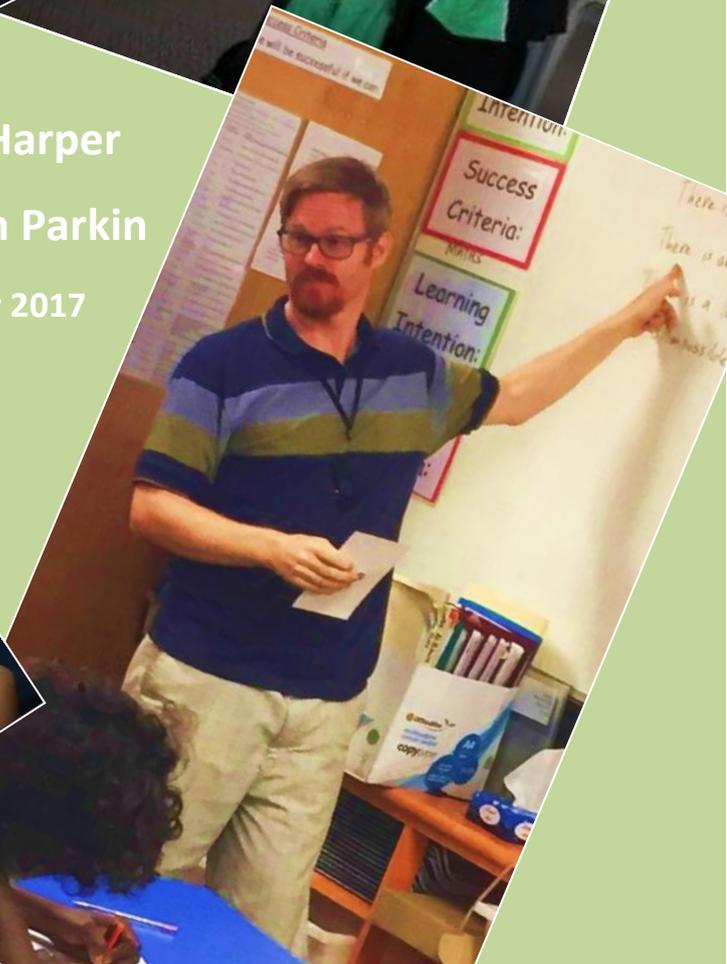


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Scaffolding academic language with educationally marginalised students



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Scaffolding academic language with educationally marginalised students

Executive summary

Aims and rationale

This report describes our project to develop a theoretically-informed account of the effective teaching of academic language and literacy in disadvantaged contexts. Through the project we aimed to articulate a robust and reliable set of principles for scaffolding academic English to educationally marginalised students. We also aimed to address fundamental questions about the relationship between classroom interactions and students' appropriation of academic language and literacy.

To accomplish these aims we worked collaboratively with four teachers of educationally marginalised students in content-specific (science and mathematics) lessons. Our goals in working with the participating teachers were to:

- establish shared understandings of the principles of contingent scaffolding
- document, test and refine the principles to make sure they can be used effectively across learning areas and across contexts, as well as being accessible to teachers
- investigate student outcomes in participating classes
- monitor changes in the teachers' perceptions of their pedagogy.

This classroom work was underpinned by our interest in the role of theoretically-informed practice. Notably, we drew on three complementary theories: Vygotsky's sociocultural activity theory, Halliday's systemic functional linguistics, and Bernstein's theory of pedagogic discourse. We aimed to show how the theories, working together, can help negotiate the complex relationships between language, learning, curriculum knowledge and the socially situated creation of meaning.

The project was motivated by our view that it is essential to develop a pedagogic approach that can support teachers of educationally marginalised students - and the students themselves - to engage with the literacy demands of 21st century participatory citizenship. This is a clear social justice issue, as, with explicit access to discipline-specific language, educationally marginalised students are more likely to achieve at secondary level and therefore have a greater range of life choices in their post-schooling years.

Additionally, we saw a need to document effective literacy teaching in disadvantaged contexts, which are presently under-researched.

Methods

We collaborated with four highly skilled teachers of middle and upper primary students in two schools: Maningrida College, a remote Indigenous Northern Territory school; and Cowandilla Primary School, an urban Adelaide school with a low socioeconomic multicultural demographic. Data were collected at each site in November 2016 and February 2017, during which time 18 mathematics and 15 science lessons (33 in total) were video-recorded. The lessons were recorded using Swivl™ (a robot that pairs with an iPad™), and full transcriptions were made of several teaching sequences.

Teachers taught one topic per data period. The topics were 'Probability' and 'Telling the time' (mathematics), 'Electric Circuits' and 'Lunar Eclipses' (science) .

At each site we held a preparatory workshop with the teachers to develop common understandings about scaffolding principles and how we intended to analyse scaffolding in classroom talk. For each topic we worked with the teachers to develop focus texts to guide the language and teaching sequence.

We planned and subsequently analysed scaffolding processes at two levels, which we referred to as:

- (i) macro-scaffolds (topic sequences). The focus texts were key tools in defining these.
- (ii) micro-scaffolds (moment-by-moment contingent language choices in the course of classroom dialogue). We developed an observation tool to guide teacher reflections and to analyse the lessons at this level.

Key Findings

1. Focus texts are effective in the teaching of discipline-specific language and literacy

The project provided an opportunity to study the systematic and efficient use of focus texts to (i) provide a scope and sequence for each topic, and (ii) to help structure oral and written assessment. In science, we found that it was straightforward to align the texts with the language expectations of the Literacy Capability and to match the genres of assessable oral and written tasks. By contrast, in mathematics, focus texts had a different and more innovative role. The mathematics focus texts worked as definitions, as consistent sentence beginnings and as generalised mnemonic statements that students could draw on in times of cognitive challenge.

The focus texts assisted the teachers to structure the movement from speaking to writing. A noteworthy strategy in this process was the use of class notes. Intentionally structuring class notes helped teachers simultaneously to support the oral negotiation of meaning and to prepare the structure for students to produce written texts (as a class and independently).

2. Shared experience is the foundation for learning in cross-cultural contexts.

In cross-cultural contexts we noted occasions when contrasting world views caused interactive trouble and confusion for students because the subjectivities of teacher and students were not shared. By contrast, effective classroom dialogue was best facilitated when teachers created intersubjectivity by drawing on shared experiences with their students.

3. The 'Three lenses' observation tool is valuable for analysis and reflection

Our observation tool is organised into three lenses, representing different perspectives on the complex nature of whole-class dialogue. These are: Shared Purpose (contextualising learning intentions in their cultural and historic setting); Whole Class Interactions as Scaffolding (maintaining positive affect and adjusting teacher talk to provide contingent scaffolding); and Sense Making (using language and other semiotic resources to build shared meaning).

Analysing our lesson transcripts through these lenses gave us a detailed understanding of the micro-processes through which whole-class dialogue is scaffolded effectively.

4. Student assessment demonstrated language growth

Student assessment consisted of a pre- and post-text in the form of a story retell and in the science topics, an independent writing task. Language features included technical language, complex sentences, extensions with circumstances, expanded noun groups. New language was evident in student talk and writing in all cases.

Feedback on the process and benefits of collaborative research

The collaborating teachers indicated that the project was invaluable for them as experienced teachers who otherwise have few opportunities for in-class mentoring. They stated that the process gave them an outsider's view on their teaching, with supportive and non-judgemental feedback; and that it made them engage with the inter-relationship between theory and practice, bringing new consciousness to practice, and practice to consciousness. In particular, the teachers indicated that they valued the use of focus texts as planning and teaching tools in both science and mathematics.

Further directions for research

Some future directions for research include:

- (i) The use of focus texts in mathematics. Further research into other aspects of mathematics, such as number, would help to clarify the role of focus texts in mathematics.
- (ii) Assessment tools. Further work is needed in how to assess longer term student concept development alongside language development.

- (iii) Student appropriation of new language, including the impact of teaching relevant grammar on student uptake of academic language.
- (iv) Working with teachers. We need to know how we can refine our support for teachers, so our pedagogic principles are accessible to teachers.

Further directions for implementation

Using our observation tool as a frame, there is a potential for developing a series of modules or workshops for teachers, either face to face or online. Modules might include:

- (i) Focus texts: their purpose, how to write them, and how to analyse them as preparation for teaching;
- (ii) Teacher talk: how to consciously modify talk to help students appropriate subject-specific language;
- (iii) Using focus texts effectively to guide the movement from speaking to writing in a lesson sequence; and
- (iv) Using visual texts together with language to support sense-making.

An abridged version of the observation tool has already been developed for a project involving the South Australian Department for Education and Child Development (DECD) and the University of South Australia (UniSA) to develop a two-day Professional Development workshop in teaching the language of science. UniSA has contracted Bronwyn Parkin as lead writer for this pilot project.

In future PETAA might consider developing a similar modular online course, linked to the Teacher Professional Standards, drawing on resources such as the planned PETAA teacher publication, the abridged version of the Observation Tool and video clips from this project.

1. Introduction

1.1 Aims

This report describes our project to develop a theoretically-informed account of the effective teaching of academic language and literacy in disadvantaged contexts. Through the project we aimed to articulate a robust and reliable set of principles for scaffolding academic English to educationally marginalised students. We also aimed to address fundamental questions about the relationship between classroom interactions and students' appropriation of academic language and literacy.

To accomplish these aims we worked collaboratively with four teachers of educationally marginalised students in content-specific (science and mathematics) lessons. Our goals in working with the participating teachers were to:

- establish shared understandings of the principles of contingent scaffolding
- document, test and refine the principles to make sure they are robust, reliable and effective in their applicability across learning areas and across contexts, as well as being accessible to teachers
- investigate student outcomes in participating classes
- monitor changes in the teachers' perceptions of their pedagogy.

A further aim of the research was to demonstrate the importance of theoretically-informed practice. Notably, we drew on the three complementary theories: Vygotsky's sociocultural activity theory, Halliday's systemic functional linguistics, and Bernstein's theory of pedagogic discourse. We aimed to show how the theories, working together, can help negotiate the complex relationships between language, learning, curriculum knowledge and the socially situated creation of meaning.

1.2 Rationale for the project

1.2.1 Educationally marginalised students

In designing this project, we saw a need to develop and document a pedagogic approach that is suitable for educationally marginalised students, those who might otherwise have difficulty engaging in academic language across the curriculum.

We understand the term 'educationally marginalised' to refer to situations of acute and persistent disadvantage in education (as distinct from the overall distribution of education opportunity)' (Harttgen & Klasen, 2009, p 3). The notion of educational marginalisation goes beyond basic inequality in schooling to encompass the systemic factors that affect access to schooling and opportunities for learning (Lugaz et al., 2010). Factors that strongly affect

students' marginalisation are 'being a migrant, being disabled, living in rural areas, being a member of an indigenous group (or being the minority race), and being poor' (Harttgen & Klasen, 2009 p. 18). Thus, educationally marginalised students can be identified through their relationship with schooling, its systems and cultures, rather than through any personal characteristics (Smyth et al., 2000).

In the Australian context, educationally marginalised students are identified in the Education Act 2013 as categories of students for whom schools attract additional financial support (Commonwealth of Australia, 2013). The categories are Indigeneity, geographic isolation, low English proficiency, low-socioeconomic status and students with a disability.

1.2.2 Teaching science and mathematics as a social justice issue

A second motivation for our study was that we saw a need to develop a pedagogic framework that supports teachers and students to engage with the literacy demands of active citizenship in the 21st Century (ACARA 2009). Active citizenship involves being an informed participant of a democratic society. It means being highly literate both in a general sense, and also in the sense of being able to engage with the dynamic landscape of science and technology. Without access to the language and literacy demands of the academic disciplines, students cannot succeed at secondary school and their choices, as well as their ability to participate as citizens, become limited.

While there is a growing expectation that all Australians should be scientifically literate, research suggests that the literacy aspect of science is often neglected or truncated (Tytler & Prain, 2017). The specific academic language demands of scientific literacy present a particular struggle for educationally marginalised students who are already grappling with literacy in general (ACARA 2012). Further, when students' home worldview and languages have little congruence with those of school, teachers face significant challenges in establishing common ground and helping students make sense of academic content. In science they may be required to take on a new and even conflicting orientation towards how and why the natural world functions.

Nonetheless, the Literacy Capability of the Australian Curriculum (ACARA, 2013a) spells out in detail the language and literacy demands of learning science and mathematics. In science, for example, the Capability (p.2) makes it clear that teachers are responsible for teaching the language and literacy of science and need a *clear understanding of the literacy demands and opportunities of their learning*. It is important therefore that teachers have the tools and skills to make powerful language and knowledge explicit to those who would not otherwise be able to access this knowledge and language. We consider this knowledge and language to be an entitlement for all students, especially those who are most marginalised. Hence, there is a clear social justice motivation for examining how we can best address language and literacy across the curriculum, and particularly in the areas of science and mathematics for marginalised students particularly.

1.2.3 Under-researched teaching contexts

A further motivation for our study was the need to document teaching contexts that are presently under-researched. Specifically, there is little current Australian research about effective pedagogic approaches to academic language and literacy (particularly in Science, Technology, Engineering and Mathematics, or STEM) for highly marginalised students.

Together, a remote Indigenous context, and a metropolitan school with complex disadvantage indicators offered important contexts, firstly for thinking about appropriate pedagogic principles and practices for marginalised groups of students, and secondly for examining the interplay between educational motivations, social rules of engagement, and the creation of opportunities for students to be apprenticed into the discourses of science and mathematics.

2 Theoretical Framework

At the start of this project, we reflected on what counts as effective pedagogy for educationally marginalised students, and on the pedagogic approaches that will best help them to be successful in learning the language and literacy of science and mathematics at school. We noted that, despite a growing attention to the need for 'evidence-based' research in education, the notion of effective pedagogy is still highly contested in Australia, and teachers can encounter conflicting messages on how they should organise their practice, particularly in relation to working with marginalised students.

We were informed by three interconnecting theoretical perspectives which complement and inform each other (Hasan, 2005). These are Systemic Functional Linguistics, Vygotskian socio-cultural theories of learning, and Bernstein's educational sociology. Additionally, we drew on understandings from the field of cognitive psychology (Clark et al., 2012).

2.1 Meaning, language and knowledge building

When scientists think, talk and write about their work they use an array of meaning-making resources, including gesture and movement, concrete materials, three-dimensional models, diagrams and other visual representations (such as tables, graphs, maps, photos), video recordings and animations. Scientific concepts are often represented through different modes which are deployed interactively, as semiotic hybrids (Lemke, 1993). Similarly, mathematicians use language together with symbolic notation and visual forms of representation (O'Halloran, 2005). The various modes interact with one another and help us to conceptualise the world in ways that words alone cannot. For example, diagrams can more effectively show spatial relationships, or draw attention to physical comparisons between objects. One of our interests in this project was to understand how the teachers built meanings through the interaction of different semiotic modes (Halliday, 1993a) and we particularly focussed on how they used artefacts such as models and diagrams to establish and consolidate shared meaning in the classroom.

More specifically, however, within the broader aim of understanding meaning making in the classroom, we were interested in the privileged position that language occupies in realising knowledge, and the idea that gaining control of subject-specific language is fundamental to successful learning at school (Halliday & Matthiessen, 1999).

Systemic Functional Linguistics (SFL) provided the theoretical framework for our approach to age-appropriate, subject-specific language in science and mathematics. In the Australian curriculum, the English learning area and the literacy capability are underpinned by SFL in an explicit and coherent way (ACARA, 2013b; Derewianka & Jones, 2016). Discipline-specific language is represented through the literacy capability and continuum (ACARA, 2013a), providing guidance on which texts, grammar and vocabulary should be the focus of teaching

and learning in science and mathematics. The relevant literacy goals for Years 4 and 6, the year level in the middle of the year levels in our study, are attached as Appendix 1.

In this project we adopted the term 'power language' for the texts, grammar and words of the academic curriculum areas (following Martin, 2013a). Importantly, we note that learning academic language is not just a question of acquiring new vocabulary: it is not simply 'word salad' (Martin, 2013b). Each discourse or curriculum area has its own power texts, power grammar and power words. They are characterised, for example, by features such as nominalisations, marked theme, the passive voice, technical language, and the use of complex conjunctions (Halliday & Martin, 1993; Halliday & Webster, 2004; Korner et al., 2007).

We were also informed by recent work on 'semantic waves' or 'powering up, powering down' (Martin, 2013b). The dynamic process of developing meanings with students using discipline-specific language involves condensing commonsense language into academic language as we power up, and unpacking academic language back into the commonsense as we power down (Freebody, 2013; Macnaught et al., 2013; Martin & Maton, in press, 2016; Matruglio et al., 2013). Without this two-way movement, talk remains in the abstract, or alternatively weighed down in the commonsense so that abstract and generalised meanings are not developed. This 'up-and-down' process implies that scaffolding in the classroom must shunt back and forth from the thinkable to the unthinkable, from the familiar to the new, from the concrete and context-specific to abstract decontextualised meanings, from the everyday to semantically dense language, building bridges between what children already know and the new learning goal. The process of powering down and up is not a single move in teaching, but needs to happen repeatedly.

The idea of powering up and down is relevant to semiotic systems other than language. To build depth of understanding, students need to interact among concrete materials, three dimensional models, abstract diagrams, all the time developing their use of target language so that meaning is carried across the different representations.

2.2 Learning as a culturally embedded activity

Sociocultural theories of learning framed our understanding of the culturally embedded nature of learning, and the processes through which new learning is internalised (Vygotsky, 1978, 1986; Wertsch, 1998; Wertsch et al., 1995). Through culturally-situated learning, people become members of cultural or social groups. To belong within a group such as a community of scientists or mathematicians requires the sharing of motivations, settings, goals, mediational tools (importantly the tool of language), and available roles or identities (Engeström, 1987). The gradual appropriation of these aspects of membership can be likened to a form of apprenticeship as the learner moves from novice to member to mastery (Rogoff, 1990).

The academic disciplines represent particular social groups. Schooling and teachers have a responsibility to apprentice students into the activities that are represented by these

disciplines so that they can ultimately become members of the broader literate community. Engaging in this process of apprenticeship involves asking questions such as, 'What do scientists and mathematicians care about and why?'

The sociocultural perspective on pedagogy recognises the roles of teacher and learner as intertwined, in contrast to the Piagetian view of the child as autonomous learner that dominates thinking in many western educational settings (Piaget, 1953). A Vygotskian perspective characterises pedagogy as *obuchenie*, which deliberately conflates teaching and learning, rather than child- or teacher-centred (Daniels, 2001). Pedagogy is a process of goal-oriented and purposeful dialogue between teacher and learner through which meanings are intentionally negotiated, and the learner gradually appropriates and controls new learning. Because student learning depends on the quality of classroom negotiation, this becomes an important focus of study when trying to identify effective patterns of interaction (Christie, 2002).

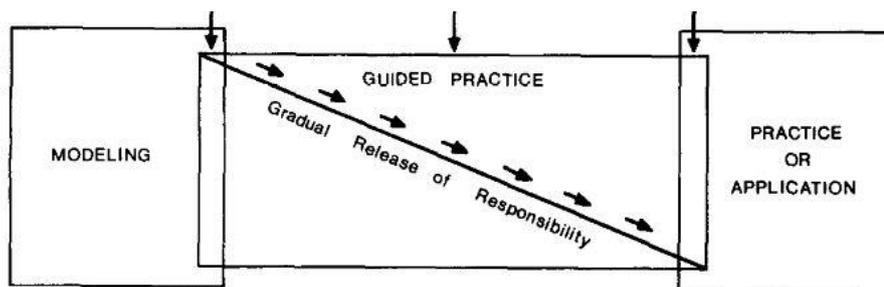
In cross-cultural situations, providing a social orientation to learning is not necessarily simple. How do we orient English learners to the belief systems of mathematics and science, particularly in geographical and social contexts where the purposes of this learning lose significance outside the classroom? How do we do this in a way which is culturally sensitive, without seeming to contradict or imply criticism of family and community values and perspectives? Publications about the nature of science (AAS, 2008) and the nature of mathematics (AAS, 2009) provided some insights, but these questions are not politically and socially neutral.

2.3 Scaffolding

In this project, we were specifically interested in the kind of interaction where teachers contingently support students in their learning, which is commonly referred to as 'scaffolding'. Drawing from sociocultural theories of learning (Vygotsky, 1978, 1986; Wood, 1988) we define scaffolding as contingent, goal-oriented support provided to novices such as students by a culturally knowledgeable other who serves as 'vicarious consciousness' for students by 'lending' cognition through language and other modes of meaning making (Bruner, 1986). The teacher works with an intention to gradually handover and support the appropriation of knowledge and language to students in a reciprocal process of appropriation.

The process of appropriation of knowledge requires a transfer of control from the adult/teacher to child/student as he/she appropriates resources. Bruner called this transfer 'handover' (Bruner & Watson, 1983, p. 60). The transfer is represented in the 'gradual release of responsibility' pedagogic model first described by Pearson and Gallagher (1983).

Figure 1. Gradual release of responsibility (Pearson & Gallagher, 1983, p. 337)



This process begins with a high level of control by the teacher who is ultimately responsible and accountable for the students' successful learning. During this process, the teacher builds a bridge between the known and the unknown, gradually moving the learner towards new meanings and forms of language and leading students towards dialogic exchange. The teacher continues to provide support as necessary, and as students show increasing degrees of success, the teacher relinquishes authority, handing over more control and freedom to the students.

By the time the student has appropriated and can apply new learning independently, scaffolding is no longer necessary, and the adult is a minor player in the context. Handover ideally means that the students take control of the discussion, initiate comments without prompting, ask appropriate questions and formulate their own responses to the teacher's questions.

The process of scaffolding therefore involves an inherent asymmetry of roles between teacher and learner: it is largely unequal and not democratic, but also not static, with the balance of control shifting from teacher to student. This asymmetry clearly represents a risk to learning in cases where the process does not involve a genuine dynamic of shift to handover. Hence, as we recognise and encourage this asymmetry we need to do so in a manner that fosters rather than hinders learning (Edwards & Mercer, 1987).

Inherent to scaffolding is the principle of contingency (Wells, 1999; Wood, 1989). Contingent scaffolding is characterised by how well the teacher is able to judge the need and quality of assistance required by the learner, and related to the way in which help is paced on the basis of students' developing understandings. Contingent scaffolding requires the adult to recognise the inherent asymmetry and monitor and respond to moment-by-moment signs of success and failure by the child. As Wood explained, when the child shows signs of success, the adult hands over more control and greater degrees of freedom. If failure ensues, the adult provides more help, increases control and reduces the degrees of freedom for error (Wood, 1989). Wood pointed out that maximal contingency is not nearly as easy as it might sound, even for adult-child dyads. The challenge of contingency in a classroom setting is exponentially greater. The sensitivity and skill involved in responding contingently to students is sometimes seen as the defining quality of teaching (Hammond, 2001).

The need for contingency means that handover is not quite the neat trajectory suggested by Pearson's diagram; it is more like a 'pedagogic dance' (Parkin, 2015, p. 52), or a 'shuffle', where the teacher is always prepared to shift the balance of responsibility, taking it back or handing it over whenever the child needs it.

Further, not all support qualifies as scaffolding according to the definition we are using here. For example, when an adult sits beside a student and coaxes them through a task it is not necessary consistent with our definition of scaffolding. This type of interaction may be a response to time pressure to get through a task, or to habitual helplessness on the part of the student, and has been referred to variously as 'shepherding' by Sugrue (1997, p. 178), and 'piloting' (Lundgren, 1981, p. 200). The goals of shepherding/piloting are short-term: to get the task done, and to relieve the pressure in the classroom situation rather than to develop a longer-term shared understanding of the aims of the task.

The goals of scaffolding are long-term: they involve the teacher sharing language and behaviours that convey the 'perceptions, conceptions, feelings, and intentions' (Wood, 1980, p. 282) that will allow the student to take over active roles in the target discourse.

2.3.1 Cognitive load and scaffolding

Cognitive load theory, from the field of cognitive psychology, adds a perspective which affirms the principles of scaffolding (Chandler & Sweller, 1991; Kirschner, P. A. et al., 2006; Merriënboer et al., 2003). Cognitive load theory is based on the principle established by Miller on the limited capacity of the working memory which can only manage to engage with a small number of units of new information at any one time (Miller, 1956). There are three types of cognitive load: the load intrinsic to the level of the task, the cognitive load which is germane to the learning and extraneous cognitive load, in the control of the teacher (Kirschner, D., 2011). The effect of contingent scaffolding is to reduce the extraneous load, and break down the intrinsic load into smaller manageable parts, so that the germane load, that which builds new schema (organising information in the brain into logical systems), can be effectively carried out (Chandler & Sweller, 1991). Without contingent scaffolding, cognitive overload leads to ineffectual learning. The concept of 'cognitive load' has proved to be very useful in deciding on contingent levels of scaffolding in our planning.

2.3.2 The role of imitation in learning language

Another aspect of scaffolding that reflects the dynamic nature of the process is the role of imitation in learning. Imitation is the first stage of language appropriation, a process which is often regarded as anathema by western educators because of its connotations of mindless rote learning (Willingham, 2009). Nevertheless, its role in development is crucial.

We draw here from Vygotsky's view of imitation as an indispensable active process that requires an understanding by the learner of the purpose of the task, and allows the child to

borrow the culturally mediated means from the knowledgeable others around them (Gray, 2007, Vygotsky, 1986).

Imitation is the first level of appropriation, where the learner tries out new ways of talking and behaving, borrowing language and gestures from other discourse members. Cazden (1981) refers to the early stages of appropriation as 'performance before competence', while Wertsch describes these early attempts at taking on new language as 'mouthing' or ventriloquation, after Bakhtin: *the process whereby one voice speaks through another voice... the word in language is half someone else's* (Wertsch, 1991, p. 59). Neuroscientific research suggests that the development of mirror neurons is linked to 'goal-oriented imitation' in social contexts, and has an important function in developing language (Iacoboni, 2009).

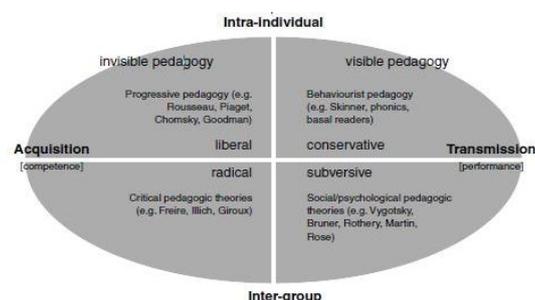
Intentional imitation (where the learner understands the motivations, goals and values of the activity) is a sign that the process of development is underway, but not complete. Eventually, learning must move beyond imitation as meanings develop through dialogue and application in new contexts, supporting learners to take control of the three aspects of Register: the topic, the relationship they wish to express, and the manner in which to communicate their intent. Nevertheless, imitation is the first step in this process, and the use of imitation in learning the language of science and mathematics was a strong focus in this project.

2.4 A subversive pedagogy

Finally, in characterising the pedagogic approach that we pursued in this project, we found Bernstein's (1990) analysis of 'pedagogic types' to be extremely useful.

Bernstein proposed a way of characterising pedagogies based, firstly, on whether we see learning as more of an individual endeavour (intra-individual), or whether we see it as more to do with changing the relationship between social groups (inter-group); and secondly, on whether pedagogic practice places greater emphasis on learning through implicit understandings, or learning through the explicit ordering of knowledge and discourse.

Figure 2. Bernstein's pedagogic types (adapted from Martin, J. R., 2011)



Of the four pedagogic types that are represented in this diagram, we are most interested in the one that has been variously labelled 'radical visible' (Bourne, 2003, 2004) or 'subversive' (Martin, 2011; Rose, 2005). The term 'subversive' refers to the intention *to challenge social order by giving away the keys to knowledge then almost exclusively appropriated by agents of symbolic control* (Martin, 2011, p. 39). In other words, a subversive pedagogy aims to make

explicit the language and knowledge of those in power to those who would not otherwise be able to access this knowledge and language.

This pedagogy has a number of characteristics:

1. It is visible: rules of engagement and success criteria are made explicit and shared with all. Subversive pedagogy aims for all students to succeed. The goal is common knowledge amongst the teaching and learning community (Edwards & Mercer, 1987) so that knowledge and learning processes are made explicit. Importantly, whole class activities, guided by the teacher, are an important part of the pedagogic process whenever learning is new. As meaning is established, shared and deepened, and control of language is strengthened, students can begin to engage in activity in groups, and eventually individually.
2. Subversive pedagogy regards teaching and learning as two sides of the coin. Learning is not the sole responsibility of the student, but is the shared responsibility of the teacher and the learner. The teacher leads the student to the next stage of development through goal oriented activities. Importantly, the appropriation of subject-specific language by students is considered an essential goal of pedagogy, with abstract language vital for engaging with school subjects as students progress through school (Halliday & Martin, 1993).
3. The role of the teacher in the subversive quadrant changes as teaching and learning progress. When new learning begins, the teacher may well act as the sage on the stage. As learning progresses, control is gradually handed over to students, until the role of the teacher becomes guide on the side. Hence, to work towards success for all requires a radically dynamic or fluid approach to teaching and learning, where the teacher must strive to provide contingent levels of support at the point of need, always moving towards the gradual handover of control of the learning to students (Gray, 2007). This is consistent with the notion of scaffolding that we aimed to realise through this project.

The implications for teaching and learning are threefold: (i) first, there is a need to orient students to the activity system of mathematics and science; (ii) second, language is the essential mediational tool for meaning making; and (iii) third, we need to circumvent the binary debate between progressivist and transmission pedagogies, and instead explore how a more dynamic and responsive role for the teacher - a 'gradual release' approach - might contribute to student outcomes.

This 'subversive' approach to pedagogy is often neglected or misinterpreted and is under-represented in science and mathematics teaching (cf. recent work by Roth, 2007, 2014). However, we argue that it warrants serious attention because it carries the potential to make a significant difference for marginalised students

Research Methodology

3.1 Context Overview

Four teachers from two schools agreed to work with us on this project. The two schools were Maningrida College, a remote school in the Northern Territory, and Cowandilla Primary School in Adelaide. The two schools were ideal sites for this project. First, both schools represent a demographic of students with high levels of educational disadvantage, and second, both schools have a whole-school approach to literacy that is aligned with the teaching approach we designed in this project.

The teachers we approached were all considered by the principal and colleagues to be highly proficient in the scaffolding pedagogy acquired through Accelerated Literacy training.

We asked the teachers to contribute to the research project by planning with us to teach their topics of mathematics (Maningrida) or science (Cowandilla) to their classes, allowing us to record their lessons, and by reviewing the lessons with us in order to reflect on the scaffolding processes in their classes.

All four teachers currently teach in the middle or upper primary years.

In exchange for their time spent with the project, teachers were given two release days for each cycle, to be taken at a time convenient to the school, funded by this project.

Further detail on each school follows.

3.1.2 Maningrida College

Maningrida College is a government school that services the coastal town of Maningrida in western Arnhem Land, about 500 km to the east of Darwin. A former Welfare settlement, Maningrida is now one of the largest remote Aboriginal communities in the Northern Territory, with a population of around 2,600 people. It is a highly multilingual society. At least 11 Indigenous languages represented, including Ndjébbana and Burarra, the languages of local landowning groups, as well as Kunwinjku, Rembarrnga, Gurrgoni and the Yolngu languages from northeast Arnhem Land. Kriol is also increasingly spoken, especially among younger people.

The College caters for students from preschool to Year 12 and also services around 20 homeland education sites located up to 150km from Maningrida. Most of the students (about 95%) are Indigenous. Although the official enrolment is around 700 students, school attendance at Maningrida fluctuates greatly, averaging at around 50%, particularly during the cooler dry months of the year when many people move away from the community to traditional country. Literacy and numeracy levels as measured by the National Assessment

Program Literacy and Numeracy (NAPLAN) are low, and more than 80% of students score in the lowest Band 4 for reading (compared with just 3% nationally) (ACARA, 2015).

The official language of instruction from the primary years is English, although many children hear little English in their daily interactions and have very little knowledge of English when they first come to school, or if their school attendance is irregular. For the past five years, the school has strongly supported a scaffolded approach to English instruction, through the Accelerated Literacy program.

Maningrida College uses Accelerated Literacy as a whole-school approach to teaching language and literacy. Teachers attend two days of professional learning on arrival in the school and are supported in planning and implementation by a full-time literacy coordinator and 'Visible Learning' coordinator.

The classes involved in this research project were middle primary to middle years, (Years 4-Year 8). However, as can be seen in Table 1 below, each class had its own complications in presenting the topic.

Table 1. Research student cohort, Maningrida College

Class	Year levels	No students	EALD	Low SES	ATSI	Average attendance	PAT-M median (range)	PAT-R median (range)
2016								
1	4-6	22	60%	67%	58%	n/a%	Yr 3 (Yr 1-Yr 8)	Yr 7 (Yr 3-7+)
2	6-8	26	100%	88%	100%	n/a%	Yr 1 (K-Yr 2)	Yr 6 (Yr 3 -6+)
2017								
1	5-6	12 ¹	83%	n/a	100%	91%	Yr 3	Yr 3
2	7-8	18	100%	n/a	100%	60%	Yr 1	Yr 2

Class 1 had the younger students. It was a high attendance class. (The school streams into classes with students who are regular attenders, and the 're-engagement' classes, where students attend on average less than 60%.) One third of Class 1 were English speakers; the children of school staff and community support staff. Two thirds of the class were Indigenous, speaking English as a second or third language.

This combination of Year 4-6 students created its own challenges. The median performance level in Mathematics was Year 3, but the range spread from Year 1 to Year 8. The median performance level in reading comprehension was Year 3, but the range spread from Transition

¹Before the second research period, one of our research teachers won a leadership position and no longer had his own class. To teach the mathematics topic for this project he therefore withdrew the Aboriginal students from their class and taught them one lesson per day for four days.

(pre-Year 1) to Year 10. Provision of a contingent level of scaffolding for all students in this class requires a highly skilled and reflexive teacher.

Class 2 was a re-engagement class (average attendance 60% or below). Although the students in this class were older, the median performance level for mathematics was year 2, with a range from Transition to Year 2. The median performance level for reading comprehension was Year 1, with a range from Transition to Year 3.

While the Class 1 teacher faced the challenge of teaching students with such a wide range of performance. The teacher of Class 2 with such consistently low student performance faced other challenges when trying to teach an age-appropriate topic. Establishing meaning of English language was the priority, and students' low level of mathematical performance meant that transitioning from an everyday understanding of probability to mathematical representations such as 0-1 and fractions (e.g. $\frac{1}{4}$ chance) was beyond the class in the five lessons which we planned and observed.

3.1.3 Cowandilla Primary School

Cowandilla Primary School is located in the western suburbs of Adelaide, South Australia. The school caters for children from Preschool to Year 7 and has about 420 students enrolled. 60% of students are from non-English speaking backgrounds, 3% are Indigenous, and 35% of students hold a School Card (they are from low-income families and eligible for financial assistance).

Cowandilla Primary hosts an Intensive English Language Centre (IELC), where students are taught the Primary School subjects while focusing on learning English. Students generally stay in the IELC for up to a year, or longer if needed, before moving into the 'mainstream' classes. A high proportion of these students stay on at the school after that intensive year.

Like Maningrida, the school uses Scaffolded Literacy (formerly known as Accelerated Literacy) pedagogy as a whole-school approach to literacy teaching. The school has been involved in scaffolding pedagogy, through the Accelerated Literacy program for more than 10 years and a number of teachers in the school are expert scaffolders.

The teachers and principal nominated science as the focus of this research to align with school priorities. The science topics were selected by the teachers from their Australian Curriculum priorities for the year. The teachers were invited to be involved in the project because of their knowledge of, and experience and proficiency in scaffolding pedagogy.

The school is a 'Climate Change' school, with a strong commitment to science. It has been selected as a site for a new STEM centre which is currently being built, and employs a biologist part time to work with teachers on their science program. One of the teachers who worked with us on this project is also particularly knowledgeable and passionate about science.

In contrast to Maningrida CEC, Cowandilla Primary School has a relatively stable and regularly attending school population, stable staff, with a small number of newly graduated teachers who are supported by the highly expert teachers around them.

The students in the research classes came from diverse backgrounds: from Iraq, Palestine, Afghanistan, Syria, Pakistan, the Philippines, Indonesia, Sudan, Sierra Leone, China, Vietnam, and Japan; some with educated parents, and some whose parents had very little or no education. The classes involved in the research project ranged from Years 4 to 7 in 2016, and a combined Year 7 class in 2017, co-taught by the two teachers in the project. In 2017, the median reading age was Year 7, and ranged from Year 3 to Year 10. 73% of students in the class were from non-English speaking backgrounds, and 44% of students held a School Card. Both classes had similar student cohorts. Two Indigenous students were enrolled in 2016, but none in 2017. The median reading age was year-level appropriate, but reading levels ranged from Year 3 to Year 10. The Non-English-Speaking Background (NESB) students ranged from those who were born in Australia, have been here for several years, or have just exited from the New Arrivals class (1 year in Australia).

All classes had students with high levels of disadvantage. In each classroom, the teacher identified the factors of disadvantage associated with each student, specifically Aboriginal and Torres Strait Islander (ATSI), EALD and low-socio-economic status (MCEETYA, 2009):

Table 2. Research student cohort, Cowandilla PS

Class	Year levels	No students in class	EALD	Low socio-economic	ATSI	Average attendance	PAT-R median (range)
2016							
1	4-6	26	73%	20%	0	n/a	Yr 7 (Yr 3-7+)
2	5-7	25	65%	38%	2	n/a	Yr 6 (Yr 3 -6+)
2017							
1	7	41	70%	44%	0	92%	Yr 7 (Yr 3-7+)

3.2 Research process

3.2.1 Research questions

In working with the collaborating teachers, we asked the following research questions:

1. How can we work with existing scaffolding principles to support teachers to use contingent scaffolding in teaching the language of science and mathematics?
2. In implementing these principles, what issues arise in classroom interactions, and what refinements to principles are needed for improvements in teacher and learner outcomes?
3. What developments in student subject-specific language and literacy are evident from the start to the end of the study?
4. What refinements in the observation tool can be made in response to its utilisation by participating teachers?

3.2.2 Data collection periods

The first cycle of data collection took place in October-November 2016, and the second in February-March 2017. For each data collection cycle we spent one week at each school. The purpose of organizing two data collection periods in each school was to allow us to consolidate and refine scaffolding principles so that they could be retested during the second period.

We had planned to record one lesson with each teacher for each day of the week during a data collection period. During the second data collection period we recorded fewer lessons. In Maningrida the teachers were both able to commit to four (rather than five) lessons, while at Cowandilla the two teachers had combined their classes for the year and were team-teaching one larger class.

In total we recorded 33 lessons. The number of lessons collected during each data collection period is given in Table 3 below.

Table 3. Data collection periods

	Data Collection 1 (DC1)	Data Collection 2 (DC2)	Data Collection 3 (DC3)	Data Collection 4 (DC4)
School	Maningrida	Cowandilla	Maningrida	Cowandilla
Dates	31 Oct – 4 Nov 2016	7-11 November 2016	20-24 February 2017	27 February – 3 March 2017
No. lessons	Matt: 5 lessons Dan: 5 lessons	Louise: 5 lessons Michael: 5 lessons	Matt: 4 lessons Dan: 4 lessons	Louise & Michael: 5 lessons (shared)

3.2.3 Professional development and planning with teachers

Before the start of the research, we were in communication with the teachers to clarify the scope of the project and the teachers' role, to identify topics and begin discussing scope and sequence. For the Maningrida teachers this communication took place mostly by phone and email, and the Cowandilla teachers attended two after-school meetings.

In both cases, the specific topics were selected by the teachers.

On the Sunday before each data collection week, we met with the teachers at each site to run preparatory workshops and prepare the lessons. The agenda of the preparatory workshop covered the following:

- i. An introduction to Bernstein's model of the four pedagogic quadrants, and the positioning of this research in the radical social quadrant
- ii. Discussing and revising the previously established scaffolding principles, based around the observation tool, and relating these to the learning area and topic
- iii. The place of focus texts in supporting teachers to be mindful of the genres required to express meanings within the topic; constructing one or more focus texts to frame the instructional register.
- iv. Continuing with the planning the scope and sequence of the topic in consultation with the Australian Curriculum.

The teachers taught one lesson per day during the data collection weeks, except during the 2017 data collection period in Maningrida, when, because of school events, they were only able to teach 4 lessons. Lesson times ranged between 40 minutes and 1 hour 30 minutes. The researchers attended each lesson, took notes, and met after school or during release time with the teachers to review and plan for the following lesson.

3.2.4 Feedback from teachers about the research process

The teachers supplied us with a written reflection at the end of each data collection week, in response to a series of question prompts. Teacher reflections are included throughout the report.

3.2.5 Lesson analysis

Once the lessons were transcribed, we used NVivo™ to analyse selected excerpts, coding according to our set of observation criteria, which allowed us to examine the lessons through the perspective of three lenses (see Sections 5 and 6).

3.2.6 Types of data

Lesson documentation

Lessons were recorded using an iPad™ mounted on a Swivl™ robot, which tracked the teacher's movements. A visual tracker worn by the teacher also served as a microphone. Two supplementary trackers were used to catch audio from students in different parts of the room, although these were less effective.

In total, 33 lessons were recorded across the duration of the project (see Section 3.2.2)

The recorded lessons were uploaded into the Swivl™ Cloud and then converted to mpeg format so that they could be linked to NVivo™ (qualitative data analysis software). Lessons were viewed and assessed for points of interest (the extent to which the material in the lessons would satisfy our observation criteria). All lessons were then uploaded to *TranscribeMe™* (an online transcription service) which provided a fast and cost-effective return on transcriptions.

Photos

Still photos were taken during the lessons of objects, texts or activities that contributed to sense-making during the lessons. For example, we took photos of board work, teacher-made posters, student activities (such as students collaborating to construct models, students demonstrating the motion of planetary bodies), diagrams and models.

Teacher artefacts

We collected various artefacts that were used in planning and conducting the lessons, such as lesson plans, the focus texts, notebook files, video links and worksheets. We took records of meeting highlights both before and after lessons.

Student products

We took photos of samples of student writing during the lessons.

At Cowandilla, in addition to writing, many students were able to record oral versions of their work, together with diagrammatic and other information, using an app called *Explain Everything™*.

Individual student pre- and post-tests

Pre- and post-topic data was collected from the three students in each class, for each iteration of the study. Although we hoped to retain the same students across our two visits in 2016 and 2017 to get a longer-term view of language development, this was not possible because of the changes in class make-up.

To select the students, each teacher nominated one high performing, one average performing and one low performing student in comparison with the rest of the class.

The intention in collecting this data was to enable an analysis of student oral language proficiency in talking about the topic, checking for the presence of specific language resources (lexis and grammar). We compared students' use of these language features before and after teaching.

Each student was individually recorded in conversation with the researcher using a GoPro™ camera (chosen because it is inconspicuous). In each iteration, a short text relevant to the topic was read to each student in small sections. A visual artefact (diagram, photograph or clock) was used as a prompt. After hearing the text three times, the student was asked to say back to the researcher what they had heard. The same process was used for the pre- and post-tests. The texts, prompts and text analysis for the pre- and post-tests for all four topics are attached as Appendix 1.

While this process produced useful data in three out of four data collection periods, it proved too easy as a post-test for the middle- and high-performing Cowandilla Year 7 students. For their post-test, the prompted repeat test was followed with an independent oral presentation, using a diagram of a lunar eclipse as a prompt. The instruction in this instance was 'Tell me everything you know about a lunar eclipse'. A separate analysis of their language use was made from their independent oral text.

All student talk was transcribed and analysed for the presence of particular language features. It should be noted that we couldn't expect significant changes in language use in such a short period of time. Hence these pre- and post-tests were only one way in which we evaluated the quality and outcomes of the lessons observed. We also observed students taking part in the lessons, their ability to participate in classroom dialogue, and in the way their confidence grew across the week.

Teacher/principal feedback

After each lesson we met with the teachers to discuss the lesson and plan for the following day. Meeting times were arranged in consultation with school principals either during teacher release time or after school. In many instances the reflection and discussion led to the following day's lesson being revised.

We asked all teachers for a written reflection at the end of each data collection week, in response to a series of question prompts.

4 Pedagogic approach

We have synthesised our theoretical perspectives from Section 2 into a number of pedagogic principles which in turn lead to pedagogic processes. These principles and processes were held in the forefront of our thinking during this project. The principles are listed below as section 4.1, followed by the pedagogic processes as section 4.2.

4.1 Introducing the pedagogic principles

4.1.1 Principle 1

Each learning area in the curriculum has its own powerful texts, powerful grammar and powerful vocabulary. If active citizenship and choice in life trajectories is the goal of our education system, then all students are entitled to control this language. It is not sufficient for students to simply engage in the classroom with scientific looking artefacts and be able to recount their experiences using commonsense language. This shift from concrete experience to abstract talk requires conscious and informed effort on the part of teachers, particularly in the throes of the lesson, when they have to attend to many aspects of the context at once. The teacher has to be conscious of the text knowledge, grammar knowledge, word knowledge and visual knowledge that together create meaning in each learning area. They have to understand how this knowledge of language and visual resources fits together to express meaning in powerful and authoritative ways.

4.1.2 Principle 2

As children develop, they learn language, learn through language and learn about language (Halliday, 1993b). Science and mathematics are construed in meaning systems in which language, symbol and visual images work powerfully together to make sense. Nevertheless, language is central in the pedagogic process to mediate learning in fields made up of systems of abstract language. It is through language that children's orientation to scientific and mathematical worlds can change from outsider to apprentice, and later expert.

4.1.3 Principle 3

Establishing trust and a sense of community and common purpose between teacher and students underpins effective learning. This is particularly the case for educationally marginalised students who are reluctant to take risks when meaning is low. While our educational aim is to work towards age-appropriate academic goals, our pedagogy has a second fundamental aim: the maintenance of positive affect in the classroom.

4.1.4 Principle 4

Scaffolded pedagogy is the pedagogic process which is aligned with first three principles. Scaffolding can be understood on two levels. The 'macro-scaffold' is the scope and sequencing

of a topic over a series of lessons, the logic of which provides a predictable and logical format. In contrast, the 'micro-scaffold' is the structure of the moment-by-moment interactions between teacher and students occurring through classroom dialogue (Hammond, 2001).

The macro- and micro-scaffolding processes in this research process are introduced below.

4.2 Introducing the pedagogic processes

4.2.1 The macro-scaffold: proposed teaching sequence for integrating language and science

The process we followed through our teaching and learning sequence mirrored the developmental steps of language learning (Principle 2 above) over a very short time frame. First students learned the target language, in the context of orienting activities to build meaning. Second, they used that language as a mediating tool to consolidate and extend their learning in new contexts. Finally, to lead towards independent writing, students and teachers used the now familiar language as a launching point for learning more about grammar and texts.

Important characteristics of language focused lessons were:

- Each topic began with an orientation to the topic; a stage we called the 'So What?'. We could not assume that students from communities with widely varying world views would understand the goals, values and motivations of scientists or mathematicians. If we wanted students to think and talk like these specialists, we have to help them enter new worlds.
- To support planning, and teaching and learning, the teachers were involved in the development of a 'focus text'. Its role is outlined in Section 4.2.5 below.
- While the teaching and learning sequence for the topic was guided by, and reflected in the focus text, the staging of each lesson reflected the learning outcomes of the previous lesson, the extent to which previous learning has been handed over, and whether repetition is required before moving on.
- To build meaning around the topic, students took part in a number of different meaning-making activities, such as: making an electric circuit with wires and a battery; photographing the circuit and using the photo to record the circuit using symbols; role playing a lunar eclipse; watching video clips, often with the sound off so that the teacher can use the target language; looking at a poster. All semiotic systems had to work together, bound by carefully selected language to build meaning (sense-making). The focus text connected these different activities to make them a coherent whole.
- There was a gradual shift from concrete activity to notes and/or posters recording important information, to the oral and written construction of a whole text. Early in the topic, other semiotic systems did a lot of heavy lifting as language was learned, first as

imitation. As meaning was established, students began learning more through language, and language began to take on more of the meaning-making load.

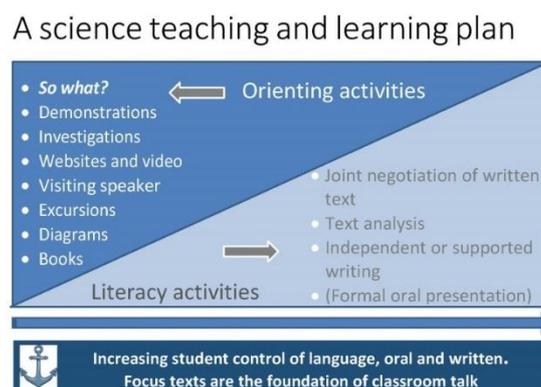
- There was a conscious shift from commonsense to abstract and technical language across time. Guided by the focus text, the teacher used both commonsense and technical terms and grammar, with the need to refer to commonsense language reducing as students appropriated the new language (although the teacher needed to check to make sure students understood and were not just parroting the new language).
- The role of the teacher was to encourage the students to extend their talk, but at the same time to contribute what the students could not, managing the talk so that students were carefully and respectfully directed to the target language. Before moving on to jointly constructed written texts, the teacher involved the students in what we called 'long turns' (Brown & Yule, 1983): jointly constructed oral texts with contributions by many students in the class, demonstrating what they knew.

To quote one of the teachers: *It's a bit like a 3D printer: you keep going back and forth and each turn adds a new bit of meaning, so the shape eventually becomes apparent.*

4.2.2 The macro-scaffold: a model

To date we have developed a draft model for the teaching and learning sequence for science. The purpose of such a model is to support teachers in taking into account the processes outlined above when introducing a science topic. It is our current iteration, but is being continually refined as we trial it with teachers.

Figure 3. Science teaching and learning sequence



The model consists of two interacting segments, whose relationship and proportions change over time. The topic begins with a number of activities which orient students to the scientific thinking, language and processes around the topic. They can include 'hands-on' activities, excursions, websites and so-on. Linking these activities together is the focus text, with language first used by the teacher, but gradually handed over to students. As students begin to make sense of the topic, and as their control of the language of the focus text grows in classroom dialogue, the pedagogic focus moves to the construction of abstract

representations through text and diagrams. It is at this point that the notion of 'inquiry' plays a role, as students individually or in groups conduct inquiry, drawing on their new knowledge and language as problem-solving tools.

4.2.3 The micro-scaffold: classroom dialogue

Classroom dialogue is the medium through which meaning and language are developed and shared amongst all participants. Classroom dialogue is not simply a chat or a yarn; it is intentional, goal-oriented, negotiated talk that purposefully leads to learning outcomes (Alexander, 2005). It is one form of pedagogic talk.

Principle 3 (Section 4.1.4) established two aims for a teaching and learning program: the maintenance of positive affect, and the achievement of academic goals. To reach these goals, contingent levels of support and challenge are required; when there is sign of handover, support is decreased. As noted above, scaffolding pedagogy is dynamic: it cannot be presented as a 'grab bag' of pedagogic strategies, but rather a sequence of strategies that can be called on at the right time, to provide the right level of support for each student, resulting in movement forward to the learning goal. When there are signs that the child is struggling, support increases. In other words teacher input must change over time to develop alignment. This 'pedagogic shuffle' is the basic principle of scaffolding (Refer Section 2.3). Teachers must manage and modify their talk in order to relinquish authority; this 'handover' allowing increasing student autonomy as learning proceeds.

The achievement and maintenance of contingent scaffolding requires ongoing effort. It requires a high degree of consciousness by the teacher in order to attend to and monitor student talk to respond appropriately, as well as being self-consciousness about her/his own talk in maintaining the direction of the lesson without losing positive affect. By summarising and grouping scaffolding principles, we developed an observation tool: a set of three lenses through which the teacher can reflect on her own language, and through which the observer can analyse scaffolding interactions. The observation tool is introduced in the following section.

4.2.4 An observation tool for scaffolding pedagogy: three lenses

Because scaffolding in practice involves such a complex array of dialogic moves on the part of the teacher, we developed an observation tool to help us better understand and articulate the moves and mechanisms of scaffolding (Appendix 2). Initially we sought a set of criteria that we could use as guide when we reflected with teachers on their teaching. Subsequently we realised that we could also use the tool as a framework for analysing classroom discourse and for identifying principles of scaffolding as they are realized in instances of teaching.

To adequately capture the nature of scaffolding through classroom dialogue, we needed to account for a complex range of pedagogic elements. We needed to account for:

- How teachers and students come to share and maintain attention on the academic tasks they are doing;
- How the activity of the classroom comes to be framed as academic and how teachers help students to develop a scientific 'mindset', along with the appropriate discipline-specific language;
- How the teacher maintains a 'respectful invitation into the discourse' (Gray and builds trust;
- Changes in the nature of the classroom dialogue across time, as students are able to take more control of the language and knowledge, and as the teacher enables that handover, and adapts the supports accordingly; and
- How meaning is made in a classroom, often with different meaning-making resources being used simultaneously: through talk, through writing and reading, through images, diagrams and other visuals, and through pointing and other gestures.

In elaborating the criteria for 'what counts as scaffolding', we found that they fell naturally into three 'ways of seeing a lesson', or 'lenses', and these provided the structure for the observation tool. Each lens can be characterised by an organising question, as follows.

Lens 1. Shared Purpose: *What are we doing together; what are we talking about and why?*

In a scaffolded lesson the academic purpose is shared at the start of the lesson sequence and each individual lesson. It is also reiterated, maintained and elaborated throughout. We can observe a lesson by looking for how its purpose is restated and maintained, how the teacher draws students' attention to academic goals, and the extent to which students demonstrate understanding of the purpose of each activity within the context of those goals.

Lens 2. Whole Class Interactions as Scaffolding: *What language are we using to interact with the knowledge and with each other?*

In scaffolding, teacher talk and questioning are used to build common knowledge and hand over control of the knowledge, expressed through carefully considered language. The relationship between the teacher, the students, and the content changes over time, depending on the level of shared understanding. That is, over time, control of the dialogue shifts from more teacher-controlled, to more student-controlled. Throughout, the teacher uses contingent levels of support and respectful responses to maintain positive affect.

Lens 3. Sense Making: *How do we use various meaning-making resources in a cohesive way?*

We can also observe how meaning in a classroom is created using multiple modes of communication (oral, written, images, diagrams, video, etc.) in a supportive and complementary way. Different combinations of meaning-making resources can be used to

add layers of meaning to a topic, and to shift between situated and decontextualised language, and between personal instances and the general or abstract. If they are not skilfully managed, however, too many simultaneous sources of information can cause confusion and overload.

For each lens we then elaborated a number of observation criteria. These are set out in an Observation tool (See Appendix 2a). While there is some overlap among the lenses and their observation criteria, the advantage of viewing lessons through one or another lens is that it simplifies the view. With multiple viewings through different lenses, we can see how talk functions to achieve the dual purposes of maintaining positive affect and academic goals. When we worked with teachers, the lens analysis helped us to identify and isolate scaffolding strategies that teachers could realistically work on, but in a systematic (rather than ad hoc) way.

Examples of specific observation criteria and examples of teaching that demonstrates the realisation of the lenses are given below in the discussion following the presentation of the lessons in Section 6.

4.2.5 Identifying interactive trouble

The observation tool is useful in identifying successful practice, but there were times when the lessons did not go as planned. This was often noticed intuitively at first, identified only as 'interactive trouble' (Freebody et al, 1995).

4.2.6 The role of the focus text in the macro-and micro-scaffolding processes

The focus text contributes to both macro- and micro-scaffolding processes. It is the pivotal resource in the shift from spoken to written language as the topic progresses, and from commonsense to scientific or mathematical. The focus text helps teachers to become conscious of, and effectively foreground, the language they require students to appropriate in both oral and written form.

The focus text has a number of functions, all of which are useful in the logical development of the topic:

1. It assists with the macro-scaffold as a planning tool. It establishes the scope and sequence of the topic and sets up a coherent logic. By referring to curriculum achievement standards and content descriptors, it helps teachers identify concepts that are assumed knowledge, to pause and teach or revise those concepts before the new learning begins. For example, in writing the Electric Circuits focus text, the teachers realised that students didn't know what an atom was, and would therefore not understand electrons. They began the topic by teaching the structure of an atom, based on a separate focus text.

2. Additionally, the focus text helps teachers to identify the parts of the science or mathematics topic where they feel tentative, so they can clarify before they start teaching. This is particularly important for primary school teachers who are generalist, rather than subject specialist teachers.
3. The focus text assists with the micro-scaffold. It guides the classroom dialogue and the oral negotiation of meaning, moving the talk towards scientific or mathematical language, and with students gradually contributing increasing amounts of the target language. Establishing the focus text means that, in the hurly burly of the classroom, teachers have a reference to help anchor the dialogue.

Instructions for teachers on how to construct and use a focus text in their planning and teaching are attached as Appendix 3. Examples of the use of the focus text are explored in the accounts of the lessons below.

5 The lessons

5.1 Maths in Maningrida - summary

Mathematics was nominated as the learning area in Maningrida because it matched school priorities. The topics were selected by the teachers involved. They were among the topics recommended by the Northern Territory Department of Education for these year levels in Terms 1 and 4, our data collection periods. The teachers chose 'Probability' and 'Telling the Time' as our topics because they are two of the most difficult and contentious topics faced by a teacher in remote Indigenous schools.

It goes without saying that the influence of the broader Australian society continues to impact on remote Indigenous communities, and that cultural practices change and evolve over time. Nevertheless, the juxtaposition of contrasting world views inside the classroom creates moment-by-moment challenges that have to be thought through for effective teaching and learning to occur. It is the classroom teacher who is at the interface of these different cultural orientations. We do not want to essentialise any cultural practices, but we do want to raise, from the literature, possible cultural factors which teachers need to take into consideration.

One big issue facing western education in remote Indigenous communities is differing logic systems. Western syllogistic reasoning is only one system of rationality, based on the abstract, rather than the personal (Hasan, 2009). Stephen Harris described the difficulties faced by Milingimbi students in syllogistic logic, where the thinker enters into and accepts the logic within the text itself, rather than relying on external personal experience. One example provided by Harris is *All wallabies on Groote Eylandt are yellow. I went to Groote Eylandt and saw a wallaby. What colour was it?* Most students in his data set replied 'Brown', drawing on personal experience (Harris, S., 1977, pp. 508-510). When asked where they got their answer from, they replied 'I saw it'. This logical orientation to lived experience creates a challenge in using 'word problems', the little narratives created by maths teachers to provide 'real life' contexts for practising maths. It does not mean that we should not use word problems. It means that we have to be explicit about their purpose: that they are made up stories to help them practice maths and see how maths can help in everyday life.

We faced a second issue when explaining the social motivation for the topic choice; in other words, why we were studying this topic. In contrast with the future orientation of western cultures, where progress and planning for the future are important cultural values, historically Aboriginal societies tended to have a past-continuous orientation (Harris, S., 1990). When compared with western societies, Harris describes Aboriginal communities as more 'fatalistic', accepting of what comes and dealing with it when it happens (ibid, p. 33). Ask any teacher in a remote Aboriginal community, and anecdotes of immense resilience and lateral thinking to solve a problem by Aboriginal people abound. One example is 'Bush Mechanics' (Batty, 2001),

Days are measured, not by a clock, but by the position of the sun and stars. As an example of natural measurements of the day, mathematician Pam Harris describes some daily time measurements of the Ngaanyatjarra people near Warburton, Western Australia:

The ground becomes clear / the first light / sunrise / early morning / mid-morning / sun has risen up some distance / midday / not quite afternoon... and so on. (Harris, P., 1984, p. 13).

Although artificial measurements of time are used in some places in the community, such as the school, the clinic, the store, and the airstrip, each important time marker is also announced with a siren or music over the loudspeaker, or the lunch arriving, or the plane flying over before it lands, so there is no pressing motivation for being able to tell the time, and it is possible to manage day by day without understanding artificial time at all. Students have digital time on their phones, but being able to read 4:30 on a digital clock does not mean that the student has any mathematical understanding; that those numbers mean *Four hours and 30 minutes (half of one hour) past midday or midnight*. In addition, we have the confusion in English of 'day' meaning both sunlight hours and 24 hours beginning at midnight, and the 'second' hand on the clock measuring the minutes, while the 'third' hand measures the seconds. The clock measures 12 hours, even though there are 24 hours in a day.

We observed that teachers experienced considerable frustration about the failure of students at the school to read and use clocks, engage with timetables, and generally to 'be on time'. The frustration was manifest in casual comments from teachers, such as this one made in passing: 'I don't know why you bother with telling the time - I've taught that year after year and they just don't get it'.

In this context, there is a danger of 'essentialising' Aboriginal people into a stereotyped explanation in which 'They don't use time', or 'They live in a culture where time is not important'. This kind of account is potentially reinforced by teachers' feelings of ineffectiveness in teaching what appear to be basic mathematical concepts.

A third challenge is the cultural role of questioning in social relationships. We heard from at least two teachers about the difficulties faced with teaching probability in the past. One teacher told us how she had spent several days teaching about chance, impossibility and certainty. On the final day, she asked: *Does it ever snow in Maningrida?* (Student answer: *No.*) *What is the chance that it will snow in Maningrida tomorrow?* (Student answer: *Maybe.*) How might this answer come about? Stephen Harris is again the source of a possible explanation. Remote Indigenous people do not like direct verbal confrontation. It is bad manners to reject a request outright (Harris, 1990). It is possible that the student was trying to avoid a direct 'no' to the teacher, and was instead letting her down gently, seeing as she was hoping for snow. Of course, we do not know for sure, but what is evident in our own experience and in the experience of many teachers in remote contexts is the appearance of these instances of unexpected incongruence in question and answer; when there is obviously a difference in perspective, despite the best of intentions and goodwill on both sides.

When such different world views are juxtaposed in the classroom, it is vital that students' home practices are not represented as deficit. At the same time, the very fact that an unfamiliar cultural activity such as predicting and planning for the future, or telling time with artificial, regular, and finely calibrated measurement, is included in the curriculum might imply a cultural lack. The position of the research team was that we would present the learning of probability and time as useful cultural tools for specific purposes, to add to students' repertoire of cultural practices. How they use that tool in the future is up to them. Our decisions on how to introduce the cultural purpose for these topics will be described later.

We are not mathematics specialists, although we sought advice from expert mathematics educators. The sequence of maths lessons described here are the product of negotiation with the two classroom teachers, Matt and Dan. They knew their students, the principles of scaffolded pedagogy and the curriculum. We contributed our expertise in pedagogy and language and our consciousness about the need for social purpose. The sequence of lessons are not held up as the best way of teaching the topics. They do contain their own logical progression, based on the development of language and concepts over time.

5.2 Mathematics Topic 1: Probability

5.2.1 Considerations

One of the most challenging considerations in teaching probability was the range of language choices available in English to realise this concept. The table below (Fig. 3) represents some of the options available to the English speaker:

Figure 5. Examples of language choices when talking about probability

Degrees of chance		
0	50/50	1
<p><i>It is impossible that</i></p> <p><i>There is zero chance that...</i></p> <p><i>There is no likelihood that...</i></p> <p><i>The likelihood that... is zero</i></p>	<p><i>There is an even chance that...</i></p> <p><i>There is a low chance that...</i></p> <p><i>There is a high chance that...</i></p> <p><i>There is an even likelihood that...</i></p> <p><i>It is equally likely that...</i></p> <p><i>There is a chance that...</i></p> <p><i>It is likely that...</i></p> <p><i>The likelihood that... will happen is...</i></p> <p><i>It is more likely than not that...</i></p> <p><i>It is possible but not probable that...</i></p> <p><i>It is probable that...</i></p> <p><i>There is a greater chance that... will happen than...</i></p>	<p><i>It is certain that...</i></p> <p><i>It is definite that...</i></p>

In summary, decisions had to be made about whether we would use adjectives such as 'likely', 'possible' and 'probable', or nouns such as 'chance' or 'likelihood' and how we would represent 0 and 1 at either end of the continuum. Would we include comparisons of likelihood such as *more or less likely*, or *a greater or lesser chance*? Would we teach the difference between *possible* and *probable*? The focus text outlined below represents the final decisions which guided the teachers as they introduced probability. We opted for the nominalisation of 'chance', and the noun groups 'a high chance' and 'a low chance' because they most seamlessly moved to the mathematical 'one in six chance' as the students moved from the everyday to the numerical representations.

The next consideration was where to begin. Most suggested sequences to teach probability begin with the mathematical: dice, playing cards or spinners (e.g. Discovery Education, 2017). We contend that beginning at this point assumes a great deal of prior knowledge that was unlikely to exist in this context:

- why we learn about probability and why we care about risk
- what dice and playing cards have to do with the purpose of probability
- what range of choices are available in discussing probability
- our assessment of probability is based on prior knowledge.

Furthermore, there was no certainty that the meaning students assigned to language they already used was equivalent to the very exact mathematical meanings used in mathematical discourse. For example, one student used 'fifty fifty' to describe an event that had approximately an even chance, but without understanding that this term referred to percentage. Many students used the term 'not even' or 'nothing' to describe events that were unlikely or impossible (as in *What is the chance that Matt will let us have free time this afternoon? Not even. What is the chance that there will be a swimming carnival on Friday? Nothing*).

To situate chance within mathematical discourse required a social orientation and the establishment of more exact mathematical meanings of important language. We determined that this had to be done initially without the complication of assigning numerical value, and decided to begin by talking about the probability of everyday events. The decision is congruent with the Vygotskian principle of the bi-directionality of building scientific concepts (Vygotsky, 1962), and the notion from Legitimation Code Theory of 'powering up, powering down' (Maton, 2014).

5.2.2 Probability Scope and sequence

Scope and sequence are attached as Appendix 4.

5.2.3 The focus texts

Unlike science texts, where more extended cohesive and recognisable genres could be identified, the focus texts that supported the teaching of probability were more specific. Three focus texts were developed.

Focus text 1

Focus text 1 was a definition of probability, including a definition of 'event'. The definition of probability consisted of three parts: 'what', 'how' and 'why'. The definition of an event consisted of two: 'what' and 'tell us more'. This led us to spend time in the first lesson establishing meaning not just about what chance means, but also the meaning in mathematical terms of an event (anything with a verb), and the important message that prediction is about the future, and why anyone would bother to do this work.

Figure 6. Probability focus text 1: text structure

What
<i>Probability is the chance of predicting future events</i>
How
<i>by thinking about what we already know</i>
Why
<i>to help us plan for the future.</i>
What
<i>An event is anything that happens.</i>
Tell us more
<i>There are big events and small events, past, present and future events.</i>

Focus texts 2

When we began work on the chance continuum, these three sentence starters helped the teachers to use consistent language for describing chance so that students had every opportunity to talk and write a coherent mathematical sentence.

Figure 7. Probability focus text 2: sentence starters for probability

<i>There is a high / low chance that....</i>
<i>It is impossible that...</i>
<i>It is certain that...</i>

Focus text 3

The issue once we began studying a spinning wheel was how to describe the broader variables such as colour, number, shape and size, and how to describe the variables within those, such

as red, blue and yellow, or odd and even numbers. This focus text helped the teachers to use 'variable' for the broad choices, and 'options' for the narrow options.

Figure 8. Probability focus text 3: variables and options

The variable we are looking at is colour. There is a one in six chance that I will get a red, because there are four colour options altogether, and red is one option.

5.2.4 Changes in students' language use

The assessment text devised for Probability was to do with commonsense experience (See Appendix 1: the chance of rain in Maningrida). Five students selected completed both the pre- and post-tests. In the pre-test samples, two of the five students provided commonsense accounts with no clue that the topic was chance (e.g. *Um, um, rain. Raining for the next week and until the rain comes the ... and we can wet.*). In the post-test samples, all students attempted to talk about chance, (e.g. *There is a low chance because... There is a low chance recess time because at the school... Because there are no cloud at the air.*) Two students used commonsense rather than technical terms ('maybe', rather than 'high and low chance'). Almost all grammatical and lexical features increased in the post-test. Four of the five students expressed cause and effect using a clause beginning with 'because'. Four of the five students used verbs in future tense in the post-test, compared with one in the pre-test (e.g. *There is a high chance that it will rain this year cause it's the build-up and it often rains...*), and three of the five qualified a verb with an adverb (e.g. often) in the post-test, compared with 1 in the pre-test. Four of the five students used technical terms such as 'chance' in the post-test, compared with two in the pre-test. One of the largest increases was in the elaboration of sentences with circumstances of time (e.g. *rain will fall down next year, next week maybe*).

Five lessons is a short period of time to appropriate complex concepts like probability. The post-test shows changes in language use by all five students, representative of the range of student abilities in the classes. We had not predicted that students in Class 1 would get so far in the mathematical measurement of probability, so we have no assessment of the numerical language required as they moved from the everyday into the mathematical.

5.2.5 Reflections

Class 1, the higher performing, high attending class, worked from the everyday to the mathematical within one week. The lower performing class managed to produce some extended language when talking about everyday events, but did not have time to move into quantifying probability.

Some significant findings were:

The usefulness of the focus text to guide the target language: both teachers confirmed that narrowing down the language helped them stay focused, even though it was difficult at times:

One instance of interactive trouble occurred when one teacher moved from the everyday to mathematical idea of probability. He introduced a spinner which had both colours and numbers as variables (Extract 1):

Extract 1. Problem with variables [Probability, Lesson 4 lines 153-5]

- T What's one way that we could sort them, if I said sort them out? Alfie? We could-
- S Colours.
- T Colours. Okay, we could make a pile of reds. We could make a pile of green, a pile of blue, and a pile of yellows. So that's one **option**, that's one **variable**. I could say sort them by colours. What's another way?

It was apparent to the observers that the interchangeability of these two terms 'option' and 'variable' was creating confusion, and the issue became a point of discussion in our daily review and planning session with the teachers. We clarified the different roles of 'variable' and 'option' and firmed up the focus text. Our carefully chosen words were: *The variable we are looking at is colour. There is a one in four chance that I will get a red, because there are four colour options altogether, and red is one option.*

In the following lesson, the teacher put aside teaching about probability using a spinner until the students understood how to identify and isolate variables in objects, and understand that an object can be sorted using a range of variables. He had up on the board a large number of different shapes, with variables such as shape, colour, size and the following conversation occurred (with two word choices, variable and options in bold) (Extract 2):

Extract 2. The difference between variables and options [Probability, Lesson 5, lines 84-87]

- T It's what we decide to look at when we're thinking about what we already know. Okay? So we-- if I said to sort those into different groups-- we said colour. Colour would be one way you could those shapes, yeah? So colour is a **variable**, okay. And how many colour **options** are there? There's yellow, blue, green, and red. There are four colour **options**. Could we sort them into a different **variable**? If we're-- could we use a different variable when sorting those shapes? Ah, who hasn't had a go? Ah, someone else. What else can you see there? Apart from colour. Simon, what else could you see there? How else could you sort it?
- S Shapes.
- T Shapes. Excellent. Good boy. So shape is another-- what's that word?
- S **Variable**.

- T **Variable.** Fantastic. Shape is another **variable**. How many **options** are there? How many shape **options** are there? We've got a square. We can see a circle, triangle, star. Is there any other shapes?

The careful distinction between variable and option helped teacher and students to classify sets and subsets:

It has confirmed my understanding that it is critical to nail down specific language around a subject area when teaching in an ESL context. Although English as first language speakers can (usually) easily switch between different terms for the same thing (Greater chance, more likely, bigger chance, high chance, etc..) without losing understanding, Learners for whom English is an additional language cannot easily make this switch. It can overload the learner who has to attend to deciphering the different terms being used, rather than attending to an understanding of the concept.

The issues faced when beginning with 'everyday' events.

When trying to think up events that students would identify with easily, we chose some from school, such as the chance of getting lasagne for lunch (the cook provides lasagne at least once per week), but we also sought to draw on students' home experiences. This led to teachers asking questions such as

- *What is the chance that you will brush your teeth before you go to bed tonight?*
- *What is the chance that we will see a crocodile at the barge landing tomorrow?*

Here we discuss the most memorable and, in hindsight, what became for us the most problematic question, which was:

- *What is the chance that David's dog can speak Ndjébbana?*

The exchange took place in Lesson 3 with Teacher 2. The teacher was working through a set of prepared questions about probability with a small group of students (while another group of students completed the questions on their own). In this exchanged, the teacher asked the students to consider the probability of a statement about the dog that belonged to one of the students, David: *David's dog can speak Ndjébbana* (the language of David's family). For the teacher, the answer was straightforward: clearly it was impossible that the dog could speak Ndjébbana because dogs do not speak; they bark. This was designed to be an 'easy' question that the student could not get wrong.

David's response, however, was not as expected.

Extract 3. David's dog [Probability, Lesson 3 Lines 1-14]

Teacher *We're going to do this one. We're going to do number 7. (Points to chance questions on the board.)*

- T *No, we're going to do this one because I need to do an easy one with you. (Reads) David's dog can speak Ndjébbana.*
- SS *(Raucous laughter)*
- T *No, David's dog, we need to do this one. Here we go. David, can your dog talk?*
- S *(David nods.)*
- T *David is going like this (teacher nods his head). Look at me. He's saying his dog can talk. What does your dog talk?*
- S *Ndjébbana*
- T *Your dog talks Ndjébbana?*
- SS *(Laughing. Inaudible responses to David from students.)*
- T *No David, your dog only... David, your dog only... (points to sentence on board)*
- SS *...barks.*
- T *...barks. It doesn't talk. Okay? It doesn't talk English, doesn't talk Ndjébbana. Yeah. (Picks up card and holds up.) If it doesn't talk, never happens, what's the word?*
- SS *Impossible.*

We cannot know the motivation for David's response, and it is possible that he simply did not understand the question. However, we realised in retrospect it is quite possible that David understood the question perfectly well, but that he was considering it from a local cultural perspective, and attributing his dog with kinship status (Phelan, 2007) and therefore thinking of his dog as full a member of an Ndjébbana-speaking family. From a local perspective, therefore, it is quite possible that David's dog does indeed 'speak Ndjébbana'.

Other misalignments in conversations between the teacher and students seem to back this up. For example, students consistently claimed that they saw a crocodile 'often' at the barge landing, even though sightings are relatively rare. It is common knowledge that a crocodile lives near the barge landing. It was possible that the students' claim might be mere bravado, or that they might go down at night and see its eyes, or that there might be confusion in meaning; knowing the crocodile was there carried the same meaning for the students as seeing it there.

These confusions highlighted for us that we were on dangerous ground when we assumed shared premises with students whose world view and lifestyles were different from those of the teacher. First, there was a lack of agreement about what was 'highly probable'. The chance of children brushing their teeth before bed might be highly likely in the teacher's

house, but not in the students' homes, and students responded in a variety of ways. Second, the confusions ate up valuable class time and frequently led to a loss of focus: the class spent a significant amount of time trying to clarify and negotiate the premises on which predictions were based, such as who saw the crocodile, and who claimed they saw the crocodile, and who didn't swim at the barge landing because of the crocodile. The outcome of this confusion was that students began to lose confidence in their predictions of probability, and, we suggest, called out randomly rather than making an informed prediction. The teacher too, sometimes resorted to just telling the students the premise, in an attempt to move on.

Trying to work with commonsense experiences from home proved a risk point for the teaching and learning. The premises on which predictions of probability were made were very subjective, and the subjectivities were not shared between teacher and students. Not only did these questions not help to establish common knowledge in the classroom, in fact we went backwards. Moving to the quantification of probability by using numbers was something of a relief:

One of the issues for me at the end of this research week would be understanding the need for common understanding in chance scenarios, rather than using indigenous scenarios or Balanda (white-fella) scenarios as it relates to framing Probability questions. Several examples used during question time left students misunderstanding the question, resulting in the learning opportunity losing its potency. That might be ok once, but not twice or regularly.

It took time to establish the language of probability using commonsense events, and one teacher questioned the amount of time we spent on this. He wrote:

The students had much more success when we moved into numerical representations of chance (particularly using percentages), as opposed to using ranking terms such as low, even, high chance.

Our interpretation of the teacher's response is that the objectivity of working quantitatively meant that the class was working from a firm, shared foundation. The uncertainty of trying to work with everyday experiences had disappeared.

5.3 Mathematics Topic 2: Telling the time

5.3.1 Considerations

The students

Two classes undertook the topic of telling the time by analogue clock. The first was a Year 7 're-engagement' class, i.e. students who attended less than 70% of the time, and struggled to make sense of school. Their mean reading age and maths age (PAT-C and PAT-M) was Year 1. The second was a sub-group of Year 4-6 class of regular attenders with average attendance of 94%. By the second data collection period, their former classroom teacher had taken up a leadership position in the school. For the purposes of this research project, he withdrew the

12 Aboriginal students from the class for a total of four lessons. Their mean reading age was Year 3.

Rationale and goal

Telling the time was a curriculum objective set by the school for Term 1. We understand the frustration expressed by some teachers at having to use an analogue clock at all, because reading the digital clock is so much simpler. However, students can read a digital clock without any mathematical understanding of the time measurement system that it represents. The analogue clock represents time in three scales: one full rotation of the short hand measures 12 hours; one full rotation of the long hand measures one hour; and one full rotation of the second hand measures one minute. We isolated each scale and taught it separately, deciding it gave students the best chance of consolidating the concepts involved.

As explained in our discussion of teaching probability, drawing on students' home experiences created a level of uncertainty because of differences in values and world views. For this reason, we resolved to only draw from experiences shared by students and teacher, so that the risk of misunderstandings was reduced. In the context of Maningrida, there was no certainty that children had a meal-time and bed-time routine set according to the clock, so it was meaningless to use that as an example. That meant that we could only talk about the school day, probably the arrival of the plane, and probably the span of a football match, had it been the right time of the year.

Our theoretical approach leads us to avoid positioning 'failure to know' as the responsibility of the students. To gain some understanding about perceived failure of students to engage with clocks and measuring time, and to consider where we might start with the teaching, we spent time with the teachers discussing: (i) the place of measuring time in the students' lives; and (ii) the social and historical motivations that underpin the place of time measurement in the maths curriculum.

Over the centuries, many cultures have invented mechanisms to divide the day evenly into units of time (Grattan, 2016). We wanted to find a way of making explicit the cultural, social and economic motivations for artificial time-telling without necessarily going into a detailed history. At the same time, we wanted to think beyond the most superficial reasons for time-telling: that if you cannot tell the time you will be late for events, and you will not be able to function in a workplace. While these are valid reasons, they are unlikely to be motivating for children who live in a social context where people are not reliant on clocks. Importantly, we could not assume that students share the value system of a post-industrial culture, in which 'being on time' is implicitly understood as a positive virtue.

After some discussion with the teachers we settled on an account of time-telling that fit with the social historical facts and which we thought would carry some weight in the intercultural context of school at Maningrida: that measuring time is most important when large groups of people organise themselves to carry out activities together, such as participating in a school

(as a teacher or a student), or creating and making use of a transport system, attending any kind of workplace. Because such collective activities require people to be present at the same time, not observing the agreed times is disruptive to the activity of others. In other words, 'being on time' is a respectful way to be with others, and it allows organisations to function smoothly.

We agreed that we could use this account to 'make sense' of time-telling with the students, and to help build a shared understanding not only of the conceptual basis for understanding a clock, but also of the social motivations for using the clock.

Vocabulary

The Australian Mathematics Curriculum stipulates that students first *tell the time to the quarter hour, using past and to*. Linguistically, this supposedly simple first step creates complexity. Students would have to first use fraction vocabulary, then shift to telling the time by skip counting, then another shift to digital time-telling. The students were not strong on fractions, and could skip-count by fives, so the language we settled on was to state the hour first and the minutes second, and to focus on 'past' (e.g. 20 past), not 'to', in the four lessons available. This language set up a clear trajectory from analogue to digital clocks.

Time constraints

We acknowledge that the scope and sequence outlined here is incomplete. This is due to the constraints of time, and because it took a relatively large percentage of the available time to establish the underpinning knowledge. There was an expectation that the teachers would continue building the topic and practising with the students beyond the time frame of our recording period.

5.3.2 Telling the Time Scope and sequence

The scope and sequence of these lessons are attached as Appendix 5.

5.3.3 Focus texts

A series of focus texts guided each stage of the topic. They are introduced in Figure 9:

Figure 9. 'Telling the time' focus texts

The hour hand takes 12 hours to move around the clock face. Because there are 24 hours in a day, the hour hand moves around the clock face twice each day.

The hour begins when the hour hand points straight to a number on the clock face. It stays that hour until it clicks over to the next number.

There are 60 minutes in an hour. The minute hand moves around the clock face once every hour. There are five minutes between each number on the clock face.

When we read the time, the hour goes first and then the minutes past and a divider in between.

5.3.4 Changes in student language

Six students completed both the pre- and post-tests: three from each class, identified as low, middle and high performing students. Three students could recognise 2 o'clock in the pre-test. Four recognised 2 'clock in the post test. No students recognised 2:20 in the pre-test, while three could say 2:20 in the post test. When I asked students how they had reached that answer in the post-test, 4 used the word 'skip' or demonstrated skip counting. Three students used a time clause beginning with the conjunction 'until' in the post-test compared with only one in the pre-test. The biggest improvement was in the use of technical language: clock face, hour hand, clicks, day and so on. Five students in the post test extended a phrase into a sentence by beginning with 'there are' instead of launching straight into the content words, compared with two in the pre-test. There was also considerable expansion in the messages about time provided unprompted in the post test (i.e. what can you tell me about a clock?).

The table below (Figure 10) provides one example of a student's responses. The target text, read twice by the researcher before the students had to repeat, is in the first column. The second column shows the pre-test answers of one student, as an example, and the third column shows the post-test of the same student:

Figure 10. Example of one student's responses in pre- and post-test

Target text (read by researcher)	Student pre-test	Student post-test
There are 24 hours in a day. The clock face measures 12 hours.	<i>24 days the clock turns into...(Did not finish repeating the sentence.)</i>	<i>There is 24 hours in a day. The clock face turns into 12.</i>
Each day the hour hand goes around the clock twice.	<i>Each day the hour clock... Each day the hour clock. (Did not finish repeating the sentence.)</i>	<i>Each day the clock face goes around on... Each day the clock face turns around each day.</i>
When the hour hand points to a number, it starts the hour. It stays that hour until it reaches the next number.	<i>When the hour clock turns... When the hour clock turns ... (Did not finish repeating the sentence.)</i>	<i>The hour hand stays that number. It points straight at the number. It clicks to a next number.</i>

This student has moved from simply repeating the first phrase heard in each sentence and being unable to complete the sentence, to using full sentences. She has used 'There is...' to

begin the sentence, she is using phrases of time and location (into 12; each day; straight at the number; to a next number).

In summary, after four lessons, there is evidence across students of an increased use of lexical items, but not cohesive devices.

5.3.5 Reflections

Using shared experiences: our decision to draw on shared experiences as examples of time use proved to be more reliable in the second research period, as we had hoped. The teachers restricted their examples of artificial time use to the school context and to catching the plane. Unlike the probability topic, here was no evidence of interactive trouble caused by the confusion of differing perspectives.

This included developing with students a lived sense of how long a minute, a second or an hour' actually are. For this, the teachers created practices, such as 'everyone sit completely still for one minute', 'let's time how long it takes to walk from here to the other classroom', and 'When we have assembly on Friday, let's notice how long it takes, because it usually takes about an hour.' We note that these kinds of experiences and observations need to be repeated over a much longer period than one week for the students to be able to develop an experience-based recognition of these units of time.

The mnemonic function of focus texts in mathematics: there was a clear purpose in using focus texts in the teaching of mathematics. In this remote ESL context, focus texts helped enormously in anchoring teacher language so that students had many opportunities to hear it, to appropriate it, and to use it to continue to negotiate meaning. However, the end goal of telling time, as we soon realised, is not to use extended oral or written texts, it is to be as succinct and efficient as possible. Time is represented in numbers such as 2:40pm. We observed the focus texts, once recorded in written form, become a mnemonic for students when they were beginning to tell the time. When they got stuck, they could retrieve the language and use it as self-talk, talking their own way through the process of using a clock.

Working multi-modally: to create meaning, the teachers worked systematically across semiotic systems. They moved from a real clock, to students' handmade clocks, to jointly constructing a written text which remained on the board for reference, to the worksheet. When there was any doubt in meaning, they would shift back from the worksheet to the focus text written on the board, to the student-made or real clock.

In the teaching, the movement between the concrete object (the clock), talking about the time (and getting the students to say the words) and the written versions of the language (numeric and in words) was vital for keeping the meaning at the forefront. With every iteration, the meaning had the potential to be deepened.

5.4 Science at Cowandilla - summary

Science was nominated as the learning area at Cowandilla Primary School because it matched school priorities. The science topics for the year had already been set, and these two topics; Electric Circuits and the Lunar Eclipse were the nominated term topics.

Unlike the Maningrida context, Cowandilla classrooms are more complex, because of the diversity of their students and the range of world views which they represent. We could not possibly familiarise ourselves with all those different cultural perspectives. There was such a range of students in the classes: those to whom science is completely foreign, those for whom science is a passion, and some students in between. One of our responsibilities was to ensure that, through this project, we paid attention to the needs of the silent marginalised students.

5.5 Science Topic 1: How an electric circuit works

5.5.1 Considerations

Students

Two classes participated in the work on Electric Circuits: a Year 5/6 class with a median reading age of Year 6; and a year 6/7 class with a median reading age of Year 7. Approximately 70% of students were English as Another Language or Dialect (EALD), and the average attendance rate was 92%.

Rationale and goal

Electric circuits rely on the release of electrons from an atom, so it made sense to the research team that students had to know, as prior learning, that matter was made up of atoms, as well as the structure of an atom. There was consensus to teach this first.

Vocabulary

There were two big challenges in this topic. The first was for students to understand and to trust the concept of all things as 'matter', consisting of atoms, even though they are not visible to the naked eye. The second challenge was the shift to understanding everyday objects as part of a broader generalisation, a taxonomy. For example, things became matter; wires became conductive material; a lightbulb became a load, and a battery became a power source. Because so many concepts had to be defined, there were also a number of expanded noun groups, defining very specifically, for example: *the flow of negatively charged electrons, called a current, moving from atom to atom in a circuit.*

5.5.2 Electric Circuits scope and sequence

The teaching scope and sequence is attached as Appendix 6.

5.5.3 Focus texts

Below is the text without illustrations (Figure 11). The complete version with diagrams is attached as Appendix 7.

Figure 11. Electric Circuits focus text

All matter is made up of atoms. Inside each atom is a core or nucleus made up of protons and neutrons. Orbiting around the nucleus are electrons. Protons have a positive charge. Neutrons have no charge. Electrons have a negative charge.

Electricity is the flow of negatively charged electrons, called a current, moving from atom to atom in a circuit. A circuit consists of three essential components: firstly a power source such as a battery; secondly material(s) to carry the current, such as wires; and thirdly a load to use the electricity; for example, a light globe or a motor. A switch is a fourth component which can be added to make or break the circuit, switching the load on or off.

In an electrical circuit, a force is needed to push the electrons around the circuit. This force, which is called the voltage, comes from the battery. The electrons flow from the negative terminal of the battery, along a wire to the load, then along another wire to the positive end of the battery. If the circuit is broken by a switch, the electricity stops flowing.

5.5.4 Changes in student language

Three students; who ranged from low, to middle to high performing, were selected by each classroom teacher for pre- and post-assessments of scientific language use. The researcher read small pieces of text twice, accompanied by a diagram, and the students were asked to repeat the language as closely as they could. The same text was used before and after the topic was taught.

The biggest difference between pre- and post-tests was the use of technical language, with students increasing from an average of 4.7 technical words per test to 9.5 technical words, compared with a possible 10 in the model text. The number of expanded noun groups also increased. These noun groups were definitions, and the components of an electrical circuit, with each component expanded with its function or an example (such as...). This increased from an average of 1.8 instances per text to 3.8 per text, compared with a possible 5 in the model text. Circumstances of place and manner also increased, due largely to the use by one student. All students used at least once circumstance in both pre- and post-tests. All students put 'electricity' in theme position in the definition in the post test, while two out of the six students omitted this in the pre-test.

The students who had problems with deictics (*a* and *the*) in the pre-test had problems with deictic in the post-test. This is a common issue with EALD students and needs to be worked

on over time. Three grammatical structures which appeared in the model text did not appear in most students' pre- or post-tests. Two of these structures assist with lexical density. The first was the use of the dependent clause beginning with the non-finite 'moving'. Only one student used this in the post-test. The second grammatical structure was the inclusion in the one sentence of the generalisation 'components', followed by examples. The third grammatical structure assists with the logical sequencing of the text. The rheme (last part) of one sentence appearing as theme (opener) in the next sentence e.g. *...in a circuit. A circuit consists of...* Most students did not use this structure.

5.5.5 Reflections

Lesson coherence and flow

This research project is strongly influenced by the work of Bernstein, including his notion of the four pedagogic quadrants: progressivist 'discovery' pedagogy; traditional transmission pedagogy; emancipatory critical pedagogy; and socio-cultural, language based pedagogy (Refer Theoretical Framework Section 2). In Australia, the ongoing debate in science education is between progressivist enquiry-based pedagogy, held up as best practice, and the traditional chalk and talk pedagogy (Goodrum, 2000). Our research project investigates the enactment of socio-cultural, language based pedagogy in science. However, there is a tension between what counts as a 'good' discovery science teacher, and what counts as a language focused, scaffolding science teacher.

To demonstrate this tension, we would like, with the teacher's permission, to contrast the first lesson of this topic in one of the two classes, with lessons later in the week. The teacher was thoroughly prepared. He had found a number of relevant YouTube clips, and prepared materials for several activities to develop the concept of an atom, as well as the history of the development of electricity. He had the sequence of activities carefully laid out so there was no lost time moving from one to another. The lesson was launched. Videos were played in sequence. Often the language on the video was very fast, with an American accent and unfamiliar vocabulary. The size of a proton was likened to a blueberry in a football field. While the teacher responded to aspects of the video, explaining the significance of what the students had seen, he did not share the purpose, preparing the students for what they were about to see, to draw their attention to the anticipated learning from the video. The class jumped from one activity to another, each with a different purpose, but the language to tie these activities together was scant. A frequent strategy was for the teacher to ask a question, and ask students to quickly talk to their neighbours to develop a response, a strategy known as 'Think-Pair-Share' (SCTL, 2017).

The teacher's preparation had been exemplary, as was his respectful and positive interactions with students. His understanding of and enthusiasm for the science was a great contribution to the project. Yet the lesson left us with many questions. The biggest issue was coherence: the lesson jumped from activity to activity, with little language preparing the students for what

they were about to watch or do, nor making the links between activities. Another issue was pace: there were so many video clips, and we questioned the necessity of some of them. Not every concept requires hands-on activity or entertaining visuals. For example, to emphasise the size of an atom, it is more efficient to say '5 million million atoms would fit on a pin head' than to spend time tearing paper into small pieces. The practice of getting students to talk to a neighbour for a few seconds, then feedback to the class, seems to be a common progressivist practice in the name of student voice, and not letting the teacher dominate. We question whether this practice at the beginning of a new topic helps students to develop understanding, or to use appropriate language. There is little time for any depth of discussion, and no chance of guidance by the teacher for those students who have no idea. It appears to be a high energy, high engagement activity, and the cooperative students in this class were willing, but the danger is a consolidation of what Bernstein calls 'Spon-tex' (2000): the perpetuation of spontaneous commonsense language with no mechanism for moving to the technical.

In our opinion, this lesson would have been fine for students who were already oriented to science and electricity, but would have left the marginalised students still on the outer.

We expected our meeting at the end of the day to be difficult, but it was very positive. We reiterate our gratitude to both the Cowandilla teachers for their commitment, their willingness to listen and negotiate, and their understanding of scaffolding which helped us to overcome this hurdle. We would now like to describe a beautiful sequence of activities which followed in later lessons. On the surface, they did not look any different. Students were engaged in activities, they were talking together, but the shared purpose and coherence were very different.

After learning about how electricity worked, the students had the task of making an electric circuit. Before they were given the materials, the teacher did a demonstration, labelling each component with technical terms and checking for handover of understanding and specific vocabulary. The light was a load, the battery was the power source and so on. He emphasised that there had to be a clear connection at each point so that the electrons could move freely and create a current. The language of the focus text was evident in his talk.

Students then worked in pairs with their own materials to make an electric circuit. As they did, the teacher moved around the room, helping out and checking for handover of language. Students took a photograph of their circuit with their iPad™. The whole class then negotiated the construction of a written text that described the components of an electric circuit (focus text paragraph 2). Using the software 'Explain everything', each student imported the photograph, then recorded their own description of an electric circuit as a voiceover to the photograph they had taken.

To learn how to represent an electric circuit in a more technical way, students then used the drawing capacity of 'Explain everything' to produce a labelled, technical drawing directly over

the top of the photo before removing the photograph. By this time they had also jointly constructed a text on how an electric circuit works (focus text paragraph 3), and they used this as the prompt for another voice over, this time an oral explanation.

One observable difference in this sequence was the gradual move from the concrete to the abstract, that is a shift from concrete materials, to 2D, to language doing the hard work. Another difference was the way the teacher used the focus text to keep consistent language, and the way he slowed down the pace of the lessons to provide time for students to appropriate that talk. There was clear purpose and direction in the activities.

Appropriation of grammatical structures

Student uptake of new technical vocabulary and simpler grammatical structures, such as extension with phrases of time and space was impressive. However, in the five lessons available, we could not fit into the teaching sequence a specific grammar lesson to explicitly teach the more complex grammars such as non-finite clauses. We expected that students would not intuitively take up these new language structures, and resolved to try to include a grammar lesson as part of the teaching sequence during the next research phase.

5.6 Science Topic 2: The Lunar Eclipse

5.6.1 Considerations

For the 2017 year, the two teachers involved in this project had joined their classes into one, a straight Year 7 class, which they team taught. There were 42 students in the class. 73% of students were EALD, with attendance at 92%. The median reading age (PAT-R) of this class was Year 7, with a range from Year 3 and 4 (22%) to Year 7 or above (71%).

Consequently, instead of the planned 10 lessons, we videoed 5 team-taught lessons. One teacher predominantly taught the science content, using activity accompanied by language from the focus text, while the other teacher took responsibility for moving language into writing (note taking, joint construction of model texts, and text analysis).

5.6.2 Lunar Eclipse scope and sequence

The scope and sequence is attached as Appendix 8.

5.6.3 Focus texts

The focus text is attached as Appendix 9.

5.6.4 Changes in student language

Seven students were selected from this combined class to be involved in the pre- and post-tests. For some of the students, the challenge of a prompted test, repeating an explanation sentence by sentence, was low. For this reason, a further independent, unprompted sample of an explanation of the lunar eclipse was also collected before and after the teaching period.

The average use by students in the prompted sample of almost all targeted grammatical and lexical items increased between the pre- and post-tests, with the exception of the pronoun *this*, which all students used in both pre- and post-tests. The largest increases were in the use of circumstances of time, place or manner and in dependent clauses of time.

The independent unprompted pre-test was taken before the teacher began the lunar eclipse lesson, and the post-test at the end of the week after the final lesson. Importantly, no students could correctly and independently explain how a lunar eclipse occurred before the week began, and five out of seven had the correct science at the end. Their independent spoken texts had moved along the register continuum towards more scientific, authoritative language in all aspects, and because this language was independently produced, the changes are more remarkable. The instances of colloquial language such as 'like, and, so' with a predominance of simple and compound sentences was reduced by 33%. There was an increase in circumstances of time, space and manner, and significantly the use of dependent clauses, both non-finite clauses beginning with the -ing form of the verb, and clauses of reason and time, beginning with 'when', 'if' or 'because'. A big increase in the use of technical terms was also observable, with some students using terms such as 'umbra', 'refracting' and 'penumbra' which did not appear in the focus text, but had been mentioned during the week.

5.6.5 Reflections

The shift from hands-on activity to language. There was a clear direction across the week from engaging students in understanding the lunar eclipse with video and role play to meaning making through language. The teachers had a strong control of the focus text, and used it consciously. Two important developments in this research period were the more sophisticated use of taking notes, and the text analysis-/grammar lesson.

While notes were taken in the previous topic of electrical circuits, this time the notes organised information in preparation for writing. Figure 12 shows the notes scribed by one of the teachers while the other teacher led the lesson:

Figure 12. Using notes for text construction



The teacher shifted meaning to another level of abstraction at this stage, by labelling the lunar eclipse as a 'phenomenon', labelling the direct alignment required for an eclipse as 'a condition', and the casting a shadow on the moon as an 'effect'. This metalanguage began to give students a framework inside which they could write their own explanation.

The production of the metalanguage moved to a formal text analysis, when the second teacher displayed the text, involved the students in organising the text alongside its increasingly familiar labels (working at sentence level), then looking inside each sentence to identify the grammatical features that needed to be explicitly taught.

Figure 13. Text analysis of jointly constructed text



The increasing use of scientific language by students as this topic progressed was exciting, and they were able to use the language independently to continue to discuss the influences on the eclipse such as the tilt of the moon. Two qualitative differences in the teaching of this topic when compared with the Electric Circuits topic were the careful construction of class notes to assist with the structure of future writing, and the explicit teaching of grammar before students were sent off to produce written and oral assessment texts.

Working multi-modally The cohesive planning and teaching of this topic was evident in the way that the teachers worked with their multi-modal resources. Often the sound was turned off on the video, and the teacher would start and stop, explaining what was about to come in the video, explaining as he went, and replaying to build meaning. Many of the videos and diagrams had representations of different scales and perspectives. The teachers left nothing to chance: explaining that, for example, that this view of the earth is taken from the moon; that the sun is implicit in this diagram - we can see the rays, but the sun has to be imagined off the page; that the earth only has one moon, so the many moons shown here represent the different phases of the moon as it orbits the earth.

As the teachers moved from video, to diagram, to role play of a lunar eclipse, to a demonstration with a hoop and balls, the goals were clear, and they very skilfully handed over the language to students.

6 Lesson analysis

In Section 4.2.4, we introduced the Three Lenses observation tool (attached as Appendix 2a), which we initially designed to support our work with teachers in planning and reflecting on their classroom practice.

In this section we extend our use of the tool to serve also as a framework for analysing classroom talk. We will demonstrate that the tool is useful for helping us to identify, examine, and describe the elements of teacher talk and the pedagogic choices that contribute to effective scaffolding. Importantly, the lenses make scaffolding observable as a dynamic process, in which the pedagogic choices are contingent and changing across time.

In the following sections, we present each lens in turn, illustrating the discussion with examples from the lessons at Maningrida and Cowandilla.

6.1 Lens 1: Shared Purpose

Looking at the lessons through the lens of 'Shared Purpose', we ask the question:

What are we doing together; what are we talking about and why?

Shared Purpose brings into relief the ways in which the academic purpose of the topic, and the specific purposes of the lesson, are collectively shared amongst the class. We can observe Shared Purpose when the pedagogic goals are clearly stated by the teacher at the start of a lesson or the lesson sequence and then reiterated and elaborated throughout.

Shared Purpose involves much more than the organisational talk that choreographs a class, such as 'Everyone get their books out', or 'Next we're going to get into small groups.' The teacher's role in creating Shared Purpose is to build alignment in discipline-specific and academic ways of thinking, making his/her mindset explicit, establishing common ground and helping students to make sense of academic content. This is particularly important with students, like many in our study, for whom the purposes of schooling are not self-evident.

We observed that teachers realised Shared Purpose in a number of ways, and we characterised these with the following headings:

1. Look back, look forward
2. Frame the topic and activity as academic
3. Use written or visual texts to focus students' attention and support the goal.

We discuss these elements in the following sub-sections, exemplifying with extracts from the 'Telling the Time' (Maningrida) and the 'Lunar Eclipse' (Cowandilla) lesson sequences.

6.1.1 Look back, look forward

To share the lesson purpose with students, the teacher needed not only to state the purpose of the lesson and where it was going, but also to contextualise the stated purpose within the context of previous learning or experiences, so that students had some way of positioning themselves in relation to the progression of the topic. We referred to this as ‘Look back, look forward’.

In Extract 4, the teacher introduced the week’s work. Before beginning to talk, he had projected a diagram of the sun, the earth and the moon on the white board.

Extract 4. Looking forward to stating the focus within a context of the known. [Lunar Eclipse, Lesson 1, line 13]

- T *So the key words that we're going to be investigating in this unit of work are seasons and eclipses. For the first-- for the lessons that we're doing with the filming, we're going to be focusing on eclipses. Eclipses have to do with earth and space science, space sciences, and we're going to be looking at the relative positions, or the positions of these three things. What are these three things on the image here? Caleb, do you know [Refers to diagram of sun, earth and moon].*

In this extract the teacher looked forward by stating the longer-term topic for the unit of work (seasons and eclipses) and then noted that the next few lessons would focus on eclipses. He powered his language up to foreground the relevant technical language (*eclipses, space science, relative positions*), and then looked back by using the projected visual image to help the students locate this talk within what they already knew by asking, ‘*What are these three things on the image here?*’

We also observed ‘Look back, look forward’ when, with each new lesson, the teacher checked previous learning before moving on. The teacher prepared the new learning by asking the students to recall previous conversations, and, in doing so, reiterated, consolidated and broadcasted the academic purposes that had already been established. In Extract 5 below, for example, the teacher first drew the students’ attention to the salient part of the clock (the clock face), before reminded the students to think about what they already knew about the purpose of the clock (*‘This clock helps us to measure time’*).

Extract 5. The function of a clock [Telling the time Lesson 3, lines 9-11]

- T: *So this big round bit here's the clock face [gestures around the circumference of the clock face] Fantastic. And we use a clock to do what with time? We spoke about time. Now, remember, we spoke about a time[...]. We use a clock to do what with time?*

S: *Measure time.*

- T: *You are a champion. Excellent. Measure time. So just like you would measure the length of your book or measure from here to the airport in length, this clock helps us to measure time.*

Importantly, we observed ‘Look back, look forward’ not only at the start of a lesson, but also within a lesson, at moments of transition between activities when meanings and purposes

could easily dissipate for students if the teacher did not work to explicitly maintain them. For example, in moving from a whole-class discussion to a worksheet or small group-based activity, the teacher could not assume that all students could do the mental work of remembering the lesson focus, and applying it to the new activity. So it was important that the teacher could reiterate, and create links between the purpose and the 'here and now' of the lesson.

Extract 6 illustrates a transition from class discussion to the hands-on activity of making clocks out of paper plates.

Extract 6. Shift from 'hands-on' to purpose [Telling the time: Lesson 1, line 466]

T: *Now, the reason we're making this clock is because we're gonna have a look at the clock works and how it actually measures time. Now, I said the clock measures time. It measures a certain amount of time. Boys, what does the clock measure?*

Importantly in Extract 6, the teacher's commentary moved the students' attention beyond the basic hands-on focus to remind the students of *why* they were doing the activity: '*We're gonna have a look at how the clock works and how it actually measures time*'. In this way he connects the activity back to the cumulative goal of the lesson sequence.

6.1.2 Frame the topic and activity as academic

Shared Purpose was also observed through the teacher's discourse in orienting students to the academic focus of the lesson. We observed how the teacher aligned the topic and classroom activities with the role of the scientist or mathematician. Similarly, we could observe how teachers shared their own thinking about topic, and especially how they foregrounded the kind of 'scientific' or 'mathematical' thinking they wanted the students to appropriate, sharing what was most important about the topic with the students, and particularly the 'why' as well as the 'how'. We also noted the foregrounding of the relevant academic language, and the promotion of this language as part of the learning goal.

In Extract 7, the teacher 'lent consciousness' about scientific thinking to the students, thinking aloud that '*we have to be careful*' of the language we use, as everyday expressions like '*the dark side of the Moon*' could lead us to misconstrue the relationship between the moon and the sun. His question '*it just depends on where the moon is in relation to the --?*' then re-oriented the students to a more scientific way of thinking.

Extract 7. We have to be careful about our language [Lunar Eclipse, Lesson 2, line 593]

T: *No, so, so we have to be careful about our language because people often talk about the dark side of the Moon. There is no dark side of the Moon. It just depends on where the Moon is in relation to the --?*

In Extract 8, the teacher oriented the students to the task of using previously constructed notes to help them write their text as '*that's what scientists do*', simultaneously highlighting the technical terms *explanation*, *phenomenon*. In this way he gave a purpose to the activity

that went beyond the level of a teacher-instigated classroom exercise, flagging the much higher-level scope of the work of the competent scientist.

Extract 8. That's what scientists do [Lunar Eclipse, Lesson 5, line 7]

T: *So, like Louise has just said, we want to see if you can use the information-- some people might just be able to remember it, some people might need a reminder. Remember that's what scientists do is they take notes to help them remember the things they think they might need some help recording in their writing, or in their explaining, or their explanation, about a particular phenomenon.*

Again, in Extract 9, the teacher shares his thinking and invites the students to join him ('*and I want a nod from you if you're the same*') as he shares his way of thinking about the moon, and aligns this way of thinking with '*scientific reason*'. Importantly, by the end of this statement, he has also attributed this way of thinking to students as well as himself ('*you're actually thinking ...*').

Extract 9. Thinking about the scientific reason [Lunar Eclipses, Lesson 5, line 74]

T: *Hands up if you've been looking at the moon as part of your moon homework? Keep your hand up if you looked at it last night. So I don't just look at the moon anymore, and I want a nod from you if you're the same, I'm looking at it thinking, "Ah, it's different amounts of light, there is more of this part in the shadow and this part's in the light." Hands up if you're now looking at it differently and you're actually thinking about the scientific reason for what you're seeing? That's excellent.*

Emphasising the academic orientation to a topic can begin with helping students understand the purpose of simple shared experiences, and relating these experiences to the academic goals and language. In Extract 10, the teacher creates an academic purpose for the class experience of timing their walk between two classrooms, reminding the students of what they did, and reframing the memory with '*So it's really important to remember*'. Having used everyday language thus far, ('*it's gonna be about the same time*') he then powers up to the mathematical language of '*even measurement*'.

Extract 10. An even measurement [Telling the time, Lesson 3, line 13]

T: *So if, if it was two and a half minutes yesterday to get to Robert's room, and we walked back the same way, it's gonna be about the same time, isn't it? 'Cause time itself doesn't change. It's the same, isn't it? Yeah? Okay. A-and we could have run. If we'd have run back, that would have changed the time. But walking; the same time. So it's really important to remember that time is even measurement. It's an even measurement that stays the same.*

In a further example (Extract 11), we can observe the teacher foregrounding the '*why*' of telling the time, embedding the technical skill in a social context that is accessible to the students. In doing so he acknowledges that he is asking the students to think in a way that is not easy, makes the task manageable by powering down to everyday language, but then returning to the rationale of the topic: '*And that's why we measure things*'.

Extract 11. And that's why we measure things [Telling the time, Lesson 3, Lines 120-120]

T: *Can anyone think about why we might measure things? Why is it better to say, "I'll meet you at 1 o'clock," than to say, "I'll meet you at the daytime"? Liam? It's a tricky question, okay. [...] This isn't easy thinking. It's not straightaway, "Oh, I know the answer." It takes some real thinking. Why would it be important for people to measure time? Remember when we said more accurately, so that it's more accurate, rather than to say, "I'll meet you at lunchtime," or, "I'll meet you in the daytime," or, "Let's do that at night time." Liam?*

S1 *because if someone just said, "Meet me in the daytime," they wouldn't know what time.*

T: *That's exactly right.*

S2 *To meet*

T: *That's right. Liam might be thinking, "Oh, yeah. 3 o'clock, that's daytime." I might be thinking, "Lunch-- uh, midday, that's daytime." Are we gonna make it the same time then?*

S3 *No.*

T: *No.*

S4 *Yes, but you might.*

T: *No but we might. There's a chance we might, but we want to make sure. And that's why we measure things, is because we wanna make sure.*

6.1.3 Use written/visual texts to focus students' attention and support the goal

The third element of Shared Purpose is concerned with the ways in which the teacher directs students' attention to specific features of written texts, visuals, written vocabulary and links these to the lesson purpose.

Clearly there is crossover between this element and the other elements of Shared Purpose, as a number of our earlier examples have involved teachers using various kinds of texts to support meaning making. Our specific concern here is that the potential for students understanding the lesson purpose can be maximised when the teacher draws their attention to supporting texts in effective ways. Often a visual image is a direct and efficient tool for reminding students about a topic, and for focusing students' attention on a key idea, as in the following example, where the teacher uses an image to prompt students to recall 'a really key point'.

Extract 12. 'This image here was helping us talk' [Lunar Eclipses Lesson 2, line 289]

T: *Earth is one of the planets in our solar system. Now does anybody remember what this image here was helping us talk about and remember? A really key point for when we come to eclipses.*

A video can serve to communicate complex information, but it is most important that students are oriented to the purpose for viewing the video, and to which bits of information will contribute to their learning goals.

In Extract 13 the teacher uses a still image to focus students' attention on the relevant concept and language ('*they're not in direct alignment, are they?*'), before foreshadowing not only what they are going to see, but also what he wants them to focus on (*So I want you watching...*), and why the animation is relevant (*That's why we don't always get a lunar eclipse*). In this example it is clear that watching a video is not a substitute for working with technical language: throughout this explanation the teacher continues to present the technical terms *direct alignment, orbital path, lunar eclipse, the moon's orbit*.

Extract 13. Orientation to the teaching purpose of a video [Lunar Eclipses Lesson 5, line 214]

- T: And also they're not in direct alignment, are they? So we could draw a line through the centre of the sun and the centre of the Earth, but line would continue in the shadow. So, remember, and I'll just-- I'll press play in a moment, so we're going to see that white line, which represents the orbital path, move position-- or change its orbital path, so that the orbital path ends up in the shadow. That's why we don't always get a lunar eclipse. So I want you watching that side of the orbital path over here, and I want you to see what happens as time passes in relation to this part of the, uh, moon's orbit, moving into the shadow.

In teaching mathematics, a 'hands-on' tool such as a real clock, large enough to be seen easily by the whole class, provides an obvious and essential support for teaching students to tell the time. At Maningrida, however, given that telling the time was quite new for many of the students in our research class, it was important that the teacher not simply assume that students knew how to 'see' the clock, even after they had been working with it for some time.

Figure 14. The hour hand is pointing to the 2.



The following extract (Extract 14) is taken from Lesson 3 of 'Telling the time', where the teacher systematically checks that everyone knows how to make sense from the clock face. Although this is not new material, the teacher makes no assumptions that all the students are familiar with every symbol on the clock. Rather, he takes the opportunity to remind the students of the complexity of the symbolic systems on the clock face (*this is a really ingenious invention... it's a super clever machine*) and broadcast the necessary understandings to those

students who might be less certain. At the start of this conversation the teacher takes care, once again, to share the purpose of using the clock [*'This clock helps us to measure time'*], so that the lower level identification questions [*'It's got, what?'*] are contextualised in the learning goal.

Extract 14. Contextualising questions in purpose [Telling the time, lesson 3, lines 9-22]

T: *So this big round bit here's the clock face [gestures around the circumference of the clock face] Fantastic. And we use a clock to do what with time? [...]*

S1 *Measure time.*

T: *You are a champion. Excellent. Measure time. So just like you would measure the length of your book or measure from here to the airport in length, this clock helps us to measure time. Now the clock-- this is a really ingenious invention. What do I mean by ingenious? I mean really, really super clever [pointing to head]. Okay? So it's a super clever machine. [...]*

--can we talk about why this is so super, super clever? Number one is, as, [...] Kendon so rightly said, it measures the time. But it's got a lot going on. It doesn't just measure one part of time. It's got all these different things happening. It's got dots. Let's talk about-- what else can we say? It's got the dots [points], it's got, what?

S2 *The numbers.*

T *Numbers [points], yep. It's got--*

S3 *Second, uh--*

S4 *Hands.*

T *What are th-- hands. Fantastic. Should we-- should we name the hands? What are the hands again?*

S5 *Hour--*

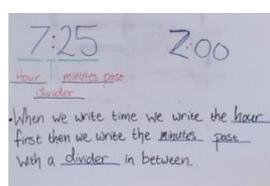
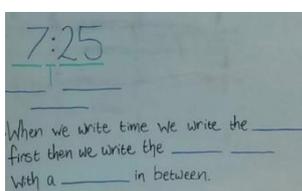
S6 *Minute, second, hour.*

S7 *--minute, and second.*

T *Awesome.*

In Extract 15, a conversation about reading the numeric representation of a time involves the integration of several modes of meaning into the conversation: numbers written in a conventional form to represent time, and the oral and written labelling each element of this representation (Refer Figure 15). Creating a written label for each element is a helpful visual way of reinforcing the vocabulary.

Figure 15. Written cloze activity around recording the time



The conversation is more than a mechanical labelling exercise, however; the teacher takes care to remind the students of the important point to remember: *'And that's a really important thing to remember, okay? It tells me how many minutes past [points] the hour of seven'*. He also flags the importance of the words for the next activity: *'Now, those words are gonna help us write the next sentence.'*

Extract 15. That's really important thing to remember [Telling the time, Lesson 3, lines 275-289]

T *Have you got eyes here? Really important you make sure that you're reading. Next one I'm gonna be asking you lots of questions, okay? [...] The first thing we need to do is remember the labels. What each part of the time-- remember, we said there was three parts when we write time? Who can remember those three parts? We said-- what does this time say? Who can read it for me? [points] 7:25. Now in that 7:25, what's the seven representing? The seven is what? Is it telling me, what?*

S4 *Hour.*

T *The seven is the--?*

S? *Hour.*

S1 *Erica? Hour. Fantastic. So we put the hour [writes label on board]. Uh, now what's the 25? [points]*

S6 *Minutes.*

T *The 25 is the--?*

S? *Minutes.*

T *Minutes. Thanks, Joanne. [writes label on the board]*

S6 *Minutes past.*

T *Good. Who said minutes past?*

S6 *Me. Cherie.*

T *Fantastic, Cherie and--? Cherie and who?*

S6 *Erica and Joanne.*

T *Erica and Joanne. Good on you, girls. Yes. Minutes past. And that's a really important thing to remember, okay? It tells me how many minutes past [points] the hour of seven. So 7:25 is 25 minutes past 7.*

6.2 Lens 2: Whole Class Interactions as Scaffolding

How do our interactions with knowledge and with each other change over time?

Viewing a lesson through the scaffolding lens allows us to focus on the interactive processes through which the teacher supports students to gain control of academic content and language. In whole class interactions, these processes involve a dynamic relationship between the teacher, the students, and the content, changing across time as the students gain more control of the knowledge. Importantly, the processes must also work to maintain positive affect in the class, that is strong positive interpersonal relationships.

6.2.1 Maintaining positive affect

Maintaining positive affect and teacher-student trust throughout classroom interactions is a pre-requisite for venturing into the unknown of new learning, and underpins the shift to academic engagement. This is not simply feel-good ideology, but an important neurological foundation for joint activity (Damasio, Tomasello, Lochner, D’Mello et al). The absence of a strong positive relationship between teacher and students has significant ramifications. It consolidates the sense of exclusion in the classroom for marginalised students and reduces their motivation to take the risks necessary for trying out new language. We observed many strategies used by all the research teachers to demonstrate respect and affirm inclusion. Some examples are:

The use of first-person plural ‘we’

Evident in all lessons was the use of first-person plural ‘we’, rather than ‘you’ when addressing learners. This was an important embedded strategy that expressed the social nature of learning, that they were all learning together, with each participant contributing to common knowledge: e.g. *If we’re estimating, do we just guess? No, we really think about it, don’t we?*

Managing behaviour in respectful ways

None of the research teachers spent a great deal of talk time on behaviour management. They just got on with the job of teaching and learning. When they did focus on behaviour, it was to make sure that everyone was paying attention to important new learning. They did it in a respectful way that meant the student didn’t lose face, and they often linked the required change in behaviour to its purpose in learning.

Extract 16. Managing behaviour 1 (Lunar Eclipse, Lesson 4, line 809)

- T *So if the person next to you isn't reading, give them a, a friendly nudge or something non-verbal, without interrupting your own reading, just to encourage them because if you're not doing it, you're not getting that learning.*

Extract 17. Managing behaviour 2 (Time, Lesson 1, line 639)

- T *First, thank you, Larissa. Thank you, Eunice. Thank you, Cherie. Thank you, Pauline. They stopped their writing.*

These strategies are not exclusive to scaffolded pedagogy of course. What is worthy of comment is the small amount of time spent on behaviour management, and the fact that it was managed in a respectful manner.

Acknowledging and valuing student contributions to the dialogue

The research teachers paid attention to, and acknowledged student contributions. For some students, it was a chance to include their prior knowledge in the classroom dialogue.

Extract 18. Valuing student contributions (Time, Lesson 1, line 500)

T So Larissa just mentioned that the clock goes around twice, but she's actually bought up a really great way that people measure which time it's gone around. If it's gone around in the morning, it's AM. If it goes around after lunch, it's PM. We're gonna get to that, but really great idea. Fantastic.

For others, it was a chance to affirm student efforts at learning.

Extract 19. Valuing student contributions (Lunar Eclipse, Lesson 3, line 339)

T So many things happening. You saw Aisha, and Holly, and Paula having to navigate these very things, very complex.

Acknowledgement was a very important way of including the contributions of the most marginalised students and showing that these contributions were valued:

Extract 20. Valuing student contributions (Probability, Lesson 2, line 383)

T What is the chance that Matt will toss a coin and get [chorus] heads? Ronnel?
S It is an even chance that Matt will--
T Good boy. Did everyone hear what Ronnel said? [applause]. Let's say it with Ronnel. There is [chorus] an even chance that Matt [chorus] will toss--
SS --a coin [chorus] get heads.

Drawing on student experiences

When teachers expected that students had prior experience with the content, particularly at the beginning of the topic, they would use student everyday experiences to link to new learning. Even when students didn't know much about mathematics or science, their everyday experiences had a place. In Extract 21 the teacher wanted to find out what prior knowledge students had about the lunar eclipse before he launched into the lesson.

Extract 21. Prior knowledge (Lunar Eclipse, Lesson 2, line 74)

T Has anyone ever seen an eclipse? You've gone out to watch one? Yeah? Fantastic. Lots of people have done it. That's great. Um--
S Is it the one where the moon turns red, the Blood Moon.
T So that is one of the terms that's used, absolutely, yep, yep. Why do you think it would be called the Blood Moon? Um Mahmoud?
S Um, because it looks like blood.
T Yeah, it's gone red in colour, hasn't it?

The teachers then built on these every day experiences by reconceptualising from the everyday to the mathematical or scientific. The teacher expanded on Extract 21 to explain the difference between commonsense, often superstitious interpretations of an eclipse, compared with the scientific (Extract 22):

Extract 22. Building on prior knowledge (Lunar Eclipse, Lesson 2, line 79)

T Scientists use their own technical language, but they also have to be mindful of all of the cultural language that's happened before because before we have

scientific theory, there's all these other theories about why things happen. So there would have been a lot of ideas around what the, the gods might have been doing or what other things might have been happening, or what magic might have been happening, and that's why it might have been given the name the Blood Moon.

In Extract 23, the teacher attempted to call on student knowledge about daytime and night-time.

Extract 23. Prior knowledge (Time, Lesson 1, line 18)

T *What can we say about time when the sun's up? When the sun's up, we can say it's what time? What time is it when the sun's up?*

S1 *Morning.*

This was a low-level question, but the teacher expanded on Extract 20 to explain the difference between 'natural' measurements of time, and artificial measurements of time. He responded to 'morning' in this way (Extract 24):

Extract 24. Building on prior knowledge (Time, Lesson 1, line 27)

T *Okay, so no human being has made up morning, have we? That's part of nature. So when, when I say, it's part of nature, it means it comes from the Earth. Man didn't make it, okay?*

He affirmed the value of student responses by incorporating and reconceptualising them as part of the new learning.

6.2.2 The changing nature of classroom dialogue across time

The gradual shift of responsibility from teacher to student was explained in Section 4.1. The topic begins with high teacher input, and, if the scaffolding has been affective, ends with high student output. One big challenge for teachers is how to change their talk across lessons to facilitate and consolidate this handover.

To exemplify the changing nature of classroom talk, we have isolated two teaching and learning sequences: the first from the Cowandilla 'Lunar Eclipse' topic, and the second from the Maningrida 'Telling the time' topic. In each case, the teacher had in mind a focus text which he/she introduced through talk, and which the students were to appropriate. By tracking the language of the focus text and the pedagogic language around it from lesson to lesson across a week, by observing who said what and under what circumstances, we could describe the changing nature of talk. Lens 2 of the observation tool provided guidance about the types of teacher talk that were likely to appear when there was little common knowledge, as handover took place, and as students moved towards control of new learning.

Handing over control at Cowandilla

The teaching and learning sequence focusing on the 'Lunar Eclipse' aimed for students to write explanation of a lunar eclipse, using the language resources identified in the focus text. The relevant focus text was:

A lunar eclipse occurs when the sun, the earth and the moon are in direct alignment, and the earth passes between the moon and the sun, blocking the sun's rays and casting a shadow on the moon. This only happens at full moon.

The description to follow identifies the pedagogic strategies used by the teachers (either or both) as they worked to handover this language to students.

Classroom talk when there was little common knowledge

When the teacher expected that students would know little about the topic, we expected a lot of teacher 'telling', i.e. the teacher providing information to students about the topic. An important scaffolding principle is not to use 'probing' questions as a strategy for eliciting knowledge that the students don't have. It is alright just to tell them.

We observed a lot of telling in Lessons 1 and 2 of the Lunar Eclipse topic. For example, in Lesson 1 (Extracts 25-29), the telling includes the rationale for studying the topic and the learning goals:

Extract 25. Teacher explaining rationale for the topic (Lunar Eclipse, Lesson 1, line 13)

T1 *Eclipses have to do with earth and space science, space sciences, and we're going to be looking at the relative positions, or the positions of these three things... (points to diagram on the board). And the positions of those three things cause the seasons and cause eclipses.*

And a bit later in the lesson, the teacher explained why they were learning about the rotation and the tilt of the moon in so much detail:

Extract 26. Teacher explaining why moon is important (Lunar Eclipse, Lesson 1, line 177)

T2 *The reason why moons are really important is when we're learning about eclipses, one of the types of eclipses that we'll be learning about, or both of them, the moon plays a really important role.*

When the teacher used questions, they were generally eliciting low-level 'locating' answers:

Extract 27. 'Locating' questions (Lunar Eclipse, Lesson 1, line 13)

T *What are these three things on the image here? Caleb, do you know?*
S *The earth, the sun and the moon.*

Questions such as these would be dismissed as inappropriate by many teachers because of their low level 'naming', but they were used intentionally. They invited students into the conversation, with knowledge that they could contribute, and at this early stage in the topic,

the teacher had to work hard to maintain positive affect so that students felt confident to engage.

Asking direct wh- questions of specific students, particularly in the early stages of a topic, when common knowledge is low, carries a high risk for marginalised students. It is more likely to result in the confirmation of 'failure to know', of embarrassment or shaming than in getting a correct answer. Instead, the research teachers would open the question to all:

Extract 28. Opening up questions to all (Lunar Eclipse, Lesson 1, line 220)

T *Now does anyone know what this image is? Has anyone seen this one or this one before? Can anyone tell me what they are?*

These open questions, directed at 'anyone' avoided any particular student being forced to answer, with the risk of losing face if they didn't know.

The teacher also used question tags, i.e. a questioning clause added to the end of a statement as an important inclusion strategy. Some examples have been underlined in the following extract when the teacher was explaining a diagram on the white board:

Extract 29. Question tags (Lunar Eclipse, Lesson 1, line 198)

T *See just there? That thing, the red spot? That is the Milky Way galaxy. You can't even see the dot for earth anymore can you?*

SS *No.*

T *Huge, isn't it? Now this whole thing here, this is this little red bit just here. It is huge, isn't it?*

The use of the question tag has three important interpersonal effects: firstly it flags that a response is expected, so it invites the listener in. Secondly, it creates positive affect within the classroom because it implies shared and mutual understanding; that of course the students will be able to affirm the teacher's statement, and thirdly, the balance of power in the classroom changes in that the use of question tags implies that students have the authority to make an evaluation of the teacher's comment (Eggin, 1994; Eggin & Slade, 1997).

The teacher also used the questioning sequence developed by Gray, and described earlier in the report (Section 2.3). It consists of, in sequence, a cue or preformulation to direct students' attention; the question; the answer; an affirmation; and a reconceptualisation, pulling the answer into scientific discourse, adding value to the student response. Here is an example:

Extract 30. Scaffolding questioning sequence (Lunar Eclipse, Lesson 4, line 100)

T	Preformulation	<i>So here we had the Moon on the other side of the Earth from the sun and we could draw a line straight through them. Important thing to look at is the position. Sun, Earth, and Moon,</i>
	Question	<i>what are these lines, sort of, here?</i>
	Preformulation	<i>And there's different colouring here coming from the sun towards the Earth,</i>
	Question	<i>what is that indicating?</i>

S	Answer	<i>Uh, and the Earth's creating a shadow over the Moon?</i>
T	Affirmation	<i>Absolutely.</i>
	Reconceptualisation	<i>This part just in here-- see that sunlight that's shining here? Then it hits the Earth and then they've still got these lines and the different colouring here. And you're absolutely right, it's indicating that on the other side of the Earth or the half of the Earth that's facing the Moon and not facing the sun, that is in darkness because it's night-time, and the, the Earth casts a shadow onto the Moon. So the Moon's light is being blocked by the Earth, isn't it?</i>

Extract 30 exemplifies how the teacher's reconceptualisations were used to gradually introduce the technical terms to the class. The student used in her answer the previously introduced *shadow*, and the teacher here introduced two important words into the conversation: *cast* and *block* (highlighted in bold above). These were technical terms in the mind of the teacher because of the previously prepared focus text, that would be later used as students jointly constructed an explanation with the teacher.

As meaning and language began to be shared

As common knowledge begins to grow, changes were observed in teacher talk. The teachers continued to manage their questions so that they could respond positively to each student, including the use of preformulated questions when necessary to direct student attention; they still used question tags to mark shared understandings. The 'telling' reduced, and the teacher began to elicit responses from students. The lessons always began with a 'Look back' phase: reminding students of the previous lesson, and checking for handover:

Extract 31. Looking back (Lunar Eclipse, Lesson 4, line 11)

T	<i>What are the three major things that we are talking about that are going to help us describe lunar eclipses? I think you can tell me. What are the three?</i>
S	<i>Sun, Moon, and Earth.</i>
T	<i>Sun, Moon, and Earth, absolutely, those are the three key ones. Um, so yesterday we were talking about--actually, can you refresh my memory? There's something around the room that could help you, ah, remember what we were having a look at yesterday. (Teacher stares at the poster.) Aisha?</i>
S	<i>Moon phases?</i>
T	<i>So the Moon phases, absolutely. Who can tell me something more about the Moon phases? That's exactly what we were looking at, give me some information about them.</i>
S	<i>We were looking at how they occur.</i>
T	<i>So you said, "We look at how they occur." Can you give me any more information about how they do occur?</i>
S	<i>Like, a new Moon occurs when the Moon is between the Earth and the sun.</i>

There are some interesting differences in questions evident in this extract. When the teacher was sure that students could answer, such as a naming, he asked a direct 'wh'-question: *What are the three major things...* He reminded students that this was prior learning with prompts such as *can you refresh my memory?* When the expectations were higher, when he asked 'how', the questions changed. They were less direct, less demanding: *who can tell me something..., can you give me any more information...* The effect of this conscious control of questioning is so important for inclusion. It built trust that the teacher was with the students, that he was not going to embarrass them for 'failure to know'.

The teachers now had a resource of prior student contributions that they could include and develop into common knowledge.

As the topic continued, previous reconceptualisations were transformed into questions, so that the teacher was checking for handover of 'why' and 'how', rather than just names. Earlier in the lesson, during a joint written text construction, the teacher had asked what three letters could be added to 'cast' to make it continuous. One student answered:

Extract 32. Explaining the purpose of -ing (Lunar Eclipse, Lesson 4, line 119)

S -ing.

S2 -ing, yeah. We're going to say, 'Casting'. We're going to say, 'Casting a shadow'. Because that's something that scientists do, they use -ing to show that things are happening continuously.

In her response, the teacher affirmed the answer and reconceptualised by explaining why they would use -ing. Later in the lesson, that reconceptualisation was recast as a question to check for handover. Because it was recent information, it was a less direct, open to all, 'remember' question:

Extract 33. Handover of purpose of -ing (Lunar Eclipse, Lesson 4, line 742)

S2 On the Moon. And who can remember why we say 'casting' instead of 'casts'? Great, two of you can remember. You can remember Sterling, why?

S? Uh, because it's continuous.

Two additional pedagogic strategies encouraged students to begin to take up the language themselves. The first is the oral cloze technique, which required the teacher to begin the sentence, which was then completed by students if they can. This was useful as an interim, 'safe' strategy, because if no-one could complete the sentence, the teacher completed it himself or herself, making a mental note of the lack of handover, but with no-one losing face. The second strategy was the teacher's invitation to the class to repeat the student's answer, so that everyone had a chance to speak the new language. These strategies are exemplified in Extract 34 when the class was jointly constructing a written text:

Extract 34. Students repeat new language (Lunar Eclipse, Lesson 4, line 269)

- T 1 *We've got the Earth, can you finish it off?*
 S 2 *Uh--*
 T 3 *I'll give you some help, the Earth passes between the...*
 S 4 *The sun and the Moon.*
 T 5 *And...*
 S 6 *The Moon.*
 T 7 *The Moon. Put it all together for me.*
 S 8 *The Earth--*
 T 9 *You can use-- let her help you as well, absolutely.*
 SS 10 *The Earth passes between the sun and the Moon.*
 T 11 *Can we say that, everyone?*
 SS 12 *The Earth passes between the sun and the Moon.*
 T 13 *So when the Earth passes between the sun and the Moon, at some point it is in...*
 S 14 *Direct alignment.*
 T 15 *Wonderful.*

In turn 1, the teacher asked a student to complete the sentence they were writing. In turn 2 the student hesitated, so the teacher began the sentence in turn 3 for the student to complete (oral cloze). In turn 7, the teacher asked the student to speak the whole sentence. She began in turn 8 but hesitated again. This was not ideal, because the student was becoming embarrassed at not being able to answer. However, in turn 9, the teacher retrieved the situation by signalling that of course, someone else could help her. Together they spoke the sentence. This was not the end of it, because in turn 11, the teacher got everyone to speak the whole sentence again. In turn 13, the teacher continued by turning that sentence into a dependent 'when' clause and asking for an extension of information, once again as a form of oral cloze: *at some point it is in...* The student completed the sentence, and the teacher affirmed her answer.

When there was a high level of common knowledge

By lesson 5, there was a lot of shared knowledge within the class about a lunar eclipse. The teacher's language changed again whenever he thought his students would be able to talk about the phenomenon. In Extract 35, the teacher was beginning what we called a 'long turn', a jointly constructed oral text about the topic. Its function was to consolidate language orally before the students moved to a written explanation.

Extract 35. Long turn (Lunar Eclipse, Lesson 5, line 7)

- T1 7 *Okay. After this question I'm just going to start choosing people. Okay, so Kurulla's got his hand up, I'm going to go to him first, and then I'm just going to be picking anybody... Remember that's what scientists do is they take notes to help them remember the things they think they might need some help recording in their explanation, about a particular phenomenon.*

- T2 8 *And Michael, do we want them saying, "I remember there's like a thing and this guy called Amin"?*
- S1 9 *I think what we'd be trying to look for now is people putting this information and using big bits of information together, so using sentences and big clauses.*
- T2 10 *Technical language?*
- T1 11 *Technical language, scientific language, remember our learning goals? Talking, behaving like a scientist. Using scientific language to describe a lunar eclipse. Kurulla, tell me something.*
- S4 12 *We were learning about how to [inaudible] eclipse and everything.*
- T1 13 *Absolutely, the phenomenon was a lunar eclipse, wasn't it? Absolutely. Thank you. Joanna?*
- S5 14 *We were learning about how it only happens twice a year and it's always on a full moon.*

In turn 7, the teacher flagged that everyone should be able to contribute to the class learning. Even now though, he reminded students that they didn't have to recall the information, that the class notes were up on display for reference. In turns 8 to 11, the teachers made explicit that they wanted scientific, not commonsense language, and they wanted the students to extend their talk from answering questions to providing whole clauses. Clauses 12 and 14 provide examples of the language and information that students offered at this point. While Kurulla was already confident in science before the topic began, Joanna was not, but there was no hesitation in her contributions at this end of the topic.

From this point in the lesson, the teacher moved on to negotiate a joint written construction of the lunar eclipse explanation that looked very similar to the focus text. The process was negotiation, not scribing: The students contributed a great deal of information, and the teacher now added more 'written-like' grammar to the construction.

Finally, the students wrote their own lunar eclipse explanation. The more scientifically advanced students researched and added additional information, but every student was able to construct a text that approximated the focus text. Many then took photographs of their diagrams, and recorded their learning orally on their iPads™, using the application 'Explain Everything™'.

When we explained the scaffolding principle of 'handover' earlier in the report, we stated that although we might begin with 'teacher tells', our end goal is for the students to be able to tell, with little or no support from the teacher.

As an example of this, here is an account from Aisha, a student in the class. She was not one of the scientific experts at the beginning, but here is some of what she said about the topic:

On note taking:

The point I got to what a lunar eclipse is when the teachers were talking with the diagram and taking notes. I was being careful what information I needed and what information I didn't need and then I bring key words and then I bring a whole sentence.

-How she constructed the diagram of the lunar eclipse:

In the diagram, first I drew the direct alignment and then I chose a point where I made like a triangle kind of shape and I put the moon face the I put the sun, the I put the earth which is in between the sun and the moon then I drew day and night by making day facing the sun and night facing the moon and making it darker.

-How a lunar eclipse occurs:

A lunar eclipse occurs when the sun, the earth and the moon are in direct alignment and the earth passes between the moon and the sun, blocking the sun's rays and casting a shadow on the moon. This only happens at full moon approximately twice a year.

-Why a lunar eclipse doesn't happen every month:

Because the tilt of the orbital line for the earth doesn't always tilt the way that it makes direct alignment, so it tilts every time and when the end is up to the moon and it's in direct alignment, that's how a lunar eclipse occurs.

- Thinking about audience:

And in my writing, when I put 'casting a shadow on the moon', I also put in extra information about an umbra and I put a definition of what an umbra is, and it's 'An umbra is the scientific name for the dark shadow created by the earth in a lunar eclipse'. I did that extra sentence so cause I wrote 'casting a shadow on the moon and that's called an umbra' then I asked myself if the reader didn't know about an umbra, I could say what an umbra is so that would extend their knowledge.

-Her evaluation of the learning process:

For me that style of learning is different but it also helped me a lot with trying new things and learning. Before I did this... I didn't know about the lunar eclipse, and with the teacher starting off easy and making more complicated and taking notes, it made me learn more, made me learn more about lunar eclipse.

Handing over control at Maningrida

The mathematic teaching and learning sequence in Maningrida aimed for students to be able to read an analogue clock and tell the time. Because so many students had trouble correctly identifying the hour once the hour hand had moved past the relevant number (i.e. any time other than o'clock), the focus text was:

When the hour hand points to a number, it starts the hour. It stays that hour until it clicks over to the next number.

At first sight, the teaching sequences from Maningrida have little in common with the fast moving and high-level conversation that took place in the Cowandilla classroom. Yet from our perspective, the language of the teacher here had the two same important characteristics. Firstly, it was dialogic in intent, even though on the first lesson it was more like a monologue. Secondly, the language reflected as closely as possible the contingent level of scaffold to support a group of new English speakers whose world view was quite different from his. Although the teacher had taught most of these students previously, this was not his class, and the effort to which he went to strengthen and maintain positive interpersonal relationships is apparent throughout.

Three sequences are included here that correlate with three stages in the topic development: little common knowledge, growing common knowledge, and a higher level of common knowledge (although after only four lessons, no claim is made that the job was finished!). The words from the focus text are highlighted in bold.

Talk with little common knowledge

- Extract 36. Classroom talk when there was little common knowledge (Time, Lesson 1, line 742)
- Teacher 1 *Okay? And that can be quite tricky for kids, where the hour hand's pointing. Okay? [...] So **the hour hand's pointing to the two**, so Wally, I know it's going to be what o'clock?*
- S12 2 *Two o'clock.*
- Teacher 3 *Good boy. But **it stays the hour** of two until it clicks over to the--*
- S9 4 *Three, three.*
- Teacher 5 *The three. Okay? So it's gonna be 2 o'clock--*
- Teacher 6 *If it's halfway between the two and the three, if the hour hand's halfway between the two and the three, it's going to be half past--*
- Chorus 7 *Two.*
- Teacher 8 *Two, that's right. **It stays that hour until it clicks over to the next hour.** And what I really want us to take away, okay, is **when the hour hand points to a number that starts that hour.** So when hour hand points to the three, TJ?*
- S9 9 *[inaudible].*
- Teacher 10 ***When the hour hand--** this is the most important thing I need you take away for tomorrow, okay? So if you take away nothing else, you need to take away this. **When the hour hand points to a number, it stays that hour until it reaches the next number.** So if it's pointing at the three, it's 3 o'clock. Yeah? But it [chorus] **stays that hour...** It stays the hour of three.*
- Teacher 11 ***Until it gets to the next number.***

As we expected, the teacher did a lot of 'telling' in lesson 1; explicit teaching about how to read the clock. He included the students by using many oral cloze sentences, where the students only had to complete the sentence with one word to be successful e.g. *But it stays the hour of two until it clicks over to the—*(S: three). Three times (turns 1, 8, and 10), the teacher marked the important language e.g. *So if you take away nothing else, you need to take away this*, before he used the new language to which he wanted them to attend. This

was an important strategy because it meant that if students were losing focus, these markers drew them back into the learning. Only in turn 10 do the students begin to use any of the language of the focus text when they chorus *stays that hour...*

As meaning and language began to be shared

In Lesson 2, there was no new information. The purpose was handover of the same concept: the fact that once the hour hand points to a number, it stays that hour until it clicks over to the next number. At this point, the teacher was holding a real clock in front of the class. They were not holding in their hands the clocks they had made the day before. This was essential if he wanted to make sure they were all attending to the important features. He wanted to build common understanding before they worked with their own clocks.

What we want to emphasise here is the huge role that language played in mediating action. The teacher had lengthy preformulations before brief questions and answers, followed by extended reconceptualisations. Here is one example:

Extract 37. Example of scaffolded questioning sequence (Time, Lesson 2, line 427)

T	1	Preformulation	<i>Now we've found something really interesting about the hour hand and about the way that it measures the hour. And we said-- let's have a look. Let me move it to the two, okay? So have a look. Now when the hour hand's pointing to the two,</i>
		Question	<i>which hour is it?</i>
		Answer (cloze)	<i>It's the--</i>
SS	2	Answer	<i>Two.</i>
T	3	Answer (repeated)	<i>It's the two.</i>
		Reconceptualisation	<i>So 2 o'clock, isn't it?</i>
		Preformulation	<i>But if I have a look at this minute hand move around the clock once, which is one hour,</i>
		Question	<i>what happens to the hour hand?</i>
		Question	<i>Does it stay right on the two?</i>
SS	4	Answer	<i>No.</i>
T	5	Answer (repeated)	<i>No.</i>
		Question	<i>But is the hour still two?</i>
SS	6	Answer	<i>Yes.</i>
T	7	Reconceptualisation	<i>It's still the, the second hour. It's still the hour of 2 o'clock, even though the minute hand's moved off. So it's something past two.</i>

First of all, the teacher uses particular language forms to mark shared work - the first person plural: *Now we've found something interesting..., and we said...;* the verb form *Let's (have a look)* and *Let me...* which invite other participants and give them agency. He draws student attention to the salient features with *Have a look...* and questions are addressed to all. The questions are all closed, requiring one-word answers; but the teacher used these to involve the students in incrementally developing understandings. Most importantly, he uses language

in preformulations to mediate the rotation of the hour hand and minute hand around the clock, and in reconceptualisations to extend the language used to describe the action.

The quality of this talk can perhaps be understood by contrasting it with alternative, less scaffolded pedagogic choices. For example, another teacher might have just pointed the hour hand to the two and said *What time is it?* He/she might have shifted the hour hand forward slightly and said *What time is it now?* And when the student got it wrong, responded in a friendly way with *Tricked you!* The response would have been well-intentioned, and an attempt to maintain positive affect, but at best inefficient because the students are still left not knowing why, and at worst, counterproductive because that student has yet again failed to be included as a knower.

In lesson 3, the teacher again worked on the more general concept that the hour hand starts at any hour and stays the same hour (Extract 38).

Extract 38. It's still the hour of... (Time, Lesson 3, line 228)

- T 1 *Shh, listen to Brendan, please, everybody. Go again.*
- S 2 ***It hasn't clicked to the new number.***
- T 3 *Did everyone hear what Brendan just said? I wanna give it a clap too. Do you know what he -- clap. Do you know what Brendan just said TJ? Stop. Brendan really, really accurately said that we know that this is **still the hour** of four because **it hasn't clicked to the next number.***
- T 4 *How do I know that this is still in **the hour** of nine? And let's try and use Brendan's words, 'cause I love the words that he used. Can someone explain to me how this is still **the hour** of nine? Lee.*
- S 5 *'Cause it hasn't gotten to the 10 yet.*
- T 6 *Hasn't gotten to the 10 yet. Or what, what was that great word that Brendan used? It hasn't--?*
- S 7 *It hasn't [passed?] the--*
- S 8 ***Clicks.***
- T 9 *What did you say?*
- S 10 *If it hasn't **clicked.***
- T 11 ***Clicked onto the 10 yet. That's right. It hasn't quite [someone clicks], **clicked onto the 10.** All right, fantastic.***

This extract from Lesson 3 will be described in some detail because it exemplifies the incremental nature of language development happening in the classroom. One student, Brendan, had approximated the target language *It hasn't clicked to a next number* in response to a teacher question. The teacher drew everyone's attention to Brendan's language (turn 1) and Brendan repeated it (turn 2). The teacher reconceptualised by expanding the response into a complete sentence (turn 3.) In turn 4 he looked for the same language (*clicked to the next number*) from someone else, choosing a new hour on the clock. Another student answered (turn 5), using some of that language but not all. In turn 6, the teacher tried again to get the word *clicked*, this time partially completed the sentence which directed the student to the verb. In turn 7, Lee tried again with *passed* but now another student contributed *clicks*

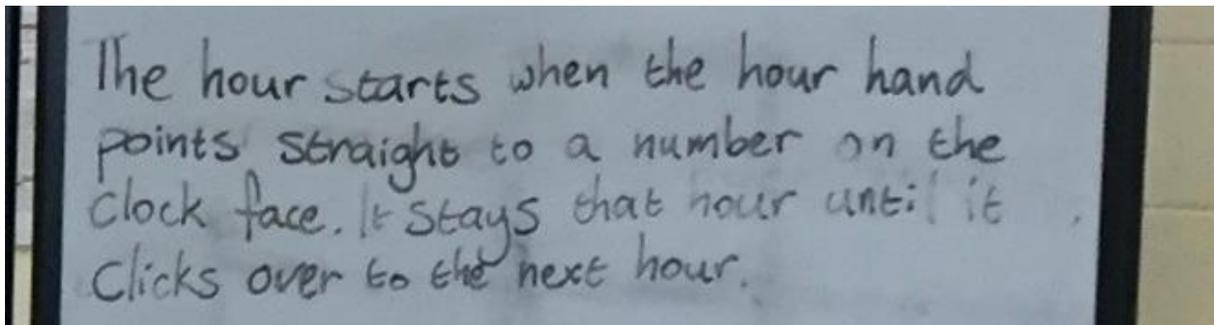
and the teacher drew in that contribution to the answer and finished the sequence in turn 11 by restating the whole sentence.

To achieve this moment-by-moment adjustment to the language to try and find contingent levels of scaffold was hard work. It required the teacher to be conscious of and open to student responses at every moment, providing enough but not too much support. The teacher didn't always find the level of contingency straight away. We called it the 'pedagogic dance': moving back and forth as students succeeded and failed to keep them moving towards the goal.

When there was a higher level of common knowledge

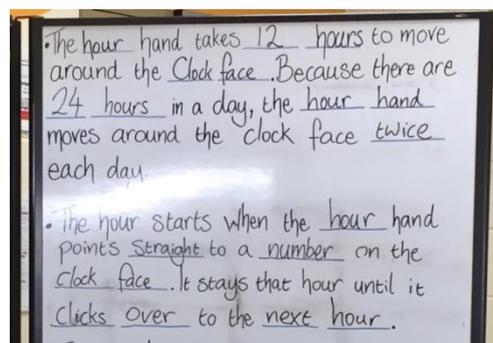
In the final lesson of the week, the class participated in a written cloze activity. They had jointly constructed this text with the teacher recording it on the white board the previous day:

Figure 16. Lesson 3 Jointly constructed text about the position of the hour hand



Overnight, the teacher had deleted many important words which they were now jointly re-inserting. This slightly changed activity gave the students another opportunity to see, hear and use the target language.

Figure 17. Lesson 4 Joint written cloze exercise



Extract 39 begins with the negotiation of the second paragraph. The teacher and students did a 'run up' to each gap in the sentence, reading the previous phrase or sentence beginning, bringing meaning to the task of filling in the blank.

Extract 39. Joint written cloze activity (Time, Lesson 4, line 183)

- SS 1 [Reading, loud voices] *'The hour starts when the hour hand points blank to a number on the clock face.'*
- T 2 *Can anyone remember—'the hour hand points'-- and this is the key word—'the hour hand-- the hour starts when the hour hand points'--*
- S 3 *To a-- straight to a number*
- T 4 *Big loud voice. Say it again. 'When it points--?'*
- S 5 *Straight to the number.*
- T 6 *Straight. You remember? It has to point straight to the number. If it's pointing straight at the number like this clock [picks up one of the paper clocks and holds it up]. Is it pointing straight to the six?*
- S 7 *Yes.*
- T 8 *So it's starting the hour at six. So when it points-- what did you say, Lee? 'Straight to a number on the clock face.' Now, who remembers the second part, Cherie?*
- T 9 *Let's read it. It-- everyone. [pointing to each word]*
- S 10 *It stays the hour until it blank--*
- S 11 *Click.*
- T 12 *Remember yours from the other day? Yes, Jessica, what does it do? It goes--?*
- S 13 *Clicks to a next number.*
- S 14 *Yes.*
- T 15 *So the hour starts when the hour hand points straight to a number. It stays that hour--*
- S 16 *Click to next--*
- T 17 *--until it clicks-- what was it? It clicks--*
- S 18 *over.*
- T 19 *Over. Fantastic. Until it clicks over to what? [writing] What does it click over to? The--?*
- S 20 *Next number.*

The extract demonstrates three important aspects of scaffolding as common knowledge grew in this lesson. The first is the increase in pace: the class had already jointly constructed this text the day before, so the teacher expected that students would contribute more than the previous day. The expectations had risen. The second important aspect is that despite the increased expectations, the teacher still increased the scaffold to maintain or build meaning as the need arose. For example, while the focus in this part of the lesson was on the written text, concrete materials were used when necessary to clarify meaning (turns 6-8). The teacher was still opening the question up to all: *Can anyone remember...* The third aspect is the increased number and quality of student contributions. The text was indeed jointly constructed with appropriate student contributions in turns 3, 5, 11, 13, 16, 18 and 20. After four days, most students in the class could successfully tell the time on the clock, and had access to this little kernel of language which served as a mnemonic to help them in that process.

To summarise, effective scaffolding is a sophisticated, nuanced process. The sequences provided here demonstrate the way in which the teachers were constantly monitoring student responses to find the next most appropriate response which continued to maintain trust, but would still move students towards independence.

6.3 Lens 3: Sense Making

When we observe a lesson through the third lens, ‘Sense Making’, we ask:

How do we use various meaning-making resources to the greatest effect?

Meanings in both science and mathematics are realised through a range of semiotic modes. As well as spoken and written language these include visual and the concrete modes, all of which can be used with students to create shared meaning and subsequently to build deeper layers of meaning. Our third observation lens ‘Sense Making’, allowed us to focus our observations on the ways in which the teachers incorporated a range of meaning-making resources into their lessons in supportive, cohesive and complementary ways. We observed a number of elements of Sense Making, as follows.

6.3.1 Moving between concrete and abstract representations

Teachers incorporated a range of concrete objects, diagrams, 3 dimensional models and videos into their teaching to support and reinforce the development of shared meanings with the class. These varied from model clocks (real and made from paper plates) in *Telling the time*; electronic spinners in *Probability*; diagrams, 3D models and video animations in *Lunar Eclipse*; and concrete electric circuits, photos and diagrams in *Electric circuits*.

Even using a concrete object in the simplest way through, for example, explaining the parts of a clock, teachers took care to check that understandings about the educational intentions in using objects were shared within the group. In the following extract (Extract 40), the teacher checked the students’ knowledge about the names and functions of the parts of a clock:

Extract 40. Clock hands (Time, Lesson 2, line 312)

- T 1 *See this clock? What are these long sticks called? There called-- they're not called sticks, they're called what? The clock--?*
- S1 2 *Hands.*
- T 3 *Hands. Well, see this big white part? It's called the clock-- who can tell me?*
- S2 4 *Face.*
- T 5 *Good girl. Clock's face. So see this is called the clock face. So we have to call it the clock face. Now we said in one day the hour hand goes around the clock face how many times? In one day, the hour hand goes around the clock--?*
- S3 6 *Twice.*

Although this knowledge – the terms ‘hour hand’ and ‘clock face’ - seemed very basic and had already been covered, the teacher did not simply assume that all students already knew it, and the questions served to broadcast the information to any students who might not be sure.

Similarly, in using video, teachers took care to focus students’ attention on the relevance of the images to the lesson topic. Often voice-overs on video are very rapid, or the visual images pass too quickly for students to follow. Perhaps there is more information than the students need at that moment, or perhaps the explanations are not detailed enough for the particular

cohort of students. In this project teachers used a key strategy of turning the sound to mute, so that they could lead the class dialogue in way that best met the needs of the students.

In Extract 41, the class was watching a video that showed a presenter explaining the phases of the moon using a 3-dimensional model, building a scientific understanding of the conditions that create a new moon.

Extract 41. In shadow, not reflecting light (Time, Lesson 2, line 572)

- T 1 *On here, on this part of the, the dia-, sorry, the illu-, the video which is representing the Moon, it's, it's dark, isn't it? There's no light on it. The light is behind the Moon. Can you see that?*
- SS 2 *Yes.*
- T 3 *Yeah? Yeah, the reason why she's just showing a little bit on the side there is so that you can see that the Sun is behind. So what's important with a new Moon? How much do we see?*
- S 4 *Nothing*
- T 5 *Nothing because it's going to be in shadow, not reflecting light. So at a new Moon, how much light do we see on the Moon?*
- S 6 *None.*
- T 7 *None. We don't see any light. There is no light being reflected.*

Keeping the sound muted, the teacher directed the students' attention to the relationship between the light and the moon, and then tuned the students in to the rationale for the particular view of the model that they were seeing: *the reason why she's showing a little bit on the side there*. The teacher then maintained the focus on the rationale for what they were seeing by asking *what's important with a new moon?* This talk therefore served to help the students understand the educational purpose of the video, as well as to take meaning from the images.

6.3.2 Intentionally building academic vocabulary and grammar

A second element of Sense Making was that teachers intentionally built academic vocabulary and grammar. We observed that the process building and practising technical language through spoken discourse could involve a number of steps. In Extract 42 the teacher was using a diagram to build the language of the focus text: *the Sun, Earth and Moon are in direct alignment*.

Extract 42. What does direct alignment mean? (Lunar Eclipse, Lesson 4, line 178)

- T 1 *And so what does direct alignment mean everyone? It means that you could draw a line through the centre of each of these, these circular shapes that we're looking at from-- on this 2D model, aren't they? It's a circle for the Moon, a circle for the Earth, and a circle for the Sun, correct?*
- S 2 *Yes.*
- T 3 *So this line that goes through the centre of each of those three things shows us that these three things, the Earth, Moon, and Sun, are in...*
- SS 4 *Direct alignment.*
- T 5 *Can everyone say that for me? The Sun, Earth, and Moon are in direct alignment.*
- SS 6 *The Sun, Earth, and Moon are in direct alignment.*

- T 7 *Okay. That's a fancy way of saying it, what does it mean to be in direct alignment?
Hmm. Khaya?*
- S 8 *Um, that, um, they're in a row, like--*
- T 9 *Yeah, so I know what you mean, but we want to use that word, "line," don't we? So
they're in--*
- S 10 *Straight line.*
- T 11 *They're on a straight line, aren't they? The centre of them is on that line, aren't they? So
direct alignment means that these things, you could draw a straight line between the
centre of them.*

The teacher began by signalling that he was focusing on the language: *what does direct alignment mean everyone*. However, he did not allow the students to guess the answer with insufficient information. Rather, he supplied them with the definition himself: *it means you could draw a line through the centre of each of these circular shapes*. He then requested that the students actively engage with the language by saying the whole sentence for themselves (Line 5). It was only at this point, once the students had heard the definition and had practised the target language that he threw the floor open to the students to provide a definition in their own words. He accepted the word *row*, encouraged the class to also use the word *line*, before reiterating the definition again.

6.3.3 Powering up, powering down

Extracts 41 and 42 also illustrate the processes of powering up and down. We touched on this process in some of our earlier examples in Lens 1. We also see powering up and down as being an essential element of Lens 3 in its own right.

As noted earlier in Section 2, teachers build bridges between what students already know and the new material, shunting back and forth from the familiar to the new, from concrete and context-specific to abstract decontextualised meanings. The dynamic process of developing academic meanings with students involves condensing commonsense language into academic language (powering up), and unpacking discipline knowledge back into the everyday, less abstract and more grammatically congruent language (powering down). It also means powering up again: repacking ideas, and getting the students to appropriate the discipline-specific language in their speech and their writing. Without this two-way movement, talk remains in the abstract, or alternatively weighed down in the commonsense so that abstract and generalised meanings are not developed.

As an example of powering up and down, in Extract 41 above we observed the teacher using 'bridging talk' to power up to the statement *There is no light being reflected*. The teacher began with commonsense phrases: *it's dark isn't it? There's no light* (line 1); *[we can see] Nothing* (line 5), before introducing the word *reflecting* by creating an equivalence between *shadow* and *not reflecting light* (line 5). The teacher then powered down to elicit a student response and ground the conversation back in the students' everyday thinking (lines 5-7): *So ... how much light do we see on the Moon? We don't see any light*. Finally, the teacher powered up again to the target language (line 7): *There is no light being reflected*.

Extract 42 above also exemplifies a semantic wave (the semantic movement between the more abstract ‘up’ and the more commonsense ‘down’). Here the teacher began ‘up’ with the technical term *direct alignment* and powered down to two statements in more everyday language: *you could draw a line through the centre of these circular shapes* (line 1) and *So this line that goes through the centre of these three things...* (line 3). The teacher then powered up again to the term *direct alignment* (lines 4-7), this time putting it meaningfully into a sentence and partially handing over to the students by getting them to say the sentence for themselves. This was followed by a second powering down, again with handover, as the teacher asked the students to offer a definition. Accepting the student’s term *row* (line 8), but then suggesting the alternative term *line* (line 9) demonstrated yet another movement ‘upwards’ towards the definitional language that the teacher had earlier suggested.

As these examples suggest, the process of powering down and up is not a single move in teaching, but happens repeatedly and contingently, according to the needs of the students.

6.3.4 Managing cognitive load

The final element of Sense Making is managing cognitive load. Teachers do this by helping students notice and attend to what is salient, moving purposefully between spoken, visual and written modes of meaning-making, and foregrounding aims of the task. At the same time, they need to be aware that too many simultaneous sources of information, if not well managed, can be confusing for students and may detract rather than support the development of shared meaning.

Limiting the number of simultaneous messages and modes that a student has to process is an important aspect of managing cognitive load. For example, keeping the video’s sound muted (Extracts 41 and 42) allowed students to focus on the visual images while the teacher directed their attention with spoken language that supported the lesson goals. Another way of organising information that we have already seen was the use of class notes (Extract 6, Extract 33) which gave the students a visual reminder of the academic language that was being introduced into their spoken discourse, and subsequently gave the students a prompt to help them contribute orally during the negotiation of their written class text.

Similarly, Extract 43 illustrates an instance where the teacher carefully managed information and language that was highly challenging for this group of students.

Extract 43. *The teacher doesn’t keep secrets* (Probability, Lesson 2, line 13)

- T 1 *Who remembers, what are we calling all of these words that are to do with one idea? Starts with "P". All these words, all these ideas have to do with one word that's called pr-r-r-r--*
- S 2 *Probability*
- T 3 *Everybody?*
- SS 4 *Probability*
- T 5 *Fantastic. Now, we came up with a really excellent, excellent definition yesterday of probability. Do you remember what we came up with that? Yeah? Remember*

- definition's like the meaning of the word, what that thing is. All right. Okay, can everyone remember that?*
- S 6 *Yeah.*
- T 7 *If you can't remember that-- cause I probably struggle to remember that. Is there anywhere in this room-- again, secret squirrel [teacher] who doesn't keep secret? Probability. [Points to poster on board]. So we've got our, what is it? Can you guys see this up here? We might need to shuffle down. What did we decide probability was yesterday? We said, everybody*
- SS 8 [reading together] Probability is predicting the chance of future events.
&T

Reminding the students of the term *probability*, which they had encountered the previous day, he asked them first to say the word and then to recall the definition. This would have been beyond the recall of most of the students in the class, but they were supported by a written version of the definition clearly visible on the wall. The teacher reminded the students that the poster existed, while emphasising (line 5) that the purpose of this part of the wall was to broadcast information that might otherwise seem to be secret (*Is there anywhere in this room [that]... secret squirrel ... doesn't keep secret?*). He took time to make sure everyone could see, before getting everyone to read the definition together. From this exchange, at the very least, even for the students who struggled with literacy, everyone in the class could know where the information about the term *probability* was displayed. The clearly visible poster helped support recall that would otherwise have been difficult.

7 Discussion

7.1 The value of the observation tool for analysis and reflection

We initially designed our 'three lenses' observation tool with two main purposes in mind:

- (i) as a framework for analysing classroom discourse and for identifying principles of scaffolding as they are realized in instances of teaching; and
- (ii) as a guide for teachers in reflecting on their teaching, and particularly on their use of scaffolding techniques.

In Section 6 of this report we tested the analytic potential of the tool. In reflection, we are satisfied that the three lenses have facilitated our analysis of classroom discourse, allowing us to see the lessons in a multi-faceted way, and to account for the dynamic nature of effective scaffolding.

When the observation tool was first developed, the three lenses were identified intuitively as useful categories for a teacher, to separate the principles into manageable chunks. Over the course of the project we have refined the tool to make it more accessible and systematic for analysis and in working with teachers.

We make no claim to have identified all possible scaffolding mechanisms, but we have certainly found the observation tool a useful structure for teasing out aspects of teacher practice and their effects.

Two out of four teachers made use of the observation tool in planning and teaching. One teacher said:

I used this tool mainly between and before lessons to check the structure of the upcoming lesson was appropriate. I found I didn't need to use it as much when we had the debrief meetings with you and Helen after each lesson, but when I was feeling like I wasn't prepared or just getting stuck then I would refer to this to help me ensure I was covering what I needed to.

Another wrote:

It was very useful to guide my thinking in the initial planning phase, recap my scaffolding literacy knowledge. Particularly when I became a bit disoriented when switching from an English to a Science focus.

In summary, the observation tool brought to consciousness aspects of pedagogy for reflection and planning purposes.

We recognise that the ideas embodied in the tool are quite dense, and that ultimately it will be most useful if teachers can assimilate these ideas over time, and with expert support. To this end, we have developed an abridged, 'teacher-friendly' version, and in 2017-18 are trialing its use as part of the DECD 'Language for Learning Improvement: Science' pilot (See

7.10). The abridged version has simplified headings that are easy for teachers to recall, and are intended to serve as mnemonics, such as ‘Look back, look forward’, ‘Power up, power down’.

The full and abridged versions are attached as Appendices 2a and 2b.

7.2 The value of using focus texts for planning and teaching

The value of developing a focus text has been reinforced by all teachers for both data collection periods. Even though its construction in some ways added pressure to the planning stage, its benefits were more than we anticipated. Observations and reflections from all teachers and researchers found that it contributed in three ways:

- a) It scoped and sequenced the whole topic because the logic of the written text mirrors the logic of the topic. Paragraph 1 of the text directed the content of the first lessons from introduction through to writing before the content of Paragraph 2 was introduced, and so on. The teachers found the focus text very useful:

Essential for guiding the scope and sequence of the topic.

Having the focus text made it easier to work with the scope and sequence and choose appropriate, relevant and interesting activities to engage students with the language and therefore the science knowledge/curriculum outcomes. This part can be somewhat difficult to begin with, but once some planning and discussion has been done you flesh out many of the possible questions/possible difficulties and therefore have the content of the lessons and possible responses required already set in your mind.

The focus text made the lesson easier to plan, and became the build-blocks of the overall learning intention.

The focus text provides a solid base of understanding, upon which further learning about the topic can be made. The formulation of a focus text at the beginning of a unit actually assists in clarifying my own understanding of a topic.

- b) It guided language use during the teaching and learning process. All teachers became conscious of introducing not just technical terms to students, but more ‘written-like’ grammar. They became adept at pedagogic strategies to hand over new language to students so that students were talking and writing new language, not just hearing it from the teacher:

The focus text is an excellent resource to come back to, ensuring teaching stays ‘on track’.

Using the focus text as a guide for my language is probably one of the most valuable parts of having the focus text, as instead of changing my language lesson to lesson a common and shared text (language) is created and all members of the class support each other to use the relevant language. This allows you to provide a lot of repetition and gets

to the point where the students are using the power up language and the teacher is supporting this with the power down language.

This has been really good, because as a Non-ESL trained teacher, I am not as acutely aware of the simple pitfalls I can create for ESL students like other trained ESL teachers maybe. Accuracy of language is vital to ensure clarity of common understanding and the focus text helps keep do exactly what it's called - focus. It also helped me slow my teaching down, rather than rush things, and better pace the lesson.

Once a common language around the fundamental elements of a topic has been reached, it is essential that this is referred to throughout the rest of the learning on the topic regularly and consistently, gradually releasing control of the language to students as they consolidate the understanding on a deeper level, requiring less and less scaffolding. Once the fundamental concepts have been internalised by the students, their ability to transfer this knowledge to explore more complex ideas within a topic is greatly increased. Misconceptions and guess work do not impede the learner's ability to access deeper learning on a topic.

- c) The structure and language of the focus text provided a valuable guide for the jointly negotiated text, for text analysis and for students' written assessment. Our planning with teachers in Science included a text analysis, highlighting the targeted grammatical features and their purpose. This meant that teachers who might not be confident with grammar could at least teach about these features.

The focus text structure became the structure of the final written assessment, at text level, and within paragraphs. The same structure was used to record class notes in preparation for writing, so that ideas were already classified in systematic ways before any writing began. The teachers saw it this way:

It would have been very difficult to do this without the focus text.

The text was quite valuable, particularly for those less capable students who required more prompts/support during the construction of their own text. Joint constructions throughout the lessons were also valuable to demonstrate to students (particularly those who [thought they] could work independently but needed small amounts of support before they could) a process to follow when creating a text, e.g. Create notes from research texts, decide on a structure, use appropriate scientific terminology.

This was a wonderful way to consolidate their literacy learning of the Maths concepts. Gives the teacher the ability to check for handover, and helpful before the kids begin to practice their learned knowledge.

7.3 The roles of the focus text in science and mathematics

Prior to this research project, we had worked with teachers to develop focus texts in science. Because the production of multi-modal texts is core business in science, we were confident

of their use as guide to teaching and to an assessable product at the end of the topic. The texts we planned together were recognisable genres, aligned with the language expectations of the literacy capability in the Australian Curriculum (ACARA, 2013a), and in genre, matched formal assessment written and oral tasks at the end of the topic.

In contrast, the role of the focus text in mathematics was unclear to us, and a new application for the pedagogy, and we are grateful for the opportunity to investigate in this area. Together, teachers and researchers negotiated the focus texts, identifying the target language and learning content of probability and telling time. However, we discovered a significant difference in the role of the focus text in these mathematics topics when compared with science. They were not recognisable discrete genres. Instead, the focus texts tended to be briefer and not as cohesive. There were short but dense definitions which assisted teachers in orienting students to the purposes of learning mathematics. Students did not learn to recite them independently, but they became a reference written on posters in the room e.g.

Probability is predicting the chance of future events by thinking about what we already know to help us plan for the future.

Some were sentence beginnings to help the teacher remain consistent in making a mathematical statement. These sentence starters were also displayed in the room for students to call on in composing statements:

It is impossible that...

There is a high chance that...

Others were simple generalised statements that acted as a mnemonic when students were engaged in the cognitively challenging process of telling the time:

The hour begins when the hour hand points straight to a number on the clock face. It stays that hour until it clicks over to the next number.

When we read the time, the hour goes first and then the minutes past with the divider in between.

Language is one of three semiotic resources available for meaning making in mathematics; the other two being mathematical symbolism and visual images (O'Halloran, 2005). Importantly, these resources work inter-semiotically, that is meaning is created and enhanced, not just within each mode, but across modes.

Unlike the science topics, the writing of an extended text in the two maths topics was not the end goal. Our end goal was for students to be able to recognise and write 5:20 but also have the language to express what those numbers represented. When we write the time 5:20, we are symbolising 'Five hours and 20 minutes, that is five and one third hours past the hour of 12 which could be 12 midday or 12 midnight (and to know which this is you have to look at the context and then add am or pm to the numerals)'. Mathematics values the economic expression of very concise and dense meanings, and one process through which this is achieved is the production of semiotic metaphor through a reconstrual of semiotic resources,

such as transferring from and reducing language to symbols (O'Halloran, 2005). On the one hand, we wanted students to express the time as succinctly as possible, and it is inefficient to express time with all that language. On the other hand, it was important for students to be able to retrieve and use language when required, and not just mindlessly read the numbers on the clock without meaning.

Being able to call on language as a mnemonic is significant in Vygotskian child development theory. As children appropriate language, there is often a stage of 'ego-centric' speech where language is spoken out loud to accompany an action. *The relative amount of egocentric speech... increase in relation to the difficulty of the child's task* (Vygotsky, 1978, p. 27). Once the language has become the child's own, it can be retrieved and spoken when necessary, a 'thinking out loud' to support a cognitively challenging activity (like telling the time). It serves as a guide to accompany action, as well as a planning tool (ibid).

In other words, our focus texts played a different role from focus texts we employed in science. There is no doubt they were still highly valued and useful in the development of language and the topic scope and sequence, and we look forward to further exploration in this area.

One of our ongoing questions is the cognitive load created by our expectations that students would use specific language. This was an observation made by one of the teachers:

My reflection at the end of the unit is that we have spent so much time on the language of chance that the content, at times seemed relegated to the back seat. Even when the language of chance had been learned by students, and they were able to respond using appropriate and specific phrases and terminology, it appeared that the student's cognitive load was so dedicated to answering questions using the correct language that they often made basic concept errors.

It was apparent that we were ambitious in what we hoped to cover in the five days of each data collection period. More time was needed to gauge how long it took for everything to come together. This was also the conclusion of the teacher who continued teaching the topic beyond our research period and who wrote:

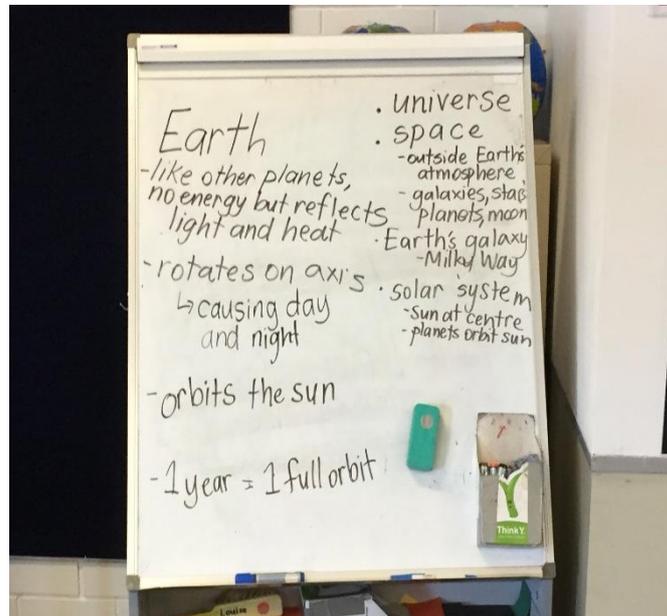
My first instinct in this is that it is a question of time. As the unit was only 5 weeks in length, and chance is not necessarily a high priority for these learners there was perhaps not really enough time for students to gain automaticity with the language. Had they done so I feel that they would have been able to use the language as a way of gaining a deeper understanding of the content.

7.4 Class notes as a pivotal link between oral and written meanings

In the course of planning and reflecting on the science lessons we refined our understanding of the potential of class notes as a powerful and pivotal link between the oral negotiation of meaning and the class- and independently-constructed written texts.

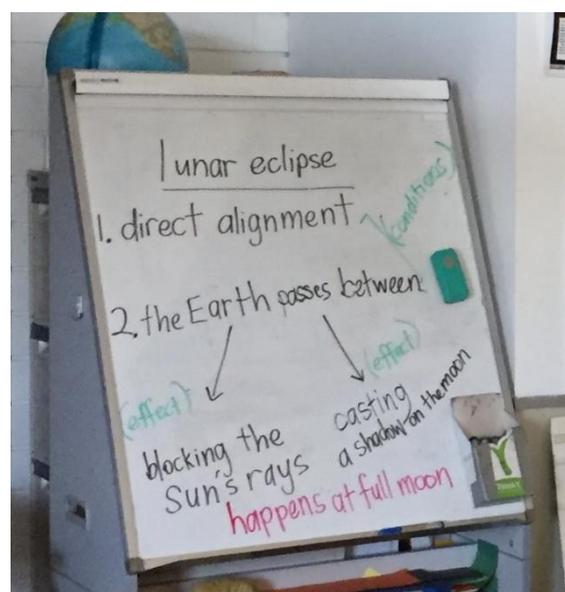
At the most basic level, the notes could serve as a record of the language that was developed in the orientation stage of the lesson, a written reminder of key words and concepts, as in the photo below. These notes, from Day 1 of 'Lunar Eclipses', provide summarising information about the Earth's orbit and its place in the universe:

Figure 18. Lunar Eclipse notes Cowandilla



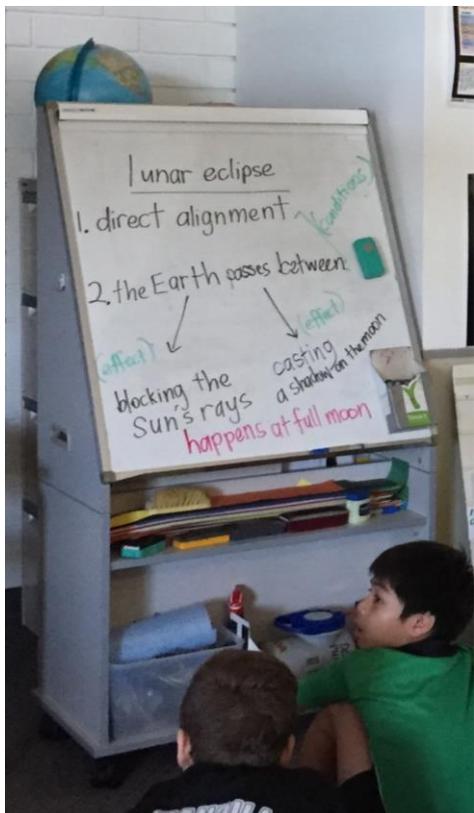
However, as we reflected on the effective use of various semiotic modes in the classroom we realized that class notes could also be used in a more systematic and ultimately more powerful way. The photo below shows a set of class notes that were constructed by the teaching team on Day 2 of their teaching, both to support the oral language of the topic orientation, and to serve as a visual organisational cue for the class text that would be negotiated later.

Figure 19. Revised Lunar Eclipse notes Cowandilla



This second set of notes was constructed more intentionally to foreshadow the structure and language of the focus text, as we can see when we view the notes in light of our original text analysis:

Figure 20. Relationship of class notes to Lunar Eclipse assessment text



A lunar eclipse occurs	Phenomemon
when the sun, the earth and the moon are in direct alignment ,	Condition 1
and the earth passes between the moon and the sun,	Condition 2
blocking the sun's rays	Effect 1
and casting a shadow on the moon .	Effect 2
This only happens at full moon .	Condition 3

The teachers also made sure to orally introduce some metalanguage for the text structure ('conditions', 'effect') and they added these terms to the notes, so that the terms would subsequently be available to frame the staging of the written text.

Creating and using notes in this way required teachers to be highly cognisant of the focus text throughout the entire teaching sequence, and we recognize that this placed a high demand on the teacher's working memory as they simultaneously managed the class and facilitate the activities and dialogue. However, well-constructed notes also lightened the teacher's load when they came to lead a joint construction, as the logic of the target text was already laid out and visible to all. For the students, the notes remained a stable artefact on view throughout the teaching sequence and therefore served as a visible reminder of the completed orientation activities, as well as a visual plan for the writing that was to come.

Figure 21. Intersemiotic mediation: from text notes to joint text construction



7.5 Shared experience as a foundation for learning

The confusion over the probability of Darren's dog speaking Djebbona in Section 5.2.5 highlights the potential confusion created by different world views, even with the best-intentioned teachers. We were introducing the notion of probability and chance in the everyday, and everyday experiences are highly subjective. Because the subjectivities of teacher and students were not shared, coming to a common conclusion about the degree of probability was difficult. In fact, it was a serious risk to the teaching and learning, because students lost confidence. They learned not to rely on their own judgement, but to carefully watch the teacher for signs that hinted at the 'right' answer.

In this cross-cultural situation, it was far more reliable to base our lessons on shared experiences, mediated through language, to create intersubjectivity needed for learning negotiation. We adhered to this principle in the second round of data collection, with much more success. Gray had learned this lesson almost twenty years before we did:

Shared experience allows the process of joint construction to operate. Without it, the activity often breaks down... It is in this way that the notion of inter-subjective sharing (D'Andrade, 1987) ... becomes so central to the scaffolding process. It is knowledge that is inter-subjectively shared that is brought forward by the child from one interaction context to the next. Moreover, inter-subjective sharing underlies the capacity of the adult to build accurately on what the child already knows. It allows the adult to target and structure information and questions that are genuinely interpretable by the child (Gray, 1998, pp. 102-103).

The word problems and questions developed for the teaching and learning of probability were not always 'genuinely interpretable'. Our experiences in Maningrida bring into question the pedagogic principle of 'cultural competence' for non-Indigenous teachers working with

Indigenous communities (DEEWR, 2009; Plummer, 2013; Prouse, 2011). Cultural differences identified in the literature on cultural competence tend to reduce different perspectives to country and kin:

But at its core, Aboriginal pedagogy hinges upon people and place—land and community. Any learning not situated within these two dimensions will produce limited outcomes for our students. Culturally responsive teaching involves grounding learning in students' own experience and knowledge of people and place, and ensuring the school and classroom environment reflect these (AAMT, 2013).

In our case with teaching probability, grounding learning in students' own experience, and trying to second-guess the cultural values underpinning everyday practices sabotaged our topic and the result was not harmless. Learning through shared, mediated activity reduces the risk of these cultural confusions.

Although the cultural clashes at Cowandilla in the high-ESL mainstream class were less conspicuous, it stands to reason that multiple world views were represented in the multicultural mix. We follow a fundamental principle that we can make no assumptions about alignment, and that explicit teaching must establish shared meaning through the learning activity.

7.6 Efficiency - every move counts

Closing the educational gap for marginalised students requires time-consuming meaning-making work in the classroom. This becomes even more urgent for remote Indigenous students who may only attend 60% of the school year. Therefore, every step, every move, every minute counts. The quest for efficiency became part of our planning and review with teachers, as we discussed the purpose and potential consequences of pedagogic choices.

To illustrate this point, we discuss two common activity types in Australian science education. These strategies would be regarded by many as best practice for inclusive, engaging science education.

Think-Pair-Share (SCTL, 2017) is a strategy where the teacher asks a question, and students are given a few seconds to think, then turn to the person next to them and discuss, sometimes for as little as 20 seconds, before sharing the answer with the class. We observed this at the beginning of a topic, with the intention that students had a chance to express what they already knew about the topic. Our concern is that this process pays lip-service to the notion of 'student voice'. Students didn't have time to talk anything through thoroughly; because the answers were not mediated by the teacher, there was a risk that misconceptions were consolidated and handed on to the partner; if students didn't have the language to answer the question, they only had one other person to rely on to get that language, and there was little time for appropriation of new language and meaning. The teacher only accepted one or two answers, and there was no time to further expand on meaning. At the beginning of a

topic, this strategy was inefficient because, while on the surface there was a high level of engagement, a 'buzz' in the room, there was no mechanism for using this activity for developing academic language and thinking. For students who didn't know the answer, the teacher's crucial role as mediator was absent.

If on the other hand, *Think-Pair-Share* was conducted towards the end of a topic, and time was given for pairs of students to produce a statement about something they had learned, or to contribute to a jointly constructed text, or to comment on a diagram on the board, then there could be real value. It would be a useful step towards independence, where students together practiced the language and meaning they had appropriated through the lessons to come up with an academically valued statement that would be understood by all.

Hands on activities are valorised in mathematics and science, and certainly academic meaning is established by exposure to a range of semiotic systems, such as hands-on activities, viewing videos, reading books, field trips and diagrams, all mediated through carefully chosen language. However, we suggest that teachers need to think carefully about the value and timing of hands-on activities, and not offer them just because they encourage a high level of energy and superficial engagement. One example from our data was an activity to demonstrate the size of an atom. Year 6-7 students were given an A4 sheet of paper, and kept folding and tearing the paper as many times as they could until each piece was so small it couldn't be torn further. The point made was that atoms are even smaller than this in comparison to the size of the sheet of paper they started with. We observed the time it took just to distribute the paper before the teacher could even begin to give instructions. Students then paid attention to folding and tearing and getting the little bits of paper to stick to their finger, rather than to the fact that each represented an atom. Previous work tells us that, because of the situated nature of hands-on activities, academic language development can be backgrounded, because pronouns pointing to objects are sufficient for communication (Parkin, 2015). We suggest that it might have been far more efficient simply to explain to the class that 5 million million hydrogen atoms would fit on the head of a pin and give students time to digest this fact.

A contrasting use of hands-on activity was the development of the electric circuit described in Section 5.5. The teacher efficiently mediated the activity beforehand with a demonstration, an explanation, and labelling of parts so that students were already resourced with process, an understanding of the end product, and language.

Some forms of inefficiency are subtler and can be found by analysing the classroom talk. One example is *Losing sight of the target language*. This is easy to do in the complex setting of a lesson and especially when the teacher is learning to use this language-centric scaffolding process. We observed this in 'Telling the time', when the teacher intended to teach *It stays that hour until it clicks over to the next hour*. This is a complex sentence, with a dependent clause of time. Instead, the language he used for several turns was *This is still the hour of four*

because it hasn't clicked to the next number. The grammar here is a complex sentence with a dependent clause of reason. There was nothing wrong with the sentence, but, instead of the students having the chance to hear and appropriate one grammatical structure, they were exposed to two alternative structures and two alternative logics, one of time and one of reason, each for half the time. We had a mantra for teachers that 'no-one dies'; it's just that the teaching and learning process became less efficient and had to be revisited in the next lesson.

We do not want to place efficiency in opposition to the important concept of *built-in redundancy* which is an important principle of scaffolding pedagogy (Hammond, 2001), with students gradually building meaning and language with each pass, with each revisiting of the content. To be efficient, the teacher has to contingently hand over some control to students at each pass, checking for handover, eliciting increasing amounts of academic talk from students, so that, by the time the class engages with joint and independent writing, they have appropriated new academic language resources, both vocabulary and grammar, with which to express their learning.

7.7 Use of technology

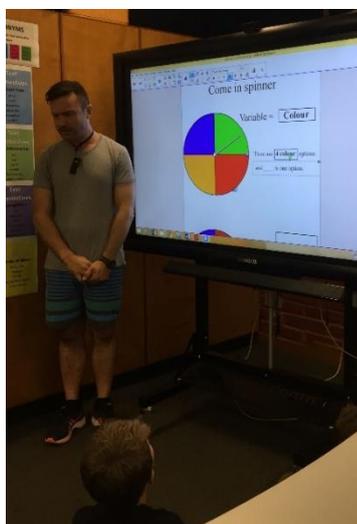
In recording the lessons and working with the teachers we have used technology, and observed teachers' use of technology in ways that we consider to be highly productive and are worth commenting on here.

In class and for assessment

Interactive whiteboards are an invaluable tool for enabling teachers to bring various forms of sophisticated content into the classroom, and to retrieve that content quickly and efficiently.

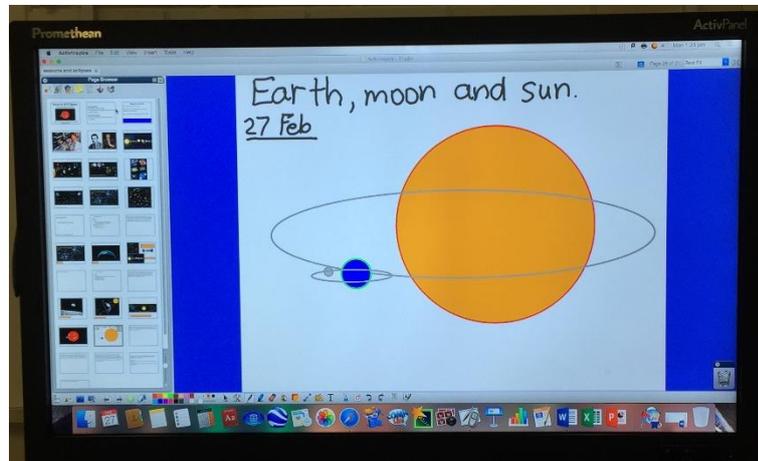
For example, in the Probability lessons, the teacher used a digital spinner to teach 'one in four' chance:

Figure 22. Use of a digital spinner



In 'Lunar Eclipses' the teachers selected a range of diagrams and animations in advance of the lesson and retrieved these efficiently whenever they needed them.

Figure 23. Lunar eclipse diagram on interactive white board



In the science lessons we observed video used in a highly effective manner. The teachers used animations that represented the configurations and movements of celestial bodies in ways that were easy for the students to understand. Showing the videos with the sound muted allowed them to introduce the language of the focus texts and to avoid the kind of semiotic overload that otherwise makes video in classrooms a less effective too.

The Cowandilla teachers also made excellent use of:

- *Explain Everything™*, an app that allows students to write, draw, add and move objects on their iPad™ screen, and to voice record their explanations. The Cowandilla teachers work regularly with this app and the students are used to working in pairs, using the app to help explain diagrams and concepts to one another, and recording their explanations. The app was a great bonus to our project as it allowed us to gather extra data of the students' oral, diagrammatic and written explanations.
- *Airdrop™*, allowing them to share documents, pictures, diagrams quickly, so that, for example, all students could upload diagrams or texts on their iPads™, supporting efficient transition between activities.

In all their use of technology, we noted the teachers were able to considerably 'value-add' to their lessons, using apps and tools in a way that was purposeful and coherent with the aims of the teaching sequence: it did not detract from or hijack the aims of the lesson.

For research

To record the lessons we used a Swivl™, a robot that pairs with an iPad™ to allow video and audio recording of the classroom in a relatively unobtrusive way. The robot (with iPad™ as a camera) follows a tracker which the teacher wears around his neck, and which also serves as

a microphone. Two additional trackers can also be given to students or placed in strategic places in the classroom. These serve as supplementary microphones.

The Swivl™, mounted on a tripod, created an easy camera setup, and once the students knew what it was they mostly ignored it. The Swivl™ allowed us to have the teacher constantly in the frame without having to move the camera ourselves, and we always had a clear pickup of the teacher's voice. Once recorded, the videos were uploaded to the cloud, which meant they were easily saved and stored (although good wifi access was essential for this).

A negative point was that we did not control what was in and out of the video frame, and sometimes fidgety students or non-teaching interactions 'upstaged' the visual of the teacher. For this reason, the resulting footage would not always be ideal for teacher professional learning purposes.

On the whole, however, we found the Swivl™ was a useful recording tool for classroom research.

7.8 Types of student assessment - limitations and potential

For the purposes of this project, we focused on assessing student appropriation of academic language in the form of a 'story' retell as well as in their independently written texts. This meant that we could do more than simply focus on the use of isolated technical vocabulary; we could compare the use of grammatical structures. The assessment process provided useful quantitative data from the educationally marginalised students on language, but no comprehensive assessment of the concepts through application of the language with diagrams for example.

Given that each data collection period was one week, covering four to five lessons, we were not able to test for longer-term understanding of concepts or retention of language. However, in the case of the Cowandilla, teachers continued with the topic and collected their own student assessment data. Students used the app 'Explain Everything™' to talk about their writing, to further explain the concept of eclipses, and to reflect on the teaching and learning process (Refer Aisha p74).

The appropriation of grammar is a developmental process, and we are interested in how teachers continue to consolidate student grammar use, and its appearance in subsequent curriculum topics. We are also interested in students' appropriation of text in meaningful ways, and the processes for ensuring that we avoid the risk of mimicry in students' work with the focus text. We suggest that to better address such issues in the assessment of conceptual understanding, we would need a more longitudinal study.

7.9 The value of collaborative research between academics and classroom teachers

Working with high quality teachers in researching effective pedagogy for marginalised students was, for the research team, a privilege. We were advantaged from the beginning because we had well-established mutually respectful and trusting relationships with the school principals and teachers, so we could start the project 'on the run'. The teachers were remarkable in their willingness to take risks, to be reflexive and accept recommendations and requests for change in their practice.

There were two instances when one of the researchers modelled particular pedagogic language when the teacher became stuck. This is not the usual 'at arms-length' role of researchers, but it seemed illogical in our research context to limit support for teachers to after-school talk, when modelling was necessary for the teacher to keep going and not lose confidence.

The role and backing of the school principal was also crucial and to them we are grateful. They monitored the progress of the project, mediated with the school governing council when needed to explain our purpose and seek consent, and ensured that the project continued unhindered, despite the event-filled school calendar.

The feedback from teachers was very positive, and we are pleased that satisfaction in the research process was mutual:

I found having the researchers in the classroom to be a fantastic opportunity to fine tune and tidy up my own teaching routine, and develop a more precision based approach when using language as I mentioned above.

Both researchers are clear in their expectations, provide sound insight into the theory behind the project and offered ongoing support throughout.

Hugely valuable and rewarding process. Found the first unit with electricity a bit easier in terms of planning as we had the text analysis in advance. Later unit felt more rushed, although I was a lot more confident with the pedagogy. Always felt support and safe to try and make mistakes. THANK YOU!

The support you gave to me throughout the entire project was valuable, having knowledgeable and supportive experts makes you feel more confident with the process and the teaching of the lessons. If other teachers were to working this way and people such as yourselves were not available, having a science/maths expert teacher working with others would, I think, allowed teachers to engage with the process with less stressed as there would be someone there to support them. Providing resources like you did, such as the observation tool, the text, websites/videos for research further supported the process. Finally, a text analysis from an expert helps me (being more of a science than English

expert!) ensure that the important English/grammar information was presented to the students as clearly as the science content was

As a classroom teacher, you are often so involved in 'doing' the teaching that it is hard to dissect and actually pinpoint exactly what it is that you are doing at any given moment. There is a certain level of unconscious competence that is necessary in the moment to allow teaching to be responsive to student need and dynamic. Having the researchers observe the teaching practice and offer their expert insights as they dissect it with you can be highly beneficial. It can be surprisingly satisfying to not only find what's working in your own practice, but by becoming conscious again of what is happening in the moment, you are able to see where you are being truly effective and where you may perhaps need to adjust.

7.10 Further directions for research

We see the following areas as creating possible topics for research:

- The use of focus texts in mathematics: we have only just begun this work. Further research in other aspects of mathematics, such as number, would help to clarify the role of focus texts in this learning area.
- Assessment tools: further work is needed in how to assess longer term student concept development alongside language development.
- Student appropriation of new language: the effect of teaching relevant grammar on student uptake of academic language.
- Working with teachers: how do we continue to refine our support tools to make them accessible for teachers in a way that produces effective student outcomes

7.11 Further directions for implementation

A number of aspects of the research, using the Observation Tool as a frame, have the potential to be developed into a series of modules or workshops for teachers, either face to face or online. Modules might include:

1. Focus texts: their purpose, how to write one, and how to conduct a text analysis.
2. The observation tool to guide the practice of scaffolding, helping teachers to:
 - Consciously modify classroom talk so that students can appropriate subject-specific language;
 - Use high-challenge focus texts effectively;
 - systematically use images and diagrams together with language to support sense-making.

The South Australian Department for Education and Child Development (DECD) has contracted UniSA to develop a two-day Professional Development workshop called *Language for Learning Improvement: Science(LLIS)* as a small pilot project with 20 Year 4/5 and 20 Year 8 teachers. UniSA has contracted PETAA researcher Bronwyn Parkin as lead writer.

The DECD project has the potential to become a useful template for PETAA. For example, PETAA might consider developing a similar modular online course, linked to the Teacher Professional Standards, and using the planned PETAA teacher publication, the abridged version of the Observation Tool and video clips emanating from the Scaffolding Academic Language project as resources.

In this project we worked with the willing: four competent, reflexive and hardworking teachers. What we are proposing is complex, and requires the unsettling of classroom practice. It requires knowledge about how to contingently select appropriate scaffolding, as well as a familiarity with genres and grammar, and experience in text analysis. As supported by research into best practice in teacher development, we suggest working with volunteer teachers for fidelity of implementation and quality practice if this alternative to constructivist pedagogy is to continue.

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Appendices