Accelerated Literacy in Science

A Research Report prepared for the
Department of Education and Children’s Services

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University of South Australia
October 2008
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Acknowledgements

This research project was funded by the Australian Government Quality Teacher Program (AGQTP), the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands District, and the English as Second Language (ESL) Program in the Department of Education and Children’s Services (DECS) in South Australia. I am very grateful to these groups for their support. I am particularly grateful to Ms. Bronwyn Parkin, the South Australia Accelerated Literacy (AL) program officer. Bronwyn has provided the energy and impetus for the uptake of AL in South Australian schools. Without her understanding of the principles and processes of AL and her commitment to successful pedagogies for ‘at risk’ groups of students this research would not have been possible. I would also like to thank the participating school principals who allowed us into their schools with cameras and tape recorders. Most importantly I would like to thank the five teachers and the students in their classrooms. The teachers and students were enthusiastic, engaged and always accommodating. These schools all deal with daily challenges of significant proportions. The quality of teaching and learning recorded in the project is testimony to the professionalism and dedication of these teachers and the care they have for their students.
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Abstract

Accelerated Literacy is a literacy pedagogy which has been used as a successful intervention strategy with ‘at risk’ groups of learners, particularly Aboriginal students, but more recently ESL learners and students in low socio-economic areas. Previous research about the pedagogy and classroom outcomes has taken place with narrative text, essentially the kinds of story texts that are common in all classrooms, and prevalent in literacy programs. This research project investigated the effects on both teaching and learning when the same pedagogy was extended into another curriculum area, in this case the learning area of Science. The teachers no longer used narrative texts but attempted to extend the pedagogy to work with explanation texts which are common in Science, and widely used by scientists as they attempt to explain the natural and constructed world.

Five teachers in three Department of Education and Children’s Services (DECS) metropolitan schools, each with significant enrolments of disadvantaged and ‘at risk’ students, participated in the research project. Of these, one was a specialist Science teacher in a high school, and the others were primary school teachers. All of the teachers reported that they had success in using the pedagogy in Science. The generalist primary teachers all reflected that they were previously not confident as Science teachers and often minimised their teaching in this learning area, or understood it as activities involving ‘magic’ or ‘tricks’. The introduction of text into a more central position in the teaching and learning process was a unifying step, and they were able to use the text to ‘anchor’ the units of work they planned and implemented within the research. The use of text brought with it important challenges which the teachers were able to meet to some degree, some more easily than others. Where the choice of text is relatively easy to make with narrative, and there are several texts which have been specifically analysed for use in AL, no such texts are currently available for use in Science. The teachers had to adapt texts to suit their chosen topics and constructing appropriate and useful texts presented difficulties. The research also found that the complexity in explanation texts was of a different order to that of narrative texts and the teachers were not accustomed to working with the scientific explanations.

Despite these issues the teachers noted improvements in student understanding as evidenced in their control of both the spoken and written language within their chosen topics. They all embraced the pedagogic principles and processes and expressed confidence in extending its use across the range of curriculum areas.
The research context

This report documents a research project undertaken in three DECS schools in Terms 3 and 4 of 2007. The focus of the research was on language and literacy in Science. In broad terms the interest was in the oral language of the teacher and of the students, and also in the reading and writing of the students. The five teachers who participated in the project all attempted to use their knowledge of Accelerated Literacy (AL) in a unit of work in Science. AL is defined as a specific set of pedagogic practices, distinctive in their underlying principles and the practical applications promoted as important in the successful teaching of reading and writing. In this report these principles and practices are consciously named as AL pedagogy.

The participating schools were all in the metropolitan area with significant numbers of disadvantaged students, including Aboriginal learners, ESL learners and those from lower socio-economic communities. Two of the schools were primary schools, both designated as Category 2 on the DECS Index of Educational Disadvantage. The third was the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands Secondary Program, co-located on the campus of a large metropolitan high school.

The teachers planned their programs to extend AL pedagogy from the traditional base of working with narratives as part of literacy teaching and learning in English into the learning area of Science. Accordingly they planned a discrete unit of work in Science incorporating AL pedagogy. The prime aim of the research project was to investigate and document the issues faced by the teachers in this endeavour. The participating teachers from the three schools all volunteered to participate in the project. They were encouraged by their school principals and supported throughout by the DECS Officer with responsibility for the South Australian Accelerated Literacy Program (SAALP). The research project was her initiative. The chief researcher from the University of South Australia (UniSA) was also committed to the broad aims of AL and was not an innocent or objective bystander in the overall research process. It is important to clarify these roles and perspectives at the outset. Whilst the research was conducted ethically and with a sound methodology constructed from a researchable question, the research team comprising the researcher, the DECS Officer and the participating teachers all had an interest in a positive outcome. That is we hoped to identify obstacles in the process, but not so many or so serious as to suggest that AL could not be extended usefully into learning areas across the curriculum. We started from the belief that AL pedagogy could be usefully extended to impact on the reading and writing outcomes of students in the full range of curriculum areas.
The research relationship resonates with the metaphor of the warthog and oxpecker used by Johnson and Johnson (2002) to describe school and university partnerships in research. The oxpecker and the warthog coexist in sub-Saharan Africa and benefit each other in their pursuit of inter-dependent goals. In this research we began from a 'mutualist' understanding of the possible benefits in regard to reform issues in pedagogy for the disadvantaged, through a well-documented process of participant research. For the SAALP project it offered the opportunity to seriously investigate the potential of AL in a learning area in which narrative text was not prevalent. For the teachers it offered an opportunity for time to plan, try new practices in a supportive environment and reflect on these as the research unfolded.

The research question

The overarching research question asked:

What are the issues, both theoretical and practical, for teachers as they aim to expand on their work with narrative texts in Accelerated Literacy into the learning area of Science?

The aim was to document and to understand the issues faced by teachers, both at a practical level and also at a theoretical level, as they worked to extend their successful practices of using narrative texts in AL into the learning area of Science. The underlying premise was that the learning area of Science promotes and uses specific kinds of texts which are different from narratives in the effort to describe, define and explain the natural and constructed world in which we live. Texts which are prominent in Science function to explain phenomena and are different from narrative texts in their overall structure, different in their patterns of grammatical use, and different in their choices of vocabulary. What happened for the teachers and the students when teachers attempted to use AL pedagogy in Science with explanation texts? We also wished to gather information about the resolution strategies the teachers employed during the overall process.

The schools and teachers participating in the research all had a background in working with AL pedagogy. The teachers involved were graduates of the Graduate Certificate in Accelerated Literacy offered through Charles Darwin University. They had also been successful participants in the Accelerated Literacy professional development program offered through the SAALP. They, and their schools, were committed to AL pedagogy and in this project attempted to extend the focus into the Science learning area with its shifting demand for control of a different kind of text than was traditionally used in AL. The project charted their efforts and the impact of their pedagogic practices on student learning and student outcomes. The desired
outcomes for the students were control and use of the language of Science. AL theory contends that the successful use of the specific language is a demonstration of emerging control of the discourse of the learning area, a manifestation that the students are moving ‘inside’ the discourse. Thus, successful use of the language of the Science topic by the students would be interpreted as evidence that students had gained understanding of the topic. At the outset the SAALP Officer stated:

*What we are looking for over time is how and if the teachers are handing over control and understanding. We need to see the students taking up the language. Part of it is being able to speak with authority.*

The project did not differentiate between different cohorts of learners and the teachers worked with all of the learners in their classes. However, the ESL Program in DECS took a particular interest and contributed funding to the project, because of an interest in gauging the usefulness of the pedagogy for ESL learners. This became an added dimension to the project and is addressed in the Discussion section of this report.

**Research design and methodology**

To inform the research question we collected and analysed written texts produced by students, interactions between teachers and students as part of AL in Science lessons, and also the reflections of the participating teachers as they progressed through the teaching of the unit of work. The data set comprised:

- Teacher reflections on their engagement
- Student writing samples
- Teacher and student interactions
- Model texts used by teachers.

The focus was on how the teachers used AL pedagogy to develop expertise in their students as young scientists so that they entered into Science discourse, as successful ‘doers’, speakers and writers. We investigated what the teachers did and how they went about teaching Science content within a selected Science topic, and then also how teachers taught their students to demonstrate that knowledge in both spoken and written forms.

The analysis of classroom interactions between teachers and students offered insight into how the teachers ‘apprenticed’ their students into scientific understanding and expertise. The analysis of student written texts provided information regarding the student uptake of the Science and of how they demonstrated understanding of that
Science to an audience. The student writing samples were analysed using the ESL Scope and Scales within SACSA, which is the curriculum document specific to the ESL Program in DECS. This is based on Halliday’s variety of functional linguistics called Systemic Functional Linguistics (SFL), and its theoretical model of language in context, subsequently recontextualised for educational purposes via the genre-based approach to teaching (Cope & Kalantzis, 1993). The teachers were also invited to reflect on their teaching of the Science unit with the SAALP Officer and the researcher by watching video footage taken in their classrooms. These sessions stimulated dialogue between the teacher, the SAALP Officer and the researcher, and provided additional data for the project. The thematic analysis of teacher reflections provided useful information about their perceived successes and failures, their questions and their issues as these surfaced within the project.

Research methods

Five teachers and their classes, totaling approximately 110 students, from the three schools participated in the project. Within the primary schools the teachers worked with a Year 2/3 class and a Year 6/7 class in one school, and a Year 4/5 class and a Year 6/7 class in the other. One of the schools had a sizable population of migrant and refugee students and also a small number of Aboriginal learners. The second had an identifiable population of Aboriginal learners. The third school was the location for the secondary program for Aboriginal students from the APY Lands District attending school in Adelaide. It is in fact the designated APY Lands District secondary program school. The specific class involved in the research was a bridging class of fourteen students who had recently arrived in Adelaide and were in the initial stages of adapting to life and school in the city. The teacher in this location was a specialist Science teacher whereas the teachers in the other schools were generalist primary teachers, with teaching responsibilities across a wide range of learning areas.

The schools and teachers were invited to participate because of their previous engagement with, enthusiasm for, and expertise in using AL pedagogy. All three schools were ‘AL schools’ where the inherent principles and practices were already well established. An added criterion for selection was that the teachers had graduated from the Graduate Certificate in Accelerated Literacy offered through Charles Darwin University.

The research initiative began in June 2007 with a half day professional development session for the teachers. This session was planned and delivered by the researcher, the SAALP Officer, a Science educator from UniSA and a linguist from Adelaide University. The content of the professional development was organised around the
learning area of Science and began by posing some basic questions about the nature of Science, the roles and responsibilities of scientists, and the place of language and its importance in Science and also in Science education.

The teachers, with the support of the SAALP Officer, then planned a unit of work for Term 3, based on what they considered to be a suitable topic in the learning area of Science. They used the SACSA Framework and the SACSA Science Companion Document R-10 as their starting point. The units of work were as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 2/3</td>
<td>Energy, the wind</td>
</tr>
<tr>
<td>Year 4/5</td>
<td>Simple levers</td>
</tr>
<tr>
<td>Year 6/7</td>
<td>Insulation</td>
</tr>
<tr>
<td>Year 6/7</td>
<td>Transpiration</td>
</tr>
<tr>
<td>Secondary Bridging</td>
<td>The human eye</td>
</tr>
</tbody>
</table>

The teachers were interviewed at the beginning of the project (see Appendix 1 for Interview Questions). At the end of the project, during Term 4, the teachers were again interviewed, this time in a semi-structured manner, and were invited to reflect on their engagement in the research. The questions used in the interview are attached as Appendix 2. During the teaching of the unit in Term 3 video footage was recorded of three lessons from each of the five teachers spaced over a six week period, with approximately three weeks between each video session. The content of the lessons comprised segments of the Science unit which the teachers had developed and were teaching, and these lessons were later transcribed for further analysis. Within that period the teachers were also interviewed. The focus of the interview was their experiences to date of their attempts to extend AL into Science. The videos of the lessons were used as the basis for discussion and reflections of the teachers' pedagogic practices and processes. This methodological process is known as stimulated recall (Gass & Mackey, 2000) and provided the opportunity to discuss with the teacher the steps, the moves, the interactions within the classroom, and to ask for their comments on their teaching and learning processes. We were able to inquire about their intentions at specific moments in a lesson, ask for clarification when a point was not clear, and generally build an accurate account of pedagogy from the participant teacher perspectives.
Background to the research

Accelerated Literacy (AL) is an approach to the teaching of reading and writing to groups of students who are traditionally unsuccessful literacy learners. The approach was developed in Australia initially by Brian Gray via research conducted over a number of years first as a teacher/psychologist in Alice Springs and later as a researcher at Canberra University. In Canberra Gray collaborated with Wendy Cowey in further research and refinement of the approach. It was initially called the Scaffolded Approach to Literacy and then more formally named as Scaffolding Literacy. Gray’s initial training was as an educational psychologist and he undertook his PhD under the supervision of an educator with training in Hallidayan SFL. The theoretical underpinnings of the AL are found in Vygotskyan formulations of teaching and learning, encapsulated in the metaphor of scaffolding as used by Bruner and associates in the USA in the 1970s, integrated with formulations of pedagogic discourses theorised by the English sociologist Bernstein (1990), and also with linguistic orientations to meaning and grammar articulated in Hallidayan linguistics.

In the Family and Community Centre at Canberra University, Gray and Cowey conducted research over a number of years with children whose achievements in reading were measured at a level at least two years below their age level in standardised tests. Their focus was specifically on underachieving readers. The insights they gained from this research led to the development of intervention practices which demonstrated clear successes with these underachieving learners. The theory and practices they developed were then translated into professional development programs for teachers. The bases of the professional development have since been adapted and tailored to the needs and context of SA schools via the SAALP. The SAALP promotes a visible pedagogy geared to inducting unsuccessful learners into what Gray calls ‘literate discourse’ (Gray, 1998). Essentially the effort is to enable learners to read and write successfully. AL prescribes processes and strategies which provide success to the learners at all points of the lesson. Within the total process there is no assumption made about the prior knowledge or understandings that students bring to the classroom.

The pedagogic practices inherent in AL have now been trialed across a range of State and Territory jurisdictions with those students who are traditionally deemed ‘at risk’ in the context of formal schooling. These cohorts essentially comprise:

- Many urban and the great majority of rural and remote Aboriginal learners
- Some migrant but a larger proportion of refugee ESL learners
• Some mother tongue English speakers from low socio-economic backgrounds, including some from a working class background, but a larger proportion from communities where underemployment or unemployment is the norm.

In South Australia AL was first implemented on the APY Lands District schools in the late 1990s. These schools were part of the initial pilot for the intervention. More recently, through the SAALP, the pedagogy has been embraced by a number of metropolitan and regional schools with cohorts of Aboriginal enrolments. As the program gained in popularity it was made available to schools designated as Category 1-4 on the DECS Index of Educational Disadvantage.

The rationale for the current project was the fact that the focus of the work in AL at both the national level and locally through the SAALP has been on narrative or story texts. School-based trials to work with different text types in a broader range of learning areas have been undertaken more recently, but there has been to this point no research to support such work. Accordingly, this project aimed to begin a process of systematic investigation of AL as it is applied to the language and literacy work in the learning areas of the curriculum, in this instance the learning area of Science.

There is widespread acceptance that students in school must be able to read and write if they are to be successful learners. Of course the importance of other modes of communication including the visual is not to be underestimated. However, the official curriculum of the school can only be accessed successfully if students are able to understand the written language of different discipline areas, and then produce written texts which indicate that they have appropriated the valued knowledge of the discipline. One obvious reason why the cohorts of learners listed above have been excluded from success in school is because they have traditionally been unsuccessful in these foundational areas of school language and school literacy.

In the research we were interested to understand the impact of AL pedagogy when it was shifted from its initial focus on the teaching and learning of reading and writing of narrative texts into the learning area of Science. Accordingly, the focus was turned to investigate the teaching and learning of reading and writing of the different kinds of texts which are prevalent in the area of Science via AL pedagogy. These texts, essentially factual texts which explain phenomena in the natural and constructed world, constitute an essential aspect of the knowledge base of Science. They differ from narrative texts in both structure and grammatical patterning, as well as in the more commonly understood area of vocabulary. Students who are successful in Science implicitly understand how these texts work and are then able to create or produce similar texts to demonstrate their scientific knowledge. The value of the research was the insight it offered into the issues encountered by teachers as they strove to extend AL pedagogy into Science. It highlighted the pedagogic processes and the responses of teachers and students in classrooms as they engaged with AL
pedagogy in Science. The research interest was in documenting how the focus on

text within AL might contribute to a learning area in which language or text is

traditionally not central. The more accepted wisdom about the learning area of

Science is that it is experiential, and it is these salient features which motivate and

sustain student interest. Underlying this research was a challenge to this view of

teaching and learning Science, a challenge premised on the centrality of language

and literacy to the processes of embracing scientific discourse.

**AL in South Australia**

AL has operated in South Australia since the initial pilot involving the APY Lands

District schools in 1998. At the same time an adaptation of the that program was

established at Salisbury North R-7 under the title Deadly Writin' Readin' and Talkin'

(DWRAT). News of success of this initiative originally spread by word of mouth,

and several more schools then engaged with the pedagogy with the support of the

Aboriginal Education Unit. The SAALP was established in 2006 and is currently

operating in more than sixty schools. DECS commissioned an evaluation of the

program in 2005 undertaken by Barnett and Walsh at UniSA. This evaluation

reported that AL was perceived to make a difference in participating schools, and

that the strong response from the school base was that AL worked. The information

provided by the informants to the evaluation was significant because it indicated the

viability of the program in mainstream contexts. Nevertheless, the researchers

accepted the positive response with some caution. Despite some impressive

statistical indicators, the majority of data was anecdotal, and the final report stressed

the vital need for ongoing quantifiable data to be collected and analysed.

That evaluation also noted that the strength of the qualitative data was such that the

program had the potential to grow and could be promoted within DECS as a viable

intervention with 'at risk' groups of learners. For this to happen it was important for

links to be made and developed with the full range of DECS programs and services

in the area of language and literacy. Potential synergies in this area were noted,
synergies offering the potential for the SAALP to make a significant contribution to

the improved educational outcomes of a range of learners. The Executive Summary

stated:

*The Accelerated Literacy professional learning program, involving whole school

commitment to both the coursework and follow-up mentoring, was effective, despite

being resource demanding. This whole school approach created a community of

learning within a highly supportive environment, which was conducive to expanding

the Accelerated Literacy pedagogy into the mainstream context* (Walsh & Barnett,

2005, p. 16).
AL in the national context

AL has been adopted by a range of State and Territory jurisdictions across the country since Gray and Cowey ran the pilot program in 30 schools across five States and Territories beginning in 1998. That pilot documented significant improvements in the literacy outcomes of Aboriginal students. It now operates at a National level through the National Accelerated Literacy Program (NALP). The NALP was established in 2004 to take AL from the pilot stage to a program for meeting the literacy needs of Aboriginal students in the Northern Territory over four years to 2008. Gray was the initial Director of the NALP. It has been jointly funded by the Australian Government’s Department of Education, Science and Training (DEST) (now Department of Education and Workplace Relations, DEEWR) and the Northern Territory Government, through its Department of Employment, Education and Training (NTDEET). By the end of 2008 the project has planned that:

- AL will be successfully implemented in 100 Northern Territory schools (90% of which will be in remote areas)
- Targeted support will be provided to 10,000 students
- 700 teachers will be trained
- Data on student progress will be monitored and reported.

Beyond the NALP there are a number of AL projects across the country and several of these initiatives have been evaluated and those evaluations made public. All of these reviews and evaluations have reported positively on the impact of the professional development on participating teachers and subsequently on the literacy outcomes of students in their classes and schools (Walsh, 2006). The Review of SAALP added weight of evidence to the view that the pedagogy worked for ‘at risk’ learners and supported the conclusions of previous evaluations of various AL initiatives which had been conducted in different Australian jurisdictions. It is noteworthy to document the short history of the program and also the scrutiny to which it has been subjected across the country.

As noted the first AL project was established as a pilot in 1998 when DEST funded Scaffolding Literacy in approximately 30 schools across Western Australia, South Australia and Queensland. In South Australia, the participating schools were Amata, Mimili, Fregon, and the Wilji Program at Woodville High School, all part of the APY Lands District. This was known as The scaffolding literacy in Indigenous schools project 1999-2002.

From 2001 to 2003, the same program, by this stage rebadged as Accelerated Literacy, also ran as a pilot program in a small number of Northern Territory schools, again with an explicit focus on Aboriginal learners. All schools involved in these programs demonstrated strong gains in literacy competence with average reading level
improvements for targeted students increasing by more than four times the pre-
intervention rate. The gains in literacy outcomes meant that students previously
considered ‘at risk’ were now able to reach mainstream expectations. Data from the
SA review in 2005 supported these findings. For example, Raukkan Aboriginal
School was awarded a National Literacy and Numeracy Award in 2004 in
acknowledgement of the significant improvements shown by its students in the LAN
State Literacy test. The Wiltja program at Woodville High School has produced more
Aboriginal SACE graduates since it embraced AL in 1998 than any other high school
in South Australia.

At the conclusion of the evaluation of *The scaffolding literacy in Indigenous schools
project* in December 2002, the research team at Australian Council for Educational
Research (ACER) found that the results of the introduction of the program were
‘little short of sensational’. In the executive summary the researchers stated:

1. The scaffolding literacy program for Indigenous students is an effective means of
   improving the literacy skills of those students
2. The students involved in the program achieve at a much higher level than if they had
   followed the normal course of events in pursuing literacy skills
3. The professional development provided by the program team to the teachers involved
   is detailed, supportive, and has brought about positive changes to their practices,
   which they believe has brought improvements to their students (Creswell,

In 2006 Culican, Milburn and Oakley from Deakin University reported to DEST on a
funded project titled *Scaffolding literacy in the middle years* which aimed to improve
the literacy outcomes of educationally disadvantaged students in the middle years of
schooling in a cluster of four schools in Victoria. Their report states:

*Both the qualitative and quantitative student data collected over the period of this
project provided strong indicators of the positive impact that Scaffolding Literacy was
having on student attitudes to learning, and on their increased confidence and
capacity to improve their literacy outcomes. Scaffolding Literacy is a new approach to
teaching, rather than ‘just another strategy’. It challenges teachers to rethink and
rewrite the ways they work with texts in the classroom. It requires very explicit
teaching and discourse patterns that are often quite different to those previously used
in their classroom* (Culican, Milburn & Oakley, 2006, p. 20).

In another Victorian project, this time sponsored by the Catholic Education Office in
Melbourne (CEOM), approximately 60 teachers across 24 schools involving more
than 400 students in both primary and secondary schools participated in a project
using AL. The schools served predominantly disadvantaged communities. In the
review of the project, using the AL approach but here rebadged as Learning to read: Reading to learn (LRRL), Culican (2006) concluded:

The LRRL approach was highly successful in accelerating the literacy performance of over 95% of the target students underachieving in literacy.... (the) average literacy gains across all schools and classes, and among students from all backgrounds and ability ranges, was approximately double the expected rate of literacy development. LRRL offers a powerful set of strategies that address the needs of all students within the context of normal classroom teaching practice. The results of the research project confirm that, as a literacy intervention, LRRL has an important contribution to make that addresses the literacy needs of adolescent learners in the middle years, particularly those identified as educationally disadvantaged or at risk (Culican, 2006, p. 31).

In 2005 the NSW Office of the Board of Studies engaged Erebus International to evaluate a Years 7-10 English Aboriginal pilot support project using the pedagogy in a trial in seven schools. In its report of December 2005 Erebus stated:

The universal response from both teachers and parents has been an identifiable initial increase in students’ confidence in reading. In some cases this has also extended to students’ writing skills, where they have willingly picked up a pen and attempted to construct a sentence for the first time in their lives. Equally, participating teachers have found the experience instructive and challenging. For many teachers, existing pedagogical paradigms have been challenged and new teaching methodologies have been successfully trialed (Erebus International, 2005, p. 10).

Within this set of independently conducted reviews there is a very strong recurring message. Whether used in wholly Aboriginal contexts or in more mainstream areas with other disadvantaged cohorts the impact has been positive on both teachers and learners. Each of the reviews makes similar comments regarding the benefits, a noteworthy fact given the broad range of contexts and jurisdictions in which the approach has been implemented and evaluated.

The current project

On the basis of the evidence from these numerous reviews and evaluations it is valid to state that there have been positive and consistent indicators of improved learning outcomes via the AL intervention. However, the information has related specifically to the use of narrative texts and the assessment of learning has been in the area of literacy, using evidence such as the National Literacy Benchmarks, and reading assessment tools such as Developmental Assessment Resource for Teachers (DART)
or Tests of Reading Comprehension (TORCH). There has been no AL research to investigate the impact of the pedagogy beyond the English learning area and into other learning areas of the curriculum. Such a move brings the effort closer to a related body of work and supporting literature which does claim that language and literacy do play a key role in the successful achievement of understanding and learning across all curriculum areas. This is found in writing on ‘language across the curriculum’, ‘language in learning’, ‘language for learning’, and more emphatically in ideas inherent in a ‘language based theory of learning.’ Researcher and teachers with an interest in Systemic Functional Linguistics have applied Halliday’s ideas to links between language and learning, most obviously through the genre-based approach. The extension of AL across the curriculum brings its specific pedagogic practices to this discussion. The question under review then revolves around the applicability of AL across the curriculum. Linked to this discussion is a view that different curriculum areas are different in some way due to differences in the kinds of language they use, most clearly seen at the level of vocabulary. The learning areas of Science and Studies of Society and Environment (SOSE) clearly use different words within their content areas. On closer analysis there is additional understanding that they also favour different kinds of texts made up of different patterns of grammar through which the different meanings central to these learning areas are made. Learning area content is expressed in different words, grammar and texts, and it is this angle on content which has provided some success with ‘at risk’ learners through the genre-based approach in teaching and learning writing.

It was from this knowledge base and armed with an understanding of AL pedagogy that the project began. The starting point was the position that the learning area of Science uses explanation texts as a routine way of explaining the workings, the processes and the operations of the world around us. The fundamental aim of Science education is to explain our natural and constructed world and scientists use explanations to do this. In like manner the teachers in the project would also use explanation texts to support their students to think and act like scientists. They also aimed to teach their students to create explanation texts as a way of demonstrating their scientific knowledge. The research effort was to document the work of the teachers as they attempted to bring their AL pedagogic practices to the foreground in their teaching of a unit of work in the learning area of Science in which explanation texts were prominent.

Policy context

The coverage of Science in the SACSA, and thus the policy position in DECS sees the greatest benefit in an ‘interest based’ approach. Essentially the aim is to create and maintain learner interest and this is best managed in an activity based approach.
This is certainly the basis of accepted thinking about Science education. However, it is not based in evidence that this kind of approach is the most successful. There is no data which suggests that ‘hands-on’ it actually produces greater numbers of students who maintain an interest in Science throughout their school life, or are assessed as successful in school Science, or who take up a Science related job or career. It is based in ideology, the prevalent way of thinking about Science education guided by ideas about how children learn, why they learn, and what are the optimal conditions in which they successfully learn. A critique of the approach adopted in SACSA is that it offers a ‘surface’ understanding of a broad content without any ‘deep’ understanding or engagement with scientific thinking. The approach is premised on the assumption that students will not be able to or will not sustain any interest in theoretical issues.

The theoretical underpinning of SACSA is constructivist learning theory based on the notion of learners constructing their own meanings. This, of course, sits easily with a ‘hands-on’, discovery approach in Science. Counter to this it has been argued that learners can only do this in a powerful way if the language in which valued meanings are expressed is made available to them, given to them by their teachers. Given earlier comments about disadvantaged learners AL takes the view that it is essential to adopt an explicit pedagogy with these groups; the AL in Science research project attempts to document this effort.

**Literature review**

A useful starting point for examining the literature relevant to the project is a recent review of literacy research compiled by Peter Freebody and published by the ACER in 2007. Freebody is one of the leading literacy educators and researchers in Australia and as such commands respect from across the field. The review, titled *Literacy education in school: Research perspectives from the past, for the future*, casts a wide net across research in the area of literacy in Australia and provides a very detailed review of the literature in the field.

In line with the perspective outlined in the previous section Freebody argues that schools are responsible for helping young people manage, use and produce texts that form part of the distinctiveness of the disciplines around which the school curriculum is organised. The apprenticing of young learners in this process focuses attention on how teachers work with texts as students develop their understanding of the differences across curriculum domains and learning areas. He goes on to highlight the cumulative nature of effective curriculum knowledge which he proposes as a focal point for thinking about literacy development in school. In this cumulative view of the nature of knowledge and its importance in school learning he
draws on the work of Bernstein who first theorised the idea of a cumulative, 'vertical' feature of learning in school, which he labelled as vertical discourse structure:

A vertical discourse takes the form of a coherent, explicit, and systematically principled structure, hierarchically organised, as in the Sciences, or it takes the form of a series of specialised modes of interrogation and specialised criteria for the production and circulation of texts, as in the social Sciences and humanities ... a horizontal discourse entails a set of strategies which are local, segmentally organised, context specific and dependent, for maximising encounters with persons and habits (Bernstein, 1999, p. 159, cited in Freebody, 2007, p. 62).

The cumulative development of students' curriculum knowledge in schools shows itself in different ways in the different disciplinary texts through the distinctive distributions of vocabulary and grammatical patterns (Freebody & Muspratt, 2007), the distinctive patterns of knowledge construction (Martin, 2007), and the distinctive ways of representing criteria for proof in grammatical and textual forms (MacDonald, 1994). In this way the disciplines are viewed as frameworks for acting on experience and expanding understanding and practice, and thereby for guiding the public accumulation, dissemination and scrutiny of knowledge. The distinctive practices within disciplines, including the conventions for what counts as data, evidence and argumentation, are the products of their ongoing histories. The important conclusion to this line of argument is that in successful classrooms, these distinctive practices matter for the ways in which learners are apprenticed in their reading and writing. This is precisely the line of argumentation followed and supported within AL.

From this position in which Freebody argues for distinctive disciplinary literacies, essentially different ways of approaching literacy in different disciplines, which are now recontextualised as different learning areas in the context of schooling, he sees a need to conceptualise literacy within the knowledge categories that currently organise valued knowledge in school. He refers to this as 'curriculum literacy awareness' which will lead literacy educators to contribute to an account of how programs embody and demonstrate certain kinds of knowledge in particular ways. The organisation of curriculum within schools imperfectly mirrors the more traditional organisation of disciplines but as the school years progress the materials, interactions and assessments are nonetheless increasingly oriented to these traditional disciplinary knowledge formations. Freebody calls for literacy researchers to map the evolution of knowledge-building through texts and to develop more connected, cumulative and curriculum-specific ways of teaching. The unacceptable alternative is, he suggests:
Corralling 'the literacy problem' in the early years, and trying to solve it there, with grammatically simple narratives accompanied by realistic, representational graphics, discussions about characters and what they might do next, ensuring that many students are abandoned when they encounter curriculum-specific literacy demands across the middle and later years (Freebody, 2007, p. 62).

The idea of curriculum literacy awareness resonates strongly with the underlying AL orientation. Successfully dealing with narrative is crucial in the process of learning to read. But this will not guarantee or even enable students to learn from or to reproduce the written texts they increasingly encounter across the different learning areas. In investigating the place of literacy pedagogy in the Science curriculum this research project adopts the position that literacy is core in the education process, and further, that language is central to the processes of teaching and learning in school. Thus, the research brings together curriculum interests which may not necessarily be naturally linked for many educators. It is, in Freebody’s terms, a move towards curriculum literacy awareness, a position readily espoused by educators with an interest in language and literacy, who see language as the means to appropriating the discourse of Science. The same position, that scientific knowledge and understandings are built on knowledge and understanding of the distinctive language of Science, is much rarer amongst Science educators.

Literature on the place and role of language in school Science education has mostly been developed from the perspective of those who approach Science from their interest in language. The literature field developed by those coming from a scientific perspective has more traditionally centered on the body of knowledge that constitutes Science, and then the processes of Science education, rather than any specific interest in how language features in the field of Science. The normalised and commonsense view is that Science content is the desired outcome, defined in terms of scientific concepts and ideas, and that language is mobilised to ‘put flesh on’ or ‘clothe’ these naked ideas and concepts.

However, another recent ACER publication (Tytler, 2007), commissioned for the Australian Science education community, does provide some focus on the place of language in school Science. In canvassing socio-cultural perspectives to learning Tytler diverts attention away from a focus on what is in students’ heads, and instead attends to the ways in which teachers promote a discourse community aimed at the establishment within the class of shared meanings, and to the ways in which groups of students negotiate meaning in shared tasks (Wickmann & Ostman, 2002). The role of the teacher in this process is to work with students’ ideas, scaffolding them to establish the very powerful discourses of the scientific culture and scientific ways of viewing and dealing with the world. In Tytler’s view socio-cultural perspectives attribute a more fundamental role to language and culture in the construction of scientific knowledge. The socio-cultural perspective, by which is meant the potential
to consider cognition without isolating it from social context, is attributed essentially to the work of Vygotsky. In this view school based learning is considered a social process that takes place in interaction between students and teachers in a pedagogic space termed the ‘zone of proximal development’. This is the intellectual space between what students are able to do alone, and what they can achieve in interaction with their teacher. In broad terms it highlights the cultural aspects of learning Science, the difficulty of appropriating scientific ways of thinking (Aikenhead, 2006), and the socio-economic factors and power relations that impact on learning in school classrooms. In attending to these matters Tytler articulates the belief that language plays a more significant part in teaching and learning Science than Science educators have traditionally recognised.

The development of the National primary connections project (Australian Academy of Science, 2005) is in line with Tytler’s position. Primary connections constitutes a first attempt at a National curriculum scope and sequence for Australian schools in the learning area of Science, and importantly it also accords a recognisable prominence to language and literacy within the Science curriculum. Through linking Science with literacy, Primary connections offers some promise of supporting learners to develop scientific literacy through the engagement offered by activities. Tytler suggests that Primary connections offers Science educators the chance to:

- Explore and develop understandings of the literacies more specific to Science such as investigation, report writing, data representation, and diagram and model construction
- Explore how such literacies can help students engage with and learn Science
- Establish representational issues as key to developing student engagement and understanding.

Primary Connections recognises that there are a number of Science-specific, as well as general, literacies required by children to effectively engage with Science phenomena, construct Science understandings and develop Science processes, and to represent and communicate ideas and information about Science ... Primary Connections provides opportunities for children to develop the literacies needed to learn Science and to represent their developing Science understandings and processes (Hackling, 2006, p. 75).

Primary connections does appear to offer a bridge between Science and language, with the impetus for construction coming from Science. Tytler’s reading of the Primary connections project is that teachers need to develop a stronger understanding of the relationship between the conceptual challenges of individual topics and the value of different representational and re-representational tasks in engaging with these challenges. His use of the term representational is a conscious choice and spans
multimodal areas such as models, diagrams and graphs as visual modes of meaning, complementing or even standing for the more traditional written mode of meaning:

More research is needed to develop understandings of how the literacies of Science relate to student engagement and learning, and of the challenges for teachers of Science in incorporating representational work in their classroom practice (Tytler, 2007, p. 20).

These developments are indicative of the potential synergies available to Science educators and literacy educators, and are encouraging for the current project. However, recognition of the place of language and literacy in Science education is still relatively uncommon. The title of Tytler’s review is, tellingly, Re-imagining science education: Engaging students in science for Australia’s future. He is not writing of a context that currently exists within the community of Science educators. Any impetus for dialogue has come mostly from those on the language side of the ledger. And more specifically the momentum comes from teachers and researchers with an interest in Hallidayan linguistics and/or with a broader socio-cultural orientation. It is significant that AL is a distinctive pedagogy built on insights taken from both socio-cultural theory and from Hallidayan linguistics. It is related to but also clearly distinct from the genre-based pedagogy associated most closely with SFL. Both could be described as displaying a socio-cultural orientation to learning. AL acknowledges Halliday’s SFL as one of its foundational theories, but is more indebted to understandings drawn from Vygotsky’s socio-cultural theory, as well as intellectual mediators of this theory such as Bruner. It was Bruner and colleagues working in the USA, who extended Vygotsky’s theory of cognition particularly in regard to teaching and learning in formal educational contexts. Of central importance in this theory is the view that learning is social, that what is learned by the child comes from the outside and is internalised via the process of social interaction, essentially through the ‘tool’ of language. In fact Vygotsky argued that:

The true direction of the development of thinking is not from the individual to the social, but from the social to the individual (Vygotsky, 1962, p. 10).

If individual thought starts on the ‘outside’ then of great interest to educators is the process by which thoughts get ‘inside’. Wood, Bruner and Ross (1976) coined the term ‘scaffolding’ to describe the process of apprenticeship, whereby one who has mastered a particular activity takes steps to support the attempt by another to carry out a task which is initially too difficult to be carried out independently. The term reflects Vygotsky’s view of cognitive development as ‘a social, communicative process carried out through talk’ (Mercer, 1995, p. 73), and influenced by Vygotsky’s metaphorical Zone of Proximal Development (ZPD) to contrast ‘what a person can achieve when acting alone and what the same person can accomplish with support from someone else’ (Lantolf, 2000, p. 17). Bruner (1986) also suggested that the
teacher might provide maximum support at the beginning and then plan for a gradual shift of responsibility to the student.

The notion of scaffolding is now embraced widely in education as a way of considering how teachers plan for learning, the activities with which they engage and challenge learners, and the way in which they interact with learners, all in the pursuit of achieving optimal teaching and learning outcomes. The terms macro-scaffolding and micro-scaffolding are applied to the processes of more global curriculum planning at one level and more specific interactions at another. These different foci on scaffolding, as well as all points between, occupy teachers and also those offering intervention strategies to teachers through professional development programs. Scaffolding, then is a core concept in the AL program. The SFL component within the approach is based on the understanding teachers need in regard to the relationship between meanings in a text and the grammatical resources deployed to make these meanings. Because it is meaning that is at the forefront of AL pedagogy, it is important that teachers can recognise and teach their students to recognise how meaning in a text is expressed. SFL is a more prominent feature of the genre-based approach and there is a body of literature that has developed over the past two decades in which SFL educators have made a strong case for language to be considered as central in Science education. The links between SFL and Science education are described in the next section. As a precursor to that literature it is also worth noting other contributors, each of whom acknowledges both Vygotsky and Halliday in their thinking.

Vygotsky and Bruner are influential in the work of Robin Alexander (2006), the UK researcher, who has gained international recognition for his work promoting the importance of dialogue in education. Alexander links language to learning as the central pillar of his thinking. He is particularly interested in the role of spoken language in the classroom and offers a model of different types of classroom talk and their respective influence on the trajectory of student learning. His starting point is that language and the development of thinking go hand in hand. He cites Halliday to reinforce his point:

Halliday (1993) argues: 'When children learn language, they are not simply engaging in one type of learning among many; rather, they are learning the foundations of learning itself (Alexander, 200, p. 15).

The influence of the metaphor of the child as the 'lone scientist' who develops cognitively by interacting with stimulating materials was increasingly challenged by the Vygotskyan view that the child’s cognitive development also requires her/him to engage, through the medium of spoken language, with adults, other children and the wider culture. In the current research project that metaphor of the child as a lone scientist was seen to be particularly inappropriate, metaphorically and literally. In a
social and cultural approach to learning it is significant others, essentially the teacher in the school context, who provides the mediation or intervention which scaffolds learning and supports student understanding to the next level. To this Alexander attaches increasing evidence from the field of neuro-science. He believes that it is increasingly accepted that talk is necessary not just for learning but also for the building of the brain itself as a physical organism, and consequently in expanding its power. Between birth and adolescence brain metabolism is at 150% of its adult level, building cells, making new connections between cells, pruning old cells, and generally developing capacity on a scale which decreases from that point onwards. The growth of brain connections, synapto-genesis as it is called, causes the brain’s volume to quadruple. In this process, language, especially spoken language, plays a vital part. According to Alexander it is language and especially talk that help to drive this process.

The resonance with AL is clear as classroom talk is recognised as crucial in AL as is evidenced in the dialogic routines that are at the heart of the pedagogy. However, AL also recognises that talk is only one part of the process of teaching and learning. It is equally important to recognise the importance of written language in Science. Wells, a prominent researcher in the socio-cultural tradition makes the point:

Through engaging with written texts in relation to the topics that they study in school, therefore, children gradually reconstitute their lexico-grammar in the more abstract written mode . . . . Thus, in learning to reconstrue experience in terms of the semantic structures of written language, children construct what Vygotsky refers to as ‘scientific concepts’. That is to say, it is written texts—and the talk about them—that provide the discursive means for the development of the ‘higher mental functions . . .’ (Wells, 1994, p. 81-82).

He goes on to argue that ‘the reorganisation of the grammar and the concomitant reconstrual of experience that is required in order to use written text as a tool for thinking and communicating does not occur spontaneously for most children’ (Wells, 1994, p. 82). He then makes the very important claim that developing student knowledge and understanding in school Science, and developing their knowledge of the language forms that construct and communicate scientific understanding, is one and the same thing. Whilst the importance of ‘hands-on’ investigative work, observation and negotiation of understanding through associated talk, cannot be underestimated in Science teaching, it is also clear, according to Wells, that effective use of Science texts and the development of students’ writing have a very significant role.

Gibbons (1998, 2003), an Australian researcher with an interest in language and Science, draws firstly on the idea of mediation from socio-cultural theory and then on the SFL mode continuum, essentially the abstract continuum within the model
which places spoken language at one end and written language at the other, to look at how teacher-student talk contributes to the language development of the student. An important focus of her work is the way in which teachers recast student statements, for example that magnets ‘stick’ into magnets ‘attract’. In this process student contributions are transformed and shifted across the mode continuum into the more context-independent, specialist discourse of Science.

Each of these researchers draws on Vygotsky and Halliday in differing measures to articulate their perspectives on teaching and learning. Alexander in general terms and Wells and Gibbons in specific reference to Science education. This teasing out of the importance of both spoken and written modes of language, their roles and their deployment in the teaching and learning of Science has been a particular feature of SFL research in Science. And whilst it is important to acknowledge that AL is not an SFL approach to Science education, it is useful to review the literature from within SFL, both as a means to understanding its contribution and also as a means to understanding the similarities and differences found in AL.

Science education and SFL

Since initial and detailed work by Halliday (1993, 2006) on the evolution of scientific language there has been an ongoing interest in Science education by those working from an SFL base. Martin and Halliday (1993) presented the case that the distinctive language forms of Science were crucial to the task of constructing scientific understanding rather than simply expressing it. Thus, the distinctive language of Science cannot simply be replaced by more familiar grammatical patterns of everyday language use. And, given the fact that the language experience of many ‘at risk’ students does not include a strong orientation to these ‘written’ grammatical forms, explicit pedagogic support is required in developing students’ familiarity with them, as suggested by Wells (1994) above.

Halliday (1998) proposed that learning Science involves two types of patterning: creating taxonomies of new technical terms that differ from everyday understandings, and creating logical sequences of reasoning, such as cause–effect relations. Through a focus on how these two evolved in the work of the teacher and learners over a unit of work it would be possible to see how Science discourse and knowledge developed through oral interactions and activities. Martin and Rose (2003) claim that commonsense, everyday terms and technical terms differ in that everyday terms can be learned by pointing to them and using them. By contrast the meanings of technical terms often refer to abstract concepts not concrete objects, and have to be learned not concretely but through language, as definitions in textbooks. In this way language assumes an important role in Science education, since learning
technical terms is central to success in academic scientific discourse. However, learning technical language alone is not sufficient to appropriate scientific discourse. O’Toole (1996) makes the point that specialist technical vocabulary tends to be the most noticeable feature of scientific language and, because it is understood that everyday language is not adequate for explaining scientific concepts, views of language in Science have tended to highlight the teaching of technical terms. He notes that whilst this is important, the downside is that the networks of semantic relations in which these technical terms are involved are overlooked. Semantic relations means the logical links between the technical terms, for example if the relations are of causality, consequential, or sequential.

Unsworth (2001) drew on the work of Lemke (1990) and Halliday and Martin (1993) to characterise the development of school Science learning as a gradual apprenticeship into the distinctive language structures of scientific English. Whilst Unsworth is not the first to use the metaphor of apprenticeship in relation to pedagogy, the same metaphor is consistently used by educators influenced by SFL to describe the teacher student relationship. He noted that these language features extended well beyond the obvious issue of technical vocabulary to include distinctive grammatical forms that characterise written rather than spoken language. Unsworth also demonstrated that a comparison of the language features of different explanations would indicate their relative quality as ‘apprenticing’ texts into the language of Science. He observed that initial descriptions of explanation texts indicated that they comprised distinctive stages labeled as Phenomenon Identification and Implication Sequences. However, it soon became clear that in order to account for the characteristic language forms of different types of explanations, an elaborated account of the stages of schematic structure was necessary (Unsworth, 1997). He also argued that once teachers and students became aware of the typical and distinctive schematic structuring of different types of explanation, this meta-textual knowledge could be a productive resource in critically reading and effectively producing such explanations. This is at the heart of the genre-based approach.

Mohan (1986) described how technical terms are linked to a taxonomy and to causal relations. He also explored the progression from the introduction of technical terms to problem-solving activities which necessitate their use and suggested that these problem-solving activities play a critical role in successfully linking theory to practice. In related research Mohan and Slater (2006) examined how teachers and learners linked theory and practice, more specifically how they tied the taxonomies of magnetism to their activities in class. They examined how teachers and learners connected both practical and theoretical discourse in a back and forth theory-practice dynamic. In work which resonates with that of Gibbons they were interested to investigate how teachers built up the meaning of technical terms such as ‘attract’ and related these to student experiences which were understood at the
level of ‘stick’. In their terms they wished to model an ‘ecology of semantic relationships’ within a field. In terms of the discourse of Science, how did the teacher work to help the students connect their theories with their experiments in a theory-practice dynamic? From the research they concluded that the teacher helped the students connect concrete experience with general principles of magnetism by moving between specific reflection and general reflection. There was a repeated process through which the students could develop the meanings of principles and their interpretation of these principles in tandem. An additional factor in this coordination of theory and evidence was the understanding that children may have had their own theories which were important in the learning process.

Lemke (1990), a noted US Science educator with an interest in language, proposed that Science discourse is comprised of thematic patterns which themselves are constructed from the relationships of and between the meanings within the topic or field. He argued that these thematic patterns are constructed from meaning relations, and it is the patterning of these meaning relations which characterise Science discourse. Difficulties in understanding the content of Science stem from the differences in the meaning relationships that individual students hold, rather than with the words themselves. This view accords with those articulated by Unsworth and O’Tolto. It is interesting to note also the similarity here with the view of Mohan, for the need to understand that the students may bring their own meanings and theories to the classroom. For Lemke the role of the Science teacher is to apprentice students into the use of new thematic patterns, or new ways of meaning and linking these meanings to each other. Lemke’s emphasis on the meanings that belong to the language of Science resonates strongly with an AL view of entering scientific discourse as well as with the SFL perspective. The SFL approach to providing the explicit pedagogic support has been through the genre-based approach. Particularly relevant here has been the work of Veel and colleagues in their work on the Write it right project within the Disadvantaged Schools Program in Metropolitan East, NSW, in the period 1990-1994. This project focused on the learning demands of the junior secondary (Years 8-10) curriculum areas. Naturally, one of these was Science, and the project analysed in detail the literacy demands using an SFL framework, and then used a genre-based approach to offer professional development for teachers as an intervention. Those operating within a socio-cultural framework identify the same issue but approach it in a slightly different manner. The AL approach which is at the centre of this research project works with the same challenge drawing on both theoretical bases.

The participating teachers in the research had no prior knowledge of the ideas within the literature reviewed here. They did have knowledge of AL, but as AL has worked principally with narrative type texts, there has been no literature produced about AL and Science. They also had some knowledge of SFL as part of their studies in the Graduate Certificate, but again had no background in the work on SFL and
Science. One of the four courses in that program is devoted to a study of grammar within the SFL framework. All of the teachers had undertaken the DECS Language and Literacy Course to meet this requirement. This offered some introductory knowledge about the overall model of language from the SFL tradition and some acknowledgement of the variety of text types across the school curriculum. However, knowledge about the grammatical detail within texts, particularly about texts in Science, and especially about explanations, was not part of their repertoire as they began in the project.

Results

The following section details the results of the project by looking closely at the data which was collected and analysed. Comment is made on the interactions during the lessons in which the video was used. These lessons were transcribed in full providing fifteen lessons (three lessons for each of the five teachers). This is a great deal of data and is considered too large to be included in this report as an appendix. A small sample of one lesson is included as Appendix 3. Comment is also made on the texts used by the teachers as the core texts they drew on for their teaching units. These are included as Appendix 4. A sample of the written texts produced by students as evidence of their learning was also analysed and is included as Appendix 5. The interviews with the participating teachers at the beginning and at the end of the project are included, as are their reflections as they watched themselves on video.

The research project began with a half day professional development session for the participating teachers. The rationale for the session was to bring the teachers together, to create some sense of a collaborative effort within the project and also to provide some input. The SAALP Officer introduced the meeting and set the scene for the project. The input was linked to the language of Science and more particularly the specific language and structure of explanation texts. This part of the meeting was led by the researcher and also by a Hallidayan linguist with an interest and expertise in the language of Science. The meeting also contained a session by a Science educator from UniSA. She talked about the role of scientists in society and how they work. This input was well received by the participants, particularly in light of the notion of intentionality which is central in AL. Intentionality refers to the intention of the writer of the text, and in the case of narrative writing this is the author. AL foregrounds the choices in language made by the author as an important aspect of the pedagogy, and discussion and questions arise in AL literacy classrooms around the particular choice of words made by the author as s/he crafts the narrative text. In like fashion the idea of trying to get inside the ways of thinking of a scientist allowed the teachers to focus on how and why scientists created Science texts, and to
get some sense of the intentionality of the writing in Science. One matter which quickly became apparent was that narrative texts and Science texts are clearly different in the extent to which the author is present in the text. In narrative text it is often possible to consider personal style in the creation of the story. In Science texts there is an opposite tendency through which the author of the text is mostly effaced from the text in favour of 'content'. What is important is the content, or the ideas and how they link to each other. The effort is to remove the voice of the author from the text, to aim for a neutral and objective text.

During the session the research question was closely examined so that the participating teachers had a clear idea of the focus of the research project. The common starting point for all was the fact they had worked with the clearly structured teaching and learning sequences and routines of the AL approach to literacy with narrative texts in their classrooms. The investigation aimed to document how these teachers armed with their expertise, experience and a commitment to the AL approach would deal with extending the AL approach into Science. As the SAALP Officer commented:

We are aiming to try out some ways which will do the work of apprenticing the kids into Science discourse.

The research process was also clarified, so that the teachers understood the expectations placed upon them. The role of the SAALP Officer was made clear as the support person for all of the teachers throughout the project, to offer as much support as possible to achieve success in the project. At the end of the first half-day session she met with each of the five teachers to help plan their units of work.

**Participant comments at the beginning of the unit**

All of the participating teachers began the teaching unit with an overall skeletal plan but without much detail of what they would do and how the unit would unfold beyond the first few lessons. In this way they seemed to conform to a well established pattern for teachers. They were asked about the overall length of the unit and they based their thinking on the way AL operated in the context of narratives in literacy. In that context teachers maximally use an AL approach one hour per day and use the same text for one term, or approximately 8-10 weeks. Accordingly, the teachers planned for up to one hour for each day of the week for the Science unit, which could last up to eight weeks. The desired outcome was for their students to independently write an explanation text, related to but different from the topic within the unit. For the secondary teacher the target outcome was not the independent writing of an explanation because he considered that his 'bridging
class' of Aboriginal learners would not be able to achieve this. His target was the joint reconstruction of a text within his unit of work on the human eye.

In order to gather baseline data at the beginning of the project, the researcher interviewed the participating teachers in their schools, in pairs in the two primary schools. The aim was to document the thinking of the teachers as they embarked on AL in Science and to collect a snapshot of the issues as they perceived them at the outset. This provided a point of departure for the project. The questions for the beginning interview are attached as Appendix 1. The intent of the questions was to gather information at the outset about the teacher perceptions and experiences of teaching Science; their ideas how this might change with an AL 'slant'; how they currently approached Science in SACS; and their generalised beliefs about and attitudes towards teaching and learning Science.

The questions which were developed for the purpose of a semi-structured interview were to some degree irrelevant as it quickly became clear that teaching Science was a strong curriculum focus for only one of the participating teachers, the secondary Science specialist. For the primary level teachers there were important obstacles to the teaching of Science as a core curriculum learning area. This stemmed from the perceptions they had of themselves as teachers who lacked 'content' knowledge to do justice to Science. To some extent the primary level teachers all exhibited characteristics of the documented fear of teaching Science at the primary and junior primary level, often referred to as 'Science phobia'. Of the four primary teachers those who were most comfortable used the natural environment as the way in to Science and then built on the student interest in and knowledge of their local area. The stated aim of one participant was to make Science 'fun'. Another suggested her reason for avoiding Science was because of the need for material resources to engage in the learning area. Science was messy and the more active the students became then the greater the call on resources. Essentially this was a reference to the need for class sets of materials to engage the students in activities, whether it was balloons, straws, ice-cream containers etc. Where these were not kept by the school in storage, it was the responsibility of the class teacher to collect a set or seek school funding to purchase the requisite materials. The primary teachers found this an important obstacle to teaching Science. As one teacher noted she spent a great deal of time 'on the hunt' for these resources. The comment was made that a focus on language and on scaffolding, as this teacher has envisaged her AL approach would require, would be easier than finding the material resources required.

The importance of preparation for Science teaching was mentioned as another deterring factor in teaching Science as an everyday activity. The teachers felt that they had to research the content and then mobilise the resources which could be very demanding. As one said:
Essentially it takes a lot of energy and effort to get a little. Some kids don’t get it, they don’t see the link between the activity and the Science.

This point was reiterated by another teacher who commented that for some of her children doing an experiment, and then making the link to the science it represented in the real world, did not happen. She used as an example the link between experiments with air and water and the connection of those activities evaporation and condensation in the environment beyond the classroom. The link between the Science activity and life experiences of the students was tenuous. There was a gap between doing Science and the demonstration of understanding that the activity was related to the world in which the students live, to their everyday reality. The scaffold intended by the hands-on experience was still unable to create a bridge to scientific understanding. These perceptions would seem at odds with the commonly held views about the importance of Science and its relevance to the everyday lives of students. If this was the case, then the students in these classes in these schools were not aware of the fact. In response to this reality, one teacher stated that the starting point should be to make clear the purpose of the experiment and how the topic has relevance to life beyond the classroom and the school. For this teacher the need to make the end goal explicit was important.

Another teacher commented that the best way to start was with known experiments. For this teacher Science at primary school was about hands-on activity. The teacher went on to describe the need for three phases in teaching Science: a practical phase in which the children would be stimulated, a more theoretical phase in which the practice was linked to underlying scientific thinking, and finally a language phase which engaged the students in writing. On the topic of written language the comment was also made that in SACSA the learning area of Science does not focus strongly on writing. Rather, SACSA puts a focus on ‘doing’ Science and the doing may entail talk but not necessarily writing. From the literature reviewed in the previous sections this is at some odds with the proposition that students need to arrive at a point where they can ‘write Science’, if they are to engage with and enter into the discourse of Science. This is also the basis of AL where the aim is to move the learners into the discourse through teaching them to create a written product. For Gray and for the SFL Science educators this is the only way in which students are enabled to appropriate the discourse.

There were equally interesting comments made in response to the question about the basis on which the teachers made content choices in teaching Science. For the primary school teachers there was a common sense of discomfort with the whole Science curriculum, expressed as follows:

*The content we are frightened of we do not do. The physical world is a problem, the natural world is OK.*
As they considered planning and programming the teachers spoke to previous teachers of their class to avoid repetition and also negotiated with their students within broad parameters. For others the choice of content was more erratic. They either chose something that was topical or they selected something from the four broad scientific domains within SACSA. Another used the SACSA Science Companion document which she found to be more explicit than the SACSA itself. The choices were mainly driven by what resources were around, essentially ‘what is to hand’ was how it was described.

One primary school participant named her Science Non-Instructional Time (NIT) experience as ‘the traveling magic show’. She recounted her year as the NIT Science teacher in her school, which meant visiting classes across the school as the designated Science teacher. She practised experiments at home and then repeated them in class. This approach took up a great deal of time and was a real constraint on the breadth and sequence in her Science curriculum. As she reflected on this story the teacher considered that it would be much easier to work with texts, to do Science through AL than to do the magic show. The assessment of student learning would also be text based via the writing of an explanation.

From a different angle, however, an overly text based approach was seen as potentially unsympathetic to the needs of disadvantaged learners. The argument here was that part of reading and writing scientific texts, as described in the literature review, is having knowledge of the technical terms, for example of compression and expansion. These terms are laden with information and the point was made that the students needed to see compression in action, to see how phenomena compress and are compressed, to play with the process as a means of understanding it. This was the great benefit of a hands-on, activity based approach over a purely text-based approach. The common ground was to agree that for students in disadvantaged schools it was important to build the content or field knowledge in a practical and contextualised manner as a way to induct them into the discourse of Science. This would involve small and repetitive steps.

One way to conceptualise the process of teaching Science was to begin by ‘doing’, by experimenting through an activity based approach and then to build on the activity and move towards a language focus. One teacher commented that this was the preferred process outlined in SACSA, but that SACSA did not insist on moving into language. This highlights an interesting tension between the role of language in Science and the function of Science itself. On the one hand the statement was made that the process was to teach the language through teaching the Science. The aim was to read scientifically, to speak scientifically, to write scientifically, which would produce the outcome of thinking scientifically. However, whilst this was useful for Science literacy and Science knowledge it possibly did not make students ‘wonder’. Wonder was held to be one key purpose of Science; ‘Science should make us
wonder.’ A similar tension was expressed by one of the participants who articulated her concerns about the difficulties inherent in teaching Science and what she considered as two ways of approaching the teaching of Science; the first as ‘dry’ by which she indicated text-driven, versus her preferred, activity based approach, which she considered to be more interesting. In extending AL into Science the teachers could see the challenges in balancing such an approach with an increased focus on text and language.

**Participating teacher comments during the unit**

As part of the methodology the researcher and the SAALP Officer met with the teachers and invited them to view the videos of themselves in their teaching of the unit of work, to use this opportunity to listen to them talk about their pedagogic processes, their reflections on the actual unfolding of the unit as a whole, and also on particular lessons. We were, of course, interested in their comments regarding the AL teaching sequence and how and if they believed it worked in their Science unit. We saw this process as important to the overall research process in that we wanted to engage the teachers in the research rather than ‘do research on them and their students’. We believed that this process would offer more agency to the participant teachers, and that they would be the most expert commentators on their own teaching.

An initial comment from one of the teachers was that in relation to Transformation, which is a pivotal feature of the AL process, her students performed poorly and she needed to go over the process again with them:

> They didn’t recognise it as anything they knew or could do; it was all brand new to them. I probably tried to hand over too much and too early.

She went on to say that having gone through the routine on a number of occasions the students did ‘get it’ and impressed her with their ability to write independently. This teacher also commented that she possibly expected too much of her students in bringing AL to a Science unit. As she reflected, she felt that she controlled the overall process more tightly within an AL narrative sequence, and had forgotten some of this process in the move into Science.

An interesting point to emerge related to learning goals and the challenge in making it clear to the students why they engaged in demonstrations or experiments within the context of the overall unit of work. It was important that the activities were understood in the context of the overall unit and were seen as more than fun or entertainment. The researcher, however, noted the consistency with which the participating teachers all made clear the learning goals at the beginning of each
lesson, as least those lessons which were taped. This is a prescribed element of AL pedagogy and all of the teachers began their lessons by working through the learning goals.

In order to consolidate the knowledge that had been built up over the unit one teacher’s response was to take photographs of the range of activities and to use these as stimuli for her students. She used the photographs in the Higher Order Literate Orientation (HOLO) as part of revisiting the text, and where recall was supported by reference to photographs pertinent to particular and important aspects in the text. This pedagogic process was also used in the initial work of Gray at Traeger Park in Alice Springs in the early 1980s. What the photographs enabled the teacher to do was to do revisit and consolidate language from an earlier activity or experiment without having to go through the actual process again, in this case an excursion. This strategy worked well for the teacher who used photographs and who regarded it as a critical part of her teaching process, for supporting the development of the knowledge base of the students.

One teacher became particularly nervous with the video camera in her classroom and reported that she forgot some of the content she had planned. She thought seriously about withdrawing from the research. She was concerned about her lack of knowledge of the topic and her lack of comfort in case her students asked her for technical understanding which she did not have. The researcher’s response was that the students in her class behaved impeccably during the video lessons. The teacher suggested this was normal for this group. This teacher had a strong arts focus and was organising the major school production as well as engaging in the Science research project. The Science research suffered slightly in the squeeze to fit everything into a crowded curriculum and extra-curriculum. As part of her unit the students constructed model houses demonstrating the insulation used as a barrier to the radiant, convection and conduction energy features which had been the educational focus. The models and the student presentations of their constructions indicated their take up of the factors relevant to energy transfer, including north facing windows, water-saving shower heads, curtains and rainwater tanks.

The same teacher also used a practical demonstration to highlight the processes of conduction and convection. Her next step was to consolidate the important technical language covered within the demonstration. The students needed to be able to tell the teacher the differences between convection, conduction and radiation before going on to the need for thermal insulation. The issue for the students was to understand which aspect of thermal energy transfer they were trying to prevent by means of installations such as curtains around the house. The teacher planned for groups of students to present each of their houses to the whole class audience in which they described and accounted for the installations and their function. They used their excursion to The Model House as a base and were able to recall their
learning via the photographs from that excursion, consolidating the excursion as a successful part of the unit. It was totally relevant as an actual house which deployed the science being taught in the unit, and the photographs were able to be used later in the classroom as part of the demonstration of understanding of the Science of the topic.

It is noteworthy that this teacher found that she had to cover groundwork on conduction, convection and radiation in order to work on her chosen topic of insulation. This practical concern resonates with the theoretical issue raised by Freebody (2007) above on the structure of scientific knowledge, in which he cites the work by Bernstein on vertical discourse structure. The teacher had to confront the issue that it is not possible to deal adequately with certain topics in Science without previous knowledge of related topics. Accordingly, this teacher and her colleagues had to spend time in providing background information as prior knowledge. This manifested in classroom texts where the explanatory sequence could only be found after prerequisite information, linked to classification or definition had already been presented. For example, the secondary teacher understood that it was necessary to know about the parts of the eye and their names prior to explaining how the eye worked. This is related to the hierarchical nature of scientific knowledge in which some phenomena need to be understood before others can be addressed. Scientists customarily name and describe related phenomena as part of addressing and explaining the phenomenon under examination. This is part of scientific writing and often results in the production of hybrid texts where the explanation sequence may not be a prominent part of the text. At a more practical level this issue resulted in a lot more ‘spade work’ in the preparation of the unit of work which the teachers had not considered prior to engaging in the project.

Within the initial interview that teachers were asked about their choice of text and if they thought the text would sustain the interest of the students throughout the unit. All of the teachers commented that their texts were dense and would require ‘unpacking’, that is they would need to deal with unknown technical items. One anxiety was that there might not be enough in the text to maintain a focus for the intended length of the unit. The teacher went on to compare narrative texts with explanations which she saw as being more interpersonally ‘bland’. In a narrative there is scope to address feelings and emotions and so build up pictures of the characters. None of this would be relevant in an explanation. This was countered by the view that there was potentially more richness, more depth in the other areas of meaning, in the ideational and textual domains. Thus the ‘content’ and how that content was expressed and organised in written language would compensate for the interpersonal neutrality in the quest for scientific objectivity.

The initial aim for all the teachers was to engage in a close reading of the text whilst the desired outcome was to produce a written explanation as the end point. This
would necessarily create a focus for spelling. As part of engaging in a unit of work in Science there would be an expectation of some hands-on activities, some demonstrations and/or experiments. The focus in this unit was similar to a traditional unit in Science but differed in expectations around the place of reading and writing. Conducting an experiment in Science would traditionally be followed by the writing up the procedure of the experiment. In contrast there would be potentially no writing goal from doing an experiment as part of the AL Science unit. The intended outcome of doing an experiment or watching a demonstration could be to understand the meaning of a particular item in the text. The students would be oriented to the explanation and the activities would act as scaffolds towards the production of a written explanation as the end goal.

There was a diversity of views about the use of the text in the beginning of the unit. One teacher stated she would begin by building the field knowledge first and not work with the text immediately. For her the building of field knowledge, or the development of content understanding, was independent of the text. She aimed to start with the text and then put it away having worked out what was the required knowledge and information. Another aimed to follow more closely the AL process of telling about the text as in the AL Lower Order Literate Orientation (LOLO) stage. Thus, she intended to tell her students about the unit of work, talk about the text and indicate the content, but not to try to read the text from the beginning.

None of the teachers doubted that they could extend the AL perspective into a unit of Science. The AL pedagogic principles and processes were embedded in their practice and this was the mindset with which they approached their teaching. For one teacher her question to herself was, 'How can me doing the work help them to learn?' Another suggested that via her Pre-formulations, another key strategy in the approach in which teachers prepare students to answer questions by giving prompts and cues, she gave the students all the clues they needed to answer those questions. This was a key element in scaffolding. The teacher was clear that the AL approach permeated all her work at this time:

_I pre-formulate at all times now. I don’t play ‘guess what’s in my head’._

The topics chosen by one of the participating schools were motivated by the school’s interest in climate change and its desire to be a climate change focus school. Thus, the teachers chose insulation and wind energy as their topics. One of the teachers in this location stated that she traditionally engaged minimally with Science. In striving to meet and manage SACSA requirements in the past she would invite experts in to cover the content and/or take her students out on excursions. She was naturally more oriented to the arts/drama/language disciplines. Mathematics was less of a challenge than Science because there was a textbook on which she could base her curriculum. In her unit of work on insulation she would not rely on outside experts
but was developing her understanding and planning for the unit of work via the internet. She aimed to produce a text from information on the internet which she would then adapt for use in her unit of work.

Prior to the unit she brainstormed questions with her class such as; ‘What have we done that is Science?’ ‘What is Science?’ ‘What do scientists do?’ She made the point to her class that if they wished to sound like scientists they would have to use scientific language. Her aim was to get her students to think about what a scientist did, to imagine what a scientist looked like. Intentionality, an important concept in AL pedagogy, was addressed by the teachers through this process of engaging the students to project themselves into thinking and acting like scientists. The teachers all discussed the author’s intention in relation to why they choose particular words at particular points in the texts they used.

The end point in this Year 6/7 class was for the students to write an explanation on the topic of insulation from radiation. In order to understand insulation the class needed to understand how heat transfers in three different ways. In one of the initial lessons she demonstrated the different processes of heat transfer by cooking an egg on a gas heater. She understood that radiation, convection and conduction were all needed as precursors to the work on insulation. In her topic she knew that she was dealing with some abstract concepts and her challenge was to make concrete the concepts of insulation, convection and radiation. She expressed concern about the ‘Science mountain’ she had to climb. She felt she lacked knowledge about the scientific processes of conduction, convection, radiation and how to remain clear about them during lessons. She needed to address conduction to build field or content knowledge, as well as attend to the structure of the explanation. She then intended to deal with convection in order to do a text reconstruction, and finally radiation when she would ask the students to independently write an explanation. Energy transfer linked all of these processes. At the outset of the unit her view was that the class had some commonsense understanding of the topic; they knew that insulation was something to put in the roof. That was the extent of their knowledge and understanding of the concept. Her class excursion to the food farm and the Model House proved to be very useful. There the students watched how straw bales were used in building construction and how fresh food and vegetables were grown. An ongoing question for her was how to work on the abstract language in the text central to her unit. She raised interesting rhetorical questions in her comments about her teaching processes:

*Am I teaching AL or am I teaching Science? I don’t know where it’s AL and where it’s Science. Is it Science because it talks about something ‘sciencey’? I would prefer to look at it as AL, so in a language way rather than a Science way. Is it possible to think about it as language rather than Science?*
This teacher confided that these questions ‘rattled around’ in her head and she had no definitive answer; she was constantly changing her mind. It is interesting to consider this in the context of earlier comments in this report which point to some avoidance of Science by primary teachers because of their perceived lack of content knowledge in the learning area. The question is whether a language oriented approach to Science would be less threatening to teachers? In working on her unit this teacher brought to the surface the challenge of extending AL into Science, and the issue of placing language at the centre of the teaching and learning process in a learning area. Currently such an approach is well accepted only by those who promote a language based approach as being relevant in the area, that is by those who suggest that study about language as an object, as a tool used in making meaning can be useful in understanding literacy, and then how this might be achieved in classroom practice. These are principally educators operating with a genre-based pedagogy built on understandings from SFL. AL is different again in that it foregrounds its more socio-culturally inspired pedagogic principles in the teaching of Science. However, AL does call on a linguistic orientation, not so much as an object worth study in its own right, but more as background knowledge important for the teacher and the students in getting at meaning inside text. A point for reflection, as discussed in the literature section, is in the balance between these two complementary components as AL is extended into Science and other learning areas.

At the conclusion this teacher who felt nervous during the video work in her classroom reported that she had learnt a great deal through the process, and tellingly that she would repeat the process because she had now collected all the necessary resources. The topic was difficult but her students ‘got it.’ Their work indicated that they could be extended and challenged to do complex tasks.  

*Normally in Science I would not look for handover – the outcome would be engagement. I would never do this depth of planning and preparation in a normal situation. I had to learn the Science myself – I had to understand it first.*

She calculated that the unit comprised approximately twenty five hours of class time and additional time for excursions. Her view was that in the future she would aim to deal with heat transfer as a topic in Term 1 followed by insulation in Term 2. This was based on the need to structure the work so that knowledge was built sequentially. Her intention would be to avoid a repeat of this unit in which she found that she had to fill gaps in student knowledge and understanding. She would plan in the future so that there would be no prerequisite foundational learning within the teaching unit. Previously her Science teaching was predicated on bringing in experts or finding artifacts from the environment to observe in class. In neither case was there any particular focus on language. In this unit the focus was on the language in which a single text was the central point in the unit. She could plan for
activities and excursions but there was comfort in coming back to the text as an
anchor in the unit.

The topic chosen by the Year 2/3 teacher involved the broad topic of energy which
was narrowed to explaining the phenomenon of wind. Later the children looked at
the water cycle with the aim of independently writing an explanation of the water
cycle. When the students successfully wrote an explanation of the water cycle the
teacher concluded that this was evidence of handover, that is, that they had
internalised the knowledge of the topic. This topic was chosen because of the link to
the theme of climate change at the school level.

Her search for resources was to enable scientific experiments which would help
make clear the concepts within the text. The class studied wind, as air in motion, and
also looked at kites. The children made kites from a template which demonstrated
the concept of wind as air in motion. Kites use the notion of air in motion to ‘fly’ and
so kite flying was a commonsense interpretation of the scientific meanings.
Successful kite flying requires wind and an answer to the question ‘What do you
need to do in relation to the kite and the wind in order to make the kite fly?’ This
example demonstrates the general pedagogic process of the teachers in that they
moved from the concrete to the abstract. Previously the teachers agreed they would
have started with an activity such as kite making because this in itself was an
interesting and fun thing to do. It involved making and doing and was very
experiential. This would have satisfied the requirement within SACSA. The linking
of kite making to the notion of air in motion was not a step the teacher would have
taken prior to this project.

This Year 2/3 class also considered the movement of warm air, firstly when the
teacher made air visible, or at least conceptually visible via an inverted jar standing
in a tray of water. The children then fixed a balloon to an inverted container this time
placed in warm water. The demonstration showed that warm air rises. In order to
undertake this activity the teacher had to collect ice-cream containers, balloons and
jars with necks. She had to ensure that no child was in danger even though they
were working with hot water. This concrete activity was linked to the more invisible
climactic phenomenon through which the sun warms air in the atmosphere and the
air rises. Air above a land mass heats more quickly than it does above water. Air
drops over cool water and becomes denser and consequently heavier. Air rises over
land which as a mass is generally warmer than water. A vacuum is created and the
cool air gets sucked in and this is the phenomenon we recognise as wind.

The text used by this teacher was relatively short but she was confident that the
students would maintain interest because there were a number of activities. The
teacher commented that she had previously never had a whole picture of teaching in
Science. The use of a text enabled her to move backwards and forwards through the
unit. She estimated she spent approximately twenty five hours over an eight week period on the unit. She maintained an AL focus in literacy reading whilst in the Science project her target was on writing. This teacher decided that she needed to attend to reading because some of her students, especially those who had recently transferred from the New Arrivals unit within the school, were in the early reading phase. She reported that she had to do a lot of research herself in order to do the unit, because the information was not readily located in one site. She set up classroom dialogue in an AL way rather than as a question and answer routine. Her pedagogic processes involved the sharing of common knowledge, talking through and giving information via Pre-formulations, and then asking questions in a way which guaranteed success. She found that her students were well prepared through these processes. Another strategy was to take photographs during demonstrations, and then to use the photographs as the learners engaged in the activities.

Several of the teachers encountered challenges in working with their initial text and so treated it as a draft that changed through the unit as they ‘worked on the run.’ Only at the point of actually working with a text did the teachers sometimes come to see that a text was not useful in its present form. However, the common perception was that having the text as the starting point was very useful. It was comforting to be able to lead from and then return to the text. Experiments and activities were generated from the text, as part of exemplifying or clarifying a process or logical link. This made for a more cohesive approach to teaching the unit of Science. The teachers in general were able to move easily between activities followed by text work in which the students demonstrated their control and understanding of the scientific language.

An initial impediment for the secondary teacher was the funeral for a community leader on the APY Lands as a result of which the students arrived back at school in small groups some weeks after the beginning of term. This group of students was a Bridging class, recently arrived from the Lands and in their first term at school in Adelaide. They are ESL learners operating haltingly in English but much more comfortably in Pitjantjatjara. On reflection, it was agreed that the Bridging class was probably the most difficult class with whom to work in this way, and that it would have been easier to work with a class already established into metropolitan school routines, that is with students from the Lands who were settled in Adelaide and already acculturated into the daily routine of secondary school life. For the Bridging class normal school practice had been activity based and they were oriented to an approach in which they engaged in ‘doing’. In the chosen unit on the workings of the eye the AL approach shifted the emphasis onto the text and the activities were conducted in the service of understanding the text. The chosen topic related to the eye and vision and how the parts of the eye worked together to send a signal to the brain to enable sight. The teacher also planned to look at possible problems with parts of the eye. In their first term at school this Bridging class had studied the ear.
The teacher reported that they engaged in some interesting activities but there was no focus on a text and no text was produced as an outcome. The teacher believed that the AL approach would provide a way into the technical language of the topic. The dissection of an eye was an exciting part of the process but it would not help in understanding how the eye works. The end point of the unit, the learning goal, was for the students to be comfortable with the technical terms and to be able to read the text. The teacher hoped that the students would achieve a reconstruction of the text as a group. Ideally the students would be able to apply their knowledge to a related but different issue, and possibly go on to produce an explanation of what can go wrong with parts of the eye.

In terms of expectations the teacher assessed his students to be at a relatively low level, including some who struggled with decoding in English and were unable to read the text for meaning. The teacher was a trained secondary Science teacher and the challenge for him was to bring the language of the unit to the surface for himself because his training as a Science teacher offered no focus on the relevance or importance of language in his discipline. He reflected that the AL attention to language had made him more aware of what he needed to do with this particular group of students. He understood that the ‘given’ approach to teaching Science in his school context was to do an activity with the students, for the students then to learn the technical terms related to the Science, and finally for them to do a test comprising a single word or multiple choice answers. In the mainstream of the school there was pressure to cover a body of content which, by necessity, was done at a superficial level. There was also a need to maintain student numbers at senior levels. The strategy to achieve this was to make Science fun by engaging in more activities. The common response to assignments was to cut and paste from the internet and to produce procedural writing of practical write-ups. However, this approach was not conducive to success in senior secondary Science subjects. A critical response to this approach was that it actually undermined students in their efforts to meet the requirements of senior Science. In the current unit, using the AL approach, the aim was to focus on one phenomenon in some detail. The AL approach in which the text was important had an impact on the pedagogic approach of the teacher. The text could be left and then returned to for further investigation throughout the unit. It was a stable resource throughout the unit.

The secondary teacher commented that in his experience a major focus on behavior inexorably led to behaviour taking over as the dominant issue with Aboriginal students. He worked from the belief that not drawing attention to student behaviour was the optimum process. He reflected that addressing the content of the unit was far more energising than dealing with behaviour management. He began his lessons with learning goals and behavioral goals written on the board. He then explicitly linked the behavioural goals to the learning goals. This link is foregrounded in AL pedagogy where it is understood that the students have to be attentive in order to
learn. He found that he did need to return to the behavioural goals but the fact that they were visible on the board made this a reminder rather than a core item in the flow of his lessons. One of the primary school participants also commented that she was conscious of maintaining a focus on the learning rather than on the behaviour of the students. This teacher also worked with a challenging class, with recent new arrivals, one particularly challenging Aboriginal learner, and other ESL learners comprising the majority of her group.

When asked if he had a picture of the overall unit and what would happen within the unit the secondary Science teacher responded that he had planned for a number of activities as part of the overall process. He envisaged that these would offer a deeper understanding of the text with the accompanying activities linked to refraction, reflection and a colour blindness test. The process for the text reconstruction was for the teacher to initiate and then orally construct the next stage of the text. He was thinking out loud as an author. He then invited the students come to the board and extend the text in phrases/groups/clauses and supported them as they wrote the next piece of text. With prompting from the teacher and each other they wrote the following:

The eyes/sensory organs/create images/information to brain/hollow ball/white of the eyes/called the sclera/tough outer layer/thick clear/liquid/called the vitreous humour/it is not empty/filled/retina/movie screen/lining the inside of the eyeball/where the images are read.

Later, the teacher added what he called structuring language, including sentence starters and conjunctions. In a subsequent interview he commented that the focus on text was novel and with lower level students it was unusual to use high level text such as the text developed for this unit. There was an issue in working out how much detail was needed in the text. It was a matter of trying to strike a balance between extending the students and having a text that was too far beyond their level. In theoretical terms this resonates with the concept of the ZPD and the level of challenge presented to learners in the effort to support them to operate beyond the current level of competence. The students worked on the text in a typical AL fashion, underlining and highlighting different aspects of the text as they were inducted into how scientists put a text together to create scientific meaning. This particular text had a focus on describing the parts of the eye and where the parts of the eye were located in relation to each other. Technical terms were introduced in the definitions of the parts, their location within the eye, and how they functioned to enable sight.

He commented that his Science background did not equip him to focus on language with any expertise and so it was a learning experience for him to bring AL into Science. He suggested that scientific writing in the mainstream Science context was rare, that only in Year 11 did students really begin to write, or need to write. This AL
experience provided a greater focus on the language of the text, and as a result the students were able to use scientific language in a limited manner. There were some successes, with students focusing and following the process. However, there was not a great deal of take up of technical language which is very important in the overall process. In looking for handover, that is the student ability to appropriate the scientific language of the topic, he noted that several students did call out the technical terms at the required moment. In total he spent approximately thirty lessons on the unit over a seven week period. When he reflected on the overall unit he felt that the text was possibly too dense for the English language ability level of students in this class. As a result he did not cover all of the text.

The content of the lessons for the Year 6/7 teacher working on Transpiration was essentially text work with a large number of questions posed by the teacher, built around a series of demonstrations and hands-on activities. It is noteworthy that the students were well able to handle the range and complexity of the questions. The teacher used the strategy of Pre-formulation to couch her questions, that is she provided information and the answer to her ensuing question was invariably contained in her ‘pre-formulation’. Verbally at least they were on top of the topic. As with the secondary Science teacher her classroom processes included making explicit the learning goals of the lesson as well as the behavioural goals for the lesson.

She found that she had to address prerequisite knowledge in order to take her students to the point where they could access the required information on Transpiration. This raises an important point in relation to the teaching of Science in general, that is the understanding that scientific knowledge is vertically constructed, meaning that understanding of some basic principles and premises will be required before building on this knowledge base. Without certain scientific bases having been covered, other concepts cannot be fully understood or grasped. This matter was initially raised by Bernstein (1999), has been addressed in the SFL literature on Science education, and now more recently highlighted by Freebody in his 2007 ACER Review. The negative outcome of the realisation of the vertical structure of scientific knowledge and the subsequent necessity for preparatory work was evidenced in this project at the point where each classroom had one lesson captured on video and the teachers and the SAALP Officer had the opportunity to meet and discuss progress to date. We all concurred that the classrooms to this point were relatively ‘teacher-centred’ with the lesson time mostly taken up with teacher input. We concluded that the teachers were talking a lot because they were building up the knowledge base in preparation for engagement in the planned unit. They had to work hard to get to the beginning point of their unit. What the teachers found was that they could not assume background knowledge which seemed to be ‘prior’ or prerequisite for the units they selected for their classes. This raises really important questions beyond the scope of this project and more related to the overall conceptualisation of Science curriculum and its implementation.
A comment which summed up the units in each of the classrooms to the mid-point was ‘hands-on but no handover’. This is evident in the small sample of classroom interaction attached as Appendix 5. It is a teacher led question and answer session taped at the beginning of the project. Handover was achieved at the point when the teachers assessed that their students had understood the content and were able to control the language through which to demonstrate this knowledge. The AL challenge was how to get the students to have ‘long turns’ in which handover was visible; handover was the required outcome. At the time of these mid-unit reflections, the teachers reported that there were demonstrations and activities as part of each unit, and they all were text focused. However, the point had not been reached where the students were in control of the language of the unit; they were not yet inside the discourse. On a positive note this was still relatively early in the overall span of the unit and would not have been expected at this point.

**Participant comments at the end of the unit**

Each of the teachers was interviewed after the unit of work had been completed, and a period of time has elapsed to provide a space for reflection. Comments made as part of these final interviews are described within the question format of the interview. The questions are also attached as Appendix 2.

1. In overall terms what was your experience of this unit of work and your participation in the project?

All of the teachers commented positively on their participation in the project. Engagement had the effect of making the teachers reflect on and reassess their previous teaching of Science, and it highlighted issues relating literacy and Science. As one of the participants noted

> It made me reflect on how Science has been taught by me and other teachers I have observed, and look at where problems may arise for low literacy students from an AL point of view.

Another admitted that the experience in the project was stressful, the requirement to be organised for classroom filming was an extra work load – knowing that everything needed to be on hand. She felt she had to ‘look as though I knew what I was doing’, even though there were no clear guidelines. Participation was time consuming, researching texts and the text features and support materials did not come naturally or easily. However, on reflection, the student learning was rewarding. She stated:
I thought they (the students) showed a higher level of understanding by the end of the week, as they were 'talking the talk', explaining phenomena, using technical language and writing with a degree of understanding, and they have used this for themselves in other situations.

This engagement by the teachers is a strong positive outcome from the research. Whilst there was a degree of stress added to their normal workload, the perceived benefits outweighed any negatives. The participants received a great deal of support and were afforded opportunities to access professional development, to plan and program with the SAALP Officer, and to reflect on their practice at several points throughout the unit. This is optimal professional learning for teachers as they aim to extend their pedagogic expertise.

2. In overall terms did you consider the unit to be a success?

All of the teachers reported that they considered their unit of work to be a success. Indicators of this success included increased student engagement than had previously been witnessed, and a greater understanding and improved use of technical language. Using AL principles and processes also provided a rare authentic context for the teaching of decoding and spelling skills within the Science unit, which, given the groups of learners, was a necessary part of the unit.

The willingness of students to contribute in class discussions was generally very good, indicating that they were more engaged than in previous experiences. One teacher reported that students had a much better understanding of the purpose of activities, which he interpreted as an achievement for her learners who were not used to scientific ways of working and talking. In the experience of this teacher his students in the APY Lands Program generally made little or no contribution in mainstream classes and often had only a limited grasp of the purpose of an activity.

3. What were the highlights of the unit for you?

Obviously each teacher highlighted different aspects of the teaching and learning process. For one it was the joint construction of a passage to explain the working of a lever. For another the unit highlights were the students' understandings of the topic, particularly their knowledge and subsequent use of technical language. There was a comment from all the teachers that their students were more noticeably engaged throughout the unit than previously when they had taught Science. The engagement was visible in the lessons on video but also in lessons where the video did not capture the classroom activity.

4. Did you feel that you developed as a teacher in any way? (Please elaborate)
The following comment made by one of the primary school teachers typifies the developments made by the participating teachers.

I believe I now have a much better understanding of the language requirements of Science after examining scientific texts in detail and producing appropriate models of text for the classroom. My ability to explicitly teach these has also improved as I am more conscious of how a scientific text is constructed, and certain language choices are employed to build a shared understanding between the expert writer and the novice reader.

Another added that she was more able to build her questioning technique on the basis of her knowledge of scientific texts. Linked to the point about language another teacher commented on the importance of the shared understanding that was developed with her students which enabled what she termed, ‘scientific conversations’. She continued:

I never thought about it this way before. Previously Science was always the activity as the focus, rather than the talk and shared understanding. I think sometimes we move on too quickly and kids just get lost in the activity and don’t see what the activity is trying to achieve. Science teaching now has a different focus for me.

For another teacher the research process itself was helpful. She watched herself on video and considered this to be a powerful way to help make changes in working out what was actually useful in her teaching.

5. Did you note differences in the way your students responded in this unit?

One participant noted that her students were enthusiastic, particularly when being filmed and they had greater ownership of the topic due to their inclusion in an ‘important project’. Overall the use of technical language by the students increased over the project period.

Students seemed to enjoy displaying their knowledge of scientific terminology and the text that was studied.

The overriding comment was that students were more positive than in previous experiences. The secondary Science specialist noted that his Aboriginal learners generally had very little expectation of contributing to class discussions when in mainstream classes. Here it was noticeable that they were more engaged in the classroom work. Another teacher suggested that her class went through a ‘cycle of confusion’ in which they reacted negatively to the idea that they were being presented with something too difficult and then warmed to the work when they could see that they were being supported and that they could achieve what they saw as a difficult outcome.
6. Did the unit proceed as you planned?

For the APY Lands secondary teacher there was an issue related to attendance which impacted on the teaching and learning process. The nature of the school means that the students, who travel from remote communities, are not always at school for the start of term, and may return or leave again at various points in the term. For this teacher the class only fully assembled during Week 4 of Term because of a death in the community. These attendance issues impacted on when he could realistically begin work on the text. The unit was then condensed into a shorter period of time to try and cover all that was required.

7. Did you need to change your plans?

Each of the teachers needed to adjust and be sensitive to the pace of the learning in the class. This is the normal professional expertise of classroom practitioners as they work with the different learning abilities and different starting points of their students.

8. What did you need to change and why?

All of the participants were confronted with challenges in the texts they chose or in trying to develop a text appropriate for their unit. The research team did not consider this to be a serious obstacle at the outset but it quickly emerged as a consistent issue in all of the classrooms. This matter is not a problem when using narrative texts. Schools and teachers using AL now have a resource bank of texts and text notes which they can access at the start of a narrative unit. Text notes are developed in an ongoing way to add to this resource. Because of the step away from narrative texts the teachers in this research had no central resource from which to borrow. They worked with the support of the SAALP Officer to create texts appropriate for the work. This was the first time they engaged in this exercise and it certainly presented some of the teachers with challenges. This is noted as one of the key issues to arise from the project. Trying to merge useful information from different websites and trying to find appropriate information on their specific topic required was not an easy task. The kind of text the teachers needed was not available in text books or on the WWW. The teachers came to the realisation that they would need to create a text that was suitable for their unit. The SAALP Officer was able to support in this effort. Those who were aware of the resource bank of narrative texts saw the establishment of a similar resource for factual texts as the task for the future. As one of the teachers suggested:

*Purpose-written texts that are age-appropriate could be one way of overcoming this (issue) in the future.*
Two of the teachers needed to adjust the writing goals for their students when faced with the complexity of the explanation within the unit they had selected. The depth and scope of the unit was compromised due to the difficulty of the text and the complexity of the topic selected. This was important learning for the teachers as they grappled for the first time with the complexity of a science topic as evidenced in the language of the text they required their students to appropriate. In confronting the technicality and abstraction within a text they could clearly see the difficulties faced by their students.

I had the overall plan - share knowledge, handover gradually until students could display this knowledge for themselves, i.e., talk about a particular phenomenon and write an explanation. I struggled with 'what knowledge do I share'. My own resources were limited, the knowledge 'out there' was confusing and to narrow it down to a point where I felt I understood it was hard to do. Because of this, I seemed to be refining the knowledge constantly. This meant I was never really sure if I was on the right track. I constantly changed the text from which I wanted to base the knowledge on and write the explanation, because as I was trying to explain and demonstrate things to make it clearer, I realised there were gaps. As I tried to fill these gaps, more refinement was needed.

9. What were the problems or issues which arose for you through the unit?

The most common issue for the teachers was the difficulty in accessing appropriate texts for the units of work. The quality of texts assumed great importance especially when the teachers had to use them on a regular and ongoing basis throughout the unit. For one teacher the text proved to be too long and complex for some of her students especially the younger ones in her class. The same teacher also commented:

I found it difficult to plan and write the notes I needed as I went along as I felt unsure of the teaching sequence and how it should fit with a Science topic.

Behaviour management was also mentioned as an issue for four of the five teachers at some stage during the unit. On the other hand, all of the teachers also commented on the positive engagement of their students. One teacher commented that she had some problems in getting students used to the routines around working with text, possibly because the students did not associate text work with Science. Familiarisation with the procedures and routines in an AL Science class would help to reduce the novelty of these situations and aid in promoting appropriate student behaviour, attention and engagement. As discussed above the issue of resources, that is access to class sets of actual materials to facilitate hands-on activities, was also an issue.
10. Did you foresee these challenges at the outset?

Again, issues to do with text appeared to be important for the teachers. They had not fully considered the importance of the text as they approached the unit and then as the work proceeded they found it necessary to rework and revise their texts.

The overall novelty of the approach did cause some behavioral issues as the unpredictability of the processes within the unit was not understood by the teachers or the students. However, it was also accepted that refinements in the teaching process, such as ensuring smooth transitions between stages, would help in the future.

11. In another situation would you proceed in the same way or do something different?

All of the teachers took something from their engagement in the research and reflected on it as a valuable learning experience. As with all educational experience some drew more than others, some saw greater relevance to their preferred way of working than others, and some adapted to the requirements more easily than others. In considering how they would address the unit again, with the hindsight of experience, they commented:

* I would choose a narrower field of study and acquire a more age and ability appropriate text for my students.*

* I would proceed as originally planned (circumstances permitting) with some refinements to the process and sequencing, including activities to break up text work at specific stages to exemplify processes within the text.*

* I would make sure I had a good text to base my understanding on first. I have continued in a very similar way this term, but have found I don’t need to spend as much time on building the whole field of Science or some of the concepts.*

12. In relation to AL do you consider you implemented the pedagogy in this unit?

This question elicited several ‘yes...but...’ responses. For one the response was yes, but only in an abridged manner because she found it difficult to include Transformations and Spelling in the sequence. It is noteworthy that some of the teachers pointed to the differences necessary to consider when working with a factual scientific text rather than a narrative. As one stated:
Exactly how AL is used in Science is something that needs to be continually examined, as it is in relation to narrative. Being able to explicitly teach scientific genres and language requires the same sort of collaboration, resources, workshops, professional development etc. that is available for literacy teachers (working with narratives).

Another concluded that despite the professional development and ongoing support she found it difficult to follow the AL teaching cycle she knew from her teaching through narrative texts.

I found Transformations difficult to teach and plan for possibly because of my lack of experience in teaching explanation texts.

Again the idea of purpose-written texts was suggested as a solution to this issue.

13. What were the issues in relation to extending AL into your Science unit?

This question reiterated the overall research question and offered the teachers an opportunity to expand on their general sense of the overall process. For one teacher it was an issue of time and trying to squeeze another discrete unit of work into an already crowded curriculum. Other teachers spoke more directly about the language and Science matter:

I needed more clear guidelines and instruction in the transference of the pedagogy from English to Science and from narrative to explanation.

AL Science resources are needed, like those found for a wide variety of narrative texts, which make the generic features clear, explain how language is employed to build scientific knowledge etc., as well as videos and activities that can be used to exemplify concepts and language, preferably that can be done without requiring Science resources and laboratory facilities (as most primary school do not have access to these). This is vital, especially at a primary school level where few teachers are Science specialists but are expected to teach the subject anyway. These teachers need to have something available to make them confident that they can apply their current knowledge of AL methodology to an unfamiliar field.

How to provide ‘long – turns for talk’ (not just question – answer sessions) – how to create opportunities (groups etc.) and useful scientific demonstrations / experiments in which talk could be used to show understanding.

14. Do you feel that AL is ‘doable’ in the learning area of Science?
Again this question elicited ‘yes...but...’ responses indicating a positive experience tempered by the ‘teething problems’ associated with the move into a new and unfamiliar learning area. As stated by one respondent in the previous question few teachers in the primary sector are Science specialists and for them it was doubly challenging to apply AL principles and practices to an unknown area.

The teachers, who had all used AL in reading narratives, and who had all derived benefit from the teaching notes which accompany narrative texts, called for a similar kind of resource to be available in Science.

Yes, but with a clearer teaching sequence and text notes for teachers from the beginning, as is available when starting out teaching narratives.

Yes, but it requires a shift in focus from covering a lot of content in little detail to covering something (or even ONE thing) in depth over a longer period of time. On face value, some teachers may question what has actually been achieved in this unit, as it only focused on one thing for a whole term, when a great deal was achieved relative to the abilities of these students. The benefit of this approach is that it gives a greater understanding of scientific genres and how language is employed in scientific texts that can then be used by students in their writing and increasing their comprehension when reading new texts.

15. Was the unit of work appropriate for your students?

The teachers generally concurred that the unit was pitched appropriately for their students. However, the primary teachers, by their own admission, were not experienced Science teachers and were tentative both in the content area and then in extending their pedagogy into this new field. Accordingly, they were tentative in their judgements.

Yes, after adaptations were made and expectations were adjusted.

Yes. It took a bit of thought to get a text at an appropriate level. This would be somewhere that appropriately leveled text resources would make things easier.

16. How did this unit compare with other Science topics you have previously taught?

Given that the primary teachers’ experiences in the Science curriculum were surprisingly limited, they reflected positively when they compared their efforts with previous attempts at teaching Science, as evidenced in their comments:

SOOOO much better, it actually meant something, rather than one-off activities.
Previous units I have taught, as in most mainstream classes I have experienced, have basically been a series of activities around a certain topic. Writing would have been limited to mostly experimental write-ups and some notes copied from the board. A much wider variety of topics may have been covered but there would have been little depth of understanding or use of scientific terminology.

The text in this unit provided a focus for language in the classroom. Activities were planned to exemplify concepts and language in the text to build a deeper understanding. New understanding of scientific language construction could be used in developing understandings in different texts.

However, the whole experience was not an unqualified success for all. As one teacher noted:

I found it more stressful as I was unsure of the method and I knew that my practice was to be critiqued. I didn’t feel as though I had the same ownership of the topic as with other units and felt constrained by the text.

17. Would you consider refining this unit for another time or starting afresh with a different unit?

The final question asked the participants to make an overall evaluation of their work with this trial in teaching Science through the AL pedagogy. The responses indicated that the teachers were committed to the way of working, that is, they saw benefit in extending AL into Science, but as in any trial they would want to learn from the points which did not go according to plan, or which consistently did not work well.

Perhaps, with a different text and an entire term (or longer) to work on it, but I would try to use aspects of the AL teaching sequence with a variety of Science texts.

I would consider refining this unit for use with another group of students, perhaps with a slightly different focus like eye health rather than just eye structure and function, which I was hoping to get to in the unit in more depth, but really only mentioned in passing (like talking about cataracts when discussing the function of the lens). It is always good to build on previous units because as a teacher becomes more confident with the content they can work on refining their own practice. However, it will always be necessary to work on and develop new units including new texts and activities, which I now feel more confident in doing because of this experience.

I have continued with it to a certain degree, looking at scientific procedures. I would like to refine the unit on wind and water cycle and it would be interesting to see if another teacher could pick it up and run with it.
Discussion

This section provides comment on the results and outcomes of the research project. We began with a research question about the issues encountered by the teachers when they worked with AL in Science. The focus on issues indicates that our interest was in the challenges and problems they encountered, and this is certainly an important aspect of the research. However, it is important to state that the participants all attempted to resolve the issues they encountered, so that they presented the best possible teaching processes and materials to the students in their classes. The support of the SAALP officer was crucial in this endeavour. Before providing an account of the challenges, it is important to note that, despite the obstacles, there were some notable successes and positive outcomes for the teachers and their students. In fact, the most important outcomes are the teacher perceptions that the effort was worthwhile; that they could work with AL in Science; that it did make sense; that their students did engage with the content in the units; that the students did learn some Science; that they did enter into the academic discourse of Science; that they as teachers changed in the process of the research; essentially that the intervention pedagogy led to some very positive outcomes.

Some evidence of this is presented in Appendix 5 through some written texts from the Year 6/7 class which studied transpiration. The learning goal was to write an explanation text about transpiration for a non-scientific audience (as part of this the teacher and her students had discussed the need to elaborate on scientific language). More specifically the teacher introduced the four variables which were important to the overall process and the task for the students was to write a text explaining the process of transpiration, and independently focus on one of the important variables. The teacher concluded that each member of the class was able to achieve this goal. Obviously not all the students achieved the same outcome, and those included in the Appendix were considered to be examples of high level achievement. Nevertheless, it is salutary to reflect that these students attended a school considered to be highly disadvantaged and their achievements are noteworthy. Their teacher, and all of the participating teachers, attributed their success to the implementation of the AL pedagogy.

Some of the challenges the teachers faced were individual and particular to one specific context, possibly personal and relevant to one teacher and the students in the localised situation. Whilst these are interesting and important, we have found it more useful to analyse and interpret issues which were common to the group of five, or at least to the majority of them. These issues have been separated for discussion but they are in fact closely interlinked aspects of the complex dynamic of classrooms, and particularly of teaching and learning in a disadvantaged school context.
The teachers signed up for the project based on their enthusiasm and success with AL using narrative texts. Their challenge was to extend the use of AL pedagogy from one learning area, essentially English, or Literacy as it is in the primary and junior primary curriculum, into a different learning area, in this case the learning area of Science. There were then, at least two important shifts required, about both of which we all had some awareness, and about which we learned more as the project unfolded. One important shift was in the type of text used, explanation in Science as opposed to narrative in Literacy. Accordingly, there were text-related issues, such as the sourcing of texts, the creation of useful texts for their units, the analysis of texts, and the use of texts in teaching a unit of Science. The other shift related to their AL pedagogy, which had been developed in one learning area with its established procedures, patterns and discourse, into another learning area governed by different aims and in which the procedures, patterns and discourse were entirely different. And so, there were also issues arising from the learning area of Science itself and the use of AL within this learning area, the melding of literacy with Science, and the teaching of Science in general, particularly at the primary school level. Running alongside and interlinked with these issues are matters such as the place and importance of oral language, of the talk that is the most prevalent mode through which the pedagogy takes place, and also the usefulness of the pedagogy with other cohorts of 'at risk' learners.

In the following sections some of the issues arising around these matters are discussed, including importance of the different text types, the challenges in attempting to use the AL pedagogy in a learning area such as Science, the significance of talk and text, and the usefulness of the pedagogy for teaching specific cohorts of learners.

**Narrative**

AL was initially developed as an intervention in the teaching of reading and writing to the most disadvantaged students. The choice of text for the task was narrative because these are considered to be the most accessible culturally, as well as being the most intrinsically enjoyable, and also a useful bridge to written factual texts. Children learn to read stories and if adult and child reading activities are part of home life then the texts used are invariably narrative. As part of the earliest reading instruction in formal education the texts are also narrative. When children learn to write they are taught to write stories or recounts of personal experience. The ability to read and write narrative affords teachers and students the opportunity to explore the world through recourse to culturally esteemed stories. Students can be invited to consider aspects of personal identity, lifestyle, life circumstances and of culture in relation to the characters in the story, as well as moral and ethical issues in the story which may have relevance to their lives. In this way narratives are used in the
process of acculturation. All of this is the 'bread and butter' of early years schooling when teachers engage students in the reading and writing of narrative as a means of teaching them how to read and write.

In learning to read narrative texts the task is often made easier for the reader by the way in which the story is constructed around personal, concrete events, with which the reader can identify because of their relative proximity to personal experience. The focus of narrative work in classrooms is on the characters in the story, their actions, their circumstances, and the plot or storyline which unfolds around them. Teachers use all of these elements and more to draw links between the text and the lives of their students. Animals in these stories regularly assume human like personalities and engage in human like behaviours. Often the 'message' in the story is a moral message and it is here that a stretch is required to span from concrete experience to something more generalised or abstract. Teacher work is in the planning for and scaffolding of learning from the concrete meanings in the story to the relevance of those meanings for citizenship in the community. Within the narrative students find opportunities to consider their personal identity, for their identity to take shape, and to develop in culturally sanctioned ways. The development of AL draws on all of the cultural and stylistic aspects of narrative as a means of capturing the interest and imaginations of previously unsuccessful readers.

In AL classrooms talk is very often directed by the teacher to different features of the narrative text. This is the nature of the Lower Order Literate Orientation, the Higher Order Literate Orientation, and the Transformation stages in the pedagogic cycle. For example, the Lower Order Literate Orientation engages the students in looking at the meanings accompanying the actual words on the pages, that is the illustrations and the meanings that can be gleaned from these prior to any focus on the words in the text itself. These are the visual semiotics which most often accompany the verbal semiotic in, for example, a Big Book. At a later stage the teacher and learner focus on, and their talk shifts to, the words and groups of words in the text as part of the Higher Order Literate Orientation.

The language of narrative is often seen as amenable to meaning making by children. The plot of a narrative unfolds in ways which developing readers can understand because of the relative closeness to the lives they lead. Stories are often embedded in the everyday actions of characters with whom children can identify. These stories are very often about people, often young people, or about animals that are attributed with human personalities. Their characters are fleshed out emotionally in ways which are understood by young readers. The point here is that the language of narrative is different from the language of explanation in that it may be more accessible to readers because of its everyday quality. Stories commonly revolve around the actions of human characters in contexts not too far removed from those of the readers. As a consequence the meanings in narratives may be closer to the
lived experience of students than are those in texts which aim to explain the natural world. This natural connectedness with the lives of children provides an important advantage for narratives in engaging the imaginations of children over any other type of text.

The process of the classroom talk in AL is also distinctive in the way that it unfolds in set patterns or routines. Teacher led talk at the Lower Order Literate Orientation, Higher Order Literate Orientation and Transformation stages involves Preformulations, the pedagogic process in which the teacher proffers information to orient students to the intent of the question, and then asks a question for which the answer is apparent, once the teacher and students are similarly oriented or aligned. This is an important part of AL strategy, aligning the students with the teacher’s orientation, thereby giving students the opportunity to participate successfully in classroom routines and avoiding a ‘guess-what’s-in-the-teacher’s-head’ process of question and answer episodes. These processes of talking about different aspects of the text are systematically organised so that they target different levels within the overall system of language, and different stages of the learner’s control of the language of the text. From the level of global textual meaning the pedagogic process moves down to the level of grammar and vocabulary. For students with little previous success with reading it may also be necessary to dwell on the phonology level where the awareness of sound and letter correspondences within words and syllables becomes the focus. In combination they constitute the carefully constructed scaffolds which provide the distinctive character of AL. This distinctiveness has evolved in the research and teaching of narrative texts. The question of interest in this current research was to report on the potential of the pedagogy with a different kind of text, a different genre, in a different learning area.

Explanation

So what is Science and why is it important in the community and in school? One widely accepted response is that Science investigates and explains the ‘how’ and ‘why’ of phenomena in both the natural and constructed world and as such offers understanding of our world. Accordingly an important aim of Science education is to help students to think like, to act like, and to make meanings like scientists. Scientists most often use explanation texts when writing about the phenomena they study and so explanation texts are those which students read when reading to learn in Science, when they try to move inside the discourse of Science and when they demonstrate their own scientific knowledge in written language. Thus, the focus of Science in the curriculum is quite different from English and Literacy, and the structure of scientific texts and their function in teaching and learning Science are quite unrelated to narrative in English. These differences presented challenges for the teachers attempting to use AL in Science for the first time.
Explanation texts differ in structure and organisation from narrative texts and the AL teachers needed to be versed in this structure and organisation if they were to successfully exploit these texts in the pedagogic process. The teachers did have some understanding of the structure of different text types, but they were less knowledgeable beyond the level of organisation or schematic structure. In reference to the earlier discussion of literature the teachers were quickly aware of the technical and/or abstract vocabulary which had to be understood for meaning to be made in the texts they developed. This was one obvious and daunting element of the explanation texts they used. It was not possible to avoid ‘bumping into’ technicality and abstraction in their scientific explanations. Thus, the teachers were forced to deal with each of the technicalities which appeared in their texts and a common cause of concern for the participants was in finding texts with the appropriate amount of technicality. However, as the literature discussion also highlighted, the complexity and difficulty in understanding scientific explanations resides not only in the technical vocabulary but equally in the logic of the text, how the meanings are related to one another so that they form a coherent scientific. This is especially important in explanation texts in which elements are linked causally or sequentially to create a logical unfolding process.

In Science texts it is extremely limiting if the meanings to be made remain at the level of concrete experience. In the quest to explain the workings of the natural world, scientists by definition must move beyond the everyday experiences of humans. In Science texts it is not feasible to make all the meanings concrete. Developmentally meaning making becomes more abstract and this is quickly reflected in the language of scientific texts which deploy the resources of the language system specifically evolved to make abstract meanings. It is at this point that Science presents challenges to teachers and students. The language of abstraction varies significantly from the language of everyday talk and has the potential to alienate students and also teachers who find it difficult to get to the meanings in the language used. For example, typical in Science texts is the use of what is known as nominalisation, for example words such as transpiration, insulation, convection and evaporation and radiation all of which appeared in the texts used in the research project. Each of these is more commonly recognisable in its verb form, to transpire, to evaporate etc. The grammatical shift from the verb ‘evaporate’ to the noun ‘evaporation’ is an example of the process of nominalisation which is especially prevalent in Science and is used in the service of making more abstract meanings. The nominalisation ‘evaporation’ condenses into a single word the meaning of a series of events which have occurred in a sequence or as a result of one event causing another event to happen. Evaporation conveys the set of meanings of a total process in one single word. It is succinct, and tight in the sense that it always means this same process.
Additionally, as a single word it can be used strategically in a text as one way in which the writer of the text organises the meanings to best suit her/his purposes. This is what is called the rhetorical organisation of text and relates to how a text is best organised in a sequence so that it unfolds in a logical and coherent manner. Logical relations, or the ways in which the text is comprised of stages sequentially or causally related, are quite different from and more important in the overall meaning of explanations than they are in narrative. The logical unfolding of an explanation through a series of coherent and cohesive phases is expressed by the use of conjunctions. These may be expressed by conjunctions themselves, such as 'because', but they may also be coded as 'the cause', again through the process of nominalisation described above. So, beyond the difficulty of dealing with technical and abstract vocabulary in explanations, the equally important matter of the internal logical relations within explanation texts appeared as a challenge for the teachers and their students.

Another difference between narrative and explanation is in the use of visual cues, or the visual semiotic, alongside the verbal. In narrative, especially for younger learners, the visual may carry as much meaning as the verbal. This is exploited by teachers, particularly if they themselves understand the complementarities of verbiage and image, as AL teachers do. Some of the meanings in the text can be understood and others previewed via the illustrations as matters to be dealt with more thoroughly through the written text. In this way the students are oriented to the meanings in the text. The place of the visual in Science is much less explicit. Sometimes there is a visual text at other times it is only the written word. The visual text itself can vary from a diagram, to a graph or chart, to an illustration of the total phenomenon under scrutiny or one particular element. It is also possible for the visual to replace the verbal, to stand instead of it. The relationship between these different modes is often less clear than it is in narrative, and whilst the potential seems obvious the reality is that the synergies are often underexploited.

As a research team we foreshadowed these differences as important and spent some of the initial professional development session discussing the structure of explanation texts and the various sub-types of explanation which were prevalent in Science. As the unit of teaching unfolded it is true to say that the teachers had some difficulties in working with particular aspects of the texts they developed within their units. More accurately they did not attend to particular elements of the texts which may have been important, possibly because they did not recognise their importance. The matter of technical vocabulary was relatively obvious, but there was also the important feature of logical relations and of how the texts were structured to organise the logical flow of meanings. These were less obvious features of text, less at the level of consciousness than the more noticeable technical or abstract vocabulary. The issue for these AL teachers, as it is for AL in general, was how to accommodate all of the salient and relevant features of scientific texts into the
pedagogy. And inherent in that discussion is the requirement that teachers need to have a good understanding of the ways in which the grammar, both the words and the structures, are used to create the meanings in the text. This is an important matter for pedagogy which puts language in a central position. It brings with it an additional body of knowledge for teachers to understand and co-opt into their work. The value of this additional body of knowledge has been debated over the past twenty five years in the case of the genre-based approach. Within AL teachers do have a sound working knowledge of the linguistic features of narrative. However, a similar depth of knowledge is required for working with factual texts, in this case explanations.

Unit choice and text choice

One of the real difficulties encountered within the research project, in hindsight a methodological error of judgment, was the fact that the teachers made independent decisions about the choice of topic for their Science unit. As the project unfolded the project team came to regret the decision to allow this degree of flexibility. In effect the flexibility meant five topics in five different areas of Science. Whilst one of the primary schools did work within a whole of school orientation to climate change, even within this the two teachers worked on wind energy and insulation which offered very little common ground. As the project proceeded it became clear that the teachers did not have much common ground within their chosen content areas even though there was obvious potential for collaborative discussion regarding the pedagogy. This put greater pressure on the SAALP Officer to offer support across five distinct topics in Science, and was a particular issue in the area of text selection and development. In hindsight, a more useful alternative would have been to negotiate with the teachers at the outset so that they all taught the same unit or related units within a single area of Science. Primary teachers, especially, do not have extensive knowledge of Science content. It would have been helpful to focus the teachers on one topic addressed at different levels of complexity. This would have allowed for greater collaboration around the actual content as well as in the development of age and level-appropriate texts. In this way it would have been possible to plan for increasing complexity as students were supported in the move from commonsense to more scientific understandings.

In searching for appropriate texts the teachers found that the texts they developed and used did not neatly fit the generic structure they had expected. They discovered that the model texts provided for them in professional development about the structure of different text types were not reproduced in the real world, not in Science text books if these were available, nor in the vast amount of resources on the WWW. The primary teachers who were mostly working closely with texts in Science for the first time found that their expectations about neatly patterned explanations were not
met. As explanations they often included classifications, definitions of phenomena, and mini-reports. In other words, the texts were ‘messy’. This is evident in the comment by the SAALP Officer who took on a key role in supporting the teachers to find and adapt texts for their units:

I spent ages trawling the web trying to find explanations and an extension explanation that would fit their topic. Issues with the ones I found were that they were often simplified and didn’t use much technical language, or that they were highly complex and there would have been too much to work through with a class. Some had nominalisations that hid enormous concepts that would have to be taught first before the class could tackle the explanation.

With narratives the teachers could talk with confidence about the function of different stages within the text. They could also talk about the intentionality of the writer, particularly in the Transformation stage, as they dwelt on particular choice of word or a noteworthy placement of a word or group of words in a sentence. Here, there was not the same depth of understanding about the explanations prevalent in Science. Besides the messiness and the realisation that their texts did not conform to a neat generic structure, there was also the complexity of dealing with the set of sub types of explanation, each with their specific logical structure.

In the end we agreed that it would have been useful and will be important in the future to have some model texts to work from as a base. There is a pressing need to develop a series of texts and text notes around a single topic. This is accepted practice in dealing with narrative texts in Literacy classrooms where the AL project has developed and commissioned the development of detailed text notes for an increasing number of popular narratives. Text production was a stated outcome for all of the teachers and everything else was oriented to that end goal. The teachers agreed that they needed useful models to be able to scaffold the children to achieve the goals at the end of their Science units, that is, to write good explanations.

As in all classroom work where there is a focus on text, its quality was crucial for Science teaching in this project. This issue assumed real importance for the teachers in this project. To take a positive perspective on this matter of text, they all came to a view that they were adopting a text based approach to the teaching of Science in which written text played a central role in planning and organisation. They accepted the premise that it was their texts, and the talk around them, that provided the discursive means for the development of the ‘higher mental functions’ they hoped their students would achieve. It was, therefore, vitally important that the texts at the centre of the teaching unit were of high quality because the teaching and learning consistently began with or returned to the text at regular points in the lessons. This idea of the text as a central theme in the unit was reported by the teachers to be a unifying thread to their planning framework that maintained throughout the unit
and preserved shape in the unit. It was a consistent feature which provided a coherent link for the children as they moved across a range of different activities. After each demonstration or hands-on experience the teacher could come back to the text which was at the centre of the unit of work. Traditionally Science teachers would not have such a focus. Its centrality galvanised its importance and the teachers recognised that if the text took on a more central focus then it was crucial that it contained the appropriate information and was accessible to the students. As they came to this understanding, it became an important issue which had not been foreseen at the beginning of the research process and one which is traditionally not part of discussions in Science. Inside a single unified and unifying text all of the content of the unit of work needed to be addressed or at least signaled for a later time in the unit.

All of these comments point to a need for additional professional development for AL teachers as they move the pedagogy across the curriculum and into learning areas where text types other than narratives are the norm. The increasing demand for detailed attention to the language of the text brings into focus the important matter of the place of knowing about language for AL teachers and the issue of knowledge about language within AL pedagogy. AL has been developed with a clear acknowledgement of the concurrent work of those working within SFL, and especially its application to literacy education through the genre-based approach.

However, where the linguistic approach brings to the foreground teacher knowledge about language via an explicit focus on the rhetorical and grammatical structure of different types of classroom texts, AL’s prime focus has been on particular pedagogic principles and practices, such as Preformulations and Transformations, processes which acknowledge a sympathetic but different theoretical background, notably Vygotskyan socio-cultural theory. Knowledge about language has been seen as helpful but there has not been a conscious focus on grammar or metalanguage in the classroom. This kind of knowledge has been more in the tacit knowledge of the teacher, generally thought by some to be useful but not crucial, and by others as necessary but not sufficient. In the light of this research project, it would seem that there is now a need for a more explicit focus on the structure and grammar within the text, because in scientific explanations the textual complexity may not be instantly apparent, but is nevertheless crucial to the coherent and cohesive flow of meaning across the text. If this is the case, then it raises questions of how this might impact on the pedagogy as a whole. Would it compromise the distinctive nature of AL? Would it take it closer to genre-based pedagogy? The questions are not posed rhetorically with particular answers in mind; rather they surface as relevant questions in the light of this research for the development of AL pedagogy across all learning areas of school.
Teaching Science

In the initial stages of the research the project team discussed the most appropriate choice of word, more specifically the choice of verbal process, to accurately describe the effort of the teachers in the research. We carefully considered what this would involve and settled on the idea that the teachers would ‘extend’ AL into Science. As we reflected on that choice of word it is true to say that ‘extend’ did not do justice to the challenges faced by the teachers in the project. What they had to do was bring a strong AL language and literacy element into a learning area already well-established with its own tradition of activities and experiences, with its own discourse. Further, they came to realise that they needed to integrate both their AL pedagogy and the processes of Science to have any chance of being successful. To this end we were mindful of conclusions made by previous research in which a language focus was made prominent in Science:

Reading and writing Science is by no means the whole of an effective Science apprenticeship. Students must also be involved with the other indispensable Science learning activities including experiments, discussions, demonstrations, visual images and interactions. The scope of the curriculum needs to be widened to include the explicit teaching of scientific literacy in concert with all these learning experiences. The foundation of such a curriculum must lie in student experience as a starting point (Korner, McInness & Rose, 2007, p. 32).

However, as pointed to in the literature section, there is a question mark about the value of hands-on activity as the sole content of Science classrooms. The issue arises as to how the teacher capitalises on the potential created via the activities. What can or should the teacher do with the interest created by engagement in ‘doing’ to support the learners towards some consolidation of scientific understanding? The need for a complementary literate focus is argued by those oriented to language:

Theoretical models will not be discovered by children through their practical work... guidance is needed to help children assimilate their practical experiences into what is possibly a new way of thinking about them (Driver, Squires, Rushworth & Wood-Robinson, 1994, p. 49).

In these classrooms the distinctive routines of the Science activities were disrupted by the intrusion of text premised on AL inspired beliefs about the nature of entry into the literate discourse of Science. The required melding of the material with the symbolic is well exemplified in the case of the Year 2-3 classroom where the aim of the unit was to explain wind and wind energy. The children all had experience of wind in an everyday manner, but this experience did not provide them with any insights into the nature of wind, why and how it occurred, when it was more likely...
to occur with a greater or lesser force, and how it was related to energy. How the teacher approached the task was to develop a text which was central to the unit, and to which she returned throughout the unit. She ventured away from the text to demonstrate aspects within it which lent themselves to demonstration and which engaged the children in the work. An example of this was the activity described earlier in which she demonstrated the principle that hot air rises by heating hot water, placing it in an ice-cream container, then placing a plastic bottle which had a balloon secured around its neck. The hot water heated the air in the bottle, the air rose and the balloon visibly inflated. The children also excitedly undertook this activity in small groups. The abstract meaning relevant to this teacher’s unit of work on wind was that warm air rises and in the natural environment this phenomenon occurs when air passes over land mass and water mass at different temperatures to each other. The air warms and rises and more air then flows in behind the rising air. This is the phenomenon we recognise as wind.

**Oral and written language in AL Science**

There are always a number of important relationships to untangle in the effort to understand classroom practices, equally so in the specific practices under investigation in this project, where the effort was to work with a distinctive language oriented pedagogy in Science. In this research one crucial issue is the complex relationship between language and learning, and variations on the theme of language and thinking, including language as a vehicle for thinking, and language as a basis for thinking. And linked to this issue are various models of the relationship between language and content or subject knowledge. These models range from the view at one end of the spectrum that conceptual understanding develops and language is then used or comes into being to allow these concepts to be communicated. Here there is a clear separation between concept and language. It is the prevalent view of knowledge and understanding in which they are separated from language, and is ingrained in our ways of constructing our world. We talk about ideas and concepts as independent entities which come into being through thinking, and these same ideas and concepts are deemed to be independent of the forms of language which ‘convey’ them.

Those who have challenged this taken-for-granted view over the past thirty years label it the ‘conduit model’. At the opposite pole they present the view that there is only language (more exactly semiosis or systems of meaning making) so that content and language are in fact one and the same. Accordingly, control of the language of a topic indicates conceptual understanding of that topic or content. This position, briefly described in the literature review section, is adopted by Wells (1994) and is also supported by Alexander (2006). A similar angle is to some extent implicit in AL but more explicitly broached in the SFL inspired genre-based approach, since in both
pedagogies meanings become more central to the processes of teaching and learning, and meanings are not thought of as separate from the language forms through which they are expressed. Language is constitutive of meaning and of social context. The language of school science actively constructs a particular realm of scientific activity and also constructs roles for students within that realm. The written language of science builds distinctive ways for students to think about the world. It offers a scientific world view; it is essentially the discourse of science. And, whilst this is a theoretical matter, it nevertheless does link closely with the core aspects of this research.

Halliday (2006) suggests that Science teachers have usually thought of the difficulties students face in science as difficulties with vocabulary or lexical items. This is what is implied by the term ‘jargon’ which means a number of difficult technical terms appearing in a single text. The word ‘jargon’ often carries a further implication, namely that such terms are unnecessary and the same thing could have been conveyed without them, in the everyday language of ordinary commonsense. And this is, in fact, one view of scientific language: some people think that it is an unnecessary, a more or less ritualistic way of writing, and that science, both scientific concepts and scientific reasoning, could just as well be expressed in everyday, non-technical terms. This other kind of language is often referred to as ‘plain English’. From the opposite or semiotic end of the spectrum it would be argued that Science is totally dependent on scientific language: that you cannot separate Science from how it is written, or rewrite scientific discourse in any other way. According to this view, ‘learning Science’ is the same thing as learning the language of science. If the language is difficult to understand, that is not some additional factor caused by the words that are chosen, but a difficulty that is inherent in the nature of science itself. It is the subject matter that is the source of the problem.

Halliday goes on to make the point that the discourse of science and the difficulty with scientific writing is created more by the grammar than by the vocabulary. Whilst the two are difficult to separate, it is the total effect of the wording, words and structures, that the reader is responding to, and technical terms are part of this overall effect. Technical terms are not, in themselves, difficult to master and students are often pleased to show their mastery of highly technical words. Essentially they are put in the centre of the discussion because they are obvious and easier to talk about than grammar. Problems with technical terminology arise not from the technical terms themselves but from the complex relationships they have with one another. Technical terms cannot be defined in isolation and to make this point strongly Halliday lists a number of ways in which scientific writing employs resources from the system of grammar to make scientific meanings: interlocking definitions, technical taxonomies, lexical density, syntactic ambiguity, grammatical metaphor, and semantic discontinuity. It is not necessary or helpful to define what is meant by each of these grammatical strategies for this report, the important thing to
note is that they are used in scientific writing, even at the primary school level, as the absolutely normal ways in which scientific texts are created.

Such views are clearly a long way from traditional thinking in Science, where there is a clear separation between content and language, where such description and analysis of scientific writing would never occur. Science teachers teach Science content and most often treat language as an afterthought, as a necessary but not significant aspect of the learning area. This position was challenged by the very premise of the research project, which was that academic success in Science is contingent on control of scientific discourse. To be successful in Science students have to control the language of Science, as indicated in the following:

Language and thought are intimately related, and the extent and manner of children's cognitive development depend to a considerable degree on the forms and contexts of language, which they have encountered and used (Alexander, 2006, p. 10).

Working from this position a subsequent question arises regarding the actual scope of what we mean by language. Does it of encompass both the spoken and the written word, so that what is under the microscope in the classroom is oral language and its links to the written word, essentially 'the talk about the text', as well as the text itself. And then there is the role each of these modes plays in teaching and learning, in the teaching and learning of school Science in general, but more specifically in the teaching and learning of Science through the AL pedagogy. As discussed earlier there is an understanding that the language of Science is written-like, in that scientists necessarily make meanings which are abstract and generalised from concrete experience. They necessarily take a distant and objective stance in trying to understand and explain the natural and constructed world, and so utilise the resources of the language system which have evolved for these purposes. These resources are written-like in general, as opposed to spoken-like, and create specific hurdles to those outside of scientific discourse:

The grammar of Science and technology is based on that of everyday spoken English but, over the past four or five centuries, it has evolved highly specialised forms to express highly specialised meanings. Scientific English has taken the grammatical forms of everyday discourse and redeployed them in highly metaphorical and complex ways to express meanings that are remote from commonsense experience. It is this difference in grammatical form that makes scientific writing so hard to read for many speakers of English. It is not that their cognitive potential is insufficient to understand scientific concepts but these concepts are expressed in grammatical forms that most English speakers are not familiar with, and have never been taught to read (Korner, McInness & Rose, 2007, p. 14).
A key consideration for AL as it attempts to offer something to Science education is to reason about the nature of talk in the Science classroom. What is the purpose and function of teacher talk, of individual student talk, and of student to student talk whether in a pair, group or whole class? What is the place of written text in the classroom, and the purpose of reading texts and of writing texts? In what ways do the permutations of classroom talk link to text? Does the classroom talk, for example, focus on trying to develop student understanding of the meanings which are intended in the text? Whilst all of these varieties of classroom talk are important, of most importance for this project and for AL is teacher talk, because it is the teacher who consciously builds scaffolds for learning through talk.

Clearly teacher talk is one of the key features of AL which has developed a set of pedagogic routines in which teachers scaffold students towards understanding of narrative texts. In working with narrative texts these procedures involve teacher-led talk about particular features of the text, through the Lower and Higher Order Literate Orientation, through Preformulations, through Transformations, all aiming for handover in which the students demonstrate their control of the language, and thus their control of the content. The challenge for the teachers in this project was to incorporate these important pedagogic processes within a learning area with its own well established routines and traditional processes. The challenge for the research was to document the issues encountered by the teachers as they worked in the classroom, to document these and the teachers' responses in addressing them.

It was useful to consider the unit in a linear fashion starting from the beginning and looking to the final outcome. The goal was the independent production of an explanation text by the learners and the teacher's role was to scaffold the students so that they could successfully accomplish this final task. The teachers understood the desired outcome and their planning was based around teaching towards that end. Every activity was an orientation to the language required to achieve the outcome. This was liberating for the teachers. The students had to appropriate the language of the unit in both spoken and written modes. Their success in appropriating the language of the unit was visible through their achievement of handover. In line with the Vygotskyan basis of the pedagogy, when the students demonstrated control of the language of the unit it indicated the shift from the 'outside' to the 'inside', from the 'inter-psychic' to the 'intra-psychic' level, as discussed earlier. It indicated that they had understood the Science in the unit. In AL the function of classroom talk, and of the teacher's talk about the text, is to carefully stage manage this operation. This is the essence of AL pedagogy.

At the conclusion of this research project all of the teachers had a clear idea of the benefit of attending to language in teaching Science. However, their understanding of the language of Science shaped the ways in which they planned and worked with the language. And this then surfaces as a very important matter, because, as
discussed above, the language of Science is more than technical vocabulary, and to get fully inside scientific discourse calls for a deeper understanding of language than can be achieved at the level of vocabulary. How deep teachers need to drill is a matter for debate, and that debate is similar to, if not the same as, the one generated around the genre-based approach. When that linguistically inspired approach to literacy was first developed in Australia in the mid-1980s it produced a strong reaction from those working in the literacy field, sparking a discussion which continues today. Supporters were drawn to new insights offered by an understanding of Halliday’s functional model of language. Opponents found it overly technical and detailed to the point where they saw it detracted from the task of literacy teaching.

AL has not been involved in these discussions because AL pedagogy has not drawn heavily on linguistic theory to this point. This current research indicates that may change because of the focus on factual texts in learning areas across the curriculum. It is not these factual texts such as explanations are linguistically more complex than narrative, but with narratives the characters and plot can be often linked to the everyday lives of the students, and the students can possibly bring much to the text through their cultural understandings. With explanatory texts in Science there is less potential for the experiences of the students to be helpful in understanding the scientific content. As AL moves into the range of curriculum areas it may need to engage more strongly with linguistic knowledge, and this may well bring with it tensions not felt to this point. As mentioned these tensions have been experienced by those working with the genre-based approach to teaching writing, which in South Australia has been mostly linked with the ESL Program. The ESL Program through the ESL Curriculum Scope and Scales and through its professional development programs, Teaching ESL Students in Mainstream Classrooms (TESMC) and the Language and Literacy Course, has been a strong proponent of the genre-based approach. The ESL Program in DECS has also shown interest in AL and provided funding to this research project because a number of ESL learners were enrolled in the participating schools. This interest offers the opportunity to look in more detail at the AL and genre-based pedagogies and also at the student groups which they aim to support.

**AL and ESL**

Given the overlapping contexts in which AL and a genre-based approach operate, their motivating developmental influences in more equitable educational outcomes, and the interest shown by teachers in both pedagogies, it is relevant to offer a perspective in which the two approaches are compared, especially with a view to making useful connections between them. The question of the applicability of the AL approach across different learning areas was the starting point for the research but it
was also of importance to consider its applicability to different cohorts of learners. The usefulness of the pedagogy as a positive intervention for Aboriginal learners has been documented earlier in this report. In response to the question about ESL learners it is necessary to provide some contextual information, to compare the pedagogic bases of AL and ESL, to make comment on the classrooms in this project, and then to comment more generally.

The pedagogy promoted in the ESL Program is the genre-based approach which is linguistic in its orientation and owes much to the Hallidayan perspective of language. It originated with the work of Painter (1986) who used case studies of the language development of her own children which she modeled on Halliday’s 1970s work in child language development. From this research she developed an account of language learning in the context of middle class homes in Australia. It was this model, based on the principle of ‘guidance through interaction in the context of shared experience,’ which became the cornerstone of SFL influenced literacy pedagogy when married with knowledge about language and learning area content. The focus on the structure and grammar of the important kinds of texts in different learning areas coupled with explicit pedagogic processes became known as the ‘genre-based’ approach. The underlying principles resonated strongly with, but developed independently of, the idea of scaffolding outlined earlier in this report. However, the pedagogy was influenced by the work of Gray, and his ideas on the role of the teacher proved a useful adjunct to Halliday’s and Painter’s research on very young children.

The teaching-learning cycle, essentially the pedagogic process of the genre-based approach, was developed by Callaghan and Rothery (1988) in work at the Disadvantaged Schools Program in NSW. It was developed as an explicit pedagogy to support the written language development of ‘at risk’ learners traditionally marginalised, including ESL learners. It is important to note that the pedagogy was not developed with ESL learners solely in mind. Those who conducted the research with teachers and the thinking which went into the development of the pedagogy were concerned equally with the marginalisation of all ‘at risk’ groups of learners; working class, migrant, refugee and Aboriginal students.

The teaching-learning cycle has embraced a number of minor changes over the two decades since it was first developed. However, the changes are relatively small-scale and there remains at its heart a cyclical process of teaching for learning which teachers use to program and to plan for their teaching. The cycle is most simply adopted for a unit of work in which the topic is introduced at the beginning with the learning goal of independent writing as the desired outcome. The three, sometimes four main phases are usually labeled, Deconstruction, Joint Construction and Independent Construction. In the initial stage the topic is introduced and the specific genre or kind of text to be produced as part of the learning outcome is modeled in
terms of its structure and salient grammatical features. At this time the teacher works to develop the content knowledge of the learners through a range of activities, including excursions and visual information sources, but also including text-based activities such as reading for information or researching from the internet. This is known as the Field development, where Field is understood to equate with content. Model texts are also investigated at this time to provide understandings of how writers go about constructing texts that are deemed successful. The Joint Construction stage involves the teacher working with and reworking student oral contributions to produce a written text which is based on the expertise of the teacher and the input of the students. This is similar to the strategies of recast and reformulation described in the literature review section. In the Independent Construction stage the students take over individual responsibility for writing a different text in the same genre. Work on developing an understanding of the Field is an ongoing part of the cycle. The ultimate goal of the cycle is control over and an orientation to how authors construct the genre (Macken-Horark, 1996) in preparation for independent writing by the students.

The principle of ‘guidance through interaction in the context of shared experience’ is used throughout the process. Establishing the learning goal at the outset is part of engaging in the shared experience. There is a strong focus on interaction throughout, particularly during the Joint Construction stage, but also within the activities which help to build Field knowledge. The teacher is positioned primarily in the position of authoritative guide throughout, as the expert supporting and building learning scaffolds. The aim is for the students to develop their understanding and knowledge of the topic and also of the structure and grammar of the text through which they will be able to reproduce and demonstrate that knowledge in their own independently produced written text.

The genre-based approach has been widely accepted as helpful and is used by many educators nationally and internationally. However, it has consistently met resistance from those who have baulked at the need for teachers to learn and use grammar, particularly where the variety of grammar jarred on those old enough to have grown up with what is known as ‘traditional’ grammar. The complexity of the metalanguage has also been challenged as overly-linguistic and complex. Critics have baulked at what they see as unnecessary technicality required to engage fully with the pedagogy and have also wondered at the necessity for students to learn complex metalanguage. There has also been resistance from those who regard the pedagogy as prescriptive, as being teacher-centred and contrary to the principles of constructivist learning. Accordingly, there has been a strong dilution of the approach as it often is used in schools. What is sometimes used in schools is an approach limited to an understanding of a set of elemental genres and the organisational structure, or distinctive beginning-middle-end stages, within these genres.
It is interesting to note that whilst the genre-based pedagogy developed out of knowledge about how parents teach their young children to read, it was quickly adapted for use in the educational domain as a process through which to teach disadvantaged students to write successfully in school. The prime focus of genre-based pedagogy has been on written language since that is the primary mode of language through which students are assessed. From the perspective of those working towards more equitable outcomes for disadvantaged students it was an obvious point for intervention to improve student success. In South Australia it was adopted within the ESL Program because of the explicit grammatical focus, which made good sense to teachers who understood that a grammatical focus constituted an important part of the content of ESL. This focus, embracing for the first time a grammar equipped to deal with whole texts rather than sentences, and offering a set of pedagogic practices to guide learners towards successful writing outcomes was instantly attractive, and a genre-based pedagogy is at the heart of the ESL Scope and Scales within the SACSA.

Whilst Gray influenced the groundbreaking work of Painter, his work was also influenced by Painter, and he has always acknowledged the influence of Hallidayan linguistics in the AL approach. There are also acknowledgements in both pedagogies to the work of Bruner and Vygotsky, although AL has greater recourse to these influences than the genre-based approach. Gray also maintained a strong focus on reading and the AL approach has first and foremost been noted as a reading intervention. Where students need to learn to write in the ways of school, Gray understood that they fundamentally also need to read texts, particularly at that stage of learning where they are developing their Field knowledge about a topic. This is very often achieved through reading and at an early stage in schooling students have learned to read so that they can read to learn. Without learning to read they can not read to learn and are excluded from school learning.

Both ESL pedagogy and AL pedagogy start from the position that when we teach students to read and write and to control the written mode we have to bring language to the level of conscious awareness. This is the effort within both the AL and the ESL approaches, although they both have different bases from which to arrive at a similar goal.

One significant difference appears to be in the formalisation of the pedagogic processes within both. As described earlier in the report AL prescribes a series of interactive routines between the teacher and the students. These occur at the localised or 'micro' level of interaction. For example the teacher uses particular strategies for questioning and seeks particular responses from the students which indicate understanding. Thus, the scaffolds are close and are purposefully close to ensure little or no failure. The genre-based approach has no such prescriptions and operates more at the 'macro' organisational level. The stages within the cycle can be

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visited and revisited with the students. Particular activities may be understood to be useful within each of the global stages, but there is no requirement to engage in specific interactive processes.

Another difference is in the place of knowledge about language, foregrounded in the genre approach, but less conspicuous in AL. Given the noted criticism of the genre-based approach for its overemphasis on grammar, an enduring issue for discussion revolves around the need for teachers to understand how texts work, and how they then teach these understandings to students. Does this require an explicit focus on the language features or can it be accomplished less directly? To use an example from the project, the explanation text chosen by one of the teachers was liberally sprinkled with nominalisations which the teacher did not highlight or use as part of her teaching. By contrast an ESL practitioner would have probably put a focus on this grammatical feature as a key process within the pedagogy. This is an interesting difference in the pedagogic approaches and resurfaces the issue of the importance of grammar and the value of making it part of the pedagogy in AL. This is especially significant as AL is picked up in learning areas in which different types of text are prevalent. It may be useful to consider that AL teachers need to know more about the structure and function of language as a background to teaching Science through AL and in so doing take a step closer to a genre-based approach.

A relevant contribution to the discussion of the pedagogies has been the work by Adoniou and Macken-Horarik (2007) in which they reported on a project where ESL teachers in the ACT were introduced to AL pedagogy. Their particular focus was to document the ESL teacher responses to the pedagogic processes inherent in AL. The authors proceeded by describing the essential sequential steps in the AL pedagogy and providing an evaluation of each as part of an evaluation of the whole by the teachers. They suggest that AL is constructed on the following principles.

- A high challenge curriculum with the use of age appropriate texts which are full of 'literate language'. Essentially the effort in AL is not to 'bring the text closer to the learner' but to bridge the gap by 'bringing the learner closer to the text' by means of carefully designed pedagogic support. The text selected for work in classrooms is very important because this is the resource that students use as the basis for all oral and written work. As the developers of the pedagogy argued:

  *It is essential that texts selected for reading contain more language features than the learner can currently read without support, but not so many new features as to cause overload* (Gray, Cowey & Rose, 1996, p. 4).

- A high support pedagogy. AL uses a predictable teaching sequence that sets all students up for success in their reading and writing by making the 'ground
rules’ for participation in classroom interactions very explicit. Teachers ensure that learners can answer any questions they are asked, especially in early stages of the sequence. Once the teacher has talked about the text with students, they read the text to them. The ACT ESL teachers reported that this teaching strategy presented a heavy load of oral language for their ESL learners. ESL students without well developed oral English needed greater ‘message abundancy’ (Gibbons, 2003). This could take the form of additional visual support in the form of concept maps, diagrams, event sequences and even pictures. However, it was not just the linguistic gaps that the ESL teachers found needed more support with, but also the cultural gaps, because the gap between the cultural knowledge of the ESL learner and the selected text is likely to be larger than it is for most native English speakers.

- Principles of integration and spiral learning. In AL the same text is revisited many times and at different levels, so learners ‘return with a difference’ throughout the teaching sequence. The selected text is the primary source for the language studied throughout the reading, spelling and writing stages of the sequence. The ESL teachers concluded that the strategies were powerful because they enabled ESL to understand more about the function and effect of the author’s language choices.

- A functional model of language. Within the sequence teachers move from ‘macro’ levels of attention, looking at the overall structure and purpose, down through ‘meso’ level work on paragraphs, cohesion and coherence and then to ‘micro’ levels of attention to sentences, clauses, phrases, words, morphemes and phonemes – always within the context of the selected text. The ESL teacher evaluations indicated that the specific AL processes, for example Transformations, were powerful in enabling ESL students to segment and reorder language forms. They suggested that Transformations helped the students to see what the elements meant, how they could be put together and broken apart and the consequences of moving them around.

- A socio-cultural theory of learning. Those learners whose home culture and linguistic backgrounds differ from those in mainstream classrooms need to be explicitly taught the valued discourse and behaviours of the classroom if there is to be equity of access to educational opportunities. As Cowey (2005) argues, such students need to be taught the ‘ground rules’ of participation in dominant discourses, and AL is deliberately structured ‘to apprentice students into the particular learning tasks and texts rewarded by schooling’ (Culican, 2006).

Adoniou and Macken-Horarik and concluded that the ESL teachers who participated in the AL project were overwhelmingly positive about the experience,
especially its ability to both support and enthuse students in their writing. The teachers involved in the project were unanimous in their support for AL pedagogy in their ESL classrooms and all felt they would continue to use the sequence once the project was over.

Enshrined in both AL and ESL thinking is the belief that language is core to learning and that educators cannot assume that learners naturally have the language resources at their disposal to make or create the meanings in texts they encounter in school. This underpins the rationale for explicit and prescriptive pedagogies which assume nothing in relation to the written word. The ‘what to’ and the ‘how to’ of classroom practices invariably involves close and consistent work with written text. And whilst there are clear differences in AL and ESL approaches there are also obvious similarities; they assume nothing, they are explicit in the way they teach about the function of language as a meaning making resource, and they are prescriptive, that is, they direct teachers to adopt specific pedagogic practices. By building on the commonalities across these pedagogies there is an opportunity to develop the connections both at a theoretical and at a classroom level.

**Conclusion**

In South Australia the AL program now operates in schools designated as Category 1-3 on the DECS Index of Educational Disadvantage. These schools are in the lowest socio-economic suburbs, where the disadvantage is marked on a range of criteria including family income and housing affordability. The community profile for Category 1-3 schools is the lowest paid workers, the unemployed, Aboriginal families and also migrant and refugee groups. The profile for the school enrolment is low socio-economic English speaking, Aboriginal and migrant or refugee students. Teachers working with AL in their classrooms most often have some combination of these learners as the student body. These are, of course, the cohorts of learners who are traditionally not successful at school and who, as a corollary, may also become disengaged or reluctant participants. They are the ‘at risk’ learners identified throughout this report.

The matter for whom AL pedagogy is appropriate has been addressed to some degree in this report, because the question has been naturally raised by educators with interest and responsibility for other groups of learners, also ‘at risk’ in relation to academic discourses in school. It is useful to reiterate the point that the development of AL was not with a specific cohort of students in mind as a target audience. Rather it was developed through research with children who were failing to learn to read and consequently failing to learn in school. The fact that it was initially adopted in jurisdictions with high numbers of Aboriginal school enrolments
may have more to do with the background and political orientation of its developers than with the specific content of the program itself. However, the fact that it has been clearly linked with Aboriginal learners is natural, for Gray’s original work was with Aboriginal students. Accordingly, a consistent theme throughout the development of the pedagogy and its implementation across various jurisdictions has been the hope it offers in the education of Aboriginal learners. In this context it is noteworthy that AL is a strongly supported literacy pedagogy within the What Works Program, funded by the DEEWR as its flagship strategic initiative for Indigenous education 2005-2008. This cohort of students has consistently been assessed as the least successful in literacy achievement in Australia ever since regular and consistent assessment data has been collected. Noting successes in remote NT and SA, Victoria, and also regional NSW, other educators with a social justice and equity orientation have been interested in its application to their specific contexts and specific cohorts of ‘at risk’ learners. The extension of the AL pedagogy to other ‘at risk’ groups is a function of its documented successes with the most disadvantaged.

This research project sought information regarding the challenges faced by teachers as they attempted to use AL principles and processes in the learning area of Science. This has necessarily led to discussion regarding the profile of enrolments in the classrooms participating in the research and to the usefulness of AL with ‘at risk’ cohorts. The findings from this project support the findings from previously cited projects, that the pedagogy does have merit with different groups of learners. The cultural and linguistic profile of the learners may vary, but they are similar in the fact that they are culturally and linguistically ‘other’ in relation to the academic discourses through which school knowledge is construed.

In the introduction to Freebody’s (2007) literacy research review for ACER, McGaw draws on data from the OECD’s Programme for International Student Assessment (PISA) which has surveyed the performance of fifteen year olds in school in a large number of countries on a three year cycle since 2000. Reading literacy is defined in PISA as the ability to understand, use and reflect on written texts. It goes beyond the notion that reading literacy means decoding written material and literal comprehension. McGaw suggests that the focus of PISA is on ‘reading to learn’ not ‘learning to read’.

Given that the PISA targets fifteen year olds, it is not surprising that the emphasis is on reading texts to learn. However, there are numbers of students even at fifteen who have not mastered decoding and who have not learnt to read. It is clear that students cannot read to learn without initially learning to read. AL with its focus on the most disadvantaged and the least successful learners has aimed to incorporate both these facets of reading and learning in its pedagogy.
McGaw goes on to foreshadow a key element of Freebody's review in which he examines literacy and equity. Again he draws on PISA results to make the point that there is a positive 'social gradient' linking more advantaged social background with higher reading literacy levels across all participating countries, and then making the point that there are great differences in the angle or slope of the gradient. Australia is among the group of countries in which the gradient is steepest, that is with the least equitable results, because the steeper the gradient the more that added social advantage is associated with higher reading literacy achievement. Freebody later argues that the intervention in the angle of the social gradient, that is the lessening or flattening of the slope, is the proper focus of classroom practice. It is certainly the focus of those working with the most disadvantaged students in the community with the aim of improving their school outcomes and life chances. This is certainly the philosophical underpinnings of AL and of the research project into AL and Science. The evidence from this research is that teachers can use AL principles and processes in learning areas such as Science, and in so doing actively and positively working to decrease the angle of the social gradient as they work to provide access to the academic discourses of school knowledge to their learners.
References


Appendix 1

*Teacher interview questions at the beginning of the research project*

1. What is your topic?
2. Why did you choose it?
3. What resources will you need?
4. Are these easily available to you?
5. Have you tried to prepare the unit sequentially over a number of lessons?
6. How often are you planning to work on this unit of work?
7. Can you describe how you have programmed for the AL practices within your unit?
8. What principles of AL are influencing a change of practice?
9. How will you incorporate the prescribed AL processes into science?
10. Will this be straightforward?
11. What issues/problems/constraints do you see in teaching your unit of work?
12. Do you foresee problems with extending these processes into the science topic?
13. In my head I can imagine the overall unit the overall unit in both macro and micro terms. Is this the way you think about the unit and how you will proceed?
14. If yes, then can you talk about both?
15. In what ways will this unit of work differ from previous ways you have worked in science?
Appendix 2

*Teacher interview questions at the end of the research project*

1. In overall terms what was your experience of this unit of work and your participation in the project?

2. In overall terms did you consider the unit to be a success?

3. What were the highlights of the unit for you?

4. Did you feel that you developed as a teacher in any way? (Please elaborate)

5. Did you note differences in the way your students responded in this unit?

6. Did the unit proceed as you planned?

7. Did you need to change your plans?

8. What did you need to change and why?

9. What were the problems or issues which arose for you through the unit?

10. Did you foresee these at the outset?

11. In another situation would you proceed in the same way or do something different?

12. In relation to AL do you consider you implemented the pedagogy in this unit?

13. What were the issues in relation to extending AL into your science unit?

14. Do you feel that AL is ‘doable’ in the learning area of science?

15. Was the unit of work appropriate for your students?

16. How did this unit compare with other science topics you have previously taught?

17. Would you consider refining this unit for another time or starting afresh with a different unit?
Appendix 3

A small sample of a transcription of one lesson

This transcript comes from the beginning of one lesson in the Year 2/3 class, in which the teacher is aiming to establish the place of science and the role of scientists in society.

Student: ... science
Teacher: Yeah, that's right, the particular topic that we've been investigating, and you're right, it comes from the subject of Science
Student: Student
Teacher: And we've been thinking really hard about one particular part of science, haven't we?
Students: Yeah!
Student: Everything
Teacher: Yes! Because we've been talking about the physical things in science, and there's some important things that we've been talking about, even more specifically about physics, that we can talk about in science. Who can remember? I like to see so many helpers
Student: Energy
Teacher: Energy, thinking really hard about that, haven't we, because there's some good reasons why we're thinking about that, because in the area of science we can start to think like ...
Students: Scientists
Teacher: ... particular people
Students: Scientists
Teacher: Scientists, because they've got an important job of ...
Student: Think and do
Teacher: Yes, they have to do lots of thinking, and lots of doing ...
Student: And how and why
Teacher: And (student name), thinking about how we can show others ...
Student: How and why
Teacher: Yeah, how and why things work, and even though we know that there are adults who are scientists who do that, we can start to think about those things too, so that we can do something to be able to ...
Students: Explain.
Teacher: ... explain how things work, why they work ...
Student: (inaudible)
Teacher: So we have to do lots of thinking and doing, and that's what we're going to do today, some thinking and doing about that topic of energy,
because there's a really important reason why we need to think about those sorts of things

Student: To help our world

Teacher: Yes! If we don't do that, there are certainly going to be some things that change. We were talking about dinosaurs this morning, as part of Book Week we had our book about dinosaurs, and we know that dinosaurs don't exist anymore …

Teacher: (student name), are you helping us?

Student: Yes

Teacher: And so things might disappear and be destroyed on earth right now if we don't start to do these …

Student: Help our world

Teacher: … yes, do these sort of things. So we're going to be expert scientists today. We're going to … let's read about the things that we're going to do together

Student: Wonder about the world

Teacher: Good

Student: (inaudible)

Teacher: Helping. Let's see if I can just get my pointer. Let's read it together.

What are we going to do?

Students: Wonder about the world

Teacher: OK, what else?

Students: Describe the world; explain how things work; explain why things work; why prove

Teacher: So we're going to try and do some of those things today. We're going to do some wondering. We're going to look at a particular part of our text today and wonder about it, which will help us describe what's going on in the world, and we're going to try and explain how that works, and we're going to try and work out why it's doing that.

(student name), can I ask you to move really quickly so that you can help us as well

OK, let's have a look at our text. These are the things that we've already got really good at knowing about, because we've discovered and looked at, and learnt about how there are things on the earth that are really just two things, aren't they? What can they be described as?

Student: Matter or energy

Teacher: Yes, matter of energy, so the matter is …

Student: A physical thing [sic]

Teacher: Yes, something that takes up some space. We saw in the book this morning that it could be called a 'substance' or 'material', so it could be matter or?

Students: Energy

Teacher: Energy, yeah, so energy is slightly different, isn't it?
Student: (inaudible)
Teacher: Yes, so something that is able to ...
Student: Help you
Teacher: Help you, put it to use, do some work
Student: Heat and light
Teacher: That’s two forms of energy, isn’t it?
Student: (inaudible) and ‘lectrical
Teacher: OK, let’s wait just a minute before we start talking about the different forms of energy. Have it in your head what it’s actually doing, so that ability to do some work, the ability to do something, so what is it?
Student: The ability to do something
Teacher: Good! What is it (student name)?
Student: The ability to do something
Teacher: Excellent helping, (student name), what is it?
Student: The ability to do something
Teacher: The ability – let’s say it together then –
Students: The ability to do work (something)
Teacher: Yeah, to do work or to do something, so (student name) can you come and help us think about different forms of energy? There’s two in particular that we’ve talked lots about, what are they? Nice to see so many people helping. What are they? (student name)?
Student: Matter is ... can’t change and energy can
Teacher: Oh, you’re getting ahead of us. You’re right, energy can change, but what different kinds of energy have we talked about, different forms, different kinds? (student name)?
Student: Heat and light
Teacher: They are the two main forms we’ve talked about, isn’t it? And we have mentioned a couple of other kinds
Student: Movement, electrical and chemical
Teacher: Well done, OK. Now what (student name) was telling us is very important that we know about energy. What was it again?
Student: It was all about energy
Student: I know!!!
Teacher: (student name)?
Student: Cannot be (inaudible) change
Teacher: That’s right, so the thing it can do is ...
Students: Change
Teacher: OK, and we also know that most of the energy on the earth comes from a particular place
Student: The sun
Student: The sun
Teacher: The sun, yes, and the two forms of energy, the two kinds of energy that comes from the sun? (student name) can you help us? What are they? (student name), what are they?

Student: Oh my back is hurting (inaudible)

Teacher: Can you help us?

Student: The heat and light energy

Teacher: That's right. Andrew, what was it again?

Student: I couldn't hear him

Teacher: OK, big voice

Student: The heat and light energy

Teacher: Heat and light energy

Student: OK! Everyone tell me

Students: The heat and light energy

Teacher: OK, and we have made ourselves into the sun and made heat waves with those streamers, so that the heat and light, we pretended the heat and light could come to us on earth through a particular process, a particular way

Student: Radiation

Teacher: Radiation, that's right, and we saw also another form of radiation, didn't we, when we used ...

Student: The toaster

Teacher: The toaster. WE could feel the heat ...

Student: The light

Teacher: ... and we could see the light, and that energy was used to do some work

Student: Radiation

Student: Teacher, what ...

Teacher: What work did it do?

Student: Pooh pooh

Teacher: What work did it do in the toaster?

Student: Heat the toast up

Teacher: It did, it cooked it, didn't it, heated it up so much it cooked it. The bars on the toaster didn't touch the toast but the bread still turned brown, didn't it and got warm?
Appendix 4

The core texts used by the participating teachers

Transpiration

Used with a Yr 6/7 class
Adapted from
www.nwsp.edu/geo/faculty/riotter/geog101/textbook/biogeography/transpiration

Transpiration is the loss of water from plant leaves. Water exits the leaf through stomata, which are tiny pore spaces in the leaf. In turn, as the water evaporates, more water is pulled through the plant from the roots. The rate of transpiration depends on air temperature, humidity (air moisture), solar radiation, and wind or air movement.

Transpiration is a necessary process, and uses about 90 percent of water that enters the plant’s roots. It aids cooling for plants when temperatures or light rise too high and causes heating of the plant. Low humidity, often aided by windy conditions, creates a vapour gradient between the plant and the air. In other words, the air further from the plant is drier than the plant and this difference induces transpiration.

Soil factors also effect transpiration. Soil is made up of soil particles surrounded by air. These air spaces are called pore spaces. If the pore space between soil particles is too large (when moisture levels in the soil are low), the soil will have low soil capillary. That is, its ability to suck water up towards the plant roots is too slow for plants to extract water from the soil and maintain proper moisture supply.

During the moist season, ample soil water is available to aid the movement of soil water upwards to the root zone. However, during the dry season, a dry layer of soil develops beneath the root zone inhibiting the upwards movement of capillary water, and causing a capillary lag. The plant ultimately wilts as it cannot extract enough water to meet the increasing demand for water during hot weather. This is known as turgidity.

High levels of transpiration are a serious problem in countries such as Australia, particularly in drought. There are two important ways to reduce transpiration by improving the soil. Firstly, sandy soils drain very quickly, and move any water too deep for plant access. The addition of organic material, dug into the soil, will reduce
this problem. Secondly, the application of mulch can reduce soil temperature, and evaporation of soil moisture by 50%. As shown above, raised levels of soil moisture improve the capillary action and reduce the chance of turgidity.

Mulch can take many forms: from minerals such as gravel or pebbles, to organic materials such as bark chips or shredded leaves. Even old newspapers can be used as mulch, although these need to be covered by other materials to avoid them blowing away.
Thermal Insulation

Used with a Yr 6/7 class
Adapted from article of same name by Ron Curtis,
http://www.school-for-champions.com/science/thermalinsulation.htm

Thermal or heat insulation is the method of preventing heat from escaping a container or from entering the container. In other words, thermal insulation can keep an enclosed area such as a building warm, or it can keep the inside of a container cold. Heat is transferred from one material to another by conduction, convection and/or radiation, always moving from the warmer material to the cooler material. Insulators are used to minimise that transfer of heat energy.

Where thermal insulation is used
Thermal insulation is used to prevent an object or area at a certain temperature from becoming the same temperature as adjacent materials. This is usually done by employing a thermal insulation barrier.

In any location with materials of two drastically different temperatures, an insulating barrier minimises the transfer of heat from one area to another to avoid them becoming the same temperature.

How insulation works
Insulation is a barrier that minimizes the transfer of heat energy from one material to another by reducing the conduction, convection and/or radiation effects.

Insulation from conduction
Most insulation is used to prevent the conduction of heat. Heat conduction occurs when materials, especially solids, are in direct contact with each other. High energy atoms and molecules bump into their neighbours, increasing the neighbour’s energy. This increase in energy (heat) can flow through materials and from one material to another. Energy from the hotter material always flows to the cooler material.

To slow down the transfer of heat by conduction between solids, materials that are poor conductors are placed in between. The fibreglass insulation inside the walls of a house is a good example of this.
Insulation is also used to slow down heat transfer between a solid and air or water. Clothes are used for this purpose. When cold air or water is in contact with skin, heat flows from the warm skin, causing a loss of body heat. Clothing such as a windcheater (in air) and a wetsuit (in water) acts as an insulator and slows down the heat loss.

**Insulation from convection**

Convection only occurs in liquids (such as water) and gases (such as air), also known as fluids. Fluids often transfer heat through their motion, known as a convection current. Sometimes this is useful. For example, a fan-driven heater can heat a larger space because of convection.

Sometimes heat transfer by convection is not desirable. For example, poorly fitting windows allow cold air to enter a house, causing a transfer of heat from the warmed air inside the house. Insulation from heat transfer by convection is usually done by either preventing the motion of the fluid or protecting from the convection. In other words, turn off the fan, or, in the case of the windows, fix the cracks!

**Insulation from radiation**

Hot and even warm objects radiate infra-red electromagnetic waves, which cause heat to move from themselves to other objects. This is known as radiation. Insulation against heat transfer by radiation is usually done by using reflective materials. For example, houses can be protected from sun in winter with the use of shiny corrugated zinc-alum roofs, and from heat transfer in the other direction in winter with the use of reflective sheets between the rafters and the roof. The roof on this house is built to reflect the sun's rays and keep the house cool.
Solar energy

Used with the Year 2/3 class

Energy is everywhere and in everything. Without energy, the earth would not work. The most concentrated store of energy near to us is the Sun. Sun, or solar energy travels to Earth as sunlight. The energy in sunlight flows to the air, into the wind, into the waves, into clouds, and into plants. As it hits objects, the sunlight turns into heat.

One example of solar energy is the water cycle: when the sun's energy hits water, it turns to heat. Heat turns the water into steam or water vapour, which rises upwards, forming small droplets in clouds. When the clouds meet cool air over land, precipitation (rain) is triggered, and the water returns to the land or sea.

Another example of solar energy is wind. Wind is air in motion. Wind formation is caused when sunlight turns into heat and warms the Earth and the air above it. As the sun warms the air in the Earth's atmosphere, it causes the air to rise, because warm air is lighter than cool air. When the warm air rises, the cooler air rushes in to replace it, producing wind. Because wind is always being renewed by the sun, it can be used by humans to make electricity for their lives.
Understanding Simple Machines: Levers

Used with the Year 4/5 class

Adapted from the franklin institute science museum pieces of science
http://www.fi.edu/pieces/knox/automaton/lever.htm accessed 02/08/07

A lever is a rigid bar or arm that rests on a fulcrum (a fixed point) to move a load. To move the load, force, also called effort (push or pull), must be exerted on the lever. The amount of force, as well as the direction of the force, can change. In most cases, the further the effort is from the fulcrum, the easier it is to work the lever. This is known as the mechanical advantage. There are three classes (kinds) of levers.

A class-1 lever has its fulcrum located somewhere between the effort and the load. The direction of force is changed with this type of lever. Applying effort or force downward moves the load up, and applying effort upward moves the load down. The further away the effort is from the fulcrum and the load the greater the mechanical advantage of the lever. Examples of common class-1 levers are the playground seesaw, a crowbar, scissors, and pliers.

A claw hammer is a class-1 lever when it is being used for nail removal. The handle and the claw of the hammer work as the lever arm. The fulcrum is the top of the hammer head and rests against the wood. The nail being pulled out of the wood is the load. Although the handle is pushed for a greater distance than the claw moves, less effort is needed to pull the nail from the wood.

A class-2 lever has the fulcrum at one end of the arm, with the effort at the other end and the load in the middle. With this kind of lever, the direction of effort is not changed. Pushing up on the lever arm pushes up on the load. Once again, the further away the effort is from the fulcrum and the load the greater the mechanical advantage of the lever.

A wheelbarrow is a class-2 lever. Effort is applied to the handles of the wheelbarrow and the wheel is the fulcrum. The load sits on the wheelbarrow frame close to the fulcrum. Other common examples of class-2 levers are a screwdriver, a catapult, a nutcracker, and a stapler.
The third arrangement of the lever is a **class-3 lever**. The fulcrum is at one end and the effort is applied between the fulcrum and the load. Like the class-2 lever, the direction of effort is not changed. The load moves in the same direction as the effort.

![CLASS 3 LEVER](image)

Class-3 levers do not have good mechanical advantage. In fact they have *mechanical disadvantage*. The effort is closer to the fulcrum than the load. The effort is always greater than the load. However, the advantage of such levers is that the distance moved by the load is greater than the distance moved by the effort.

For this reason, class-3 levers are commonly used in sporting activities: baseball bats, hockey sticks, tennis rackets and golf clubs all gain speed because the hitting end moves faster and further than your arm. In each case, the ball is the load. A fishing rod is also a class-3 lever. The hand at the end of the pole is the fulcrum and the fish attached to the line is the load. The hand placed on the rod between the fulcrum and the fish applies the effort.

**EXAMPLES OF COMMON LEVERS**

![Examples of Common Levers](image)
Eyes and vision: How we see

Used with the Bridging class of Aboriginal students.

Eyes are sensory organs that provide the brain with information to create images. The eye is a hollow ball surrounded by a tough, outer layer called the sclera – the white of the eye. Even though the eyeball is hollow, it is not empty. It is filled with a clear, thick fluid called the vitreous humour. Lining the inside of the eyeball is the retina, the ‘movie screen’ of the eye, where the images are read.

Seeing begins when light enters the eyeball through a transparent front window, called the cornea, which helps to focus the image. Behind the cornea is the iris, the coloured portion of the eye. The iris is a ring of muscle with a hole through its middle (the pupil). In dim light, the iris relaxes and the pupil opens wider to admit more light. This is called dilation. In bright light, the iris tightens, the pupil gets smaller and less light enters the eye. This is called contraction.
Appendix 5

A sample of the written texts produced by students who studied Transpiration as evidence of their learning

Year 7 girl
Transpiration

Transpiration occurs when the plant releases water. The water leaves through the stomata, which are microscopic (teeny) pore spaces on the bottom of the foliage (leaf). The water then evaporates into a vapour (gas). The plant then gets more water through their root hairs and the cycle is repeated. The speed of transpiration relies on humidity (air moisture), solar radiation (energy from the sun), air temperature (measured in degrees) and air movement (wind).

Humidity is the amount of moisture in the air which affects transpiration. High humidity decreases transpiration because there is an even vapour gradient between the air surrounding the leaf and the leaf itself. Low humidity increases the speed of transpiration because there is an uneven vapour gradient and the plant transpires quicker to make the gradient balanced.

Solar radiation is energy from the sun and this affects transpiration. In the daytime the plant gets energy from the sun and can easily transpire. During the night the plant transpires much more slowly because it has to get its energy from the root system, instead of from the sun.

Year 6 girl
Transpiration

Transpiration occurs when the plant releases water from plant leaves. The water leaves through the stomata, which are microscopic pore spaces, underneath the leaf. Then the water evaporates into a vapour. The plant then absorbs more water through the root hairs then continues to release water. The speed of transpiration depends on humidity (air moisture), solar radiation (energy from the sun), air movement (wind) and air temperature (measured in degrees).

Humidity is the quantity of moisture in the air which affects the speed of transpiration. High humidity is when there is lots of moisture in the air. Transpiration decreases because the vapour gradient is balanced between the leaf and the atmosphere. Low humidity is when there is not a lot of moisture between
the leaf and the surrounding air. Low humidity increases transpiration because the vapour gradient is uneven.

Solar radiation is energy, which comes from the sun which the plant uses to transpire. During the day the plant gets energy from the sun and transpires easily. At night the plant transpires, but not as fast because the plant has to get its energy from the plants roots, as there is no sun.

Air movement is how the air moves and it affects the speed of transpiration. When it is windy the plant has to transpire faster because the wind blows the water off the leaf. When the air is still, transpiration is not affected.

Air temperature is how hot or cold the air is. When the air is hot around the plant transpiration increases because the water on the leaf evaporates into a vapour quickly. When it is cold transpiration decreases because it takes longer for the water to evaporate.

**Year 6 girl**

**Transpiration**

Transpiration occurs when the plant releases water from plant leaves. The water leaves through the stomata, which are microscopic pore spaces, underneath the leaf. Then the water evaporates into a vapour. The plant then absorbs more water through the root hairs then continues to release water. The speed of transpiration depends on humidity (air moisture), solar radiation (energy from the sun), air movement (wind) and air temperature (measured in degrees).

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**Year 6 Girl**

**Transpiration**

Transpiration occurs when the plant releases water. The water leaves through the stomata, which are microscopic (teeny) pore spaces on the bottom of the foliage (leaf). The water then evaporates into a vapour (gas). The plant then gets more water through their root hairs and the cycle is repeated. The speed of transpiration relies on humidity (air moisture), solar radiation (energy from the sun), air temperature (measured in degrees) and air movement (wind).

Humidity is the amount of moisture in the air which affects the rate of transpiration. High humidity decreases transpiration because there is an even vapour gradient between the air surrounding the leaf and the leaf itself. Low humidity increases the speed of transpiration because there is an uneven vapour gradient and the plant transpires quicker to make the gradient balanced.

Solar radiation is energy from the sun and it affects the speed transpiration. In the daytime the plant gets its energy from the sun and can easily transpire. During the night the plant transpires much more slowly because it has to get its energy from the root system, instead of from the sun.

Air temperature is how hot or cold the air is and is measured in degrees, which affects the process of transpiration. When the air is hot, the plant is forced to transpire faster because the air around it makes the water evaporate more quickly. However, when it is cold transpiration reduces speed because it takes more time for the water to evaporate.

Air movement is how the air moves, which affects the course of transpiration. When the air surrounding the plant is windy, transpiration is rapid because the wind drives the water off of the leaf and makes the plant transpire. When the air is motionless, transpiration goes at an average pace.

**Year 7 Girl**

**Transpiration**

Transpiration is the removal of water from plant leaves. Water exits the leaf from stomata, which are microscopic pore spaces on the underside of the leaf. When the water has evaporated (turned into a gas or vapour), more water is absorbed through
the root system. The speed of transpiration relies on humidity (air moisture), solar radiation (energy from the sun), air temperature (the temperature of the air) and air movement (wind).

Humidity is the amount of moisture in the air which affects the speed of transpiration. When there is a low amount of moisture in the air (low humidity), transpiration speeds up because the plant needs to create an even gradient of moisture between the plant and the surrounding air. When there is a lot of moisture in the air (high humidity), transpiration slows down because there is already an even gradient of moisture, between the plant leaf and the surrounding air.

Solar radiation is energy from the sun which plants need to transpire. When the sun is present (during the day), plants transpire more because there is energy from the sun. When the sun is not present (at night), plants transpire less because they need to get their energy from their root system.

Air temperature is how hot or cold the air is. When it is hot plants transpire more because the water on the leaf evaporates quicker. When it is cold transpiration occurs less because the water on the leaf does not evaporate as quick.

Air movement is how windy or calm the air is. When it is windy, plants transpire more because the wind blows the droplets of water off the underside of the leaf. When it is a calm day transpiration occurs less because the wind does not blow off the droplets of water.