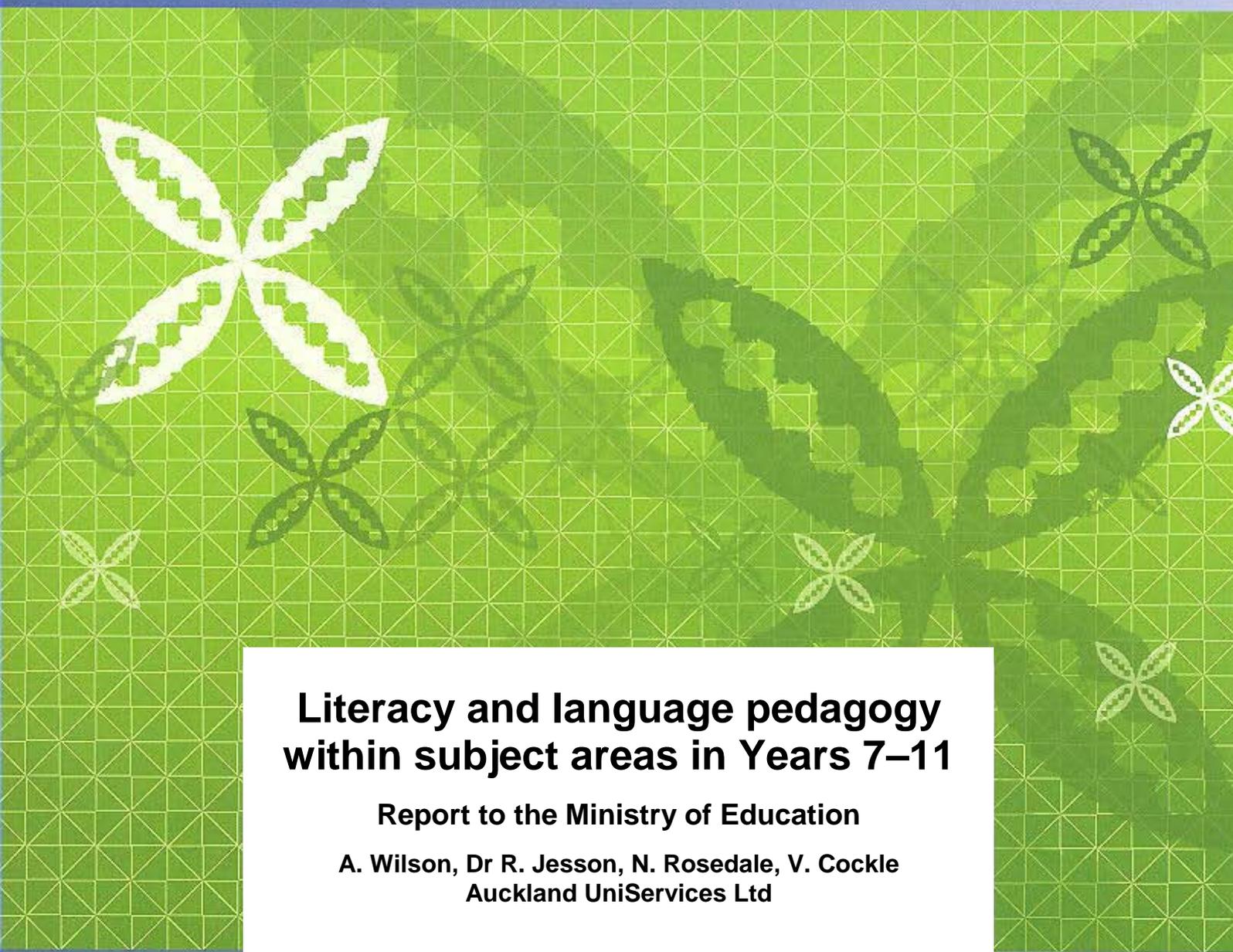




MINISTRY OF EDUCATION NEW ZEALAND

Te Tāhuhu o te Mātauranga Aotearoa



Literacy and language pedagogy within subject areas in Years 7–11

Report to the Ministry of Education

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Auckland UniServices Ltd**

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Literacy and Language Pedagogy within Subject Areas in Years 7–11

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Ministry of Education
Wellington

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November 2012



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Executive summary

This study was commissioned by the New Zealand Ministry of Education (MoE) to investigate the literacy and language knowledge and teaching practices of mathematics and science teachers in Year 7, 9 and 11 classrooms. One reason such a study is important is because there is an apparent mismatch between theory and policy that emphasises the importance of subject-literacy instruction, and actual classroom practice. This mismatch is evident in New Zealand, for example, in a recent Education Review Office Report which describes literacy instruction in Years 9 and 10 as “somewhat bleak” (Education Review Office, 2012), as well as overseas, for example, in the seminal article “Why content literacy is difficult to infuse into the secondary school: complexities of curriculum, pedagogy, and school culture” (O’Brien, Stewart, & Moje, 1995). Despite these reports, there appears to have been little systematic collection and analysis of evidence of classroom-based literacy practices in the upper primary and secondary levels in New Zealand.

Four key research questions therefore guided the study:

1. What knowledge, beliefs and understandings do teachers have about the literacy and language of science and mathematics?
2. In light of their knowledge, beliefs, and understandings about the literacy and language required, what practices do teachers use in the teaching of science and mathematics to support students’ learning and achievement?
3. What are the areas of strengths and weaknesses in literacy and language pedagogy within science and mathematics?
4. What understandings do students have of the literacy and language of science and mathematics?

To answer these questions, we employed a mixed-methods approach to investigate the literacy knowledge and teaching practices of 12 teachers through classroom observations, interviews with teachers and students, and a measure of Subject Literacy Pedagogical Content Knowledge (SLPCK).

The following sections summarise: Previous research and theories that framed our study; our methods; findings; and some implications for policy and practice.

Literacy and language in science and mathematics: background

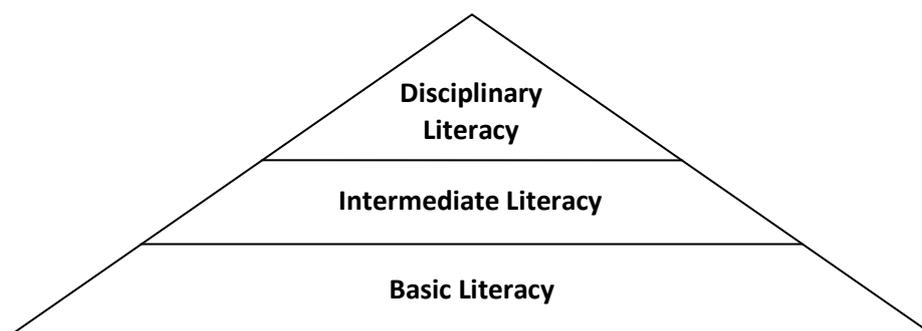
Our starting point for this study of literacy and language teaching in mathematics and science classrooms is the New Zealand Curriculum (NZC) (MOE, 2007) because this “[s]tatement of official policy” sets “the direction for student learning” in English-medium schools and therefore provides one important benchmark against which judgements about the observed literacy and language teaching might be made.

The NZC is unequivocal in its position that not only does each learning area have “its own language”, it is the responsibility of every subject-area teacher to develop the knowledge that students need to meet these specialised literacy and language demands (NZC, p. 16). As well as this general statement, subject-specific literacy and language demands are identified in the ‘Learning Area’ statements and achievement objectives for both science and mathematics and statistics. These demands include vocabulary knowledge and the ability to access and communicate ideas through reading and writing, as well as deeper demands of literacy and language, particularly applying knowledge from texts to real-world and novel situations and critically reading subject and popular

texts. All in all, in the NZC, literacy and language learning and teaching in mathematics and science has an importance that “cannot be overstated” (NZC, p. 16).

The statements pertaining to subject literacy in the NZC are consistent with a large body of recent research in the field of adolescent literacy (Draper, 2008; Fang & Schleppegrell, 2010; Moje, Stockdill, Kim & Kim, 2011; Shanahan & Shanahan, 2008). One of the main tenets of this body of research is that students are faced with increasingly sophisticated and subject-specialised literacy demands as they progress through their schooling years. Shanahan and Shanahan (2008) have represented this visually in Figure 1.

Figure 1: Shanahan & Shanahan’s (2008) model of the increased demand for specialization of literacy development



Basic Literacy: Literacy skills such as decoding and knowledge of high-frequency words that underlie virtually all reading tasks.

Intermediate Literacy: Literacy skills common to many tasks, including generic comprehension strategies, common word meanings, and basic fluency.

Disciplinary Literacy: Literacy skills specialised to history, science, mathematics, literature, or other subject matter.

The common thread in this line of research is that the ‘disciplinary literacy’ skills needed in different content areas are “more sophisticated but less generalisable” (Shanahan & Shanahan, 2008, p. 45) than those needed in the earlier years of schooling. An important implication of this model of literacy development is that while literacy at the ‘basic’ and ‘intermediate’ levels (which is not used here to refer to intermediate schools) can be taught by a specialist literacy or English teacher, the kind of specialised-literacy knowledge presented in the top section of the triangle can only be taught by subject teachers.

So, what kinds of literacy knowledge and teaching practices are likely to contribute most to achieving these ambitious goals? Our collection and analysis of data for this study is framed around the following factors that have been identified as most catalytic for effective literacy instruction (Parr, McNaughton, Jesson, Wilson, Amituanai-Toloa & Oldehaver, 2011). Firstly, there is a need to know about the texts that students and teachers use: their length, purposes, features and modes. Importantly, we would also need to know what teachers and students do with these texts, whether they use them to find information, compare and contrast, critique or evaluate; and how frequently.

Secondly, we would want to know the sites for these practices, the sorts of activities, groupings and differentiation patterns that occur. Teacher instruction and support for the use of texts theoretically mediates text use (Parr et al., 2011). Therefore, inquiry into teachers’ literacy instructional strategies is implicated, as is investigation into teachers’ goals and knowledge for their lessons. Crucially, the outcomes from the students’ point of view warrant investigation: what students understand and take from instructional sequences.

Methods

Participants

We selected participants with a view to developing the field of subject-specific literacy. The setting of the study was 12 classrooms in three secondary and two intermediate schools in Auckland. The 12 classrooms comprised two mathematics and two science classes from each of Years 7, 9 and 11. The schools were mid to low decile with ethnically-diverse student populations.

The three secondary schools were invited to participate because our analysis showed they had high enrolment and pass rates in selected NCEA Level 1 achievement standards from mathematics and/or science. Secondary principals and heads of department then identified teachers in their school who they judged to be effective, as well as one feeder intermediate school.

There were two reasons for employing a teacher effectiveness criterion. Firstly, an important purpose of this study was to identify future directions for literacy and language pedagogy, and we reasoned that these would be most fruitfully built on a foundation of already effective teaching. More specifically, anecdotal evidence from Schooling Support Services Literacy Facilitators involved in the Secondary Literacy Project (in reports to the National Co-ordinator, and co-author of this report, Aaron Wilson) suggested that without such an effectiveness criterion the amount of literacy and language instruction we would observe might be very limited.

It is important to note that because of both the small number of participants, and the effectiveness criterion, we make no claims that these teachers are representative of other mathematics and science teachers. In order for educators to similarly investigate the subject-specific literacy teaching within their own settings we have developed a supporting tool (see Appendix G).

Measures

We relied on four sources of data: Teacher observations, Secondary Literacy Pedagogical Content Knowledge Tool, teacher interviews, and student interviews.

Teacher observations

As a measure of practice, we observed each teacher over three consecutive lessons using an observation template (Wilson, McNaughton, & Jesson, nd) designed to record instances of literacy teaching that occurred within three minute blocks. We recorded details about:

- texts used in the lesson, such as their source, word length and form
- teaching activities, such as whether the teacher was lecturing, modelling or conferencing
- how students were grouped and what forms of differentiation were observed
- the content of literacy instruction that was observed, for example whether it was focused on vocabulary, text structure, audience and purpose, language features or spelling and punctuation
- instructional depth, for example whether the literacy instruction was focused on item knowledge (eg, teaching a definition), activation of students' prior knowledge (APK), providing opportunities to practise, developing students' metacognition/strategy use, or critical literacy.

Observer inter-rater checks determined high reliability (> 90% inter-rater agreement).

Subject Literacy Pedagogical Content Knowledge (SLPCK)

As a measure of teacher knowledge we employed a SLPCK Tool (Wilson, nd), which asked teachers to identify aspects of language and literacy in a subject text that might act as potential barriers for students' reading, and to suggest teaching moves they could make in response. Completed tools were qualitatively assessed to identify themes within the responses.

Teacher interviews

We also interviewed teachers about their goals for lessons, and whether they had achieved those goals. Teachers were asked about the literacy goal of the preceding lesson, the methods the teacher had used to assist the students in achieving that goal, and what measures they used to understand whether they had achieved their goal.

Student interviews

Finally, we interviewed students about particular aspects of the lessons, and what they perceived the literacy focus to have been.

Summary of findings

Finding 1: Most classroom texts were short texts created by the teacher

Working from an assumption that texts should be at the heart of literacy instruction, we analysed the frequency with which texts were used and what the features of those texts were. We took a reasonably broad view of texts and included all texts with any written words, including instructions, diagrams with labels or headings and symbolic expressions that included at least one word, but did not count texts that had no words whatsoever and were therefore solely oral or visual.

We observed a total of 91 texts delivered to students to read overall. Overwhelmingly, the texts being used in classrooms were created by the teacher, often as notes or worksheets, or modelled examples on the whiteboard. Teacher created texts were more evident in mathematics (93% of cases, compared with 72% for science). The whiteboard was the most common way texts were delivered (82% of texts in mathematics and 40% of texts in science) while the second most common form of delivery was via photocopied text resource (11% in mathematics and 32% in science). Published print materials were seldom used in either subject (2% of texts in mathematics and 6% in science).

Texts were predominantly short, with fewer than 10 words. In mathematics classes, the majority of texts contained fewer than 10 words (64%) and these were often one or two word instructions (eg, "simplify" followed by a series of equations). In science classes the highest proportion of texts contained between 11–50 words (38%), followed by fewer than 10 (26%), 51–100 (16%), 101–300 (12%) and 301–600 (2%).

Unsurprisingly, in mathematics classes the highest proportions of texts were mainly number based (41%) although there was also a relatively high proportion of running written text (32%). These were often short-sentence, instruction-based text (eg, "calculate the angle"). There were few examples of the extended contextualised word-based problems typical of NCEA mathematics assessments.

There was very little use of any real world texts or electronic or internet text, and very little evidence of students learning to use texts in ways that are valued by the discipline (eg, reading or writing 'like a scientist') or working across multiple texts.

Finding 2: The teachers know and teach much more about subject specific vocabulary than they do about other aspects of literacy and language

We analysed each three-minute block to identify whether any literacy instruction occurred and what the focus of that instruction was. In mathematics classes, the total number of instances of literacy instruction was fewer (observed in 38% of blocks) than the total number of instances of literacy instruction in science classes (observed in 69% of blocks).

Vocabulary knowledge was clearly the dominant subject literacy concern of teachers and was observed in 26% of blocks in mathematics and 61% of blocks in science.

Interviews and SLPCK responses demonstrated that teachers considered knowledge of vocabulary as an important subject-specific literacy goal. In particular, knowledge of challenging or conceptually important subject-specific vocabulary was a strong theme that emerged from both interviews and the SLPCK Tool.

There was less evidence that teachers discriminated between receptive and productive vocabulary learning, and teachers did not always seem to distinguish ‘to understand’ subject vocabulary from ‘to use’ that vocabulary. There was also less evidence that teachers had strategies for identifying which words would be most productive or catalytic to teach, or were aware of everyday words that had specialised uses.

Instruction about text structure or audience and purpose was rarely observed, and no instance of instruction about language resources, such as expected level of writing or sentence structure, was observed at all.

Finding 3: Lessons were characterised by whole class question and answer (Q & A) sessions, followed by individual work where teachers rove and assist

The teachers in our study predominantly used whole-class sessions and engaged students in Q & A sequences. Students also spent a large amount of time working individually, with teachers roving and assisting through brief exchanges. While natural discussion did occur between students who were supposed to be working alone, there were comparatively few instances of students working collaboratively in groups, except in Year 7, and in particular Year 7 mathematics, where students worked in ability groups, and participated in group interaction with the teacher.

Overall, there were no instances of teachers and students participating in extended discussions about the content of the texts, let alone aspects of literacy and language, other than those requiring short answer responses by students.

Finding 4: Instruction in both subjects was largely undifferentiated, especially in Year 9 and 10 classrooms

Students in both subjects were undifferentiated for the majority of blocks observed, that is, they were working towards the same class objectives or learning intentions. Students in mathematics lessons spent 76% of observed blocks in undifferentiated activity in which all students were engaged in the same activity, and were working in ability-grouped activities for 24% of observed blocks, while students in science classes spent 98% of observed blocks in undifferentiated activity and only 2% of blocks working in ability-grouped activity.

We observed no instance of differentiation to the level of individual students. Students in Year 7 classes were engaged in ability-grouped activities for a higher proportion of time (35%) than Year 9 (3%) and Year 11 classes (0%).

Finding 5: Formative assessment mainly consisted of Q & A sessions or checking

Formative assessment is needed if teachers are to be able to effectively identify the learning needs, including the literacy and language needs, of their students and to monitor the effectiveness of their teaching in response to those needs. This is the vision of pedagogy articulated in the NZC through the ‘Teaching as Inquiry’ cycle (NZC, p. 35).

Teachers described their strategies for knowing whether students were achieving the teaching goals largely in terms of Q & A sessions, or roving to check whether students were getting the correct answers. Some conferencing was observed, largely at Year 11, and teachers at Year 7 identified ‘working with’ students and self-assessment techniques.

In general, the students in our study were able to identify the teacher’s goal for their learning, most often identifying words or concepts that the teacher wanted them to learn.

In the secondary context particularly, we saw few practices that might allow teachers or students to diagnose whether difficulties were literacy or content based, or to monitor or regulate literacy learning. No teacher at any level referred to a standardised measure of literacy achievement, such as asTTle reading or writing.

Finding 6: There was little focus on developing students’ critical literacy or strategy use

One of the aspects of literacy instruction that we analysed was what we called ‘instructional depth’. Critical literacy is an explicit focus of the NZC, in terms of the key competencies, as well as in the learning areas, “for each area, students need specific help from their teachers as they learn ... how to listen and read critically, assessing the value of what they hear and read” (NZC, p. 16). When literacy instruction was observed, instructional depth in both mathematics and science was dominated by practice (57% of literacy instruction observed in mathematics classes and 48% in science classes). In mathematics, the remaining categories were fairly evenly distributed between item teaching (14%), Activating Prior Knowledge (APK) (14%), strategy instruction (9%) and critical literacy (7%). In science classes, a relatively high proportion of literacy teaching was categorised as item teaching (31%), with lower proportions of APK (8%), strategy instruction (8%) and critical literacy (5%).

Implications and recommendations

Before discussing implications and recommendations arising from our findings we wish to acknowledge a tension that is at the heart of this study. On one hand, we have evidence that the science and mathematics teachers in this study are more than normally-effective subject teachers. On the other, we have identified evidence of gaps in the teachers' literacy knowledge and practice. How do we explain this apparent mismatch?

One interpretation is that the kinds of literacy and language knowledge and pedagogy suggested by the literature, and implied by NZC, are *not*, in fact, necessary conditions for effective subject teaching. Our observations confirm that these teachers had deep subject knowledge, provided well planned and purposeful lessons, and created a positive and productive classroom learning environment. Is it the case that these attributes of quality teaching are sufficient to promote valued subject outcomes without a need to provide opportunities for rich engagement with written subject texts or literacy instruction other than that related to receptive knowledge of subject vocabulary?

We cannot discount this possibility with the evidence currently available to us. To test this would require us to compare the literacy and language teaching practices of this group of teachers with others who teach similar groups of students but whose students do not achieve so well.

We do think it likely, on the basis of anecdotal evidence (from our own experience as literacy researchers and professional developers as well as those reported to us by Schooling Support Service Literacy Facilitators in the Secondary Literacy Project), that despite the gaps we identified, the teachers in this study might still know more about, and do more and higher quality, literacy teaching (especially of vocabulary) than a randomly selected group of teachers would.

The combined results indicate that teachers provide content instruction, often by mediating texts. In general this seemed to be a feature of teachers attempting to prepare their students by building knowledge of the content area, therefore identifying what students need to know, and summarising this in the form of teacher-made notes or modelling for students.

We have evidence that the teachers in this study have high expectations for their students and want them to achieve valued subject outcomes, including outcomes of the sort assessed in NCEA. We suggest that the teachers in this study do not want students who might struggle with the complex literacy and language demands to be excluded from opportunities to engage with valued scientific and mathematical knowledge because of these literacy and language demands. Thus, one explanation for the relative low frequency of literacy and language teaching in these classrooms is that the teachers have responded to challenging aspects of reading and writing by minimising the amount and challenge of reading and writing that the students do.

In one sense, such an approach is understandable. After all, teachers are encouraged to provide scaffolding that enables students to access subject learning at a higher level than they can currently access independently; avoiding or minimising the literacy and language demands of the subject, and providing alternative means for students to access the subjects *is* one form of teacher scaffolding.

We have no evidence that the teachers in this study were in any way antagonistic to the idea that they have a responsibility to teach the literacy and language of their subject. Indeed, the frequency and quality of teaching receptive subject vocabulary that we observed suggests to us that when the teachers were confident in their

knowledge about an aspect of literacy and language they taught it and taught it well. We contend, rather, that the reasons that these teachers adopted such an approach are understandable and were made with the interests of their students in mind.

We are not suggesting either that these were not evidence-based decisions. Our sense is that the teachers *did* have evidence that minimising the literacy and language aspects of their subjects in the way we observed would facilitate students' learning and achievement in mathematics and science in the year levels they taught. In mediating text use by restricting or controlling the use of texts, however, there are a number of inherent risks.

Firstly, such an approach would appear to be premised on the idea that subject-content knowledge is the exclusive (or at least primary) valued student outcome in mathematics and science. We contend, rather, that being able to read, write, talk and think critically about mathematics and science texts are themselves important subject outcomes, and indeed, knowledge of language and content are so interwoven as to be inseparable. We have identified the potential for students to be denied opportunities to engage with text, thereby decreasing their opportunity to develop literacy skills to use texts independently, and also decreasing opportunity to develop subject-specific skills, in terms of using texts in ways that are valued in the disciplines.

Secondly, we think that while possibly expedient (at least up to Achievement in NCEA Level 1), such an approach might unintentionally place a ceiling on students' achievement in that discipline. Our analysis supports the teachers' view that a more sophisticated language and literacy demand is one aspect that discriminates the criteria for Excellence from the criteria for Achievement, and Level 3 from Level 1. Such a ceiling might limit students' ability to achieve the Merit and Excellence grades at Level 1 NCEA; or it might not limit students' achievement at Level 1 at all, and kick in only at Level 2 or 3; or it might suffice more for internal and less for externally-assessed standards; or it might not be noticeably restricting until such a time that no teacher is available to mediate the texts students read and write, such as at university, in the workplace, or in everyday life.

Clearly, some students *are* able to apply their generic reading and writing knowledge and skills to the specialised-subject literacy demands of science and mathematics *without* very much deliberate instruction by the teachers of those subjects. However, we contend that more frequent and more deliberate subject-literacy instruction is part of what will be needed if we are to achieve ambitious equity goals and increase the number and range of students who can achieve highly in these subjects (eg, gain Excellence) at the higher levels of NCEA and tertiary education.

Thus, a number of implications emerge related to text use, textual knowledge, pedagogy surrounding text use, and inquiry into student learning.

1. Text use: students need opportunities to engage with text in ways that are valued by the disciplines and by the New Zealand Curriculum document

Having sufficient time to learn, and repeated opportunities to practice, is essential when learning any complex subject matter (Bransford, Brown, & Cocking, 2000) so, clearly, students need repeated opportunities to read, write, think about, and discuss the types of texts valued in science and mathematics if they are to become skilled users and producers of such texts.

There is ample scope for more time spent engaged in reading texts for subject-specific purposes, and both gathering and applying content knowledge. We see as concerning the lack of alignment between the time and types of texts students *actually* encountered in class and those that the NZC implies would be important, and that students will encounter in NCEA, in the disciplines themselves, and in 'real world' contexts.

We are not suggesting at all that written texts supplant other ways of teaching content or providing meaningful contexts, however we are suggesting that written texts should be used more often for these two purposes.

2. Textual knowledge: students need opportunities to develop knowledge of how important types of subject texts work

In the service of using texts in subject-specific ways, as effective readers and writers, students develop and use knowledge of how important types of subject texts work. Knowledge of how texts work consists of knowledge about audience and purpose, vocabulary, organisational features and language resources.

It is important that teachers also have this knowledge. They need to know this so they can diagnose reading and writing problems, employ appropriate teaching strategies to address these problems, and evaluate the effectiveness of these actions.

Our findings show that the teachers knew and taught much more about vocabulary than they did other features of literacy and language. There was little to no evidence that the teachers had deep knowledge about, or taught students about, other important aspects of texts such as audience and purpose, structure, or features of language at a sentence level. One explanation for why there was so little teaching about these aspects is that teachers do not know as much about these aspects at an explicit level as they do about vocabulary. Specifically, this study suggested that they might not know how gaps in students' knowledge of these features might affect students' ability to comprehend or produce written texts, how to diagnose such problems, and what instructional practices to employ.

While teachers need to know these features, and students need to develop such knowledge, we do not agree that teachers should, or need to, teach all of these features as a matter of course. For example, "Repeated studies have demonstrated that instruction in isolated grammar, decoding or comprehension skills may have little or no impact on students' activity while actually reading" (Schoenbach, Greenleaf, Cziko & Hurwitz, 1999, p. 7). Rather, teachers need to know how these features (including, but not limited to, receptive, specialised vocabulary) may act as barriers to making or creating meaning from texts and how to diagnose and address problems identified through inquiry.

3. Strategy learning: students need opportunities to develop a toolbox of cognitive strategies they can use flexibly to make and create meaning

There was very little evidence of strategy instruction in the classrooms we observed. The strategies that we think will be most pivotal for students to learn in mathematics and science are more specific to each subject's texts and purposes and will be strategies that students can employ when features of those highly-specialised text forms become barriers to making and creating meaning. In science, for example, as well as hearing, learning and using vocabulary items, students might develop strategies for solving unfamiliar words they encounter by integrating morphological word level strategies with text level context based strategies.

4. Pedagogy: students need opportunities to participate and contribute in rich literacy learning experiences

In the classes we observed, teachers of both science and mathematics frequently modelled, and often created texts to support this modelling. However, there was less evidence that teachers used grouping or extended discussion to build understandings. We would therefore argue for a greater balance of approach. We see at least two potentially valuable purposes in incorporating greater use of participatory or dialogic teaching approaches. The first is creating opportunities for greater support through co-constructive approaches. The second is to

disrupt the traditional ‘Initiate, Respond, Evaluate’ (Mehan, 1979) classroom discourse pattern to build richer, more authentic and more cognitively-challenging discourse patterns.

5. Critical literacy: students need opportunities to develop the kinds of critical literacy valued in the subject areas

Critical literacy is an explicit focus of the NZC, in terms of the key competencies, as well as in the learning areas. Critical literacy involves a shift away from ‘getting the correct answer’ to questioning the assumptions in texts, critiquing, and challenging. In our observations of teachers we saw no evidence of any instruction that could be characterised as critical literacy. We would therefore argue, from a position of instructional depth, that students need opportunities to engage with issues, ideas and concepts, to challenge and critique them as part of deep learning within their subject areas.

6. Independence: students need opportunities to develop self-regulation (in reading and writing)

Alongside instructional support and instructional materials, students also have a vital role to play in their own learning. An environment that supports self-regulation requires that students participate in discussions and other learning tasks that focus on the learning. Teacher responses indicated that when students were faced with literacy difficulties, they supported students to solve the literacy issues. In order to foster self-regulation, however, students need to be able to develop strategies for independent solving. To do so, students need to know what literacy skills or strategies they are trying to develop. We therefore argue for strategies that develop students’ awareness of the literacy demands of their subject area, beyond knowing the meanings of words.

1. Overview

This study investigates the literacy and language knowledge and teaching practices of mathematics and science teachers in Year 7, 9 and 11 classrooms.

This study is important for theoretical as well as practical reasons. The challenges involved in meeting the literacy demands of upper-primary and secondary schooling are hot topics in the international literature at the moment (eg, Fang & Schleppegrell, 2010; Moje, Overby, Tysvaer, & Morris, 2008). In the USA, and elsewhere, a key driver for the increased interest in adolescent literacy in recent years is what some have labelled a “literacy crisis” (Alvermann, 2002; Greenleaf, Schoenbach, Cziko, & Mueller, 2001; Jacobs, 2008; Kirsch, de Jong, Lafontaine, McQueen, Mendelovits, & Monseur, 2002). In short, this crisis consists of large numbers of students graduating without the high levels of advanced literacy needed for successful 21st century living (Jacobs, 2008; Moore, Bean, Birdyshaw, & Rycik, 1999). In New Zealand, adolescent literacy interventions such as the Secondary Literacy Project (Wilson & McNaughton, 2012) have been seen as part of a wider strategy for addressing existing disparities in achievement for Māori and Pasifika students. One indicator of this disparity is pass rates at Levels 2 and 3 of NCEA, which differ markedly by ethnicity (Ministry of Education, 2012). In 2007, only 18% of Māori and 20% of Pasifika school leavers left with University Entrance level qualifications, while the rate was more than double (44%) for European/Pākehā school leavers. In this context, students’ literacy is not just valued as an important end in itself, but also as a key predictor of academic achievement in other content areas (Kamil, Borman, Dole, Kral, Salinger, & Torgensen, 2008).

Given that there is compelling evidence that quality literacy teaching has the potential to improve student learning (Alton-Lee, 2003; Hattie, 2005), it is perhaps unsurprising that many professional development interventions in adolescent literacy have been initiated, both in New Zealand and internationally. In addition to major Ministry of Education funded projects such as the Secondary Literacy Project (Wilson & McNaughton, 2012), a recent national survey of secondary schools in New Zealand found that literacy programmes had been implemented in a large majority of secondary schools, and that the percentage with a literacy programme in place had increased from 68% to 93% between 2003 and 2006 (Schagen & Hipkins, 2008). Despite this focus, there is still relatively little empirical evidence in New Zealand or overseas about how New Zealand mathematics and science teachers use texts and teach literacy in their subjects.

Our starting point for this study of literacy and language teaching in mathematics and science classrooms is the New Zealand Curriculum (NZC, 2007). This is important for framing our investigation because the NZC is a “[s]tatement of official policy” that has the principal function of setting “the direction for student learning and to provide guidance for (English-medium) schools as they design and review their curriculum” (NZC, p. 6). Thus, the NZC provides one important benchmark against which judgements about the observed literacy and language teaching might be made.

So, what is the direction for literacy teaching and learning in science and mathematics specified in the NZC? First and foremost, the NZC is unequivocal in its position that not only does each learning area have “its own language”, it is the responsibility of every subject-area teacher to develop the knowledge that students need to meet these specialised literacy demands (NZC, p. 16). In mathematics, even at Curriculum Level 3, there is a strong focus on the linguistic aspects of mathematics. This is most obvious in statistics, where students, for example, learn to “evaluate data-based arguments”. However, literacy is by no means limited to statistics. For example, the ‘Number and Algebra’ strand specifies that students “[r]ecord and interpret additive and simple multiplicative strategies using words, diagrams and symbols” whereas in the ‘Geometry and Measurement’

strand, students are expected to “[u]se... the language of direction and distance to specify locations and describe paths.” Furthermore, students’ learning is expected to take place “in a range of meaningful contexts.”

This importance of subject-literacy learning is operationalised in even more detail in science. The ‘Nature of Science’ strand is the “overarching unifying strand” for science through which “students learn what science is and how scientists work”, and, “[h]ow science ideas are communicated and to make links between scientific knowledge and everyday decisions and actions” (NZC, p. 28). ‘Nature of Science’ has a sub-strand called ‘Communicating in Science’ which specifies that students engage with an increasing range of science texts and learn to use an increasing range of scientific symbols, conventions and vocabulary. In addition, students are expected to develop skills of critical literacy which, at Curriculum Level 3, involve students “begin[ning] to question the purposes for which these texts are constructed”, so that by Curriculum Level 5, they can “[a]pply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy).” Literacy is also of central importance in the ‘Participating and Contributing’ strand, which, at Curriculum Levels 5 and 6 specifies that students “[d]evelop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate”. The NZC appears consistent with a recent report by the Chief Science Advisor to the Prime Minister (Gluckman, 2011), which claims that, increasingly, the challenges we face as a community depend on our citizens’ knowledge of science. Teaching is critical to achieving that knowledge. The objectives of science, for both ‘pre-professional education’ and ‘citizen-focused education’ in primary and secondary schools require a form of literacy that enables children to take “an informed participatory role in the science-related decisions that society must make” and to “distinguish reliable information from less reliable information” (Gluckman, 2011, p. 4).

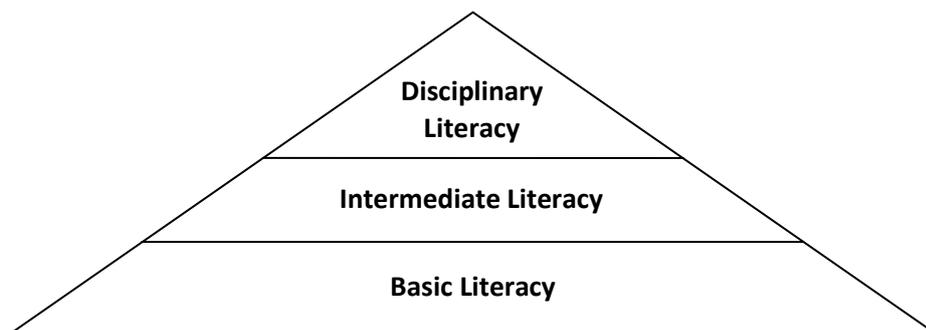
All of this suggests a view of literacy learning and teaching in mathematics and science having an importance that “cannot be overstated” (NZC, p. 16). More specifically, such a view implies that:

- students are enabled to make and create meaning from increasingly complex texts
- the application of content knowledge to meaningful contexts is valued
- students become critically literate users of popular and subject-related texts.

In one sense, as well as addressing the particular research questions established for the project, an aim of this study is to consider the extent to which the literacy and language pedagogy we observed in Years 7, 9 and 11 mathematics and science classrooms was consistent with the vision laid out in the NZC.

The statements pertaining to subject literacy in the NZC are consistent with a large body of recent research in the field of adolescent literacy (Draper, 2008; Fang & Schleppegrell, 2010; Moje et al., 2011; Shanahan & Shanahan, 2008). One of the main tenets of this body of research is that students are faced with increasingly sophisticated and subject-specialised literacy demands as they progress through their schooling years. Shanahan and Shanahan (2008) have represented this visually in Figure 2.

Figure 2: Shanahan & Shanahan’s (2008) model of the increased demand for specialization of literacy development



Basic Literacy: Literacy skills such as decoding and knowledge of high-frequency words that underlie virtually all reading tasks.

Intermediate Literacy: Literacy skills common to many tasks, including generic comprehension strategies, common word meanings, and basic fluency.

Disciplinary Literacy: Literacy skills specialised to history, science, mathematics, literature, or other subject matter.

The common thread in this line of research is that the ‘disciplinary literacy’ skills needed in different content areas are “more sophisticated but less generalisable” (Shanahan & Shanahan, 2008, p. 45) than those needed in the earlier years of schooling. An important implication of this model of literacy development is that while literacy at the ‘basic’ and ‘intermediate’ levels (which is not used here to refer to intermediate schools) can be taught by a specialist literacy or English teacher, the kind of specialised-literacy knowledge presented in the top section of the triangle can only be taught by subject teachers. We have previously proposed a mixed model of development for explaining content-area literacy in which both generic and content-specific literacy skills and knowledge are required (McNaughton & Wilson, 2010), and we use this to frame the current study rather than limiting our focus to the purely disciplinary literacy aspects of instruction.

Our collection and analysis of data for this study is framed around previous research (Parr et al., 2011), which implicate the following factors as most catalytic for effective literacy instruction:

Firstly, there is a need to know about the texts that students and teachers use: their length, purposes, features, and modes. Importantly, we would also need to know what teachers and students do with these texts, whether they use them to find information, compare and contrast, critique or evaluate.

Secondly, the sites for these practices, the sorts of activities, groupings and differentiation patterns that occur are all of interest. Teacher instruction and support for the use of texts theoretically mediates text use (Parr et al., 2011), therefore, inquiry into teachers’ literacy instructional strategies is implicated, as is investigation into teachers’ goals and knowledge for their lessons. Crucially, the outcomes from the students’ point of view warrant investigation: what students understand and take from instructional sequences.

Thus, the research aims to answer four main research questions:

1. What knowledge, beliefs and understandings do teachers have about the literacy and language of science and mathematics?
2. In light of their knowledge, beliefs, and understandings about the literacy and language required, what practices do teachers use to support students' learning and achievement?
3. What are the areas of strength and weakness in literacy and language pedagogy within science and mathematics?
4. What understandings do students have of the literacy and language of science and mathematics?

2. Methods and procedures

We have adopted a mixed-model approach to explain content area literacy in which both generic and content-specific literacy skills and knowledge are required. Using this model, we have examined science literacy, with mathematics literacy as our ‘other’ content area.

Science was identified as a priority area in the Ministry of Education’s Request for Proposal for this study. One rationale for investigating literacy and language in science comes from a recent report by the Chief Science Advisor to the Prime Minister (Gluckman, 2011). This report claims that increasingly the challenges we face as a community depend on our citizens’ knowledge of science and that teaching is critical to achieving that knowledge. The objectives of science, for both ‘pre-professional education’ and ‘citizen-focused education’ in primary and secondary schools require a form of literacy that enables children to take “an informed participatory role in the science-related decisions that society must make” and to “distinguish reliable information from less reliable information” (p. 4). The report argues that the task is to find ways to teach which integrate scientific forms of critical thinking skills into literacy and numeracy. The report links this need to a pressing concern. It summarises national and international data which show that despite overall high levels of science literacy, a long tail of underachievement exists associated with “socioeconomic disadvantage with high Māori and Pasifika populations” (p. 7).

Mathematics was chosen as the ‘other’ content area for three additional reasons. Firstly, mathematics has a significant and highly specialised literacy component, which is acknowledged in the literacy requirements for Level 1 NCEA. Secondly, mathematics is part of the core curriculum. It is the main source of the numeracy standards required for Level 1 NCEA and University Entrance and, thirdly, mathematics is the second (after English) most widely studied subject at secondary school.

The generalisability of this study is limited for two reasons. Firstly, the number of teachers we observed in each subject ($N = 6$) is small. Secondly, teachers were not randomly selected; they were invited to participate on the basis of evidence that they were particularly effective teachers of students in their subject-area. An explanation for this design follows.

2.1 Participants

Schools in Auckland were approached on the basis of two main criteria.

The first criterion was that the schools were mid-to-low decile Auckland schools with ethnically-diverse student populations. This criterion was important because of our, and the Ministry of Education’s, interest in identifying the literacy and language practices experienced by Māori and Pasifika students.

The second criterion was an effectiveness criterion which we adopted for two reasons:

Firstly, an important purpose of this study was to identify future directions for literacy and language pedagogy, and we reasoned that these would be most fruitfully built on a foundation of already effective teaching.

Secondly, and more specifically, anecdotal evidence from Schooling Support Services Literacy Facilitators involved in the Secondary Literacy Project (in reports to the National Co-ordinator) suggested that without such

an effectiveness criterion the amount of literacy and language instruction we would observe might be very limited.

Applying the effectiveness criterion firstly involved us identifying secondary schools with relatively high enrolment and pass rates in Level 1 mathematics and science achievement standards with a significant literacy component. These standards were identified with the help of the National Coordinators of NCEA mathematics and science. Twenty-nine Auckland schools' NCEA data were then ranked to identify those schools that had the highest pass rates in these standards, and high enrolment rates (> 60% of whole Year 11 roll) in those standards. Of the 29 ranked schools, 16 had been involved in the Secondary Literacy Project between 2009 and 2011, and 13 schools had not. Secondary School 1 was ranked first in mathematics. Secondary School 2 was ranked third in mathematics and first in science, and Secondary School 3 was ranked fourth in science. The schools that were ranked second in mathematics, and second and third in science were invited but declined to participate.

The final database contained participants from a total of 12 separate classes, comprised of two science and two mathematics classes from each of Years 7, 9 and 11. The classes came from three secondary schools (one of which participated in the Secondary Literacy Project between 2009 and 2011), and two intermediate schools. The two intermediate schools were nominated by the selected secondary schools as being 'feeder' schools that were effective in teaching science and mathematics. Having identified these effective schools, their literacy leaders nominated science and mathematics teachers who were effective literacy teachers.

In addition to the teachers, we proposed to interview up to three students per teacher observation, at the end of each lesson.

2.2 Measures

We relied on four sources of data: teacher observations, Secondary Literacy Pedagogical Content Knowledge (SLPCK) Tool, teacher interviews, and student interviews.

As a measure of practice, we observed each teacher over three consecutive lessons using an observation template designed to record instances of literacy teaching that occurred within three minute blocks (Wilson et al., nd).

As a measure of teacher knowledge, we employed a SLPCK Tool (Wilson, nd), which asked teachers to identify the literacy demands in assessment tasks from NCEA and to suggest teaching moves they could make in response to this demand. This had been used previously as a repeated measure of teacher knowledge in a secondary literacy intervention and found to be a useful indicator with high reliability.

We also interviewed teachers about their goals for lessons, and whether they had achieved those goals. Teachers were asked about the literacy goal of the preceding lesson, the methods the teacher had used to assist the students in achieving that goal, and what measures they used to understand whether they had achieved their goal.

Finally, we interviewed students about particular aspects of the lessons, and what they perceived the focus to be. Each of these measures and the associated primary analysis is described in more detail below.

2.2.1 Teacher Observation Tool

It was our aim to examine a teaching topic as it developed over a sequence of lessons, as this employed the idea of the topic sequence as the unit of analysis rather than independent or random lessons. Each secondary school and intermediate school mathematics class was observed over three lessons within one week. It is important to note, however, that the first lesson we observed in a sequence was not necessarily the first lesson in a topic, as to

do so would have been logistically difficult. Intermediate school science classes were double lessons and were therefore only observed over two lessons within one week. Within one observation period, observation data were actively coded for three minutes at a time, followed by three minutes of recording time where no further observation data could be included. This enabled a 50% sample of observation blocks and lessened observer fatigue throughout the lesson. The resulting database therefore contained a total of 34 lessons and 316 observation blocks. One third of the observations were recorded in Term 4, 2011, while the remaining two-thirds were recorded in Term 1, 2012.

The tool was designed to allow written recording of the aspects of teaching and learning investigated within the classroom, including characteristics of text, main teaching activity, differentiation of students, the grouping of students and the nature and type of literacy instruction. These categories are described in detail in the following sections and provided a methodological framework for analysing the observations. The tool was originally developed for use as a ‘profiling’ tool to help identify teacher professional learning needs in a literacy intervention we led, and we found it to provide a useful and reliable snapshot of literacy and language pedagogy. A blank teacher observation tool is provided in Appendix A. Observer inter-rater checks determined high reliability (> 90% inter-rater agreement).

2.2.1.1 Characteristics of the texts used in observed lessons

The observer photographed or was supplied with copies of all texts students were given to read in the lessons so they could be analysed in detail at a later date. We took a reasonably broad view of texts and included all texts with any written words, including instructions, diagrams with labels or headings and symbolic expressions that included at least one word, but did not count texts that had no words whatsoever and were therefore solely oral or visual. Texts that students were expected to read were analysed for their properties within each of seven dimensions, which were as follows.

1. *Original source*: this dimension examines whether the text source was book, magazine, newspaper, electronic, teacher designed resource, teacher adapted and amplified (teacher maintained original text but provides additional support, eg, in the form of a glossary), teacher adapted and simplified (teacher modified to decrease complexity) or student work.
2. *Word length*: discrete categories were created to assess text length. These categories were fewer than 10 words, 11–50 words, 51–100 words, 101–300 words, 301–600 words, and more than 601 words. Only words were counted, so this category does not include numbers or symbols.
3. *Form*: this dimension examines whether text was a published printed text, whiteboard, photocopy, projected (ie, OHT/PowerPoint), or onscreen (eg, web page on a laptop).
4. *Original audience*: this dimension examines the intended audience of the text, ie, youth – academic; youth – general; adult – academic; or adult – general.
5. *Original purpose*: this dimension was created to assess whether the text was created to provide content/information only, provide content and exercises, provide exercises only, procedural information (eg, instructions for practical work), or assessment based (eg, NCEA task). In a situation where students were given a handout, and provided with written questions on the whiteboard, this would have been coded as content and exercises, if provided in the same block (however this was not observed).
6. *Dominant mode*: this dimension examines whether the dominant mode of text was a running written text, bulleted/numbered/condensed, number based, or visual text (eg, information presented mainly through diagrams and other visual representations; texts were only counted in this category if the visual element was the dominant feature).

Each text was analysed according to the corresponding three minute interval when it was presented to students. It is important to note that texts were coded (for number of words) according to how much of that text students had access to. There were instances where students were assigned ‘sections’ of a larger text. In such cases, those sections, rather than the whole text, were analysed, based on an interpretation that students were not supposed to consult other parts of the text. Similarly, in workbooks or extended worksheets, only the discrete sections within the text that the students were expected to read and work on was counted and analysed within that time block. One worksheet could therefore be given to students at the beginning of the lesson, but be counted more than once. The appropriate section, however, would only be counted once.

2.2.1.2 Main teaching activity

This variable identifies the single most dominant activity occurring within the three-minute time block.

Categories included:

1. *Q & A* (quick fire sessions with little elaboration)
2. *Extended discussion* (discussion that includes initiation by students and elaborated response)
3. *Lecture*
4. *Modelling*
5. *Conferencing* (teacher engages in sustained — ie, more than one minute, deep, learning-focussed conversation with individuals or small groups)
6. *Rove* (teacher moves around class giving short — ie, less than one minute — guidance to individuals or small groups, not necessarily learning-focussed)
7. *Management* (management of resources and behaviour, eg, taking the roll).

2.2.1.3 Differentiation of students during lessons

This variable identifies the single most dominant form of differentiation within the three minute time block, and contains: no differentiation (whole class working towards the same learning outcomes); group (different groups working towards different learning outcomes); and individual (individualised learning outcomes).

2.2.1.4 Nature of student grouping within the lesson

This variable identified the size of the groups in which students were working. Students could be working as a whole class, as groups, or as individuals. The grouping variable was assigned according to physical groups of students that had been directed to work together. We made no effort to distinguish between group work and work that was genuinely cooperative.

2.2.1.5 Dimensions of literacy instruction observed

Within the observed lessons, ‘acts of literacy teaching’ were identified by the researcher. Such acts were defined as any action on the part of the teacher identified by the observer as an attempt to build student knowledge of a literacy or language aspect. Therefore, more than one act of literacy teaching could be observed within any given block of time. Whenever such an instance of literacy teaching was observed, that instance was coded according to one of the following categories.

1. *Vocabulary*: instruction which refers to specific vocabulary directly or by association — either sub-word units (eg, morphemes), individual words, or word combinations and phrases.
2. *Structure*: global structures of text, as well as structural/organisational features, eg, headings, topic sentences, etc.

3. *Audience and Purpose*: purpose and audience in relation to text, for example, “In this text the writer wants to *persuade* the reader to ...”.
4. *Language Resources*: language features in texts (other than vocabulary, eg, nominalisation, passive constructions, sentence features).
5. *Spelling and Punctuation*.

2.2.1.6 Main focus of the literacy instruction observed

This variable identifies the main literacy focus for each three-minute block in which literacy instruction was observed. Categories within this variable contained reading, writing, or reading and writing. Note that the reading and writing category requires *explicit* teacher links of reading and writing or students producing extended pieces of writing in response to reading.

2.2.1.7 Nature (depth) of literacy instruction

This variable measures the instructional depth of literacy, and contains the following categories.

1. *Direct teaching of item*: for example, “Micro-organism has two morphemes”.
2. *Activating Prior Knowledge (APK)*: reference to, use of, background and event knowledge, for example, “What do you already know about the term ‘micro’, as in ‘microscope’?”.
3. *Practice*: opportunity to apply knowledge or skills that students already have, for example, “Try to make a list of all the words you know that have ‘micro’ as a part”.
4. *Strategy*: teaching of strategy, for example, “When you are faced with a word such as this, try seeing if you can identify the meanings of the word parts”.
5. *Critical*: instruction related to questions of power and text use, such as bias, positioning and critique. For example, “Why do you think you or another author might choose to use the word ‘micro-organism’, instead of the word ‘germ’?”.

These categories were considered to be progressive, but not necessarily hierarchical, as each item is an important step in literacy development. For the purposes of analysis, however, where more than one item was selected, the highest was used for analysis.

2.2.2 Subject Literacy Pedagogical Content Knowledge (SLPCK) Tool

To investigate teachers’ knowledge of the literacy demand in their subject, each teacher was given a copy of one NCEA standard assessment task that had been identified as having a high literacy component. They were then asked to complete a survey to identify:

1. the potential literacy difficulties students might encounter (literacy demands)
2. what teaching might address these areas (teaching approaches).

Assessment tasks were given for either mathematics or science to the corresponding subject teachers. A copy of the SLPCK Tool is included in Appendix C, and each of the accompanying NCEA mathematics assessment and NCEA science assessment tasks in Appendices D and E. The theoretical basis for this tool is taken from the concept of pedagogical content knowledge that, “Effective teachers know much more than their subjects, and more than ‘good pedagogy’. They know how students tend to understand (and mis-understand) their subjects; they know how to anticipate and diagnose such misunderstandings; and they know how to deal with them when they arise” (Grossman, Schoenfeld, & Lee, p. 205). In short, we assume that teachers with developed subject literacy pedagogical content knowledge can better identify and explain those aspects of texts most likely to be

problematic for students. Teachers of Year 7 and Year 9 were given the same Year 11 text to analyse in order that comparisons of teacher knowledge could be made across levels, and because of an assumption that teachers need to know about subject progressions their students will face in future year levels, including literacy and language progressions.

2.2.3 Teacher interviews

Each teacher was interviewed immediately after each observed lesson whenever possible. (It was not always possible to interview teachers each day after lessons due to teachers' commitments.) Teachers were asked about the literacy goal of the preceding lesson, the methods they had used to assist the students in achieving that goal, and what measures they used to understand whether they had achieved their goal. A copy of the interview framework is given in Appendix B. Each teacher was interviewed as many times as she or he was able to commit. All teachers were interviewed after at least one of their three teaching sessions. The total number of teacher interviews was 25.

2.2.4 Student interviews

Up to three students were interviewed at the end of each lesson using a 'critical incident' analysis. Students were prompted to recall a specific incident, chosen by the observing researcher, which exemplified a key literacy-teaching incident. Students were asked what vocabulary, reading or writing knowledge they thought their teacher had wanted them to learn during that interaction or event, whether or not the students thought the teacher was effective in their approach, and whether the students thought it was something important to learn within their subject. The final database contained a total of 75 student interviews. A copy of the student interview framework is included in Appendix F.

2.3 Analysis

Each of the sources of data was analysed initially in separate formats. Classroom observation data were entered manually into the statistical analysis package, SPSS, from the raw (hard copy) data, with each row within the resultant database representing one observed three-minute block. Quality assurance of the final database revealed 99.8% accuracy of data entry. Descriptive statistics (percentages) for each variable, cut by subject and year level, were extracted from SPSS.

Completed SLPCK measures were qualitatively assessed to identify themes within the responses¹. The measures were then quantised, by assigning a yes/no (1/0) coding, using teacher as the unit of analysis. Teachers were coded as to whether themes were apparent in their responses. This allows both qualitative and quantitative interpretation of the data.

Transcribed interviews were assessed qualitatively to identify themes resulting from the interviews, and regular debriefing sessions were held with the wider research team to collaboratively test ideas. Each interview was then coded in relation to each of the identified themes for each question. Two researchers independently coded the interviews for moderation purposes, and debriefing sessions were conducted to resolve any coding disagreements.

Transcribed student interviews were qualitatively assessed to identify the overall themes resulting from their interviews, and research team debriefing sessions were held to test ideas. Each interview was coded in relation to

¹ The themes identified are summarised in Table 1 (later in this report) and relate to the sorts of literacy-related problems the teachers felt students would have in understanding the NCEA questions and the sorts of actions they would take in their teaching to help students address the identified problems.

the extracted themes, and descriptive statistics (percentages) were calculated to assess the relative frequencies of the themes.

Following individual analyses, we conducted a goal alignment analysis in order to integrate the various sources of information. The goal alignment utilised teacher interviews, the teacher observation tool and student interviews as described in detail above.

All teacher interview transcripts were analysed and individually coded according to the teacher's reported literacy goals. These were analysed line by line to identify each of these goals. During coding the need for delineating goal type emerged, where the teacher's stated literacy goal was deemed to reflect more of a content-based learning intention, than a literacy learning intention. As such, a subject content-based goal was coded 'content' to differentiate it from a subject-literacy based goal, which was judged to encompass a vocabulary or reading or writing focus or intent. The teacher observation transcripts for each teacher were analysed and coded across the three consecutive lessons to examine evidence of activities and comments by teachers that either corresponded or did not correspond with teachers' stated literacy goals.

Student interview transcripts were similarly analysed and coded for statements that reflected whether student understanding aligned or did not align with the stated teaching goal. Evidence of teacher goal in student voice was rated on a scale of none, some, most or all. Subsequent tabular analysis across observations and interviews reflected five final configurations of goal alignment:

1. teaching practice and student understanding align with *literacy* teaching goal
2. teaching practice and student understanding align with *content* teaching goal
3. teaching practice aligns with *literacy* goal but students identify related *content* goal
4. teaching practice aligns with *content* goal but not evidenced in student voice
5. teaching practice does not align with the teacher's espoused *literacy* goal.

2.4 Scope of the study: summary statements

In summary, the purpose of this research project, as stated in the original Request for Proposal, was to increase knowledge and understanding of literacy and language pedagogy in mathematics and science classrooms in Years 7 to 11. The underlying assumption of the research was that if teachers have a better understanding of the relationship between the pedagogy of the content, the literacy of the subject, *and* the necessary knowledge and skills, they will be able to make literacy and language pedagogy more explicit in their teaching, which in turn will lead to improved learning and higher achievement for students. To this end, we have adopted a mixed-model methodology, within a relatively small sample of purposively-selected sites, utilising teacher observations (including teacher resources), SPLCK Tool, interviews with teachers and students, and goal alignment analyses.

3. Results

We present results firstly according to the measures employed and in the following order: Teacher Observation Tool, SLPCK Tool, teacher interviews and student interviews. We then present an analysis of alignment between the teachers' reported goals, their classroom practice, student understanding, and a summary of results in relation to the key research questions.

3.1 Teacher Observation Tool

Sections 3.1.1 to 3.1.8 present results relating to each of the observation categories specified in the Teacher Observation Tool (Appendix A). These sections contain results regarding: the nature of texts used (Section 3.1.1), teaching activity (Section 3.1.2), differentiation (Section 3.1.3), main student groupings (Section 3.1.4), dimensions of literacy instruction (Section 3.1.5), main literacy focus (Section 3.1.6), and instructional depth (Section 3.1.7) analyses. Section 3.1.8 contains a summary of the observational results overall.

3.1.1 Nature of the texts used during the lesson

We firstly present our results about text use because we believe that students develop their knowledge of subject literacy and language through engagement in the reading and writing of subject texts. This sub-section describes the characteristics of the texts used within each of the mathematics and science classes observed (a total of 12 classes were each observed two to three times on subsequent days). These include the total number of words in the different texts used, the source of the texts, the intended audience of the text and the form in which the text was delivered. These categories were designed to summarise the nature of the texts with which students had opportunities to engage in their science and maths classes.

In selecting this framework for text analysis we were guided in part by The Literacy Learning Progressions (Ministry of Education, 2010) which was designed as a professional tool to support the NZC (p. 2). The Year 10 progressions were particularly important as they identify the 'step up' in demands as students advance into and through secondary school. The sources of texts identified in the Year 10 progressions, and which seem relevant to mathematics and science, include: reference materials (including primary source materials), digital materials with hypertext, textbooks, manuals and procedural texts, mathematics problems, and newspapers and magazines. Such texts are said to often include complex ideas and multiple items of information written for a general adult rather than a specialist audience. The progressions also identify that the texts students read and write at secondary school may be longer than in previous years, but also might be shorter and more information-dense. In summary, the progressions document, like the NZC itself, implies that as students advance through Years 7 to 11, a wider range of different texts which are 'authentic' and increasingly complex should be used in classrooms (p. 18).

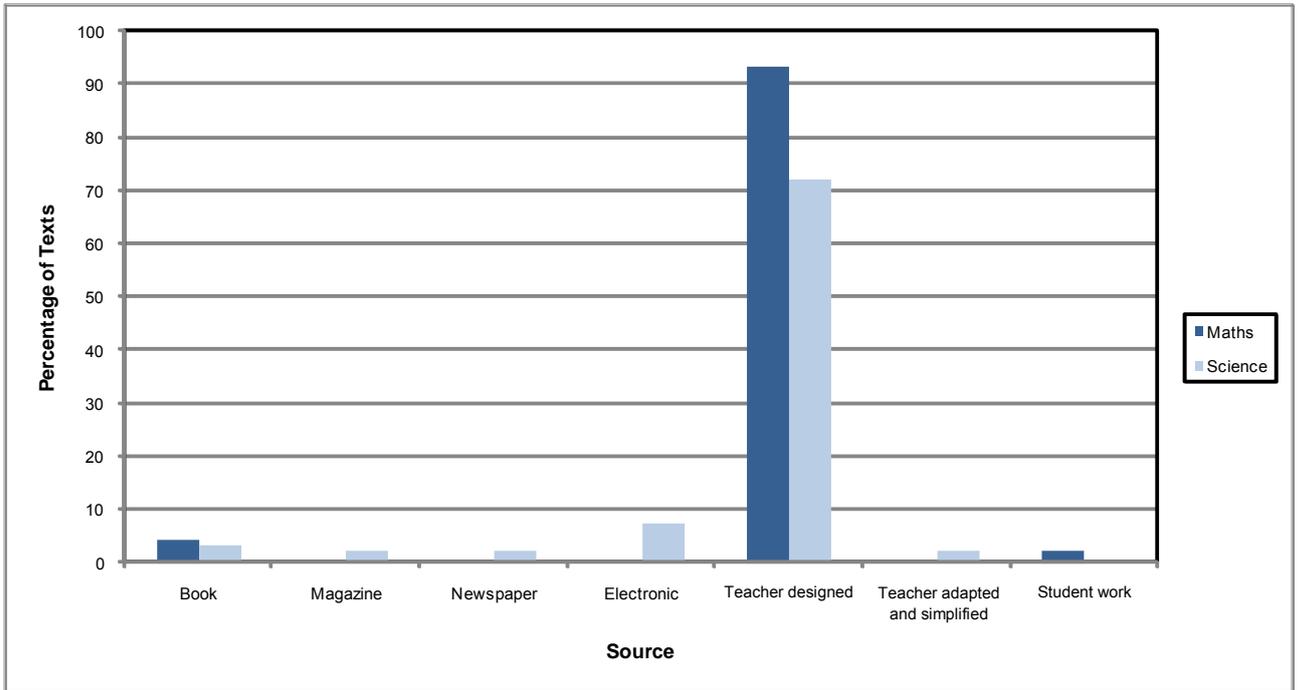
3.1.1.1 What was the source of text used in mathematics and science classes?

A total of 91 texts were delivered to students to read overall. Of these, both subjects' texts were largely teacher designed, particularly in mathematics (93% of cases, compared with 72% for science).

In mathematics classes, the only other sources of text were book (4%) and student work (2%), while science classes included a wider range of texts, including book (13%), magazine (2%), newspaper (2%), electronic (7%)

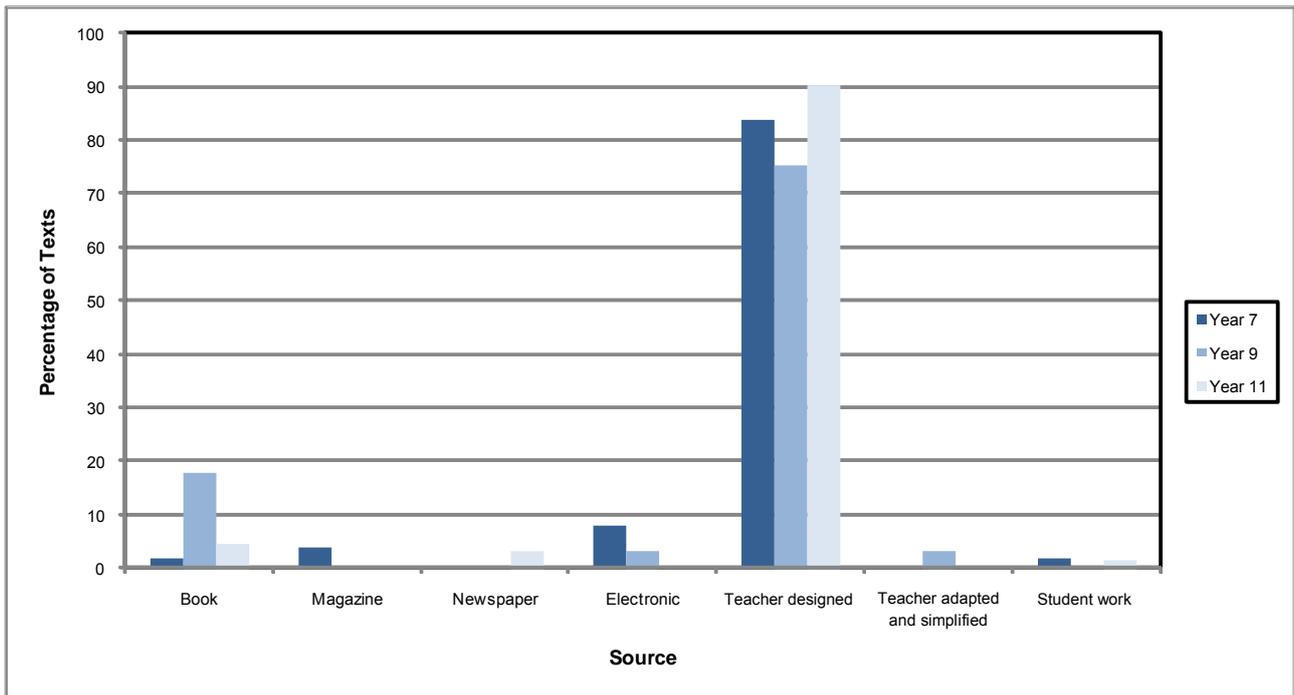
and teacher adapted and simplified (2%). The distribution of text sources between the subjects is presented in Figure 3.

Figure 3: Source of texts used in observed mathematics and science classes



3.1.1.2 What was the source of text used in Year 7, 9 and 11 classes?

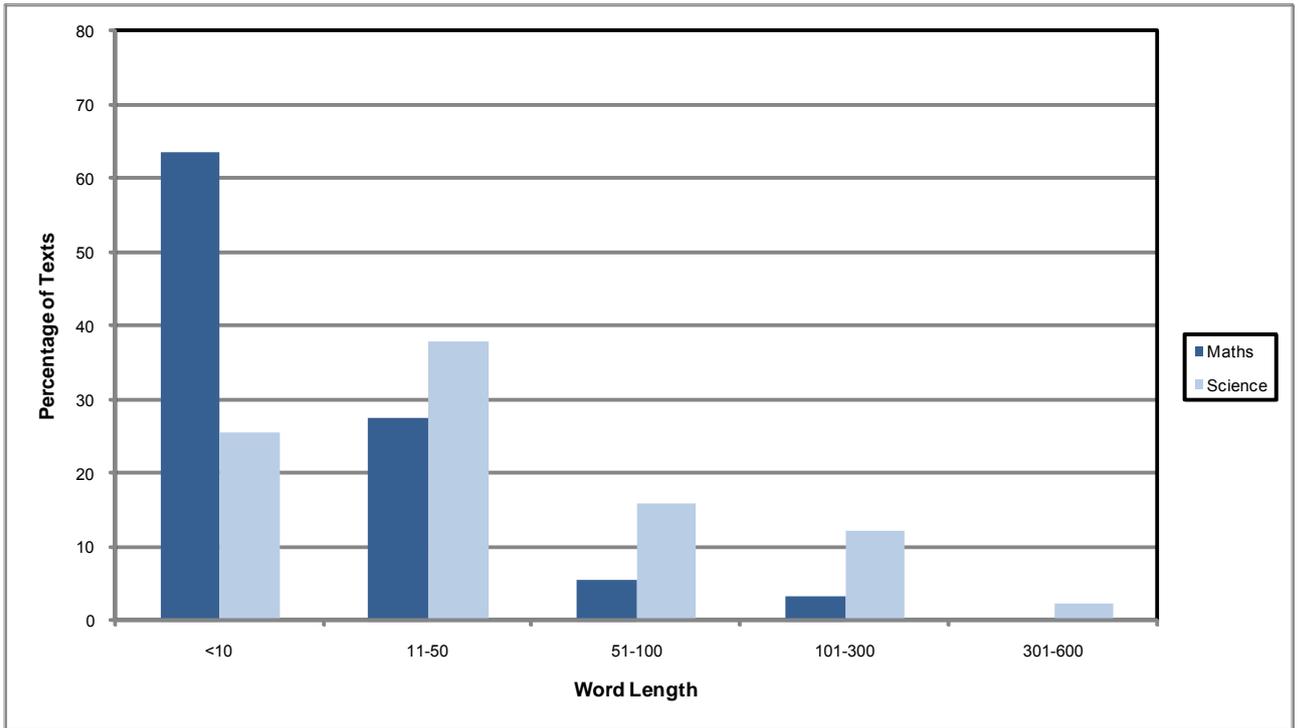
The pattern of high proportions of teacher-designed resources is replicated across year levels. In Year 7, 84% of texts were teacher designed and the remaining proportions were split between book (2%), magazine (4%), electronic (8%) and student work (2%). In Year 9, 75% of texts were teacher designed, while texts in book form comprised 18%. Small proportions of text in electronic form (3%) and teacher adapted and simplified texts (3%) were observed. Year 11 classes had the highest proportion of teacher-designed text (90%), with small proportions of book (5%), newspaper (3%) and student work (2%). The distribution of text source across year levels is presented visually in Figure 4.

Figure 4: Source of text in Year 7, 9 and 11 classes

3.1.1.3 What were the text word lengths in mathematics and science classes?

Both subject groups showed a tendency toward shorter texts, as can be seen in Figure 5. In mathematics classes, the majority of texts contained fewer than 10 words (64%), and often involved one or two word instructions (eg, “simplify” followed by a series of equations). All texts observed in mathematics classes contained fewer than 301 words, with 28% in the 11–50 category, 6% in the 51–100 category and only 3% in the 101–300 category. This pattern is similar in science classes; with the highest proportion of texts containing between 11–50 words (38%), followed by fewer than 10 (eg, schematic diagram headed “fill in the blanks”, 26%), 51–100 (16%), 101–300 (12%) and 301–600 (2%). We are not positing that longer texts are inherently more appropriate or indeed more complex. For example, short, economical, information-packed texts with a lot of ellipsis are common and challenging characteristics of mathematical and scientific language.

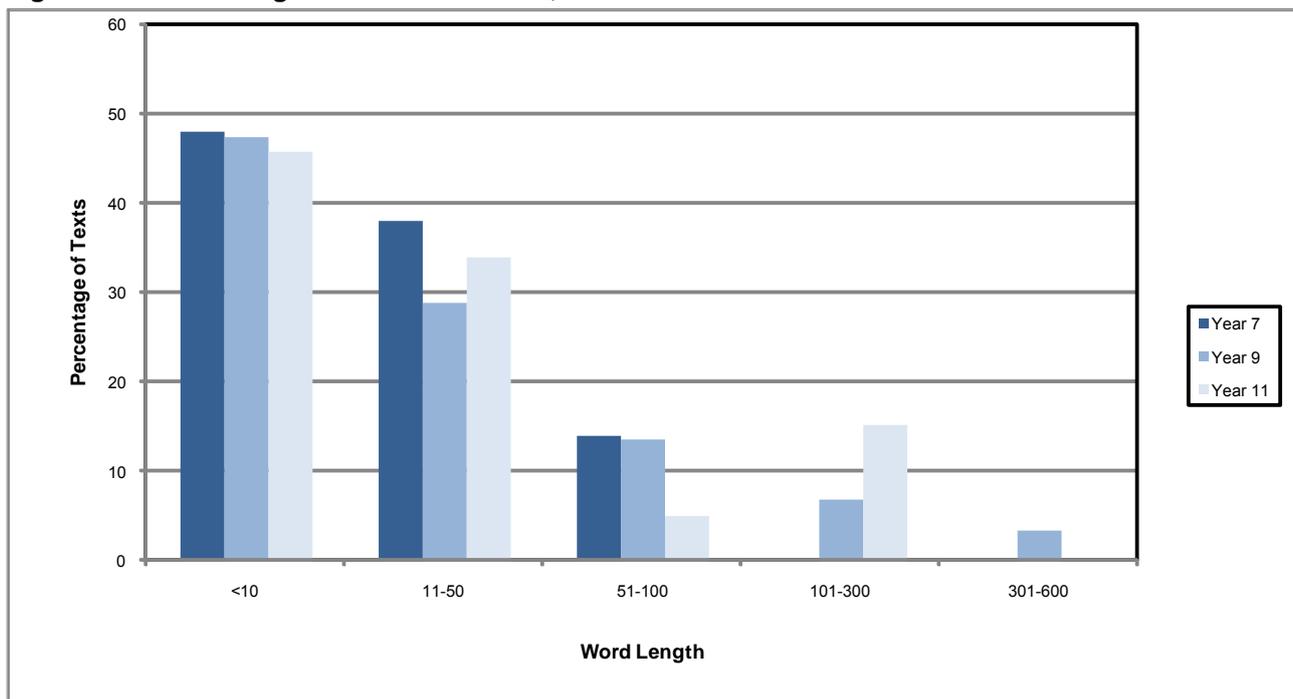
Figure 5: Word lengths of texts in mathematics and science classes



3.1.1.4 What were the text word lengths in Year 7, 9 and 11 classes?

All three year levels had highest proportions of texts in the fewer than 10 words category (48%, 48% and 46% for Years 7, 9 and 11 respectively). The distribution of word lengths across year levels is visually displayed in Figure 6. In Year 7, all texts contained fewer than 101 words, with 38% of texts containing 11–50 words and 14% containing 51–100 words. By Year 9, some longer texts were observed, with 29% of texts contained in the 11–50 category, 14% in the 51–100 category, 7% in the 101–300 category and 3% in the 301–600 category. Texts observed in Year 11 classes contained relatively high proportions in the 11–50 category (34%), small proportions in the 51–100 category (5%), and moderate proportions in the 101–300 category (15%).

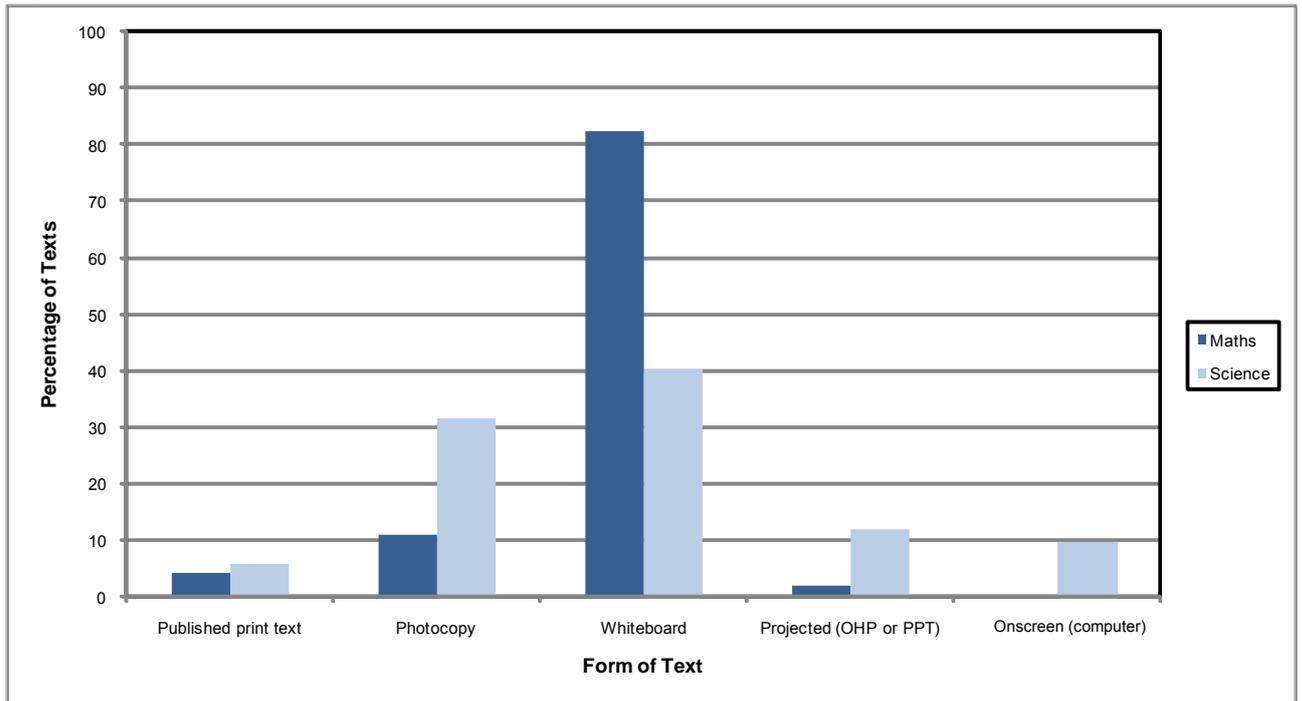
Figure 6: Word lengths of texts in Year 7, 9 and 11 classes



3.1.1.5 How were texts delivered in mathematics and science classes?

As can be seen in Figure 7, most texts in mathematics classes were delivered via the whiteboard (82%) as the content was mainly equation task based. Text form also included photocopied worksheets (11%), published print text (4%) and projected material (2%). In science classes, the distribution of text delivery was a little more even, with 40% whiteboard delivery (eg, key words or labelled diagrammatic instruction for practical tasks), photocopied text resource (32%), projected slide-show material (12%), onscreen (10%) and published print text (6%).

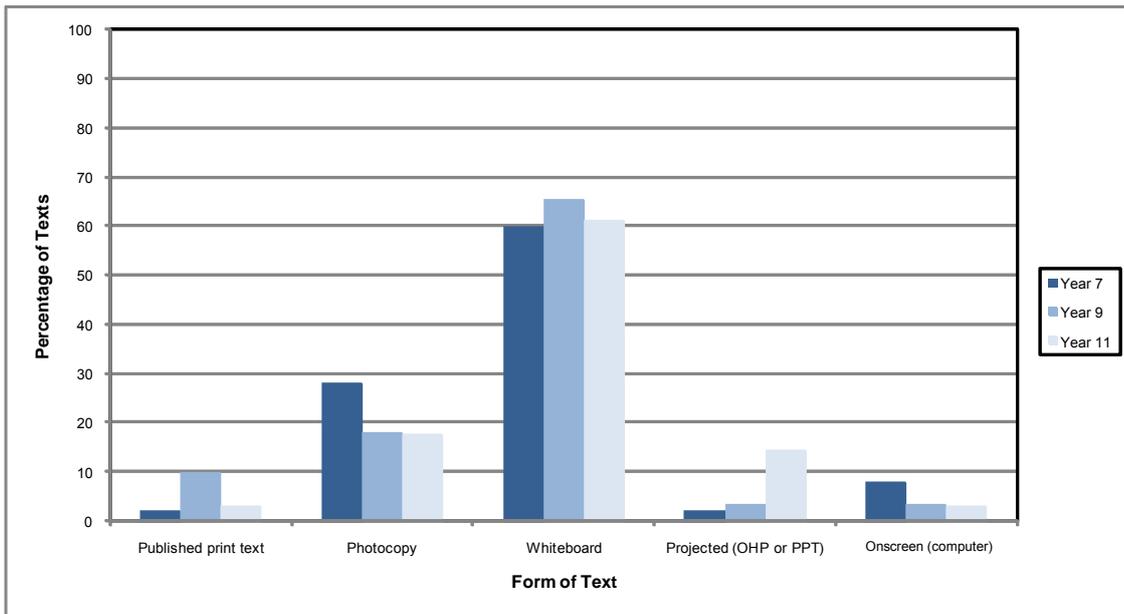
Figure 7: Form of text in mathematics and science classes



3.1.1.6 How were texts delivered in Year 7, 9 and 11 classes?

The pattern of whiteboard delivered texts being the most abundant method of delivery is consistent when split across year levels, with all three groups having similar, high proportions in this category. In Year 7, 60% of texts were whiteboard based, followed by photocopy (28%), onscreen (8%), projected and published print text (both 2%). In Year 9, 66% of texts were delivered via whiteboard, followed by photocopied (18%), published print (10%), and projected and onscreen (both 3%). Texts observed in Year 11 classes contained 61% whiteboard delivered, 18% photocopied, 15% projected, and published print and onscreen texts (both 3%). These distributions are presented in Figure 8.

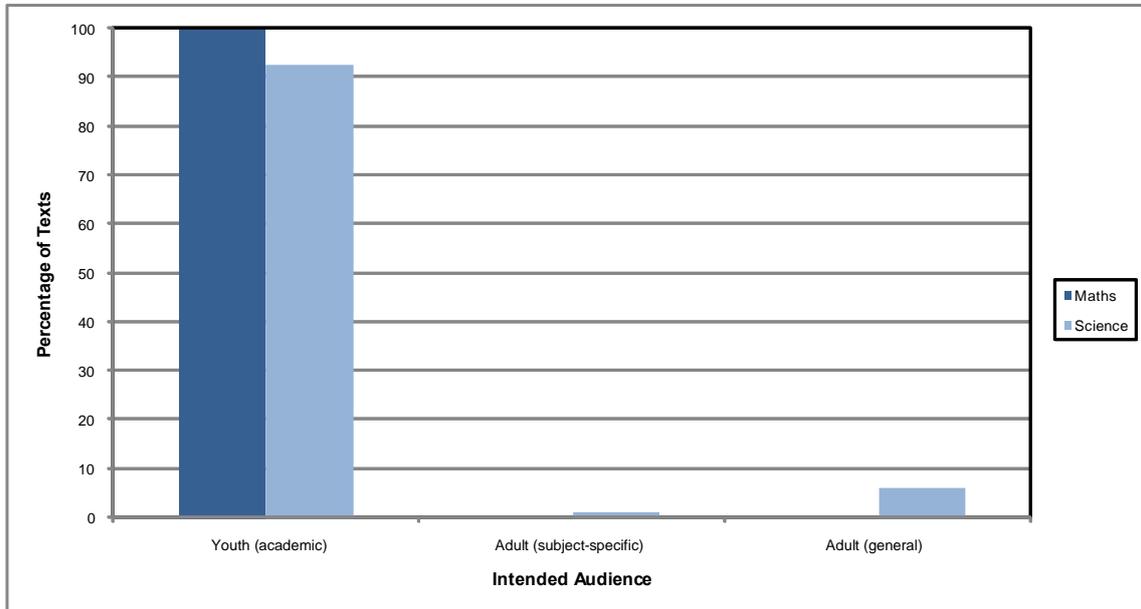
Figure 8: Form of text in Year 7, 9 and 11 classes



3.1.1.7 Who was the original intended audience of text in mathematics and science classes?

In mathematics, all texts were originally intended for an academic youth audience (100%). A large majority (93%) of the texts used in the observed science classes were also academic youth texts, although there were a small proportion of adult subject-specific or adult-general texts (1% and 6% respectively) evident as well. The distributions are presented in Figure 9.

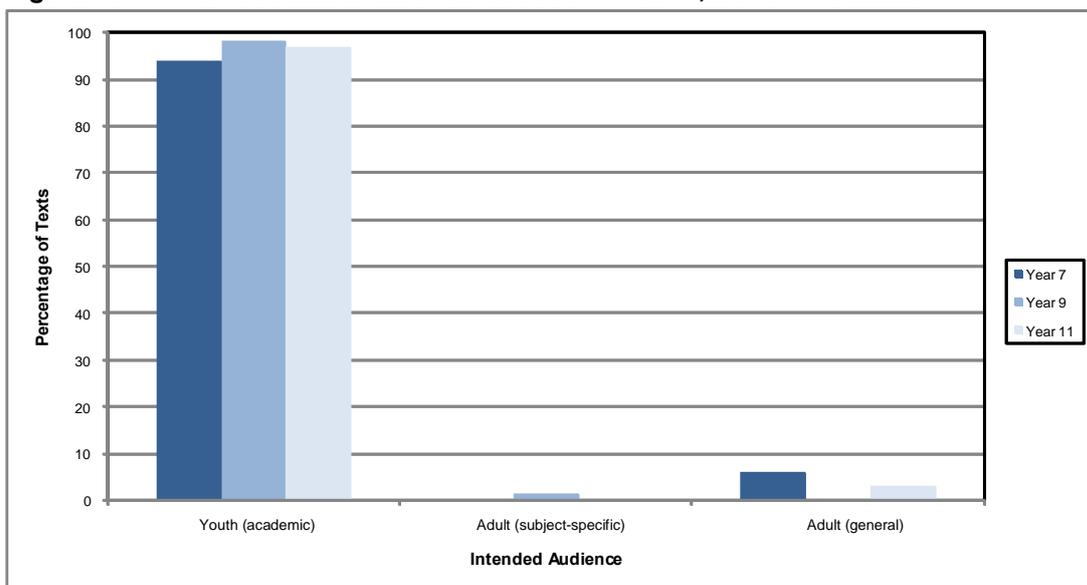
Figure 9: Intended audience of text in mathematics and science classes



3.1.1.8 Who was the intended audience of texts used in each of the Year 7, 9 and 11 classes?

As can be seen in Figure 10, all year levels had similar, high proportions of text intended for an academic youth audience (94% in Year 7, 98% in Year 9 and 97% in Year 11). Years 7 and 11 had small proportions of texts intended for a general adult audience (6% and 3% respectively), while Year 9 classes had a small proportion of text intended for a subject-specific adult audience (2%).

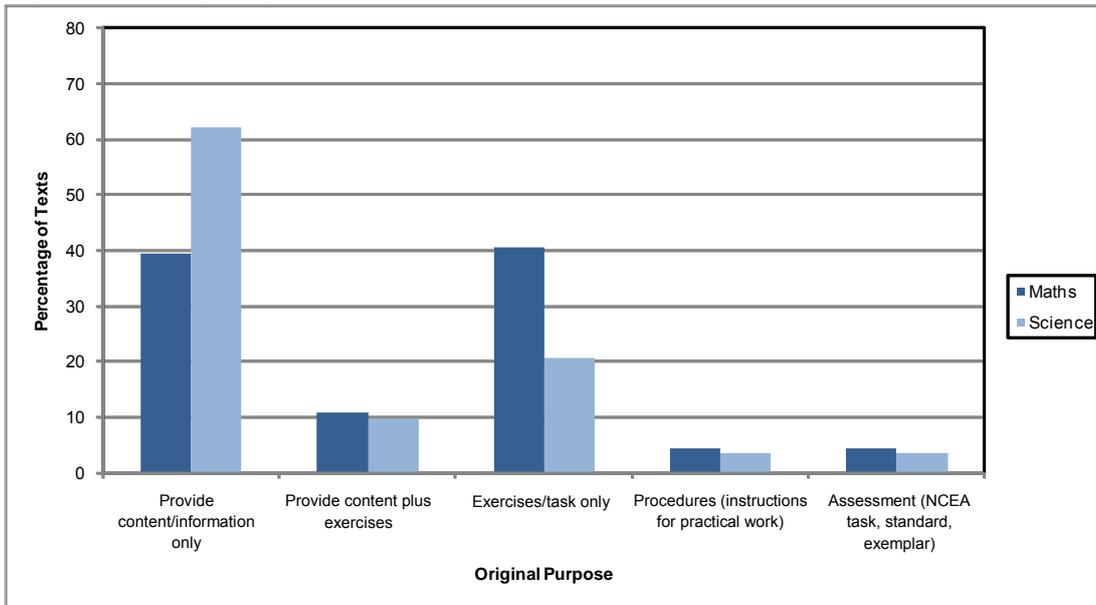
Figure 10: Intended audience of texts used in Year 7, 9 and 11 classes



3.1.1.9 What was the primary function of text in mathematics and science classes?

Figure 11 displays the distribution of the original text purpose for mathematics and science classes. In mathematics, most texts were provided as exercise/task based text (41%) and content/information text (40%), with marginal proportions of content and exercise text (11%), procedural (4%) and assessment text (4%). Many of the instances of content/information-only texts were teacher-provided worked examples. In science classes, the majority of texts were presented to provide content or information only (62%), with smaller proportions of text provided for exercise/task based text (21%), and marginal proportions of content and exercise text (10%), procedural (4%) and assessment texts (4%).

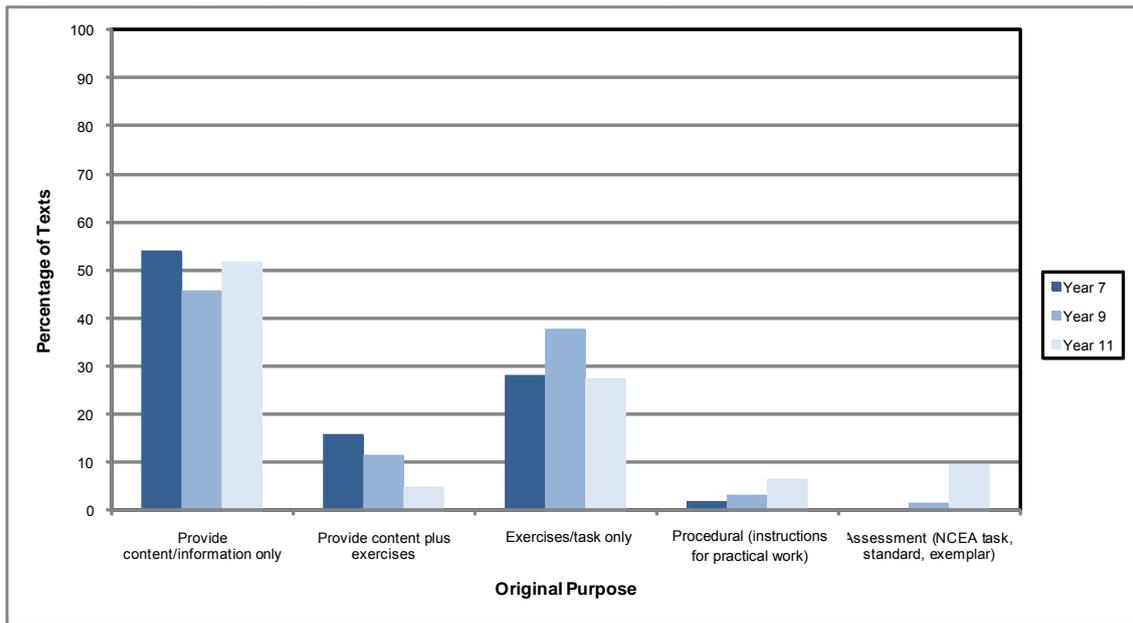
Figure 11: Original purpose of text in mathematics and science classes



3.1.1.10 What was the primary function of text in Year 7, 9 and 11 classes?

In Year 7 classes, texts were primarily delivered to provide content/information only (54%) or exercises/tasks only (28%), with much smaller proportions of content and exercise texts (16%) and a very small number of procedural texts (2%). This distributional pattern is largely replicated in Year 9 and 11 classes, as can be seen in Figure 12. In Year 9, 46% of texts were content/information based and 38% were exercise based. Content plus exercise-based texts comprised 12%, while procedural and assessment texts made up the remainder (3% and 2% respectively). In Year 11, 52% of texts were content-based and 27% were exercise-based, followed by assessment (10%), content plus exercises (5%) and procedural (7%).

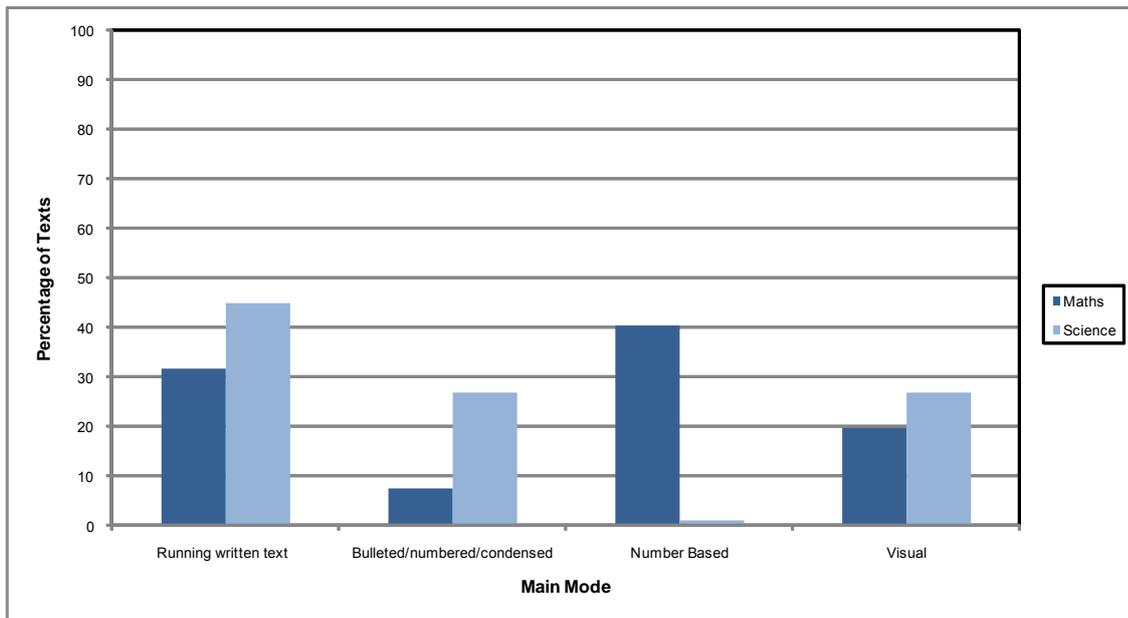
Figure 12: Original purpose of texts used in Year 7, 9 and 11 classes



3.1.1.11 What was the main mode of text in mathematics and science classes?

Unsurprisingly, in mathematics classes the highest proportions of texts were mainly number-based (41%) although there was also a relatively high proportion of running written text (32%). These were often short-sentence, instruction-based text (eg, “calculate the angle”). Texts that were primarily visual were the third most common mode (20%), and bulleted/numbered/condensed texts were the least common (8%). In science classes, running written texts were the most common (45%), followed by predominantly visual or bulleted/numbered/condensed (both 27%), with only a marginal proportion of number-based text (1%). The distributions are displayed visually in Figure 13.

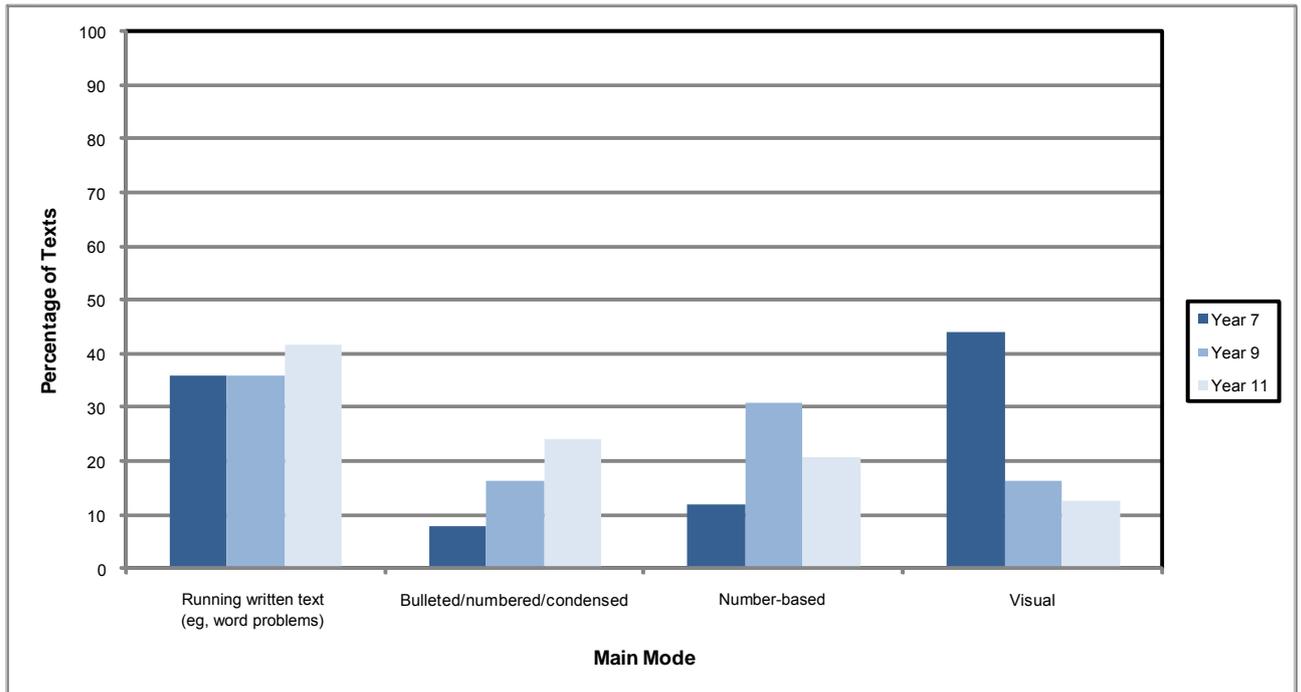
Figure 13: Main mode of text in mathematics and science classes



3.1.1.12 What was the main mode of text in Year 7, 9 and 11 classes?

In Year 7, the majority of texts were predominantly visual (44%), followed by running written text (36%), number-based (12%) and bulleted/numbered/condensed text (8%). By Year 9, the distributions have shifted to being predominantly running written text (36%) and number-based (31%), with smaller equal proportions of bulleted/numbered/condensed and visual texts (both 16%). In Year 11, we saw mostly running written texts (42%), followed by bulleted/numbered/condensed (24%), number-based (21%) and visual (13%). The distributions are presented in Figure 14.

Figure 14: Main mode of text in Year 7, 9 and 11 classes



3.1.1.13 Summary of texts used in science and mathematics classes

- A total of 91 texts were observed across the 34 lesson observations.
- High proportions of texts were designed by teachers.
- In mathematics, over half of all texts were fewer than 10 words; however, this included numerical texts with short instructions (eg, “simplify”).
- In science, the greatest proportion of texts had between 11 and 50 words.
- In both mathematics and science, the greatest proportion of texts were those written on the whiteboard.
- In both mathematics and science, texts were predominantly those written specifically for students.
- Texts had two main purposes in classes: to provide content, or as exercises or tasks.

3.1.2 Main teaching activity

The category of ‘main teaching activity’ was intended to capture what teachers were doing in the observed classes. This description of the context for the literacy teaching and learning in these classes also allows consideration of the nature of the sites for literacy learning that teachers provide. Teaching activities were coded as:

1. *Q & A* (quick-fire sessions with little elaboration)
2. *extended discussion* (discussion that includes initiation by students and elaborated response)
3. *lecture* (telling)
4. *modelling* (telling and showing)
5. *conferencing* (teacher engages in sustained — ie, more than one minute, deep, learning-focussed conversation with individuals or small groups)
6. *rove* (teacher moves around class giving short — ie, less than one minute — guidance to individuals or small groups, not necessarily learning focussed)
7. *management* (management of resources and behaviour, eg, taking the roll).

3.1.2.1 What types of teacher activities did we see in mathematics and science classes?

In both subject classes, the highest proportion of observed teacher activity was Q & A, followed by rove. In mathematics classes, we also saw relatively high proportions of modelling, management and lecture activities, with a small proportion of conferencing. In science classes, we saw relatively high, even proportions of lecture and management and small amounts of conference and modelling. The distributions and percentages are presented for each subject in Figures 15 and 16.

Figure 15: Distribution of main teacher activity in mathematics classes

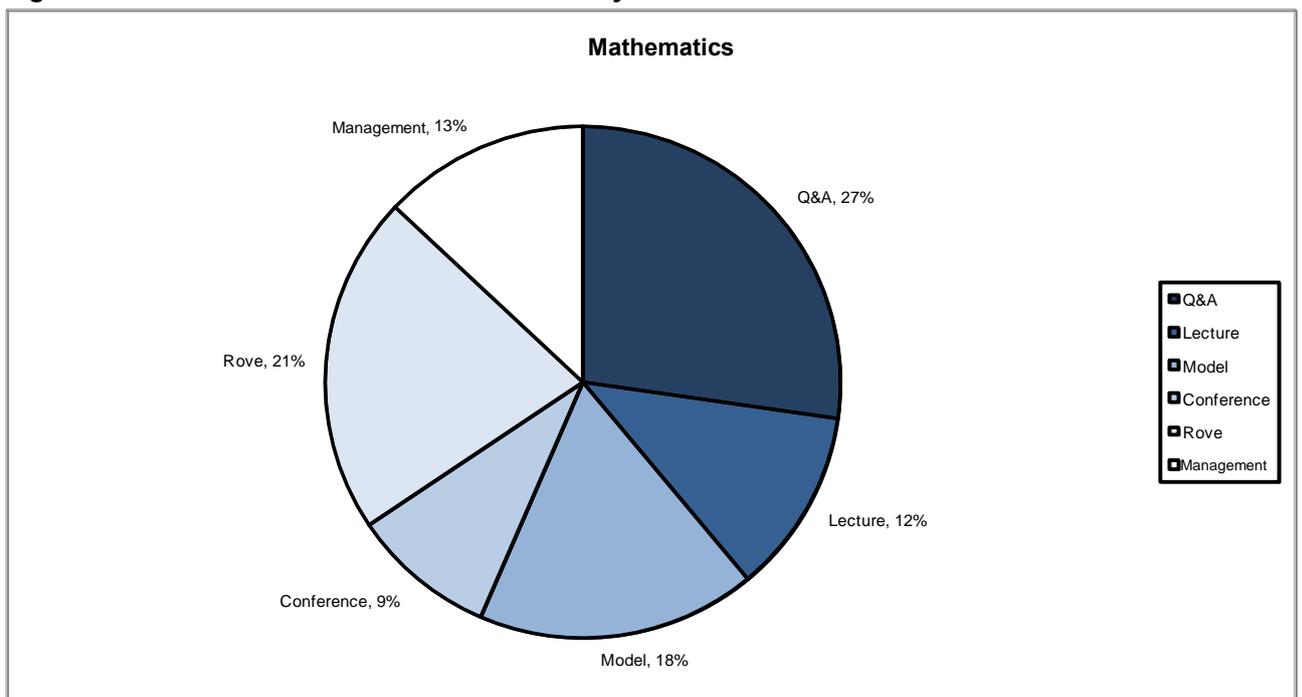
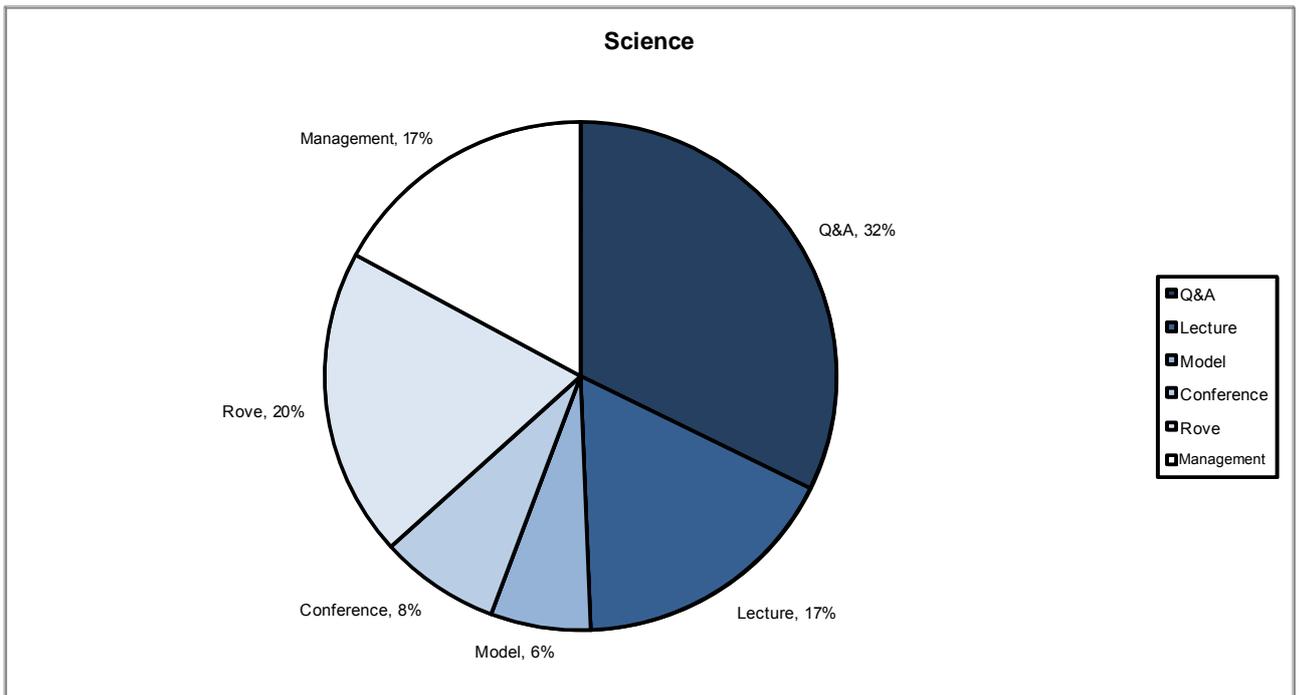


Figure 16: Distribution of main teacher activity in science classes



3.1.2.2 What types of teacher activities did we see in Year 7, 9 and 11 classes?

Main teacher activity varied across year levels. In Year 7, teachers spent most time involved in Q & A activities, followed by roughly equal time spent on lecture and management, modelling, roving and conferencing. In Year 9 classes, however, teachers spent more time roving, followed by Q & A, management, lecture, model and conferencing. By Year 11, teachers spent relatively even amounts of time on all six activities. The distributions and percentages for each year level are presented in Figures 17, 18 and 19.

Figure 17: Distribution of main teacher activity in Year 7 classes

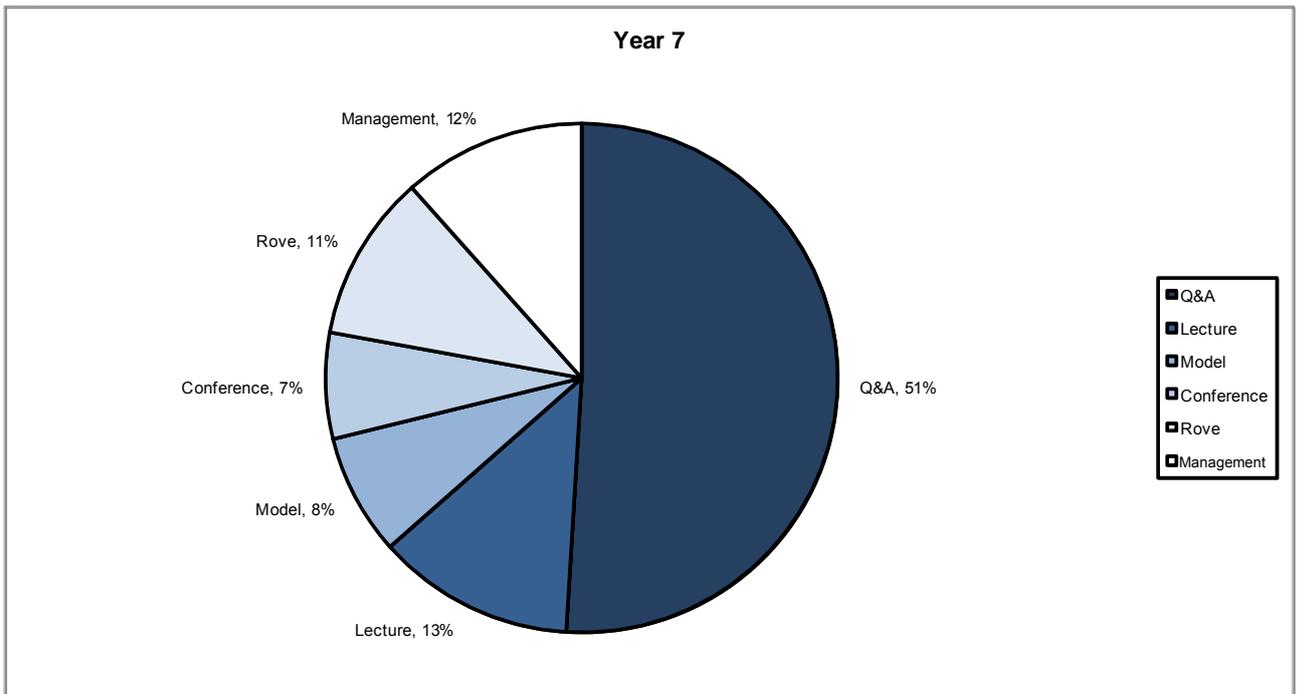


Figure 18: Distribution of main teacher activity in Year 9 classes

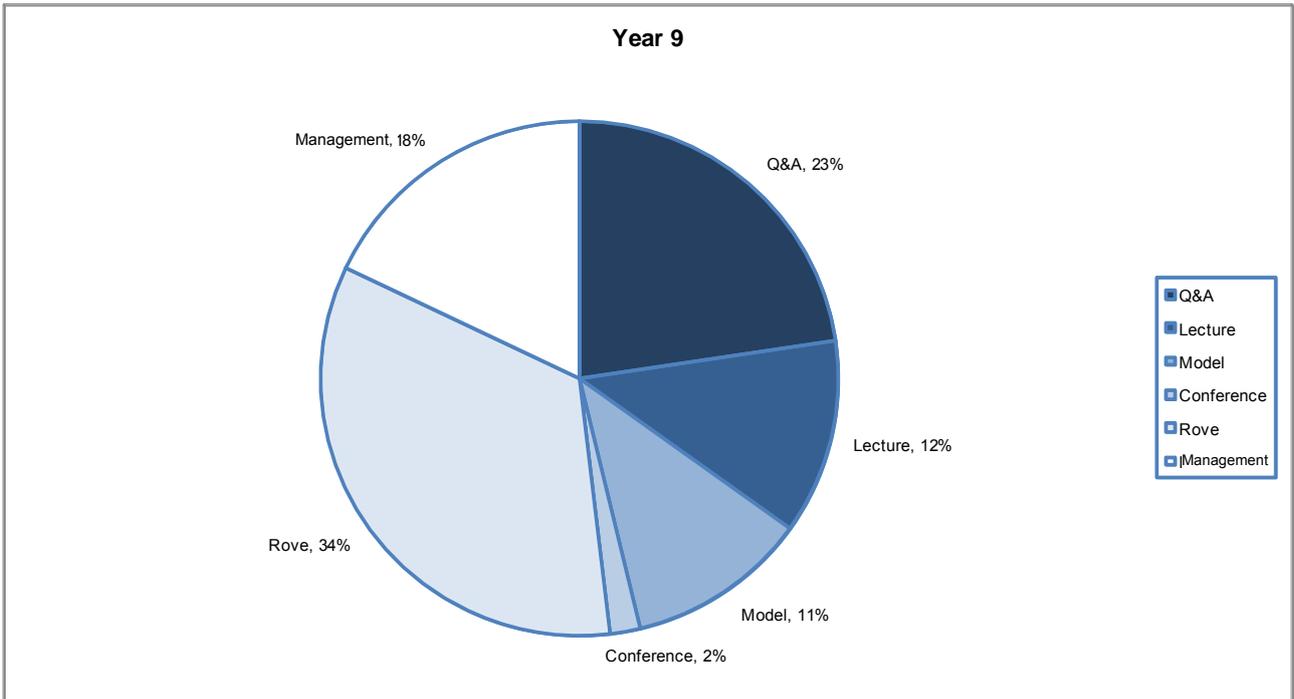
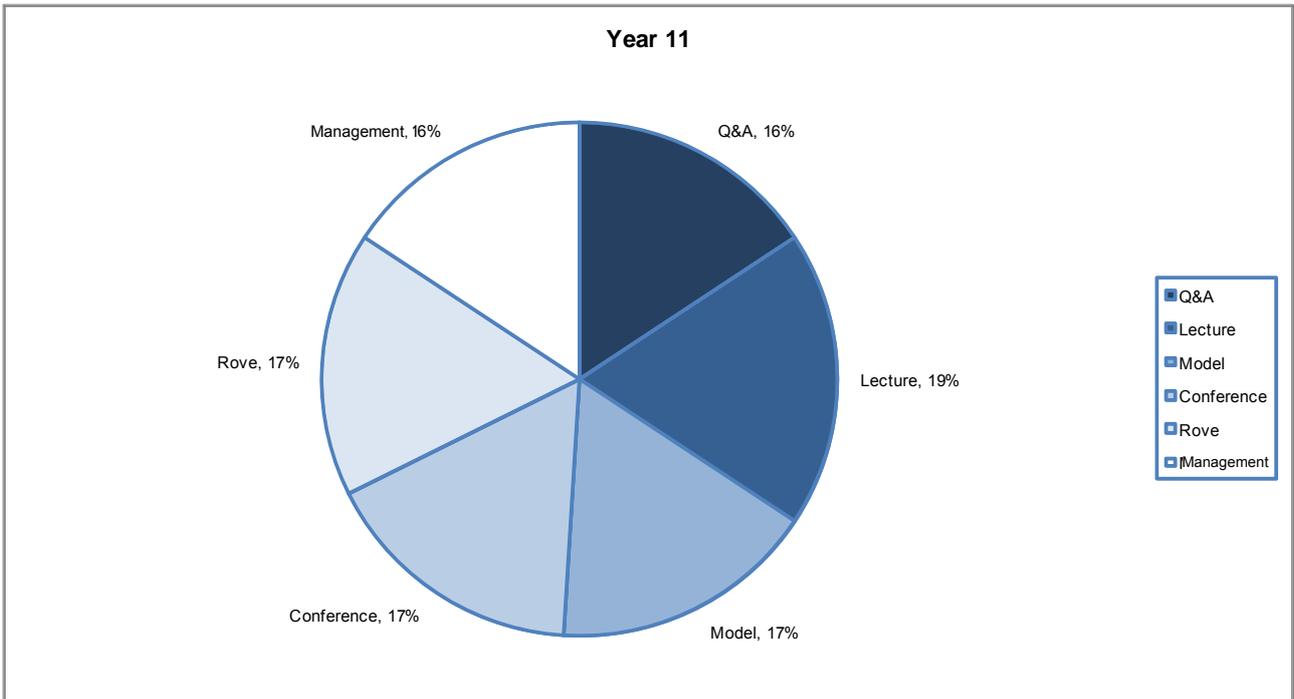


Figure 19: Distribution of main teacher activity in Year 11 classes



3.1.3 Differentiation

Classroom observations were coded to determine the level of differentiation, in terms of whether students were working on differentiated activities or toward targeted learning outcomes/objectives. Three-minute blocks were coded according to: whether lessons were designed for the whole class (no differentiation); group (different groups working towards different learning outcomes); individual (individualised learning outcomes). This analysis allows investigation of the extent to which teachers tailored instruction to divergent student outcomes (eg, group or individual learning goals) or, alternatively, provided differentiated levels of support to students with differing needs (eg, working with a group of students to scaffold meaning making from a content text).

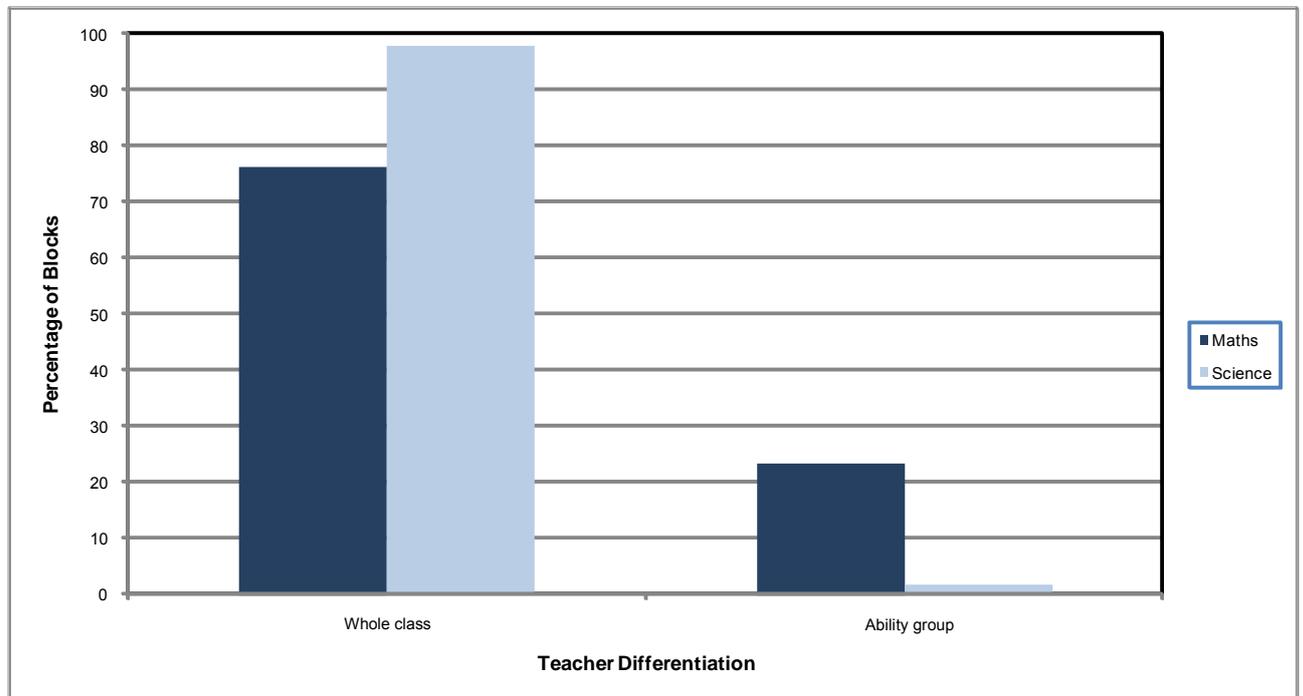
3.1.3.1 How did teachers differentiate the students in mathematics and science classes?

Students in both subjects were undifferentiated for the majority of blocks observed. In mathematics classes, students spent most of their lessons (76% of all observed three minute blocks) engaged in the same activity (undifferentiated activity). In the remaining 24% of observed blocks, students were working in ability-grouped activities.

In science classes, however, students spent 98% of observed blocks in undifferentiated activity and only 2% of blocks working in ability-grouped activity.

We observed no instance of differentiation to the level of individual students in any of the observed lessons for mathematics and science. The comparisons are presented in Figure 20.

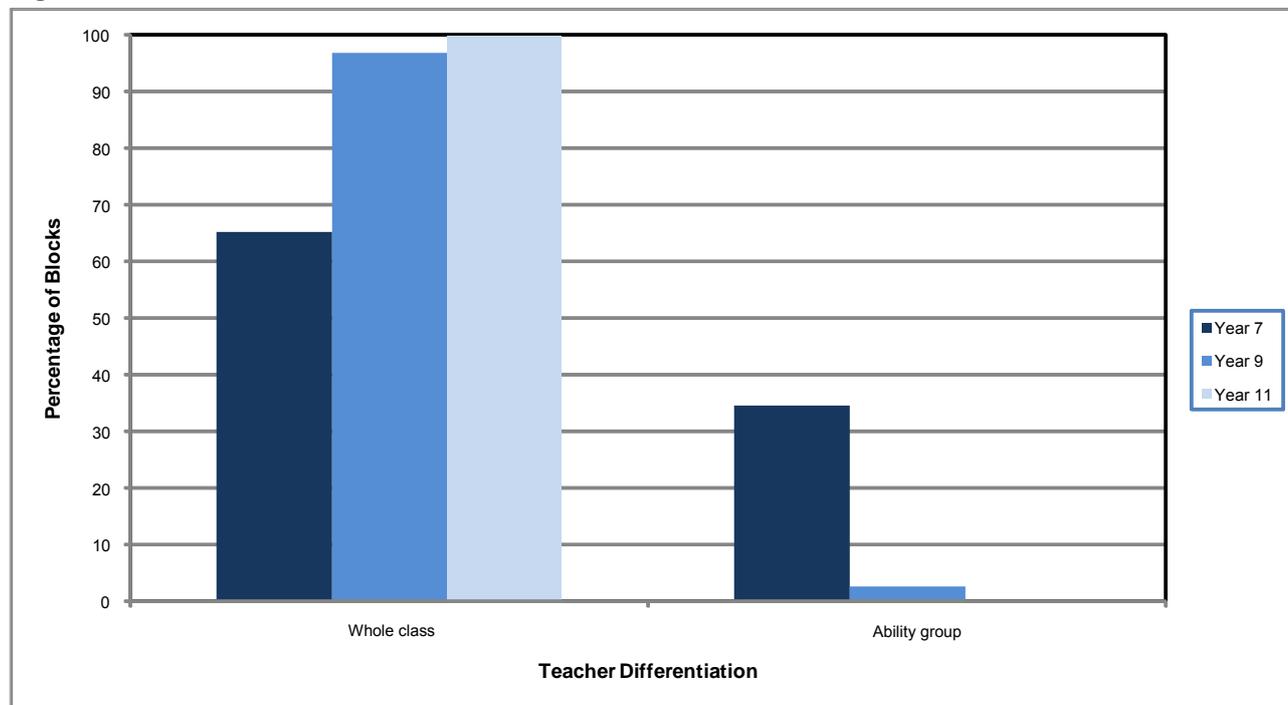
Figure 20: Teacher differentiation in mathematics and science classes



3.1.3.2 How did teachers differentiate the students in Year 7, 9 and 11 classes?

Students in all year levels were undifferentiated for the majority of observed blocks, however, students in Year 7 classes were engaged in ability-grouped activities for a higher proportion of time (35%) than Year 9 (3%) and 11 teachers (0%). Figure 21 displays this information graphically.

Figure 21: Teacher differentiation in Year 7, 9 and 11 classes



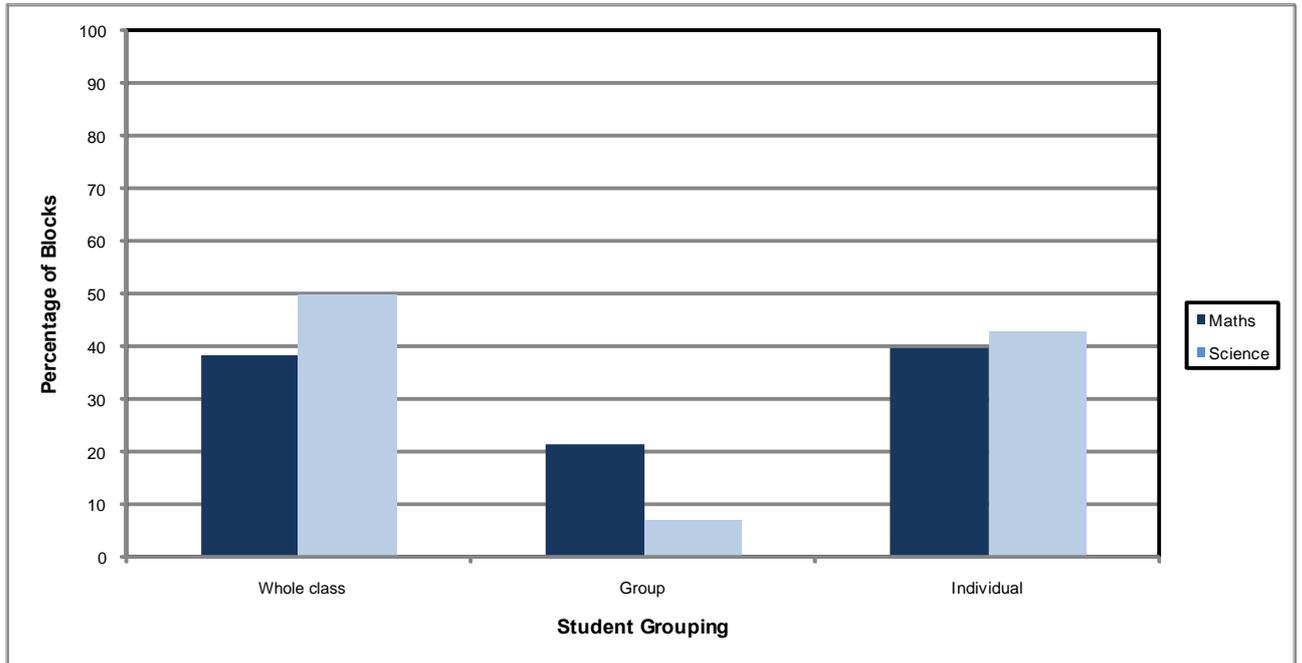
It is important to note, however, that the differentiation we observed in the Year 7 mathematics classrooms was predominantly based on mathematical ability — not literacy. We did not observe teachers offering different levels of scaffolding for students to access the same text.

3.1.4 Main student groupings

Classroom observations were coded according to the size of the group that students were working in. Students could be working as a whole class, in groups or as individuals. The grouping variable was assigned according to physical groups of students that had been directed to work together. This variable needs to be distinguished from the level of ‘differentiation’, previously discussed. For example, students may have been working toward whole-class objectives (undifferentiated), but be working in groups or alone.

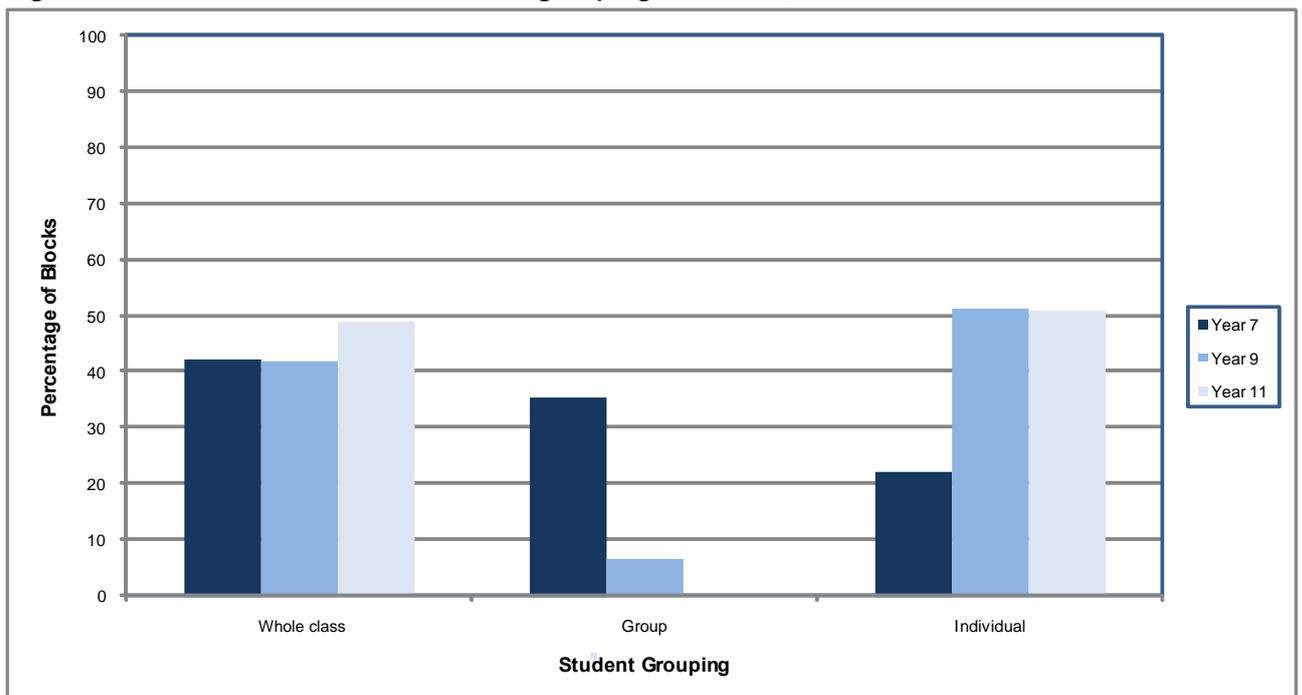
3.1.4.1 What were the main student groupings in mathematics and science classes?

Student groupings were relatively evenly distributed in mathematics classes, with comparable proportions of individual student work (40%) and whole class work (39%). Group work was observed in 22% of blocks. In science classes, students were mainly not grouped (ie, whole class, 50%) or working individually (43%), with only a small amount of group work (7%). The distributions are visually displayed in Figure 22.

Figure 22: Distribution of main student groupings in mathematics and science classes

3.1.4.2 What were the main student groupings in Year 7, 9 and 11 classes?

Figure 23 displays the main student groupings in each year level. In Year 7, the proportions of time spent between the three main student groupings were relatively even, with whole-class work observed in 42% of blocks, group work observed in 36% of blocks, and individual work observed in 22% of blocks. In Year 9, students were mainly working individually (51%) or as a class (42%) with only a small amount of group work (7% of observed blocks). In Year 11, students were engaged in individual work (51%) and whole-class work (49%). No group work was observed.

Figure 23: Distribution of main student groupings in Year 7, 9 and 11 classes

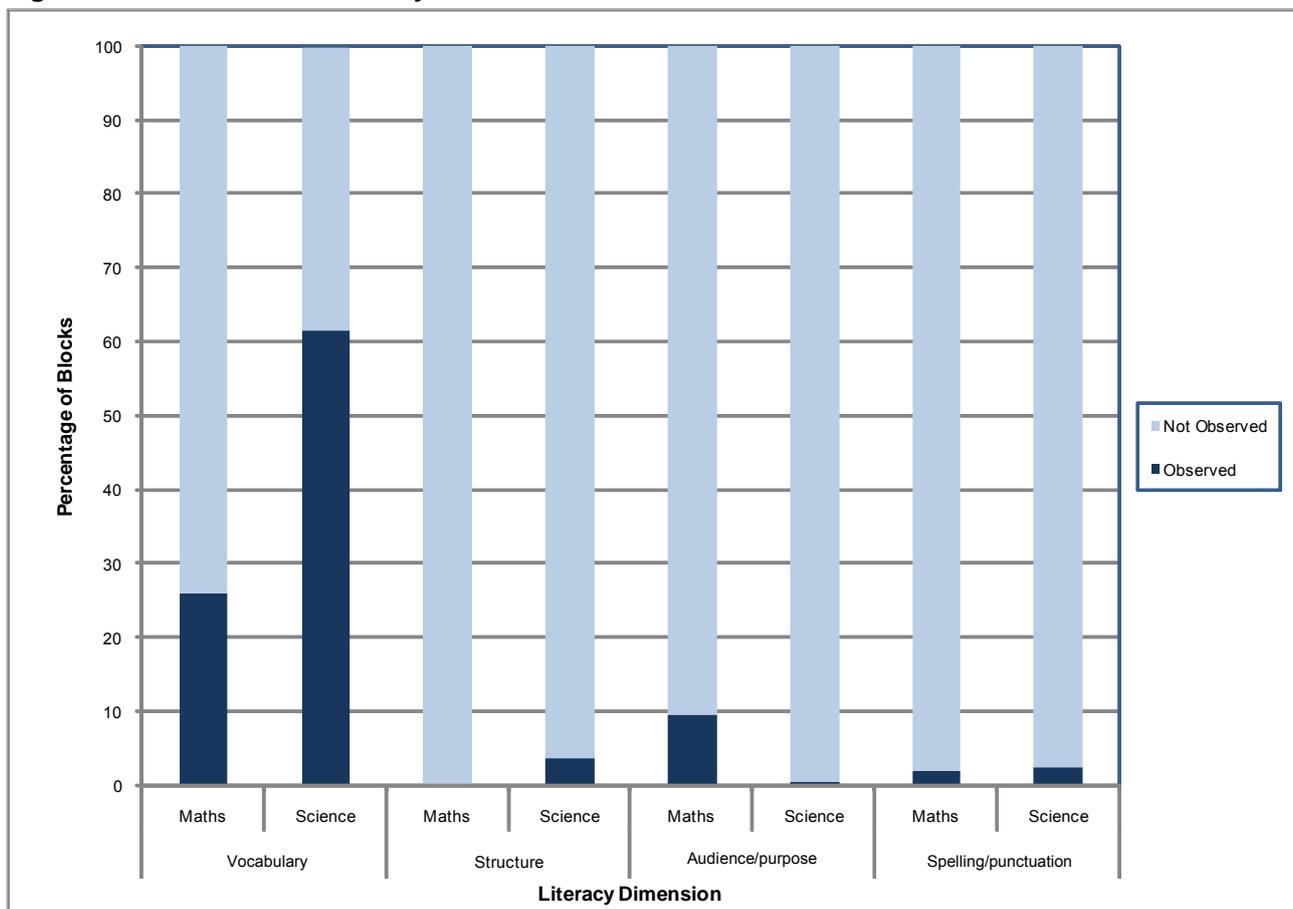
3.1.5 Literacy instruction

In this analysis we coded any instance of literacy teaching observed. This included any action on the part of the teacher identified by the observer as an attempt to build student knowledge of a language or literacy aspect of their subject. Actions included telling, modelling, and provision of texts and tasks. Therefore, one time block could include multiple categories if more than one dimension of literacy instruction was observed.

3.1.5.1 What literacy instruction did we see in mathematics and science classes?

Figure 24 presents the percentage of time blocks where literacy instruction was observed. In mathematics classes, the total number of instances of literacy instruction was fewer (observed in 38% of blocks) than the total number of instances of literacy instruction in science classes (observed in 69% of blocks). Both subjects had higher proportions of vocabulary instruction than any other literacy dimension.

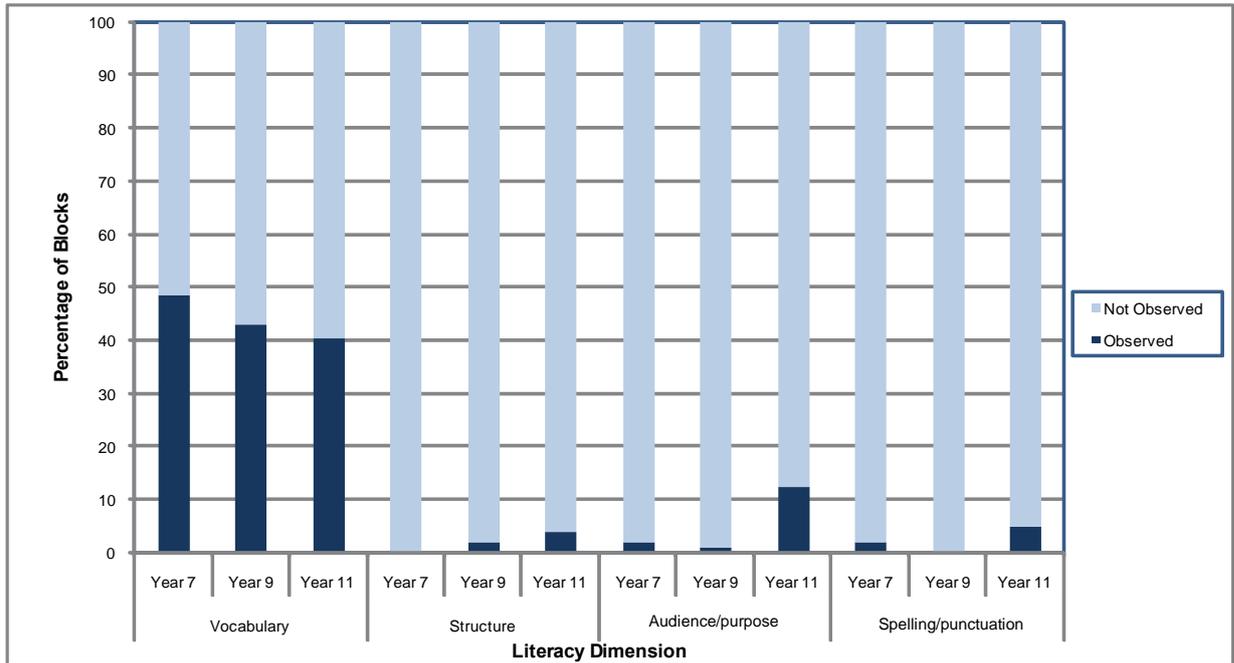
Figure 24: Dimension of literacy instruction observed in mathematics and science classes



3.1.5.2 What literacy instruction did we observe in Year 7, 9 and 11 classes?

In Year 7, the observed literacy dimensions were primarily vocabulary based (observed in 49% of blocks), with no blocks containing structure-based literacy instruction, and few blocks containing audience/purposes and spelling/punctuation instruction (both observed in 2% of blocks). In Year 9, literacy instruction was also predominantly vocabulary (observed in 43% of blocks), with few instances of structure and audience/purposes (observed in 2% and 1% of blocks respectively). No instances of spelling/punctuation instruction were observed. In Year 11, while the primary dimension was again vocabulary (observed in 40% of blocks), comparatively high levels of audience/purpose instruction were also observed (13% of blocks). In addition, instances of structure were observed in 4% of blocks and spelling/punctuation in 5% of blocks. The comparisons are visually displayed in Figure 25.

Figure 25: Dimensions of literacy instruction observed in Year 7, 9 and 11 classes



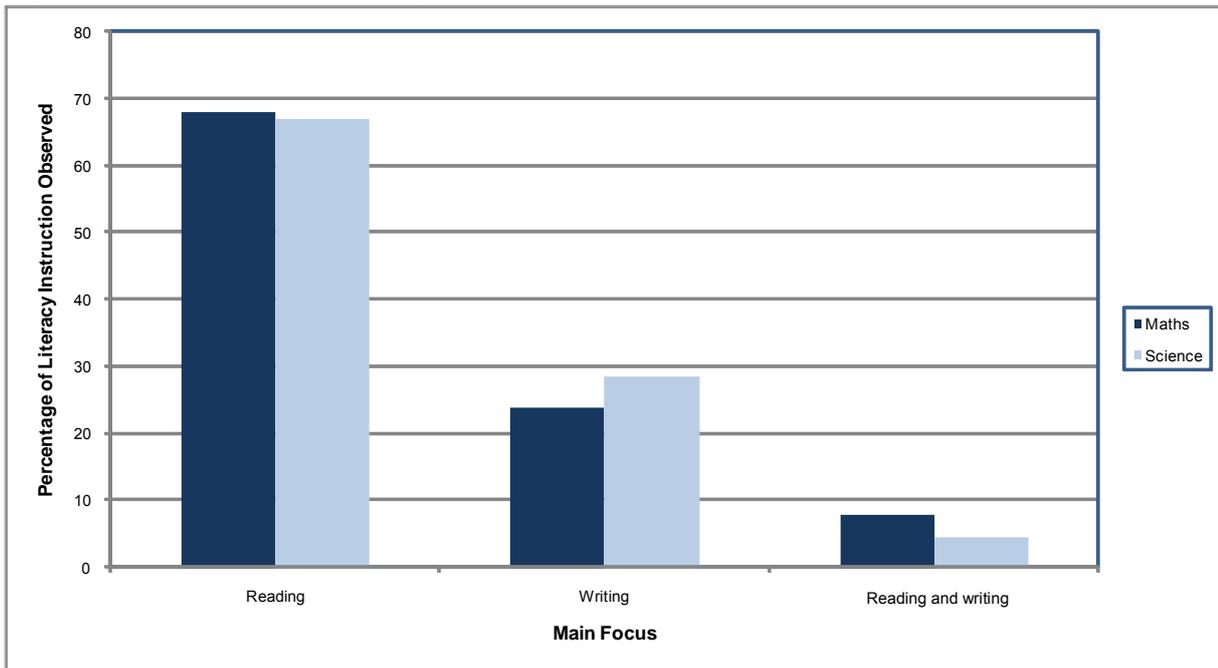
3.1.6 Literacy focus

Within instances of observed literacy teaching, each was coded according to whether the focus for the teaching was reading or writing, or both reading and writing. Note that the reading and writing category required *explicit* teacher links between reading and writing or students producing extended pieces of writing in response to reading.

3.1.6.1 What was the literacy focus in mathematics and science classes?

When literacy instruction was observed, the majority was focussed on reading for both mathematics and science classes (68% and 67% respectively). Similar proportions of writing focus were seen for both subjects (24% in maths and 28% in science). Small proportions of both reading and writing focus were seen in both subjects, with 8% in maths and 5% in science. The distributions are displayed visually in Figure 26.

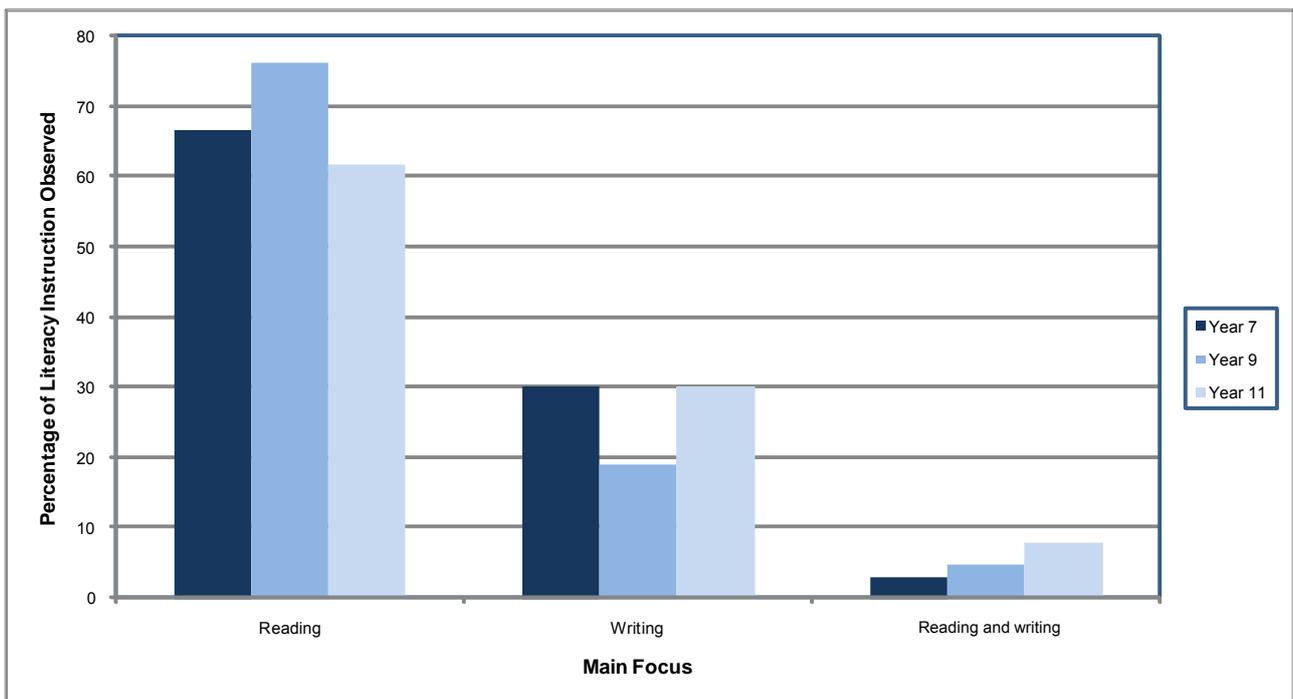
Figure 26: Main focus of literacy instruction in mathematics and science classes



3.1.6.2 What was the literacy focus in Year 7, 9 and 11 classes?

Figure 27 displays the main literacy focus within the observed classes across year levels. In Year 7 classes, when literacy instruction was observed, 67% of this literacy instruction had a reading focus, 30% had a writing focus and only 3% had both a reading and writing focus. There were similar distributions in Years 9 and 11. In Year 9, 76% of literacy instruction was reading focussed, 19% writing focussed and 5% reading and writing focussed. In Year 11, 62% of literacy instruction was reading focussed, 30% writing focussed and 8% both reading and writing focussed.

Figure 27: Distribution of main focus of literacy instruction observed in Year 7, 9 and 11 classes



3.1.7 Instructional depth

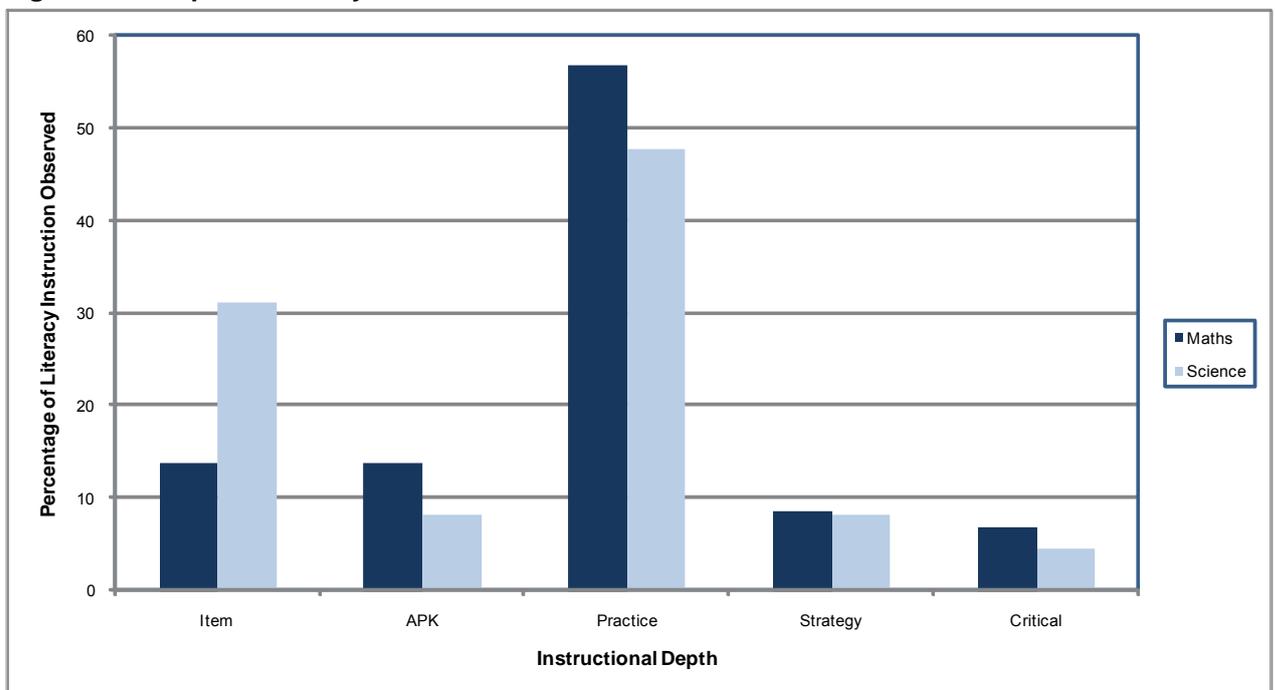
This category was designed to capture the depth to which students were required to engage with the literacy teaching. We sought to distinguish five ways in which students might be asked to engage with either general, or more subject-specific, literacy learning.

1. *Item*: direct teaching of item, eg, “a micro-organism is a ...”.
2. *Activating Prior Knowledge (APK)*: reference to, use of background, and event knowledge, eg, “What do you already know about the term ‘micro’, as in ‘microscope’?”.
3. *Practice*: opportunity to apply knowledge or skill that students already have, eg, “Try to make a list of all the words you know that have ‘micro’ as a part”.
4. *Strategy*: teaching of strategy, eg, “When you are faced with a word such as this, try seeing if you can identify the meanings of the word parts”.
5. *Critical*: instruction related to questions of power and text use, eg, bias, positioning and critique. “Why do you think you or another author might choose to use the word ‘micro-organism’, instead of the word ‘germ’?”

3.1.7.1 What level of instructional depth did we observe in mathematics and science classes?

When literacy instruction was observed, instructional depth in both subjects was dominated by practice (57% in mathematics classes and 48% in science classes). In mathematics, the remaining categories were fairly evenly distributed between item (14%), activating prior knowledge (APK) (14%), strategy (9%) and critical (7%). In science classes, a relatively high proportion of instruction was based around item (31%), with lower proportions of APK (8%), strategy (8%) and critical (5%). The distributions are visually displayed in Figure 28.

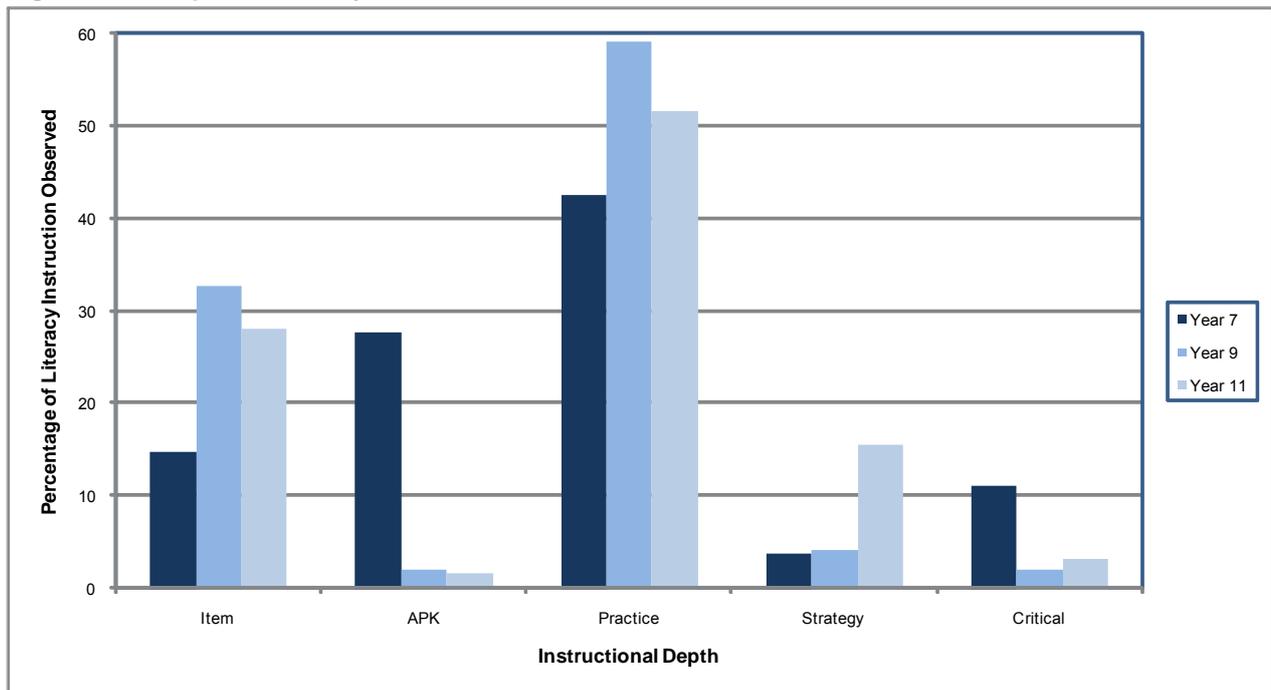
Figure 28: Depth of literacy instruction in mathematics and science classes



3.1.7.2 What level of instructional depth did we observe in Year 7, 9 and 11 classes?

Figure 29 displays the distributions of instructional depth across year levels. In Year 7 classes, when literacy instruction was observed, it was mostly practice (43%), followed by APK (28%), item (15%), critical (11%) and strategy (4%). In Year 9, most literacy instruction was practice (59%) and item (33%), with small proportions of strategy (4%), APK (2%) and critical (2%). This pattern is similar in Year 11 classes. Where literacy instruction was observed, it was mainly practice (52%) and item (28%), followed by strategy (16%), critical (3%) and APK (2%).

Figure 29: Depth of literacy instruction in Year 7, 9 and 11 classes



3.1.8 Summary of observational results

- Texts were often short, teacher-designed, content or exercise-based texts that were delivered via the whiteboard.
- Most teacher activity, between subjects and across year levels, was Q & A, followed by rove and management. The exception to this generalisation was in Year 11, where we observed even distributions of time spent in each of the six teacher activities (Q & A, extended discussion, modelling, conferencing, rove and management).
- We observed few instances of student differentiation. In other words, students were engaged in the same undifferentiated activity most of the time. Observed differentiation was predominantly ability grouping in Year 7 mathematics (on the basis of mathematical rather than literacy ability). No differentiation to the level of individual students was observed.
- Students worked individually, or as a whole class, for the majority of the observed time. The exception to this was in Year 7, where group work was more common, and students spent less time working individually.

- We observed more instances of explicit literacy instruction in science classes than in mathematics classes.
- Literacy instruction was predominantly vocabulary-based instruction.
- Of the literacy-based activities students were engaged in, reading was the most common, followed by writing. We observed few instances of reading *and* writing activities.
- The literacy instruction was predominantly practice-based, ie, students were given opportunities to apply existing knowledge. This was consistent between subjects and across year levels.

3.2 Subject Literacy Pedagogical Content Knowledge Tool

In order to investigate teachers' knowledge about the literacy and language of science and mathematics, teachers were asked to respond to our SLPCK Tool (Appendix C). In this questionnaire, teachers were given tasks from NCEA Level 1 Mathematics and Science standards (Appendices D and E), and asked to comment on the literacy demands of these tasks, in terms of the difficulties that the students at their level would face, and what teacher actions they felt would support students to cope independently with such tasks. In total, just eight teachers (four mathematics and four science teachers) agreed to take part in this aspect of the research, which means that results can only be indicative. However, when considered as a group, the teachers' responses provide an indication of the literacy demands of texts that are most salient to teachers. They also provide some indication of the sorts of teaching approaches that subject teachers understand as meeting these literacy needs across Years 7, 9 and 11. Table 1 summarises the results.

3.2.1 What types of problems did teachers think students may have in reading and understanding the text in the NCEA task?

3.2.1.1 Mathematics

Mathematics teachers who responded to the SLPCK Tool all identified that successful completion of the task depended on students extracting key information from the context and translating it into a mathematical form by completing the probability tree. One teacher described this process as “keeping what is important and discarding other words and excess information”. The reading challenges posed by the text were those which were perceived as making this process of translation difficult.

Teachers' responses were focused mostly on vocabulary; all four mathematics teachers identified that challenging subject-specific vocabulary items could be a barrier, while three also felt that unfamiliar ‘context’ words might be. Subject-specific words identified as potentially challenging included ‘probability’ and ‘random’ whereas difficult general context vocabulary included ‘vintage car’, ‘oil pressure’ and ‘reliable’. While the identification of such terms implies that the teachers saw this as an issue of experiential knowledge, as well as vocabulary, no teacher explicitly identified it in those terms.

Non-vocabulary features of the text that teachers thought would make the task more difficult were typically expressed in quite general terms, and such features were only ever identified by one teacher each. For example, one teacher wrote that the layout of the question “is not easy to follow”, and another that students “are often conditioned into thinking that word problems are the hard ones” and lack resilience to “deconstruct paragraphs of information.” A third teacher wrote that students “may not understand tree diagrams”, but went on to say that “I don't believe that this is a language barrier, more of a maths knowledge one”.

Table 1: Summary of mathematics and science teachers' responses to the Subject Literacy Pedagogical Content Knowledge Tool (N=8)

Subject	Year Level	Teacher	Problems Identified ¹	Types of Action ²
Mathematics	7	A	Prior content knowledge	Practice
			Subject-specific vocabulary	Practice
			Reading strategies	Strategy (keyword)
Mathematics	7	B	Subject-specific vocabulary	Direct teaching
			General vocabulary	Strategy (context clues)
			Prior content knowledge	Direct teaching
			Form	Strategy (keyword)
Science	7	C	Subject-scientific register	Practice
			Prior context knowledge	None
			Subject-specific vocabulary	Direct teaching
			General-academic vocabulary	Direct teaching/practice
			Form	Practice
			Writing	None
Science	7	D	General-academic vocabulary	Direct teaching
			Subject-specific vocabulary	Practice
			Prior general knowledge	Practice
			Subject-specific vocabulary	Activities
			Subject-specific vocabulary	Activities
			General academic structure	Practice
			Prior content knowledge	Practice
Mathematics	9	E	Literacy strategies	Practice
			General vocabulary	None
			Subject-specific vocabulary	Direct teaching
Science	9	G	Subject-specific vocabulary	Activities
			Prior content knowledge	Activities
			Strategy	Direct teaching/activities
			General-academic structure	Practice
			General-academic structure	Practice
			General-academic structure	Practice
Science	9	H	Subject-specific vocabulary	Direct teaching
			General-academic vocabulary	Direct teaching
			Form	Practice
			General-academic structure	Practice/direct teaching
			Subject-specific vocabulary	Practice/activities
Mathematics	11	J	Subject-specific vocabulary	Strategy (keyword)
			General-academic structure	Strategy (context clues)
			General vocabulary	Practice

¹ The literacy problems that teachers felt students would have in understanding the text in the sample NCEA question.

² The types of actions teachers would take to support students overcome the identified problems.

3.2.1.2 Science

Consistent with classroom observations, student knowledge of vocabulary was the most common barrier to text understanding/task completion that the teachers identified. All four science teachers cited academic topic words such as ‘sterilised’, ‘process’ and ‘micro-organism’ as a type of potentially problematic vocabulary. Three of the four science teachers also identified that students needed to recognise that general academic vocabulary items such as ‘name’ and ‘explain’ should guide the length and depth of their responses. No science teacher identified examples of everyday vocabulary related to the context of the problem such as ‘bottling’, ‘air bubbles’ or ‘refrigerated’ as likely to be problematic for students.

Science teachers also identified potential gaps in students’ prior knowledge which might affect their comprehension of the text, however, most of these gaps were to do with students’ subject content knowledge. All four of the science teachers identified aspects of reading other than vocabulary that might affect a student’s comprehension, but these were often non-specific or at a fairly surface level. The specific aspects of the text most commonly identified as making the text more challenging to read were to do with it having several different sections and the examiner’s use of bolding to highlight the key words.

3.2.2 What actions did teachers suggest to prepare students to cope with those problems in future?

3.2.2.1 Mathematics

Most mathematics teachers identified some form of direct teaching, particularly subject-specific vocabulary as a means of addressing this problem. All teachers also proposed providing students with opportunities to practice vocabulary. Several teachers presented extended lists of vocabulary teaching activities, for example, “[g]ive vocab list, crosswords, matching, cloze exercises, fill in the blanks, class quiz”. Teachers identified a range of strategies that they thought would be useful for students to learn, with the most commonly cited being underlining key words. Another strategy suggested by two of the teachers was a form of keyword strategy in which students are taught to look for a key word which informs them of which operation to use.

Two teachers identified that it might be useful for students to use context clues to solve unfamiliar vocabulary. There was only one case, however, in which a teacher indicated that the texts students need to practice with were of the “word-based problem with an unfamiliar context” type. Other answers suggested that teachers were confident that they would support students to work through problems in class but would find it difficult to know what they could do to foster student independence in literacy. As one put it, “To be honest I haven’t done anything in the past. Usually I say at the start of assessments that if you have trouble understanding a word or the content put your hand up and I will explain it to you”.

3.2.2.2 Science

All teachers noted the importance of explicitly teaching key science topic words, either by telling students or by providing a glossary. One teacher gave a more elaborated answer, describing the possibilities of reinforcing word meanings through the use of multiple examples and analogies. The science teachers also showed a strong understanding of the importance of students having repeated exposure to and practise using important topic words. One teacher expressed this as the importance of students ‘playing’ with new words, and the activities mentioned by the other teachers suggested that they too saw this sort of word play as important: all four identified a wide range of activities in which students played with new vocabulary, including poems, songs, cloze exercises, clines, barrier games, matching activities, and crosswords.

3.3 Teacher interviews

Where possible, teachers participated in ‘debriefing’ interviews soon after one or more of their three observed lessons. The following results were obtained from a total of 25 teacher interviews.

3.3.1 What did teachers want their students to learn (literacy goal for the lesson)?

Qualitative analysis of the transcribed teacher interviews revealed that most teachers identified, as a literacy goal for the particular lesson that had been observed, that they wanted their students to know and understand the vocabulary of their subject (receptive vocabulary). Many of the teachers also wanted their students to be able to use the vocabulary of their subject in a meaningful and precise way (productive vocabulary). Teachers also wanted their students to be able to extract specific components from written text (reading to sift, find and reorganise information) and understand the linguistic content of the text (reading for understanding). Some teachers’ goals were writing goals, although these were usually qualified as being a requirement of assessment tasks. Goals also included non-specific reading goals, visual language goals and the ability to name the specific style and linguistic protocols of their subject (declarative genre knowledge). In their interviews, two teachers declared that they had no literacy goal for that lesson. The results are presented visually in Table 2, where each shaded cell indicates the associated teacher response.

3.3.2 What reasons did teachers give for their literacy goals?

After being asked about their literacy learning purpose, teachers were then asked for their rationale for that purpose. Table 3 presents the results of the analysis. While many teachers explained that their reasons for teaching literacy were due to the fact that students with poor literacy skills would struggle with the content (literacy as a barrier), teachers also believed that a part of their subject demanded special forms of literacy, which were usually vocabulary-based. Teachers of all year levels believed literacy to be particularly needed for higher achievement, for example, to achieve Merit and Excellence grades in NCEA assessments. Some teachers felt that literacy was an inherent part of their subject, and some felt that a literacy component was important to extract subject knowledge and relate it to real-life situations. Two teachers acknowledged that they were not focussed on literacy teaching in that lesson, one of whom explained that literacy was not an important part of the subject, but was necessary as it is part of the curriculum.

3.3.3 How do teachers consider that they teach literacy?

Teachers were asked about what they did in their lessons to achieve their intended literacy purposes. Teachers often reported that they chose structured, scaffolded tasks to help students understand the literacy component of their subject. Many teachers believed that they taught literacy by repeated exposure to the subject vocabulary, and by explicitly modelling strategies to help students learn techniques for decoding vocabulary. Teachers also modelled answers, and left students to work out the strategies for themselves. Lower year level teachers also reported the importance of students' discussion and idea-sharing (discursive strategies). Practice-based tasks was another theme, either as a writing-focussed practice task or by allowing students to familiarise themselves with simpler tasks before working their way into more complex problems. Two teachers said they strategically laid out the classroom to allow students of mixed abilities to pair and share, while two different teachers used story-telling/real life techniques to add relevance and context to the literacy aspect of their subject. A further two preferred a visual approach with careful selection of text. One teacher deliberately provided inaccurate answers to evoke responses from students, and another relied on students' copying from the board. One teacher preferred to avoid whole-class literacy instruction, and assist individuals one on one where necessary. The results are visually presented in Table 4.

Table 4: How teachers consider they teach literacy by subject and year level

		Teacher A	Teacher B	Teacher C	Teacher D	Teacher E	Teacher F	Teacher G	Teacher H	Teacher I	Teacher J	Teacher K	Teacher L
Theme	Example	7 Maths	7 Maths	7 Science	7 Science	9 Maths	9 Maths	9 Science	9 Science	11 Maths	11 Maths	11 Science	11 Science
Discursive strategies	Importance of students sharing ideas and strategies in discussion												
Evoking argumentation	Through offering inaccurate answers												
Familiarity/ repeat exposure	Repetitive use of words												
Giving real life examples/ storying	Adding in a story												
Incidental working with individuals	Whole class teaching not focussed on literacy, but teaching literacy when supporting individuals to make meaning when reading 1:1												
Modelling answers (students need to infer strategies)	Identifying key words for students												
Explicit modelling of strategies	Word parts — clues to vocabulary												
Allowing for peer support (seating/talking)	Pairing students to help each other read the question												

Continued...

3.3.4 How do teachers judge how effective their lessons are in achieving their literacy learning goals?

Teachers were asked how they knew whether they had achieved their literacy goals for the lesson. As a generalisation, teachers' strategies mainly relied on observation of students' 'output' during the lesson. Most of the teachers used question and answer sessions or roving to assess their students' level of understanding. One watched body language for clues. Another thought delivery of the lesson was sufficient. However, the responses from the Year 7 teachers seemed qualitatively different from those of the Year 9 and 11 teachers. At Year 7, both mathematics teachers asked the students to self-assess, while both of the science teachers asked the students to write up their understandings at the end of the session. One Year 7 mathematics teacher worked alongside students to gain an understanding of their reasoning and thinking. A summary of the responses is presented in Table 5.

3.4 Student interviews

Up to three students were interviewed immediately after each observed lesson. Each student was asked about their understanding of a particular literacy aspect of the lesson, in terms of perceived teacher intention, perceived teacher effectiveness, and perceived student value. The results from a total of 73 student interviews, including examples from the interviews to elucidate the coding framework, are presented as follows.

3.4.1 What vocabulary, reading or writing do you think your teacher wanted you to learn when he/she did this?

Students were prompted to recall a specific literacy teaching event, identified as a ‘critical incident’ by the researcher. Such incidents were chosen to reflect a key literacy teaching point within the overall lesson. Such incidents might include an episode of vocabulary teaching, or a reading or writing sequence of instruction. Coding for this section identified whether the students had correctly interpreted the goal of the lesson, and whether they believed the goal to be literacy or content-related. Of the 73 students that were interviewed, 56 believed that they understood their teacher’s intention — although 14 of those students gave an incorrect answer. Seventeen of the 73 interviewed students did not know what their teacher’s learning intention was.

3.4.2 Was it (method of teaching) effective in helping you learn this? Why or why not?

Students were asked whether the ‘critical incident’ had been effective for that student. Of the 73 students who were interviewed, 48 thought that the teaching sequence had been effective. Four students were not sure whether the method was effective, and two did not respond.

From the responses of the 48 students who thought that the teaching had been effective, the following themes were extracted:

1. *Teacher delivers content/student understands content.* Sixty-five percent of those students who thought the sequence had been effective thought that effectiveness of the sequence was due to the fact that the teacher had built their subsequent understanding of that content. One student said, for example, “At the end, when he went over the answer, he was breaking down each part and I could see how he did it”.
2. *Teacher delivers vocabulary/student understands vocabulary.* Seventeen percent of the students who thought that the sequence had been effective thought that they had appropriately understood the taught vocabulary. For example, “She told us bi- means two so you could see how it becomes two cells” (binary fission).
3. *Group work.* Thirteen percent of students who thought the sequence was effective, thought it was so because they had a chance to work with peers: “Talking with each other, working as a team”.
4. *Teacher delivers vocabulary/student understands content.* Six percent of the students who thought that the sequence had been effective thought that the literacy teaching had helped them to understand the content: “Teacher uses simple vocabulary so we understand [content]”.

Nineteen of the 73 interviewed students did not think the teaching sequence had been effective. Examples of student responses are:

- “It needed explaining better.”
- “We could have done it in groups and asked each other questions.”
- “Most people were just talking.”

3.4.3 Do you think this was something important to learn in mathematics/science? How will it help you in the future?

Of the 73 students interviewed, 61 thought that the critical incident had taught them something important. Note, however, that while students were questioned on the importance of the literacy instruction received (if any), their responses were about the importance they ascribed to the content of the lesson. This might be because the students did not, or could not, distinguish between the literacy and content learning or because in their minds literacy was subsumed by the content. The following themes were extracted from the responses.

1. *Career*. Thirty-four percent of students cited future career as an important reason to learn the subject, however, most of these (76%) were impersonal career answers (“Maybe you might want to be a geologist”) and only 24% had a specific personal career goal to which their knowledge was applicable (“For what I want to be when I’m older. I want to be an architect or a civil engineer or like a draughtsman, so I will need to read diagrams and stuff well”).
2. *Assessment*. Twenty-eight percent of students cited the importance of the sequence for assessments: “Because you need to know how to do it for NCEA, like to achieve the assessment”.
3. *Skill*. Twenty-one percent of students identified skills needed: “In the shops you need to know what money to give”.
4. *General knowledge*. Fifteen percent of students identified general interest or knowledge: “Because it’s interesting”.
5. *Future schoolwork*. Five percent of students cited the importance for future schooling: “For the future, if we need to do statistics”.

3.5 Teacher goal, classroom practice and student understanding: synthesis analysis

The teacher observations, teacher interviews and student interviews were examined together in order to ascertain whether teachers’ stated goals, their lessons, as interpreted by the researcher, and the students’ interpretations aligned. Table 6 summarises the goal alignment of the 26 cumulative teacher stated goals. Overall, we found alignment between the teacher’s stated goal (whether it be a literacy or a content goal), their observed teaching practice and student voice in just over half of all cases.

3.5.1 Observed teacher practice and student understanding aligns with literacy goal

This category describes instances ($n = 10$) of a teacher reporting a particular *literacy* goal which is observed in classroom practice, and this literacy goal is confirmed by some or all students in student interviews.

Example: teacher espouses reading goal involving a strategy for deconstructing word problems — “To pick out the important parts of the problem, identify key words and rewrite the words”. Classroom practice confirms teacher’s modelling of the deconstruction and explicit teaching of a key word method involving underlining. Students typically confirm the teacher wanted them to ‘break the problem down’ or to ‘learn how to think about the problem and to pick put the numbers’. One student also affirmed the generative nature of the strategy for use in other contexts and curriculum areas: “In a text I will focus on the key words myself. I can use this in English, science and other subjects”.

3.5.2 Observed teacher practice and student understanding aligns with *content* goal

This category ($n = 4$) is described by a teacher reporting a particular *content* goal which is observed in classroom practice, and this *content* goal is confirmed by some or all students in student interviews.

Example: teacher explains that they have no literacy goal for the day, and reports a content based goal as their focus, eg, “Making them more efficient in their number strategy use”. The teacher is observed providing students with strategies to break numbers up to simplify multiplication, and students affirm this goal: “[She wanted us to] multiply large numbers in an easier way... she told us to do the tens first and ones afterwards”.

3.5.3 Observed teacher practice aligns with *literacy* goal and student understanding aligns with *content* goal

In this category ($n = 3$) a teacher reports a particular *literacy* goal which is observed in classroom practice, but some or all students identify a related but *content-specific* goal.

Example: the teacher reports a receptive vocabulary goal, primarily focussed around the learning intention keywords to “provide a springboard to the concepts”. Teacher is observed repeating keyword vocabulary in class, but students identify teacher goal as content focussed, eg, “To learn what kind of mixture you see” and “To learn filter, condensation and evaporation”.

3.5.4 Observed teacher practice aligns with *content* goal but not with student understanding

This describes cases ($n = 2$) of the teacher reporting a particular content goal which is observed in classroom practice, but is not evidenced in student interviews.

Example: teacher explains that she wants students to learn “to see the difference between continuous and discontinuous”. Teacher is observed explaining differences to students but in interviews students are unsure as to the learning requirements: “I don’t know exactly what we had to learn about that meiosis/mitosis. ... The brainy people understand”.

3.5.5 Observed teacher practice does not align with *literacy* goal

This category covers instances ($n = 7$) in which a teacher espouses a particular literacy goal, but this is not observed in classroom practice.

Example: the teacher identifies productive vocabulary goals — that students not only “use vocabulary correctly in context” but in the appropriate scientific register, for example, to know why it is not appropriate to use the word ‘spin’ instead of ‘rotate’. In practice, teacher models an informal register (‘waxing getting fatter’, ‘waning getting skinnier’) and no instruction or practise opportunities are provided to write in the espoused style.

Table 6: Goal alignment analysis summary: extent to which espoused goals matched with lesson observation data in student voice

Subject	Year Level	Teacher	Espoused Goal for Lesson	Observed in Teacher Practice	Evidence of Teacher Espoused Goal in Student Voice
				(Yes/No)	(None, Some, Most, All)
Mathematics	Yr 11	J	Literacy	Yes	Most
Mathematics	Yr 11	F	Literacy	Yes	Some
		F	Literacy	No	None
Science	Yr 11	L	Literacy	Yes	Most (content)
		L	Literacy	No	None
		L	Literacy	No	None
		L	Literacy	No	None
Science	Yr 11	K	Literacy	Yes	Most
		K	Literacy	Yes	All
		K	Literacy	No	None
Mathematics	Yr 9	E	Content	Yes	Most (content)
Mathematics	Yr 9	I	Literacy	Yes	All
		I	Literacy	No	None
Science	Yr 9	H	Content	Yes	Most (content)
		H	Content	Yes	None
Science	Yr 9	G	Literacy	Yes	Some
		G	Content	Yes	None
Science	Yr 7	D	Literacy	Yes	All (content)
		D	Literacy	Yes	Some
Science	Yr 7	C	Literacy	Yes	Some
		C	Literacy	Yes	Some
Mathematics	Yr 7	A	Content	Yes	All (content)
		A	Literacy	Yes	All
		A	Literacy	No	None
		A	Content	Yes	All (content)
Mathematics	Yr 7	B	Literacy	Yes	Most (content)

3.6 Summary of results: addressing the research questions

In this section, we draw together the threads from all the data sources, in order to answer the research questions. We discuss relationships between each of the sources of data, and summarise the main themes that have emerged from the combined data sources.

1. What knowledge, beliefs and understandings do teachers have about the literacy and language of science and mathematics?

Evidence from both the SLPCK Tool (Section 3.2) and the teacher interviews (Section 3.3) indicated that, in general, teachers considered that there were literacy requirements that were specific to their subjects. In mathematics, for example, teachers described successful completion of word problems as involving extracting the relevant information, and then expressing it using an appropriate mathematical form to solve the mathematics problem. In science, teachers described subject specific literacy as vocabulary based, indicating the interrelated nature of conceptual development and vocabulary development and also the importance of definitions, properties, and taxonomy when developing such knowledge.

In both science and mathematics classes, teachers indicated ‘competing’ understandings about the nature of literacy in their subject. On one hand, they considered that when students lacked literacy skills this made it difficult for them to learn effectively in their subject, thus conceiving of literacy as a barrier for these students. Most commonly, teachers identified vocabulary as the barrier to accessing the texts of their subject. On the other hand, teachers also considered that the highest levels of achievement in their subject required deep, specialised forms of literacy engagement, for example, by communicating logical reasoning, or applying knowledge to real world situations. Such literacy tasks require students to use or apply extant knowledge in different contexts.

This duality seemed likely to cause a conundrum in classrooms, in terms of whether to assist students to ‘overcome barriers’ or to engage students in subject-specific literacy activity at a high level. Taken to its natural extension, the tension between these two conceptions is likely to lead to a dual track in terms of literacy teaching in subject areas. The first track might be to support students to access subject knowledge without being hampered by their literacy skills. The second would be to ask students to apply or demonstrate content knowledge by engaging students in high level, productive, subject-specific literacy tasks which are likely to lead to Merit and Excellence levels of attainment. This might be a classroom in which subject knowledge could be delivered by the teacher, through telling, showing or summaries, and then demonstrated by students through application. Such a duality would create a division between the receptive and productive aspects of the subject, in that teachers take responsibility for extracting the knowledge from texts for students, thus paradoxically denying them the experience with the literacy knowledge needed for productive tasks.

In general, teachers demonstrated less understanding or awareness of language features in their subjects, for example, the structural or generic features. They also constrained their discussion of specific literacy to school-based needs, in terms of gaining and showing understanding (although it could be argued that this might have been a product of our classroom and assessment-based data collection). There was little evidence of wanting students to engage in disciplinary practices, for example, of reading or writing like a scientist, or mathematician.

2. In light of their knowledge, beliefs, and understandings about the literacy and language required, what practices do teachers use in the teaching of science and mathematics to support students’ learning and achievement?

Well aligned with their beliefs about the literacy and language requirements of their subject, teachers attended in large measure to teaching the vocabulary and, by implication, the concepts, of their subjects. Because vocabulary was the most salient aspect of literacy for participating teachers, repeated exposure was considered to be the most appropriate literacy and language teaching approach. Accordingly, these teachers used practice as the main pedagogical strategy, which was designed to support students to build subject-specific literacy knowledge (for example, to use the appropriate vocabulary). Modelling was mentioned by teachers as an appropriate approach for strategy instruction. This was also seen in the observed classes, with varying degrees of ‘think aloud’ or strategy instruction accompanying the ‘showing’. Critical literacy, though valued in the New Zealand Curriculum, was not mentioned, nor was it often seen.

3. What are the areas of strengths and weaknesses in literacy and language pedagogy within science and mathematics?

Vocabulary stood out as well understood and often taught. This was often taught orally, by teachers using words and explaining their meanings. In cases where texts were a feature of instruction, they were texts created by the teacher, for the purpose of delivering or practising content understandings. This seemed to lead to a situation where these teachers took responsibility for the literacy demands by summarising or explaining content to students.

Lessons tended to be whole class instruction, followed by individual practice, with unofficial support from peers. This combination of direct teaching and practice was a feature of the teachers’ responses to the SLPCK Tool, and was also noticeable as the predominant shape of lessons observed. While such explicit teaching might help students negotiate or avoid ‘literacy barriers’ to gain the requisite content knowledge, it may be that this constrained students’ opportunities to develop strategies that would enable them to independently gain content specific understandings from texts. Thus explicit or didactic approaches may have been simultaneously a strength and a weakness of the teaching.

Formative assessment stood out as being less well understood or practiced by these teachers. Teachers relied on observing students or roving and checking answers. Learning conversations and working with students was described by Year 7 teachers, but not by those teaching Year 9 or Year 11. Across the sample there were few instances of learning conversations or in-depth discussion with students either about the content or about their learning. Where interaction was a feature of the lesson, this was commonly teacher questioning and short-answer student response. There were few practices observed that were designed to foster or support students to self-regulate or monitor their own understanding. That said, students themselves were often able to identify teachers’ purposes for the lessons, in terms of the subject content, if not explicitly in terms of vocabulary or literacy.

4. What understandings do students have of the literacy and language of science and mathematics?

Students mostly assessed their lessons in terms of whether they had understood the content. In this regard, 42 of the 73 students interviewed accurately understood the teacher’s intended content goals for the lesson. They also assessed the importance of their lessons in terms of the content. On the whole, few students were aware of the literacy learning, other than trying to learn and understand subject-specific vocabulary.

4. Discussion

The purpose of this research was to identify the skills and knowledge that effective mathematics and science teachers have about the specific literacy demands of their subject. In light of that knowledge, we were interested in identifying the practices that those teachers employed to support their students' learning and achievement, and to identify what the students understood about the literacy demands of their subject.

We have presented our findings about text use first, as we believe that students should develop their knowledge of subject literacy and language as they engage in the reading and writing of subject texts. This may seem self-evident. However, while we did observe many instances of vocabulary instruction, and some instances of strategy instruction, these often occurred in isolation from any actual written text. We see this as less than optimal. We identify here the potential for students to be denied opportunities to engage with text, thereby decreasing their opportunity to develop literacy skills to use texts independently, and also decreasing opportunity to develop subject-specific skills, in terms of using texts in ways that are valued in the disciplines. Accordingly, we also identify a number of areas where teachers' own knowledge might be built, particularly in relation to text uses, textual knowledge and pedagogy, to support authentic as well as critical use of texts. Thus, a number of implications emerge related to text use, textual knowledge, pedagogy surrounding text use, and inquiry into student learning.

The findings suggest that teachers consider subject literacy to be largely about supporting students with low literacy levels to overcome this 'barrier' to their learning. However, teachers were also aware that their subject had specific literacy demands. In general, teachers focussed on the new vocabulary of their subject. They also created the texts that supported this learning. In general, this seemed to be a feature of teachers attempting to prepare their students by building knowledge of the content area, therefore identifying what students need to know and summarising this in the form of teacher-made notes or modelling for students. A combination of direct instruction and practice was both described by teachers, and observed in classes, with both aspects of lessons centred on texts that the teachers had created specifically for the purpose, either on the whiteboard or as a worksheet. In mediating text use by restricting or controlling the use of texts, however, there are a number of inherent risks, not least in terms of depth of content learning.

4.1 Text use: students need opportunities to engage with text in ways that are valued by the disciplines and by the New Zealand Curriculum document

International research suggests that the texts encountered in mathematics and science change as students progress through their schooling. Texts ought to become longer, more complex and more subject-specialised (Carnegie Council on Advancing Adolescent Literacy, 2010). In New Zealand, by Year 10, the texts that students are required to be able to read will include those written for a general adult audience and have terminology, structures, organisation and conventions that may function differently in different subject areas (Ministry of Education, 2010). There has been limited research about how texts are or should be used in subject-area classrooms, particularly in mathematics (Moje et al., 2011), but in order to develop experience and facility using texts for subject-specific purposes, students need both support and practice with the types of texts that are valued in science and mathematics if they are to become skilled users and producers of such texts and thereby progress beyond Year 11 study.

One purpose of text use in mathematics and science classrooms is to provide one of the means by which students can develop subject content knowledge. A second purpose is to provide some of the contexts to which students apply this subject knowledge. While we did see use of teacher-made texts to provide content knowledge, we also identified a paucity of use of subject-specific texts for both purposes.

There was very little evidence of written texts, including text books, as a vehicle for developing students' subject content knowledge. Most texts used were teacher developed and 'published' using whiteboards, PowerPoint presentations and photocopied handouts — effectively teacher written notes. In general, students had few opportunities to engage with extended texts.

One, seemingly harmless, practice served to illustrate unintended ways that text use might be constrained. On the few occasions observed when students did have physical access to extended texts (eg, books), teachers limited students' use of these texts by directing them to read specified pages only. We think there is the opportunity here to develop students' knowledge of how to use extended texts, for example, by giving them the responsibility to locate relevant sections using the contents and index pages. With some exceptions, it appears that in general the teachers were frequently reading and summarising written subject texts *for* their students, and that students may be better served by opportunities to learn to do this themselves.

In terms of the second purpose of texts, to provide contexts, we identified issues specific to each of the two subject areas.

4.1.1 Mathematics texts

In mathematics, we identified a mismatch in the use of texts used in mathematics classrooms and those used in NCEA assessment tasks. The NCEA assessments we analysed were predominantly word and context-based whereas those observed in classrooms were predominantly number-based. The exception was at Year 11, where word problems were a significant focus. Thus it seemed that word problems may have been absent from students' mathematics experience in prior years, indicating a missed opportunity for development of these mathematics literacy skills in previous years. There is a danger therefore that when introduced in Year 11, these may be perceived as new or difficult, rather than as an integral part of mathematics prior to Year 11. However, teachers' approaches to word problems tended to focus on algorithm identification and computation, rather than use or analysis of the language of mathematics problems. Therefore, students had few opportunities to wrestle with the problem deconstruction and voice their understanding of the language. Instead, teachers provided a paraphrased translation of the problem. The practice appeared to reflect a desire to avoid student disequilibrium or confusion. However, in offering such support teachers may have provided a solution rather than offering students independent strategies for resolving their difficulties and tackling difficult problems.

This is not to say that national examinations should be the primary driver of classroom practice, nor that number problems are inappropriate. Rather, we use NCEA as an important indicator of what is valued in the mathematics community. This trend towards more word problems is by no means peculiar to New Zealand and there has been a general trend toward more word problems in Europe and North America since at least the 1970s (Reed, 1999). In one sense, the continued privileging of number-based problems is understandable, at least at the stage of initial learning of mathematical concepts. Nevertheless, solving such problems requires more than the underlying mathematical knowledge and research indicates that students perform 10% to 30% worse on arithmetic word problems than on comparable problems presented in a numeric format (Abedi & Lord, 2001; Carpenter, Corbitt, Kepner Jr, Lindquist, & Reys, 1980; Neville-Barton & Barton, 2005). This suggests to us a need for students to engage in extensive practice working with the written contextualised problems which, while controversial with some mathematics teachers, seem to be valued in high-stakes assessments.

4.1.2 Science texts

In the New Zealand Curriculum document, the ‘Nature of Science’ strand specifies that students at Curriculum Levels 3 and 4 “[e]ngage with a range of scientific texts” and at Curriculum Levels 5 and 6, “[a]pply their understandings of science to evaluate both popular and scientific texts”. In our sample, a limited range of texts was observed and we saw no instance of students applying scientific knowledge to evaluate popular texts. One explanation for the limited provision of opportunities for students to engage with text is that teachers were seeking an efficient way of delivering the required curriculum content. We acknowledge this as a real and important challenge for teachers but there are obvious risks with this practice. Some studies suggest that teachers might deliberately avoid using complex written texts with groups of students who struggle, or who are perceived to struggle, with reading. McDonald, Thornley and Fitzpatrick (2005) observed, for example, that Pasifika students in lower-decile schools tended to have fewer opportunities to read and write than their contemporaries in higher-decile schools. Internationally, this phenomenon has also been noted, with teachers modifying text book use according to the academic levels of their students (DiGisi & Willet, 1995). Thus, internationally there is potential that students expected to achieve at lower levels, may unavoidably do so because of limited opportunities to engage with a more challenging curriculum, or to engage in practices required at higher or post-school levels. In our study, it is possible that the very low instances of scientific texts might play out similarly in unintended, but negative, ways. While the features of scientific and mathematical texts make them difficult to read, we would argue that this provides more reason to support students to use these texts, rather than scaffolding learning in ways that in effect restrict their access. While we do not suggest that written texts supplant other ways of teaching content or providing meaningful contexts, we do suggest that written texts might be used more often for these two purposes.

4.2 Textual knowledge: students need opportunities to develop knowledge of how important types of subject texts work

To be effective readers and writers, students need developed knowledge of how important types of subject texts work. Moreover, their teachers need to know this so they can diagnose reading and writing problems, employ appropriate teaching strategies to address these problems, and evaluate the effectiveness of these actions. Knowledge of how texts work consists of knowledge about audience and purpose, vocabulary, organisational features and language resources. In this section, we consider what knowledge the teachers brought to the study, and we also discuss what teachers might additionally need to know and teach students about text use and features of text in their subjects.

4.2.1 Frequency of literacy teaching

There was some evidence of literacy instruction in 38% and 69% of the blocks observed in mathematics and science classrooms respectively. We acknowledge that the teachers in our study were selected on the basis that their schools had relatively high subject achievement and were identified as effective literacy teachers, and it is possible that this rate is higher than it would have been for a random selection of teachers from a random selection of schools. However, we are unable to make direct comparisons with other studies and therefore cannot make fair judgements about whether these rates of literacy instruction are optimal or not. We do, however, note implications of the specific types of literacy learning content that is addressed within those blocks of time.

4.2.2 Audience and purpose

Although rare, we identified some occasions where instruction referenced the purpose of texts. In these instances, teachers referred to examiners’ intentions in constructing assessment tasks, and how to extend answers to reach higher levels of achievement. We see this as potentially helpful information for students, making

explicit the ‘rules of the game’, and allowing them to use texts based on an understanding of purpose (ie, that these texts are written to test knowledge). It is particularly important that students can identify the intended audience and purpose of the texts that are valued in subject areas because this knowledge can shape how they read and write such texts, and without a clear purpose, their interactions with text may be “unfocused and haphazard” (Ministry of Education, 2004, p. 63).

One way of classifying texts is according to their broad function — their writers’ social purpose. Key broad functions of the texts valued in mathematics and science include: to explain; to argue or persuade; to instruct; and to classify, organise, describe and report information (Glasswell, Parr, & Aikman, 2001; Knapp & Watkins, 1994). While knowing the broad function of a text is useful for readers and writers we argue that students need a more refined understanding of the purpose of the highly-specialised texts they are required to read and write.

To illustrate the potential importance of purpose we will take the example of one type of text commonly used in mathematics, the word problem, which does not seem to us to fit neatly into any of the aforementioned purpose categories. The general purpose of word problems is to provide a context for students to use and demonstrate their mathematical knowledge — a purpose perhaps best understood as an assessment or at least practice-for-assessment purpose. However, explicit acknowledgement of this purpose, may not be clear to all students. This is because word problems are “stylized representations of hypothetical experiences — not slices of everyday existence” (Lave, 1993, p. 77). Reading these texts requires students to “engage partly as though a context in a task were real whilst simultaneously ignoring facts pertinent to the real life context” (Boaler, 1994, p. 554).

Students who are not clear about the intended purpose of word problems may read them in unhelpful ways — as if they really are to do with real-world problem solving. Meaney and Irwin (2005) found that Year 8 New Zealand students were far more successful at recognising the need to ‘peel away’ the story shell of word problems than were Year 4 students, and report a Year 4 student responding to the question “How much of the pizza is left?”, in the context of fractions, with “All the herbs”. Less dramatically, but as deleteriously, some teachers in our study reported students ‘skipping’ word problems when they were not familiar with the context.

We see these issues arising, in part, from gaps in students’ knowledge about the purpose of these highly specialised texts. Confusion about the purpose of word problems might be compounded because at times teachers might provide genuinely authentic contexts for problem solving while at other times the contexts will be more contrived. Addressing this instructional gap may be particularly important in the context of attempts to address existing disparities, as there is some evidence that lower socio-economic students were more likely to focus on the contextual issues of a problem at the expense of the mathematical focus (Lubienski, 2000). As reported previously, we observed very little instruction related to the intended audience and purpose of texts. Nor did teachers completing the Subject Literacy Pedagogical Content Knowledge Tool identify potential difficulties related to this. This is an important area in which teacher knowledge and practice could be developed.

4.2.3 Vocabulary

The literature shows that in mathematics and science, students are required to understand and use a large number of highly-specialised technical vocabulary items (terminology), and we saw considerable evidence of this taking place in the classrooms we observed. Vocabulary teaching was found to be an area of relative strength in this study and there was much more instruction about terminology than there was about any other aspect of text knowledge. This is perhaps indicative of the fact that knowledge of subject vocabulary is very hard to disentangle from subject content or conceptual knowledge.

Explicit vocabulary instruction is a key feature of adolescent literacy programmes, with demonstrably positive effects (Kamil et al., 2008). Recommendations for effective vocabulary instruction include dedication of a portion of regular classroom instruction to explicit vocabulary instruction, repeated exposure to new words in multiple contexts, and sufficient practice opportunities to use new vocabulary in a variety of contexts through activities such as discussion, writing, extended reading, and the development of strategies to build independence in vocabulary learning. The teaching we saw was generally consistent with the first two recommendations, that is, that students had repeated exposure to new words in multiple contexts, and opportunities to practise. In particular, mathematics teachers used technical vocabulary to describe a mathematical construct and then emphasised the focussed terms in subsequent instruction. Other prominent approaches included student-constructed definitions, and, particularly in science, a proliferation of fill-in-the gap, matching terms with definitions, and cloze activities (of the type exemplified in *Effective Literacy Strategies in Years 9 to 13*; MoE, 2004). However, there were fewer opportunities to use new vocabulary in discussion or writing, which was a significant gap in the teaching of independent strategies. There were also few differentiated approaches based on students' prior knowledge, for example, whether words represented new concepts or were new terms for known concepts. There was little evidence that teachers were inquiring into the depth or breadth of students' word knowledge pre- (or post) instruction with the intention of tailoring teaching for clarifying and/or further enrichment. Moreover, the predictability of whole-class end of lesson activity review and activities in class that predominantly required students to provide or accurately circle vocabulary terms, seemed to facilitate 'wait-and-copy-at-the-end' behaviour.

Perhaps of even greater importance concerning students' future success at NCEA and beyond, is the identification of words that require transfer from students' receptive to productive vocabulary. Moving technical vocabulary from students' listening and reading vocabularies to their speaking, and particularly, written vocabularies (the prominent medium of NCEA assessment), is a significantly more demanding task: one that will not be affected via 'thinner instruction', and which goes beyond the accuracy of associations between word and definition matching or the relatively shallower processing required for fill-in-the-gap tasks (Beck & McKeown, 1991; Blachowicz & Fisher, 2000). Whilst time does not allow for richer approaches for all words students need to know, developing understandings about selective, more elaborate treatment for critical terminology will allow teachers to build students' productive language capacity and word knowledge beyond simply recognition.

There was also less evidence that teachers had a particularly nuanced understanding of which particular words would have the most effect on successful task completion. For example, none of the four mathematics teachers who completed the SLPCK Tool (see Appendix D) explained *how* issues in a student's word knowledge might affect their reading, and potentially problematic words were typically presented in lists which did not discriminate words that were merely unknown from those that might have a more marked effect on task completion. To illustrate: while one mathematics teacher listed "oil pressure, vintage car, warning light, reliable and incorrect reading" as unfamiliar vocabulary, we would argue that the last two words have relatively more importance — 'reliable' because it refers to the state of uncertainty at the heart of the probability issue, and 'incorrect' because probability trees are constructed from a series of paired opposites. That is, to accurately draw the probability tree needed to solve Question Two in the SLPCK Tool, students need to know that the descriptions of the oil pressure as 'too low' and 'okay' are used as paired antonyms which therefore necessitate different branches of the tree diagram. A similar situation exists with the 'incorrect' warning light reading but in that case students need to go one step further and infer the need for 'correct' to complete the pair. Developing teacher knowledge about the most catalytic subject vocabulary to target may be important.

Considering the importance of vocabulary other than topic words is also important. There was little evidence in the observations of direct teaching of non-topic vocabulary, and while there was some evidence in the SLPCK

Tool of science teachers in particular being aware of the influence that general academic vocabulary such as ‘Discuss’ and ‘Explain’ might have on students’ reading and writing, there was little/no evidence of this in the observations. It is also important that teachers are aware of other aspects of subject vocabulary that may confuse students. For instance, no teacher identified what Fang calls “ordinary words with non-vernacular meanings or usages” (2006, p. 494), despite the text including several such words, for example, ‘sterilised’ and ‘processed’ (which within the sentence in Question One of the SLPCK Tool beginning “Fruit can be processed ...” might be assumed by students to be synonymous with ‘blended’ — ie, in a food processor).

The teacher participants were familiar with and used many different vocabulary-teaching activities. They also provided ample evidence that they were aware of the need to provide students with repeated opportunities to engage with new vocabulary (Baumann, Kame’enui, & Ash, 2003). However, there was a much greater focus on receptive vocabulary understanding than productive vocabulary use and we suggest that students be provided more opportunities to write and speak new vocabulary in authentic situations.

Another important gap we identified was in the area of word-solving strategies. The literature suggests this is important because inevitably students will encounter novel words in texts (Scott, Nagy, & Flinspach, 2008). Word-solving strategies are broadly of two types: those related to use of context clues, and those which are morphologically based, and there is evidence that flexibly using both strategies in conjunction with active comprehension monitoring can be effective (Scott et al., 2008). This gap reflects a wider need for strategy instruction for building student independence.

4.2.4 Organisational features of text

Knowledge about the organisational features of texts greatly assists students’ reading and writing. For example, surveying organisational features such as headings, sub-headings, diagrams and captions helps students gain a general overview of the key ideas of the text, and an understanding of where key information is located. This helps activate a student’s schema and helps them form hypotheses about texts. When students better understand the hierarchical nature of organisational features used in different texts they may also be better able to separate main ideas from extraneous detail. Learning about organisational features of text also provides an important interface between reading and writing. For example, students can use the organisational features of texts they read to provide a framework for making their own written summaries of the text (McDonald, Thornley, Fitzpatrick, Elia, Stevens, Teulilo, & McDonald, 2008).

4.2.5 Language features

There are other linguistic features of texts in science and mathematics that have been identified as potential barriers to students’ reading and writing (Cocking & Mestre, 1988; Fang, 2006; Fang & Schleppegrell, 2010). For example, the sentence in the text used in the SLPCK science Tool (Appendix E) “Addition of some yeast to fruit in certain conditions can cause a small amount of alcohol to be produced” has several features which potentially affect its comprehensibility: it employs a lengthy noun phrase in the form of “addition of some yeast to fruit in certain conditions” (which functions grammatically as a single noun); nominalisation (“addition of some yeast” rather than “adding some yeast”); and modal adjuncts such as ‘some’, ‘certain’, and ‘can’.

The level of linguistic knowledge implied by this analysis is much more detailed than that addressed in most teachers’ pre-service education or literacy professional development. We acknowledge that better addressing these in classrooms would require significant shifts in teacher education (and teacher educators’ knowledge). According to Shanahan and Shanahan, “These text differences are not often within the purview of literacy courses... teachers are not prepared to address the challenges posed by the special demands of texts across the

various disciplines” (2008, p. 53). However, such knowledge is vital if teachers are to be able to diagnose and address an identified and credible source of potential misunderstanding, which is one of the hallmarks of developed teacher pedagogical content knowledge (Bransford, Derry, Berliner, Hammerness, & Beckett, 2005).

4.2.6 Reading and writing focus

There was very little evidence of teachers making links between reading and writing, and previous research suggests this as potentially a very fruitful approach to take (Jesson, McNaughton & Parr, 2011). Such a focus would involve engagement with the types of texts through reading that students are expected to write. It would also involve the use of multiple texts, and making links across texts, for example, when building content knowledge.

In building students’ knowledge about subject-specific texts, we are not saying that teachers should or need to teach all of these features as a matter of course. Indeed, “Repeated studies have demonstrated that instruction in isolated grammar, decoding or comprehension skills may have little or no impact on students’ activity while actually reading” (Schoenbach et al., 1999, p. 7). Rather, we argue that teachers need to know how these features may act as barriers to making or creating meaning from texts and how to diagnose and address problems identified through inquiry.

4.3 Strategy learning: students need opportunities to develop a toolbox of cognitive strategies they can use flexibly to make and create meaning

Cognitive literacy strategies have been defined as constructive interactions with texts in which good readers and writers continuously create meaning (Pressley, 2006). Well-known cognitive strategies include activities such as asking questions about texts, making predictions, activating prior knowledge and summarising. Unfortunately, far less is known about effectively teaching cognitive literacy strategies in mathematics and science (Conley, 2008; Moje et al., 2008).

One mathematics teacher illustrates a pattern that we identified: after commenting in the SLPCK Tool that students might be confused by unfamiliar context words, the teacher wrote that s/he would address this by telling students “If you have trouble understanding a word or the content put your hand up and I will explain it to you”. While this approach will no doubt be useful to students in that immediate context, it is less likely to help prepare students for future literacy challenges encountered when a supportive teacher is not present. This was a common pattern for the teachers across year levels in both subjects, and while we saw a range of literacy teaching activities, it generally seemed that teachers were “treating strategy instruction as rehearsal — doing a teaching activity step by step, over and over again, in the hope that somehow it will stick with students — versus considering cognitive strategy instruction as a deliberate action to develop in students a critical understanding of subject matter ideas *and* a cognitive approach to learning” (Conley, 2008, p. 91).

The strategies that we think will be most pivotal for students to learn in mathematics and science are more specific to each subject’s texts and purposes than the well-known generic literacy strategies. Strategies are not silver bullets that can, or should, be applied simplistically to every situation, but instead are purposeful, goal-directed actions employed to solve a particular problem (Afflerbach, Pearson, & Paris, 2008). It is important therefore that strategies are taught in ways that support students to use them flexibly. They will be strategies that students can employ when features of those highly-specialised text forms become barriers to making and creating meaning. Useful strategies for students to learn in mathematics may include those that students can use to identify the type of problem and relevant variables ‘hidden’ in a contextualised word problem, whereas, in

science, strategies to help them break down a complex noun phrase into more digestible chunks might be particularly beneficial.

There was very little evidence of strategy instruction in the classrooms we observed and the majority of strategies identified by teachers completing the SLPCK Tool can be characterized as routines, for example, encouraging students to underline key words in the question. Below we illustrate potential issues in strategy use in mathematics and science respectively.

One strategy suggested by two of the mathematics teachers in the SLPCK Tool was a form of keyword strategy in which students are taught to look for a key word which informs them of which operation to use. There is a risk with teaching such a strategy that it can be misapplied, as it is easy to write problems where the usual rules do not follow. For example, the key words ‘more’ in a simple number problem usually suggests addition, but not in the case of “Elisa bought four bottles of milk on Sunday which is two *more* than she bought on Monday. How many bottles did she buy on Monday?” Reed (1999) contrasts key word strategies with “more mature strategies for solving word problems [which] are based on the meaning of the text” (p. 47). This suggests that a strategy such as the key word strategy needs to be combined with a strategy for monitoring its usefulness in a particular situation.

In the SLPCK Tool, one science teacher identified that students would likely struggle to apply their scientific knowledge of micro-organism infection to a text about bottling/preserving, because they lacked prior experience of that context: “This is a subject/context specific problem and so is difficult to pre-empt [grasp]”. We agree that problems related to unfamiliar contexts are difficult to “pre-empt”, as tasks of this kind require students to apply scientific knowledge to novel situations. However, this we see as precisely the point behind teaching strategy use: that students are equipped with ways to handle novel situations independently. To do so it is firstly important for students to know that applying scientific knowledge to unfamiliar contexts is a highly-valued student outcome. It is therefore entirely predictable that some kind of unfamiliar context *will* be used. Students need to know this. It is also important for students to know that science texts are often written in such a way that unfamiliarity with a particular context will not be inevitably fatal to their comprehension. It may be that supplementary information, such as the extract about bottling in this case, is provided. Students who *expect* such support to be present in texts of this type may be more likely to actively seek out such support in the text, and be more resilient when confronted with a challenging, unfamiliar context. Moreover, a productive strategy when faced with an unfamiliar context might be to try to identify the purpose of the text, in terms of what scientific principles might apply.

There was evidence of some promising teaching of word-learning strategies in Year 11 science classrooms centred on word parts. Morphemic analysis or structural analysis involves examination of the meaningful parts of a word in deriving meaning. Research demonstrates the effectiveness of explicit instruction in morphemic analysis towards promoting vocabulary growth (Edwards, Font, Baumann, & Boland, 2004), as a bridge to less common or unfamiliar forms of the word (Baumann, Edwards, Boland, Olejnik, & Kame’enui, 2003), and as an aid to memorising terms (Gunning, 2003). Edwards et al. (2004) conceptualise instruction in morphemic analysis as teaching students to disassemble words into roots and affixes (prefix and/or suffix), acquire the meanings of those elements and reassemble the meaningful parts to derive the word meaning. Only one science teacher was observed consistently building word consciousness in signalling intraword (morphemic) cues to elucidate meaning and promote word learning. Similarly, this was the only teacher to invoke a mnemonic strategy in assisting students to independently recall previously learnt content. Given that mathematics and science present unique language challenges, including the requirement to acquire the specialised words that students only

encounter in these disciplines, more purposeful integration of word learning strategies and memory assists offer the potential to enhance students' metalinguistic awareness and skill.

Developing into more strategic readers and writers of mathematical and scientific texts therefore requires that students have repeated opportunities to practise reading texts that were deliberately chosen *because* they present challenges (such as unfamiliar contexts) as well as to learn or reflect on the strategies for overcoming these challenges (for example, by learning ways of 'mapping' their existing scientific knowledge onto an unfamiliar context, such as through meta-cognitive discussion: "I know that growth of micro-organisms can be curbed by extremes of temperature and they need exposure to air — is there anything in this context that relates to air or temperature?").

4.4 Pedagogy: students need opportunities to participate and contribute in rich literacy learning experiences

At the centre of effective teaching is pedagogy that promotes rich learning. The pedagogical tools that support learning are many and varied, and can include approaches that range from explicit teaching to more participatory and discussion-based approaches. Despite ongoing debates among theorists about which approaches might be more effective, we would agree with Alexander and Jetton (2000) that the answer probably lies not at the extremes, but through balanced use of a number of approaches. We would characterise such an approach as including, but not being restricted to, modelling, strategy instruction, guided practice, extended discussion and participation in authentic tasks. Our study suggests that teachers have particular areas of strength. Most generally, the teachers we observed and talked to were strong in teacher-led pedagogy. There is ample evidence that teachers use lecturing and modelling well and often. Teachers of both science and mathematics modelled problem-solving and answering, often creating texts to support this modelling (eg, using the whiteboard to show how to create a diagram from a word problem). However, there was less evidence of the employment of grouping or extended discussion to build understandings.

The ways that teachers give support to students are often characterised as 'scaffolding'. Using this heuristic (assisted discovery approach), teaching can be characterised as a 'Gradual Release of Responsibility' (Pearson & Gallagher, 1983), whereby, as students learn, levels of support are graduated so that students take more of the responsibility for independence. In the classes that we observed, the predominance of whole class and individual work suggested a lesson shape in which whole-class teaching tended to be followed up by individual practice, thus students moved from watching to doing, and, particularly in Year 9, teachers oversaw that 'doing' by roving. Joint construction, and group-based activities, became less frequent as students' year levels progressed, and we witnessed no group-based interaction in Year 11 classes. These activities, we suggest, provide for peer as well as teacher support. We would argue therefore that pedagogy would be strengthened in many instances by the integration of a 'joint construction' phase as a pedagogy to support independence.

The need to build student understanding in supportive, and yet authentic, ways has led to a number of approaches internationally that use extended discussion as the focus for the learning. Theoretically, the benefits of discussion reach beyond scaffolding to promoting active engagement with meaning, the ability to consider alternative perspectives, to co-construct understandings and build comprehension through discourse (Wilkinson & Son, 2010). Pedagogical approaches, such as 'Content Oriented Reading Instruction' (Guthrie & Wigfield, 2000), 'Reading Apprenticeship and Meta-cognitive Conversations' (Schoenbach, Braunger, Greenleaf, & Litman, 2003), and 'Collaborative Reasoning' (Anderson, Wilson, & Fielding, 1988), exemplify this dialogic approach. Each in turn seeks to disrupt the Initiate Respond Evaluation (Mehan, 1979) default in classroom

interaction style, and build instead interaction patterns that are characterised by authentic questions (ones to which there is no pre-determined answer in the teacher's head), and shared inquiry.

While extended discussion in this sense was absent in the classes we observed, there was a prevalence of Q & A sessions. Notably, the frequency of this progressively decreased as students' year levels increased, with higher numbers of Q & A sequences in Year 7 classes. Extended discussion at an individual level may have also been a feature of 'conferencing', which we did observe, particularly at Year 11. It is likely, therefore, that there are activities already existing in content-area classes, which could serve as sites for the rich, extended discussions which build both literacy and content area knowledge. Such discussions, we suggest, provide opportunities for students to process their content area learning, as well as practise communicating, critiquing and arguing within their subject areas in ways that we interpret as being valued by the NZC (p. 12).

4.5 Critical literacy: students need opportunities to develop the kinds of critical literacy particularly valued in that subject area

Critical literacy is an explicit focus of the NZC, in terms of the key competencies, as well as in the learning areas: "For each area, students need specific help from their teachers as they learn ... how to listen and read critically, assessing the value of what they hear and read" (NZC, p. 16). Critical literacy involves a shift away from 'getting the correct answer' to questioning the assumptions in texts, critiquing, and challenging. As Darwin (2007) suggests, critical literacy is at the heart of learning in both science and maths: "[T]he very disciplines of science and mathematics were both born from people's need to question the world around them and set out to prove or disprove theories that they had about how it functions" (p. 248). In this respect, critical literacy in science and mathematics involves thinking, evaluating and communicating in ways that scientists and mathematicians value.

Critical literacy also has a link to real life application of knowledge. In science, this need to be critical has been incorporated into a vision for citizenship, to critically evaluate information and be equipped to participate in debates and influence policy in areas such as ecology, genetics and health (Gluckman, 2011). In mathematics, critical literacy has been characterised as moving beyond the 'decoding' level of understanding the terminology, to deeper investigation into whether the information is true, significant, and fair, as well as what the implications might be, often through investigation of the mathematics underlying real world texts (Watson, 2011).

In our observations of teachers we saw no evidence of any instruction that could be characterised as critical literacy, using either of these conceptions. Rather, we saw a predominance of question and short answer sequences, modelling and individual student practice. This lesson style seemed to serve as an efficient mode of content delivery. It does not, however, build the critical literacy skills needed to critique the scientific or numerate texts that students encounter, or will encounter. It also did not involve reading, writing and using texts in ways that scientists or mathematicians use texts.

When discussing their literacy goals, no teachers identified critical literacy as a goal for their lessons. Some teachers did, however, reference the specialised forms of literacy needed for their subject, and some also equated literacy with higher achievement, deeper learning and real-world contexts in their subject. We see here a nascent opportunity to build opportunities for critical literacy in science and mathematics. We would, therefore, argue from a position of instructional depth, that students need opportunities to engage with issues, ideas and concepts, to challenge and critique them as part of deep learning within their subject areas. We would further argue that such opportunities should not be reserved for those who have already 'received' the content. Instead, we would suggest that opportunities to apply, critique, and evaluate subject-specific texts characterise the rich instruction

that all students need to deepen their understanding as well as engagement with subject-specific contexts, as required by the NZC.

4.6 Independence: students need to develop self-regulation (in reading and writing)

Alongside instructional support and instructional materials, students also have a role to play in their own learning. Learning takes more than some degree of commitment on behalf of the learner (Garner, Alexander, Gillingham, Kulikowich, & Brown, 1991). There is evidence to suggest, for example, that students' goals, and the nature of those goals, play a huge role in ultimate academic performance (Alexander & Jetton, 2000). Recent pedagogical emphases have attempted therefore to focus students' attention on their own learning, and to build classroom cultures that are 'learning focussed' (Absolum, 2006). In order for students to regulate their own learning, they need to know what it is they are supposed to learn. Making this process visible is commonly referred to as 'formative assessment': "[T]he process used by teachers and students to recognise and respond to student learning in order to enhance that learning, during that learning" (Cowie & Bell, 1999, p. 101).

For self-regulation to occur, the focus is on the students' knowledge of what it is that they are intended to learn, and how they are achieving in relation to this goal. In subject-area literacy, we would argue, students need knowledge of the literacy required to achieve their knowledge goals, and how to identify and repair issues that arise as they engage with subject-specific texts. Students therefore need to know what literacy learning they need to undertake, so that they might monitor and self-regulate these goals, for example, when literacy is needed to access learning in a subject area, or to deepen engagement with subject area knowledge.

In an environment that supports self-regulation, students participate in discussions and other learning tasks that focus on the learning. For students to know how well they are doing towards a learning goal, teachers need to know this also, which in turn aligns closely with a conception of teaching as inquiry, explicit in the NZC, wherein teachers design instruction based on establishing what their students have already learned and what they need to learn next. In our study, most teachers described 'roving' and Q & A as the strategies that they employed to ascertain whether students had achieved the teacher's goal. One teacher described 'working with' students, and some teachers described student writing as a vehicle for ascertaining students' needs. At Year 7, some teachers also asked students to self-assess. There is evidence here of a basis to engage teachers in discussions about students' self-regulatory strategies, and for teaching for self-regulation. As an overall generalisation, however, there was little evidence that teachers were able to investigate students' literacy understandings, or diagnose whether students were able to employ literacy skills to achieve their subject-area learning. In general, teachers relied on checking whether students were recording or responding correctly, potentially therefore misdiagnosing difficulties. Moreover, student interviews indicated that students also relied on teachers monitoring their understanding of content. Teacher responses also indicated that when students are faced with literacy difficulties, they supported students to solve the literacy issues. In order to foster self-regulation, however, students need to be able to develop strategies for independent solving. To do so, students need to know what literacy skills or strategies they are trying to develop. All of which is an argument for students' awareness of the literacy demands of their subject area, beyond knowing the meanings of words.

5. Implications and recommendations

Given that this is a relatively small study of a purposively selected group of teachers, the generalisability of our findings is not certain. However, one practical contribution we believe that this study can make to the field is to provide a frame that teachers, leaders and professional development providers can use to investigate and reflect on patterns of subject-literacy instruction in their own context. Our experience suggests that collecting, analysing and facilitating extended discussion about data of this type in an individual school context may itself influence teacher instruction and improve outcomes for students. To this end, we have developed a simplified framework for reflecting on literacy and language practice in schools (Wilson, 2012, Appendix G).

In addition, below are more general recommendations, for the consideration of educators, policy-makers and researchers alike.

1. Support students' engagement with and use of content-specific texts, for at least two purposes: to build, and to apply, content knowledge. While we do not have any evidence about the best provision of such support, it may, for example, include the design and provision of such texts, or the identification and ongoing collation of a pool of digital, news media or 'real world' texts which exemplify mathematical or scientific principles. Such a bank of resources would provide teachers and students with access to multiple texts, thereby supporting textual use in ways that correspond more closely to scientific and mathematical uses of text.
2. Support the design of dialogic teaching sequences and critical discussion around texts, which also provide contexts for knowledge building, application and critique. Such support might identify sites, within traditional lesson sequences, to deepen student engagement with concepts through dialogue about texts.
3. Develop pedagogies which build towards student independence. Included in this we see metacognitive conversations (in the service of reading and writing subject-area texts) which identify features of texts, and the teaching of strategies to overcome textual challenges, as well as formative assessment practices and teaching as inquiry.

Support for the implementation of these recommendations might include creation of collaborations between subject experts and literacy experts to design professional learning opportunities and to develop teacher support materials such as:

- prompts and think-aloud routines to develop meta-cognitive conversations about texts
- contextualised units of work based around multiple texts, which require students to gather and apply knowledge to texts in ways valued within that subject
- prompts, discussion starters and talking points
- annotated texts which highlight key literacy and language features.
- strategies to deal with common features of texts identified as potential barriers (eg, Fang, 2006).

It will be important for research and evaluation to be conducted to investigate the effect of these resources on subject-literacy teaching and learning.

6. Conclusions

We conclude our recommendations with our vision of textual use to support subject-area literacy. We realise that this represents quite a radical departure from traditional text use in schools, and offer this, therefore, as a starting point for dialogue.

Our reading of the research indicates to us that optimal textual use in content areas would provide students with rich and frequent opportunities to engage with the language and texts valued in that subject discourse. This involves writing as well as reading texts. The texts used would exemplify key features of that discipline, including features that may initially prove challenging to students. These rich subject texts would be the central focus of all subject-literacy instruction and tasks would be framed around the reading and writing purposes that are valued in that subject. Students and teachers would engage in extended discussions about the texts and how they employ strategies to make and create meaning from them. Through these extended discussions, teachers and students would develop knowledge about how valued subject texts work, encompassing aspects such as the intended audience and purpose, vocabulary, organisational features and language features. As well as developed knowledge about how their valued text forms work, teachers would know about common potential gaps and misunderstandings in students' knowledge about texts and strategies, and how to diagnose these.

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Appendix A: Teacher Observation Tool

Time	Lesson General			Literacy Instruction				Comment Record literacy-related statements, descriptions of tasks and activities, specific vocabulary items, strategies taught/mentioned, evidence of teacher inquiry, etc.		
	Text(s) and what students are supposed to do with it — eg. copy, read silently, convert word to maths problem	Main Teacher Activity	Differentiation	Dimensions observed	Main Focus	Main Type*	Quality 1-3			
1		Q & A ED L Model Conf Rove Mgmt	WC Group Individ.	Vocabulary	R W R+W	Item Practise Critical	APK Strategy			
			Main Student Grouping			Structure	R W R+W		Item Practise Critical	APK Strategy
						Audience/purpose	R W R+W		Item Practise Critical	APK Strategy
						Language resources	R W R+W		Item Practise Critical	APK Strategy
						Spelling & punctuation	R W R+W		Item Practise Critical	APK Strategy
						WC Group Individ.	Vocabulary		R W R+W	Item Practise Critical
2		Q & A ED L Model Conf Rove Mgmt	WC Group Individ.	Vocabulary	R W R+W	Item Practise Critical	APK Strategy			
			Main Student Grouping			Structure	R W R+W		Item Practise Critical	APK Strategy
						Audience/purpose	R W R+W		Item Practise Critical	APK Strategy
						Language resources	R W R+W		Item Practise Critical	APK Strategy
						Spelling & punctuation	R W R+W		Item Practise Critical	APK Strategy
						WC Group Individ.	Vocabulary		R W R+W	Item Practise Critical
3		Q & A ED L Model Conf Rove Mgmt	WC Group Individ.	Vocabulary	R W R+W	Item Practise Critical	APK Strategy			
			Main Student Grouping			Structure	R W R+W		Item Practise Critical	APK Strategy
						Audience/purpose	R W R+W		Item Practise Critical	APK Strategy
						Language resources	R W R+W		Item Practise Critical	APK Strategy
						Spelling & punctuation	R W R+W		Item Practise Critical	APK Strategy
						WC Group Individ.	Vocabulary		R W R+W	Item Practise Critical

Time: 3 mins on/3 mins off. Using egg-timers, observe for 3 minute block, then record for 3 minutes.

Lesson General

- **Text:** Record details of **any** texts that students read or write. Details include: title, brief description of text type, length (expected length of writing task). Photograph any texts that students read for closer analysis (eg, Range software).
- **What students are supposed to do with it:** *eg, copy, read silently, write a critical review, solve problems, convert word problem to maths problem, answer short-answer questions, summarise in own words, complete retrieval chart, draw a visual representation, follow written instructions to carry out experiment/activity, etc.*
- **Main teaching activity** — make a judgement about the SINGLE most dominant activity in that time-block:
 - Q & A:* Q & A sessions (probably quick-fire, little elaboration)
 - ED:* extended discussion (lots of elaboration)
 - L:* lecture
 - Model :*
 - Conf:* conference – teacher engages in deep conversation with individual or small groups, sustained (longer than 1 min), learning focussed
 - Rove:* rove and assist – teacher moves around class giving short, unplanned guidance to individuals or small groups – interactions typically short (less than 1 minute), not necessarily learning focused
 - Mgmt:* management of resources and behaviour, etc.
- **Differentiation** — make an OVERALL judgement about differentiation for that block:
 - WC = no differentiation; Group = different groups given different activities; Individuals = different students given different activities.
- **Main grouping** — make a judgement about the SINGLE most dominant grouping (of students) in that time-block:
 - students working as whole-class (eg, whole class discussions, teacher instructions); groups (pairs +); individual.

Literacy Instruction

Code ALL categories for which there is ANY instance of literacy teaching. When more than one category is observed, code all that were present.

- **Dimensions:**
 - *Vocabulary*: instruction which refers directly or by association to specific vocabulary — either sub-word units (eg, morphemes), individual words, or word combinations and phrases
 - *Structure*: Includes global structures of text as well as structural/organisational features, eg, headings, topic sentences
 - *Audience/purpose* – ‘Purpose’ here relates to text, eg, “In this text the writer wants to *persuade* the reader to...”
 - *Language resources*
 - *Spelling and punctuation*.
- **Focus** — choose MAIN literacy focus for that 3 minute block:
Reading OR Writing OR R+W (Reading writing links).
 R+W means explicit teacher links of reading/writing or students writing somewhat extended pieces of writing in response to reading (eg, write a paragraph summary of page) NOT writing answers to reading comprehension questions.
- **Type** — choose main type but if 2 or more have even intensity then record highest only (ie, if item and strategy observed with similar intensity of focus, select strategy):
 - *Item*: direct teaching of item
 - *APK (Activating Prior Knowledge)*: reference to, use of background and event knowledge
 - *Practise*: opportunity to apply knowledge or skill that students are assumed to already have
 - *Strategy*: teaching of strategy
 - *Critical*: instruction related to questions of positioning (eg, bias, manipulative devices) and critique.
- **Quality** — complete this in relation to EACH dimension selected:
 1= inaccurate, not focussed, ambiguous
 2= accurate but low focus, minimal information and formative direction
 3= medium to high focussed action which is informative and has formative direction.

Dimension	Item	APK: Activating Prior Knowledge	Practise	Strategy	Critical
Vocabulary	<p>“Photosynthesis is the name for the process when....”.</p> <p>“Copy down these words and definitions from the whiteboard”.</p>	<p>“What words do you know that relate to fractions?”</p> <p>“Remember last week we talked about this word....”.</p> <p>“Have you seen this word in any other contexts?”</p> <p>“Are there words that have a similar meaning in your first language?”</p>	<p>“Make sure you include words from the topic word list when you write your answers”.</p> <p>Mix ‘n’ match activities, etc, (when students assumed to know the words).</p>	<p>“What are some other words that have ‘photo’ in them?”</p> <p>“You can remember ‘percent’ by remembering how many cents there are in a dollar, or by seeing that % is a jumbled up ‘100’”.</p> <p>“You can remember that ‘acute’ angles are small and ‘cute’ whereas obtuse angles are obese.”</p> <p>“If you’re not sure about a word meaning you could have a guess then reread to see if it makes sense”.</p>	<p>“Why does the article refer to the murder victim as “the tagger” rather than by his name?”</p> <p>“Discuss why one scientist said that farmers should pay a ‘carbon tax’ because the methane released by livestock is a greenhouse gas, whereas Federated Farmers called this a ‘fart tax’”.</p>
Structure	<p>“This type of essay has 5 paragraphs – 1 introduction, 3 body paragraphs and a conclusion”.</p> <p>“This type of graph should have labels on the vertical and horizontal axes”.</p>	<p>“What usually happens at the beginning of a narrative story?”</p> <p>“What are some organisational features of books you can use to find information quickly?”</p>	<p>“Label examples in the text of these organisational features: captions, sub-headings, etc.”</p> <p>“Write an essay. Start each paragraph with a topic sentence.”</p>	<p>“ Before you read a challenging text it can be useful to get a quick overview by looking at the headings, pictures, captions, etc.”</p> <p>“The SEX mnemonic (statement, explanation, example) can help you remember how to structure your paragraph”.</p>	<p>“How helpful was the structure of this text for finding information?”</p> <p>“Does the heading capture the main idea of that section?”</p>

Dimension	Item	APK: Activating Prior Knowledge	Practise	Strategy	Critical
Audience & purpose	<p>“The audience for this essay is the NZQA marker and your purpose is to convince him/her that you know a lot about this topic”.</p> <p>“What this word problem is really asking you to do is to find the length of AF”.</p>	<p>“What are some situations in which you have had to persuade someone?”</p> <p>“What is your main purpose as a reader of word problems?”</p>	<p>“Identify the main purpose of each of these texts.”</p> <p>“Write an explanation of photosynthesis for an 8-year-old. Now write an explanation for a scientist.”</p>	<p>“Before you begin writing you could brainstorm ideas about the likes and dislikes of the person who will be reading it.”</p> <p>“Looking closely at the words used can help you identify the target audience – for example, if they use a lot of slang it might be aimed at teenagers.”</p> <p>“Underline the key variables in the word problem then rewrite it in a mathematical format — eg, equation, probability tree.”</p>	<p>“On the surface, the purpose of this text is to explain global-warming. Do you think the writer has another purpose?”</p> <p>“How is the audience of this text positioned?”</p>
Language resources	<p>Direct teaching of features such as tenses, pronouns, rhetorical devices, degree of formality, figurative language, passive voice, 3rd person, avoiding contractions, conjunctions, prepositions, etc.</p>	<p>“What are some differences between formal and informal language?”</p>	<p>“Write a story with as many alliterative words as you can.”</p> <p>“Rewrite this in scientific language/everyday language.”</p>	<p>Teaching features with a strategic reading or writing purpose — eg, “Writing in the 3rd person will make you seem more authoritative”.</p> <p>“Writing the name of the referent may be helpful if you are confused by the pronouns.”</p>	<p>“Why does the school say ‘73%’ of its students pass’ rather than ‘over one in four students fail’?”</p> <p>“Why does the writer repeatedly use the word ‘you’?”</p>
Spelling & punctuation	<p>“A colon looks like this ‘:’ and it is often used to introduce a list. For example, two types of angles are:</p> <ol style="list-style-type: none"> 1. obtuse 2. acute.” <p>$x < y$ means y is bigger than x.</p>	<p>“Who can tell me how to spell onomatopoeia?”</p>	<p>“Correct all the spelling and punctuation errors on this sheet.”</p>	<p>“Before you hand in your final copy underline some words you think might be wrong and check them.”</p> <p>“You can remember to spell ‘practice’ and ‘practise’ correctly by thinking that practice is a noun just like ‘ice’.”</p> <p>“You can remember $x < y$ means y is bigger than x because the wide part of the symbol points at the bigger value.”</p>	<p>“Why have the manufacturers deliberately misspelt this as ‘kronic’?”</p>

Appendix B: Teacher interview framework

Teacher:..... Class: School: Date:.....

Note: Interviewer will ask questions about ONE instance of literacy teaching in the lesson (vocabulary OR reading OR writing).

Introduction

- a. In terms of the literacy aspects of **your subject**, what were your main goals in *this* lesson?
- b. Where does this lesson sit in the unit/topic sequence? (Circle one)
 Near the beginning middle end

Let's talk about some of the vocabulary OR reading OR writing teaching you did in this lesson.

1. What did you want students to learn about vocabulary OR reading OR writing? (literacy learning purpose)
2. Have you taught this previously? (ie, is it new learning or something to be revised)
3. Why did you decide that this was important for your students to learn? (rationale for purpose)
4. What did you do in the lesson to achieve this literacy purpose? (deliberate acts of teaching)
5. Why did you select these activities/actions? (rationale for actions)
6. How effective was the lesson in achieving this goal?
7. How do you know this?

Appendix C: Subject Literacy Pedagogical Content Knowledge (SLPCK) Tool

Name:..... School:..... Text: A B (circle one)

Purpose

The purpose of this tool is to find out your ideas about literacy and literacy teaching in your specialist subject area. The attached text [see Appendix D for mathematics and Appendix E for science] may not be one that would be used at the level that you teach – but we are interested in the aspects of language that you think might be challenging for a Year 11 student to read.

Instructions

1. Read the attached text/task which comes from an external Level 1 NCEA assessment task. The ‘text’ includes *everything* on the page, including headings, instructions, questions and diagrams.
2. Choose up to SIX aspects of the text that you think Year 11 students would find **most** difficult or be most likely to misunderstand.
3. Complete the attached table.
4. Please explain your ideas in as much detail as you can and use specific examples from the text to support them.

Aspects of the texts that might create challenges for students include:

- gaps in background knowledge
- unfamiliar vocabulary
- unusual structure or layout
- sentence level grammar
- knowledge of reading strategies.

1. Explain important <u>types of problems</u> your students might have reading and understanding <u>this</u> text. .	2. Explain actions you could take as a teacher to prepare students to cope <i>independently</i> with similar reading difficulties in the future — eg, in an exam. <u>Note</u> : ‘actions’ might include particular teaching activities as well as pieces of information, direction or prompting.
a.	
b.	
c.	

Please turn over

1. Explain important <u>types of problems</u> your students might have reading and understanding <u>this</u> text.	2. Explain actions you could take as a teacher to prepare students to cope <i>independently</i> with similar reading difficulties in the future — eg, in an exam. <u>Note:</u> ‘actions’ might include particular teaching activities as well as pieces of information, direction or prompting.
d.	
e.	
f.	

Appendix D: The mathematics text in the SLPCK Tool

Achievement Standard 90194: Determine Probabilities

QUESTION TWO

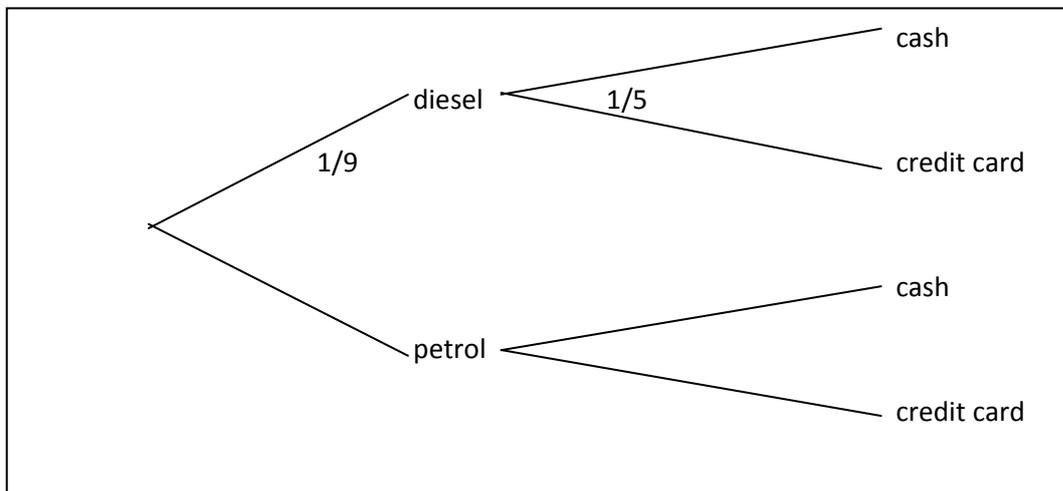
- (a) At a certain garage the probability of a customer buying diesel is $\frac{1}{9}$.

The other customers all buy petrol.

$\frac{1}{5}$ of both diesel and petrol customers pay cash for their fuel.

All others pay by credit card.

Some of the information is shown on the diagram.



What is the probability that a customer chosen at random bought petrol and paid by credit card?

What is the probability that the next two customers both bought petrol?

- (b) The oil pressure in a vintage car is noted by a warning light.

We know that the oil pressure is too low 1% of the time.

If the pressure becomes too low, the light should come on.

However, the light is not always reliable.

When the oil pressure is too low, the light is on 98% of the time.

When the oil pressure is okay, the light is on 0.1% of the time.

Find the probability that the light is giving an incorrect reading.

Appendix E: The science text in the SLPCK Tool

NCEA Level 1 Science, 2008

Achievement Standard 90188: Describe aspects of biology

QUESTION ONE

Fruit can be processed so that it can be stored for a long time and remain safe for eating. This can be done by preserving fruit (bottling), which reduces the risk of microorganism infection.

The steps in this process are:

1. **cook** the fruit
2. put the fruit into **sterilised** jars
3. remove **all air bubbles**
4. **screw down** the sterilised lid.

Adapted from *Edmonds Cookery Book*, 1990, page 179.

- a) Discuss **how** micro-organism infection is reduced by **TWO** of the steps in the process.
- b) Explain why jars of preserved fruit should be refrigerated once opened. In your answer, refer to the life processes of micro-organisms.
- c) Addition of some yeast to fruit in certain conditions can cause a small amount of alcohol to be produced.
Name and explain the process by which yeast produces alcohol from the fruit.

Appendix F: Student interview framework

Class:

School:

Date:

<p>Note: Interviewer will ask students questions about ONE instance of literacy teaching in the lesson (vocabulary OR reading OR writing).</p>

In this lesson, your teacher did (describe an instance of vocabulary/reading/writing).

What vocabulary, reading or writing knowledge do you think your teacher wanted you to learn when he/she did this?

Was it effective in helping you learn this? Why or why not?

Do you think this was something important to learn in science/mathematics? If so, why is it important? How will this help you in future?

Appendix G: Subject-area literacy instruction: reflecting on a lesson



A. Use of texts

Aspects of instruction	Comments and considerations																					
<p>Time: How much time did students spend reading and writing valued subject texts?</p>																						
<p>Learning purpose: Were texts used as a vehicle for learning topic content and/or developing subject literacy?</p>																						
<p>Disciplinary features: What disciplinary features did the texts being used have? How were these texts similar or different to those valued in the subject?</p>																						
<p>Level of challenge: What was the level of challenge in the text/task?</p> <table border="1" data-bbox="247 1317 724 1570"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="3">Text complexity</th> </tr> <tr> <th>Low</th> <th>Med</th> <th>High</th> </tr> </thead> <tbody> <tr> <th rowspan="3">Level of scaffolding</th> <th>Low</th> <td></td> <td></td> <td></td> </tr> <tr> <th>Med</th> <td></td> <td></td> <td></td> </tr> <tr> <th>High</th> <td></td> <td></td> <td></td> </tr> </tbody> </table>			Text complexity			Low	Med	High	Level of scaffolding	Low				Med				High				
			Text complexity																			
		Low	Med	High																		
Level of scaffolding	Low																					
	Med																					
	High																					
<p>Context/Setting: What were the contexts/settings of the texts? Were these appropriate for the topic learning purpose? Were contexts typical of the contexts used in the discipline? Were the texts 'Mirrors' or 'Windows'?</p>																						
<p>Extended discussion: What opportunities did students have for extended discussion about text meaning and interpretation?</p>																						

B. Vocabulary

Aspects of instruction	Comments and considerations
What words were explicitly taught?	
What opportunities did students have to: <ul style="list-style-type: none"> - read and hear new words in multiple contexts? - write and speak new words in multiple contexts? - develop their strategies for learning and solving new vocabulary? 	

C. Teaching ‘how texts work’

Aspects of instruction	Comments and considerations
What opportunities did students have to learn about important features of subject texts: <ul style="list-style-type: none"> - purpose and audience? - structural/layout conventions? - linguistic features? - critical literacy? 	

D. Strategy Instruction

Aspects of instruction	Comments and considerations
What and how were strategies taught? For example, the teacher modelling a ‘think aloud’ for skimming and scanning.	
What opportunities did students have for practising strategies?	
What opportunities did students have for discussing and reflecting on strategies for reading and writing?	