams

15. While I am reading, it's a good idea to:
    - A. Have someone read the article aloud to me
    - B. Keep track of how many pages I have read
    - C. List the articles main points
    - D. Check to see if my guesses are right or wrong

16. While I am reading, it's a good idea to:
    - A. Check to see that the information is true
    - B. Make a lot of guesses about what information might be coming next
    - C. Not look at the illustrations and diagrams because they might confuse me
    - D. Read the article aloud to someone

17. While I am reading, it's a good idea to:
    - A. Try to answer the questions I asked myself
    - B. Try not to confuse what I already know with what I'm reading about
    - C. Read the article silently
    - D. Check to see if I am saying the new vocabulary words correctly

18. While I am reading, it's a good idea to:
    A. Try to see if my guesses are going to be right or wrong
    B. Reread to be sure I haven't missed any of the words
    C. Decide on why I am reading the article
    D. List what happened first, second, third and so on

19. While I am reading, it's a good idea to:
    A. See it I can recognise the new vocabulary words
    B. Be careful not to skip any parts of the article
    C. Check to see how many of the words I already know
    D. Keep thinking of what I already know about the things and ideas in the article to help me understand

20. Read the title to see what the article is going to be about:
    A. Reread some parts, read ahead or check between text and diagram to see if I can figure out what is being explained if things aren't making sense
    B. Take my time reading so that I can be sure I understand what is happening
    C. Change the diagram so that it makes sense
    D. Check to see if there are enough illustrations and diagrams to help make the article ideas clear

III. Decide whether A, B, C or D would help you the most ***after*** **you have read** an article or non-fiction text.

21. After reading, it's a good idea to:
    A. Count how many pages I read with no mistakes
    B. Check to see if there were enough illustrations and diagrams to go with the article to make it interesting
    C. Check to see if I met my purpose for reading the article
    D. Underline the causes and effects

22. After reading, it's a good idea to:
    A. Underline the main idea
    B. Retell the main points of the article so that I can check to see if I understood it
    C. Read the article again to be sure I said all of the words right
    D. Practice reading the article aloud

23. After reading, it's a good idea to:
    A. Read the title and look over the article to see what it is about
    B. Check to see if I skipped any of the vocabulary words
    C. Think about what made me make good or bad predictions
    D. Make a guess about what information will come next in the article

24. After reading, it's a good idea to:
   A. Look up all of the big words in the dictionary
   B. Read the best parts aloud
   C. Have someone read the article aloud to me
   D. Think about how the article was like things I already knew before I started reading

25. After reading, it's a good idea to:
   A. Think of how my life would be different if I were like the people in the article
   B. Practice reading the story silently for practice of good reading
   C. Look over the story title and pictures to see what will happen
   D. Make a list of the things I understood the most

Appendix B. Student Diagram Knowledge – Interview

STUDENT DIAGRAM KNOWLEDGE

Adapted from McTigue & Flowers, 2011

Purpose			
How is a science diagram different from other types of pictures and illustrations?			
Why do you think science books have diagrams? Why are they used?			
How often do you look carefully at the diagram when you are reading?			
All of the time	Some of the time	Once in a while	Not much

Appendix C. Lesson example

Before Reading: Accessing prior knowledge

Teacher: "Today's reading is about ___________ *(insert relevant topic here).* Using what we already know is really important to help us make connections while we read. I would like you to spend the next 3 minutes writing down everything you know about volcanoes. This is not a spelling or handwriting sample, I just want to know what you already know. This will be useful to you as you read because you will be able to make connections to what you already know. Later, when we have read the passage and discussed it I am going to ask you to add what you have learned to this list – would you expect to learn something new from a reading? *(Yes)* "

3 minutes – blank sheet of paper, pens/pencils. Teacher to respond to any queries students may have concerning this task. Students independently write all they know.

Teacher collects prior knowledge sheets.

Before reading – previewing the text, text feature walk & vocabulary building

Teacher: "This is a science text, it is set out a little differently to a story. Vocabulary is sometimes a little tricky with science texts – why is this?" *(Expect children to recognise that we have content words that are not part of their regular vocabulary.)* "As we walk through the passage if you spot a word that you might find challenging, (or one you know and can help others with), we will record them on this vocabulary list – we can check in with this as we read." *(Have sheet of paper or modelling book to build vocabulary list.)*

Strategy setting phase

Hand out readings (one A3 laminated copy per student).

Teacher: "Before we begin reading we are going to look over the passage, this is called a text walk. What do you notice about the reading*?" Expect students to identify that there is a diagram, if not:* "Put your hand over the main text. What is the rest of the page filled with?

How often do you look carefully at the diagram when you are reading?" Allow students time to verbally respond and discuss.

"Earlier I said that this reading was about _____________ *(text topic).* That's true, but the lesson is also about something else. I want you to learn how text features like diagrams and the written text go together."

Walk through text features, encourage students to contribute to construct a list of text features *(text, diagram, labels, photographs, etc.).* Allow students the opportunity to provide a possible name, for example one group of students suggested: An inside diagram, a side diagram, an x-ray diagram. The act of attributing a name encourages students to think more deeply about the feature and its purpose. This may be recorded in a modelling book as shown here:

Text Feature	**Function**	**Related to passage**	**Related to diagram**
Main text	Gives information about the topic	✓	
Sub headings	Organising information. Introducing diagram content/focus	✓	✓
Labels	Names specific parts		✓
Captions	Gives further detail, facts, description, information		✓
Insert – text & photograph	Adds a human connection aside from the science		
Sequence of comparison diagrams	To show different ways a insects use their antennae		

If students miss any of the features out, teacher to initiate adding it the list: "Another feature I've notice is.../Did you notice...? /Do you think we should include...?"

Teacher: "Which feature(s) are the most important? Why?"
"Have you already gained some knowledge from this scan/text walk?" *(Expect "yes")*
"So you would agree this is a useful strategy to begin with when faced with a text like this one?"
"Can we add any further vocabulary to our chart that you noticed during the text walk?" Record, allow for group discussion to resolve vocabulary issues.
Teacher: "How do we read a passage like this? Where do we begin?
Would you read the words first, illustrations first, or switch back and forth?
Where would you start reading this page? Where would you go next?"
Allow discussion and negotiation to take place.
Teacher: "We have agreed it was useful to scan the whole page and recognise that there are different text features. Now we are going to read the text, followed by the diagram and then we are going to scan between text and diagram to make connections. Does that mean you can't scan between at any other time*? (Of course you can, but we are also going to give each equal attention).* What do we expect to learn from the text? What do we expect to learn from the diagram? Will one be more informative than the other? Which do you think is the most important? Why?"

During reading

Reading text

Teacher: "I want you to read the text quietly to yourself. When you have finished can you talk to the person next to you about what the text tells you."
Allow time for this to happen, ask groups to share their understanding/key ideas/concepts – teacher records. Use this time to reinforce and use vocabulary identified earlier in the lesson (during text walk). This provides an opportunity for children to hear the vocabulary words spoken and to use them correctly. Reinforce correct usage, prompt for usage.

Reading diagram

Teacher: "Do you expect the diagram to have any new information?
How are we going to read the diagram?"
Where would you start reading this page? Where would you go next?

What do you do if a diagram doesn't make sense to you?

These questions enable teachers to guide a think aloud process to interpret diagram

Discuss strategies here, reflect back to text feature table constructed during pre-reading. Teacher supports and guides discussion, then summarises strategy as follows..."The diagrams have sub headings, they give you a lead in to where to begin reading the diagram. Notice that the sub-heading for the main cut-away diagram is directly under the text, this seems to be leading us into the diagram. We will read the labels and captions of the cut-away diagram – we might need to scan back to the text to make connections. Then we will read the sequence of compare/contrast diagrams at the side. Do you notice that the box in the top right corner seems to stand on its own – we'll read that last. Do you all agree?"

Teacher: "I want you to read the diagram quietly to yourself. When you have finished can you talk to the person next to you about what the diagram tells you and how you read it"

Allow time for this to happen, ask groups to share their understanding – teacher records

After reading

Teacher: "Did the diagram have the same information as the text? Was it different? In what way? If we removed either the text or the diagram would it affect your learning from this reading?" *(Yes – have children elaborate)*. "In what ways did the text and diagram complement one another? Find a part in the diagram that elaborates on something mentioned in the text. Put your finger under reference in the text, put another finger under the diagram link. Share - "in what way did the two pieces of information work together?"

Have students share, compare and discuss findings. Reflecting back to discussion at beginning of lesson (strategy setting phase): "Is it useful to your learning to spend time interpreting diagrams? Why?"

Topic knowledge – repeat 3 minute prior knowledge sample

Formative feedback – allow students the opportunity to compare pre & post knowledge – "What else do you now know? How did you learn it? How much of

this do you think you will remember? Is some of the information easier to remember than other?
Ask two or three follow up questions to the group to determine the student's accuracy of interpretation – or have students make up questions to ask one another in pairs. Discuss how they used the diagram/text to answer the questions.

Comprehension response

1. Multiple choice questions, with access to text
2. 'Picture this' without text access.

Lesson conclusion

A brief discussion based conclusion that draws students back to the focus of interpreting text and diagram passages.
Teacher: "We all agree that the diagram as important as the text. We need to allow ourselves a little time before reading to scan the page and organise our reading attack. Did you find a text walk was useful for this?" *(Yes).* "If I were to give you a similar passage next time we read, how would you go about reading it?"
Expect students to review strategies used – text walk, vocabulary clarification, read text, read diagram(s), scan between for clarification.

Appendix D. Lesson 1: *Super Lizards*

Multiple Choice and *'Picture this'* questions

1. The flying lizard uses its wings to

A fly long distances in search of food

B flap at its enemies to scare them away

C leap between trees

D fly over water as it cannot swim

2. The flying lizards wings are

A feathered like a bird

B flaps of skin

C strengthened by bones

D weak meaning it cannot fly far

3. The basilisk's feet help it to walk on water because

A they are webbed like a duck

B they have sticky pads on them

C they have small air pockets under the toes that help it float

D they have long toes that spread the weight evenly over the water

4. *Distribute* means

A to share out

B to stick to something

C to dislike something

D to balance

5. If frightened basilisks run to the safety of a pond or stream because

A it feels safest in the water

B it feels safest on the water

C the water will wash away its scent and make it hard to track

D it is unlikely its attacker can cross the water

6. Before gliding to a new tree the flying lizard

A will fly to the top of the tree

B will crawl to the top of the tree

C will flap its wings several times to prepare itself

D open and close its wings to impress females

7. Picture a basilisk walking on water.

Describe the features of the basilisk that make it possible for this lizard to walk on water.