While Marylin Low approaches literacy from a content and language perspective, where the learning of English must be tied to particular content areas, Lesley Lee has been preoccupied with the language of mathematics, or mathematics as a language, for a number of years. Towards the end of 2004, both authors were asked by Pacific Resources for Education and Learning (PREL) to commit to a two-year pilot project called ASCEND-Mindanao—Lesley Lee as the mathematics specialist and Marylin Low as the English specialist. The project involved them in a larger endeavour in the southern Philippines headed by Save the Children Federation. PREL was to work with a group of about a hundred educators from seven of the poorest school districts in the region to improve the teaching and learning of English, mathematics and science.

School visits and early work with the local educators—not to mention their own backgrounds and beliefs—led them to begin developing an integrated approach to teaching. Thus their work in the Philippines was the trigger and opportunity to bring together the two fields of expertise and to create an approach to integrating numeracy and literacy where communication and problem-solving are emphasised.
and embedded in everyday contexts. The approach they call PRIME—Pacific Region Integrated Mathematics and English—takes hold of what it means to teach meaningful and empowering mathematics and English in ways that take into account the needs and experiences of linguistically and culturally diverse learners. In this chapter, the authors provide a theoretical background from each of their perspectives and the principles and practices that grew out of it to become PRIME.

**Pacific contexts**

In most Pacific communities, mathematics is taught in English, a second or third language for many students. In some jurisdictions, such as Hawai‘i, the medium of instruction is English, the dominant language of the community, and English learners (ELs) are included in mainstream classrooms; in other jurisdictions, such as Samoa, indigenous languages are the language of home and community and most if not all students are ELs. Furthermore, in some island nations, schooling begins in the local language and transitions to English in grades 3, 4, or 5, depending on the language education policy. For much of the Pacific, school is the primary source for learning English.

The English of mathematics is not, however, everyday English. The language of mathematics, or the mathematics register, is considered a second language for all learners—all students can be categorised as mathematics language learners (MLLs). The school mathematics register, or the language of western mathematics, typically is not used in Pacific communities outside the school, where it may co-exist with or even be eclipsed by indigenous mathematics. Being an EL and an MLL makes learning school mathematics challenging. Additionally, classroom teachers who are fluent in English and the languages their students speak, as well as fluent in the mathematics registers of both languages and confident in teaching mathematics, are hard to find.

Up until this time, attempts to improve mathematics teaching and learning in Pacific schools have focused on mathematical content and pedagogy, including current reforms that aim to embed students’ mathematical learning in everyday situations and emphasise mathematical talk. Other interventions work on improving
students’ competence in English. While both interventions are necessary, the English of mathematics—the very narrow and sometimes unusual use of certain English words in the mathematical register, the new mathematics vocabulary, the symbolism and syntax of mathematics, the language of hypothesising, conjecturing, generalising and proving—is not typically addressed. While the second language field has developed and implemented language and content approaches across disciplines with considerable success in Canada and on the US mainland, and the language of mathematics has been explored in the field of mathematics and education research, few have taken an interdisciplinary perspective.

**Why integration?**

**Language and content within second language education**

Language and content approaches have developed rapidly in the last decade in response to two major shifts in North American classrooms: a dramatic rise in the number of ELs in school and the growth of foreign language programmes and immersion classrooms. Research on immersion contexts closely matches environments in the Pacific, where the language of instruction is not the language of the community. Although immersion programmes have a double goal of both language and content learning, the majority of immersion research has focused on language learning. What we have learned from this research in Canada and the United States is that a language and content approach is more effective than teaching language in isolation (Mohan, 1986, 1990; Swain, 1996).

Key to language and content approaches is a focus on relating form (grammar) and function (meaning). In language and content classrooms, language is used in the service of other learning, with planned integrations of content and language that promote culturally contextualised teaching practices. Language and content teachers are concerned with the functionality of language and the need to take advantage of the learners’ communicative environment. They use a number of pedagogical strategies and techniques: student grouping strategies; active participation in concrete task-based or experiential, inquiry-based learning; graphic organisers; and a whole language approach (Crandall, 1992). In her research, Short (1993: 595) studied the language and content of social studies
The basics of learning

classrooms, defining the academic language of social studies broadly to include, “[s]emantic and syntactic features (such as vocabulary items, sentence structure, transition markers, and cohesive ties), and language functions and tasks that are part of social studies classroom routines”. Mohan (1986, 1990, 2001) claims that linguistic content is inseparable from linguistic expression and offers the notion of knowledge structures as an organising framework for language and content integration. It is a view of functional grammar in which context (content) and language relations play a central role.

Effective language and content teaching and learning includes explicit and intentional use of language to learn about subject matter and a supportive, risk-taking environment. Models of language presented are understandable to the learner and provide new ways of constructing and extending meaning through peer and teacher interaction that is structured into daily activities (Echevarria, Vogt & Short, 2004; Calderón & Minaya-Rowe in press; Gibbons, 1993, 1998, 2002). Focusing on content alone in the content classroom makes language the invisible curriculum. Teachers, aware of the language they use, deliberately create opportunities for students to hear and use it in the construction of their own content knowledge—language becomes a routine aspect of lesson-planning and teaching and learning in the content classroom. The dynamic nature of language and content provides students with an opportunity to learn what is most relevant at that time (language and/or content) while being fully engaged in learning activities and challenged at an appropriate conceptual level.

Mathematics and language

Many mathematicians and mathematics educators claim mathematics is a language—with its forms, functions and meanings, and its highly developed syntax and rather narrow semantics (Lee, 1997). The language view has served mathematics educators well, since it has allowed the community to become more aware of the nature of the mathematical language—or mathematics register as it is generally referred to—and the complexities of teaching and learning it.

Halliday (1975:65), a sociolinguist, defines a register as a ‘set of meanings that is appropriate to a particular function of language, together with the words and
structures which express these meanings’. Schleppegrell (1998), using a functional
grammar analysis of science, and Gibbons (1998), using scaffolding student-
teacher interactions in content classrooms, are two examples of register-based
research approaches to the study of more formal school registers by English
learners. Pimm (1989), a mathematics educator, devoted a large part of his book,
Speaking Mathematically, to an analysis of the mathematics register. Some important
characteristics of the mathematics register are:

- specialised words rarely occurring outside mathematics (multiplicand,
parallellogram, asymptote, isosceles, hypotenuse…)

- words taken from everyday English but given restricted or new meaning
(diagonal, straight, equality, face, degree, relation, power…)

- phrases or ways of putting English words together to produce new meaning
(simultaneous equations, absolute value, right-angled triangle, square root …)

- modes of arguing and proving (reductio ad absurdum, induction, deduction, use
of counterexamples …)

- particular sentence constructions characterised by greater use of the passive
voice (a line is drawn to bisect…), gerunds (addend, integrand, multiplicand…),
a range of imperative forms (let, suppose, define, consider…)

Written mathematics has additional peculiarities; it is not just spoken mathematics
written down in words. By middle school, students in mathematics are expected
to use a highly symbolic and succinct notational form which includes the use of
letters of the alphabet as non-alphabetical symbols, the use of Greek letters as
fixed constants (π for the fixed ratio of a circle’s circumference to its diameter),
variables (3x + 2y) or abbreviations for operations (Σn for the sum of the numbers
from 1 to n), the positioning of numbers and letters as superscripts (sometimes
to indicate powers or exponents) or subscripts, and a whole collection of symbols
for operations (±, +, ÷) and relationships (≥, ≈, ≠).

Pimm (1989: 88) states that ‘Most math classes are conducted in a mixture
of the registers of ordinary English and mathematical English, and failure to
distinguish between these two can result in incongruous errors and breakdowns
in communication’. Pimm claimed that teachers are often not aware of moving
from one register to another and do not appreciate the pitfalls for the learner.
The basics of learning

In 1994, the National Council of Teachers of Mathematics (NCTM, 1994) published a position statement on language minority students, which essentially says that “cultural background and language must not be a barrier” to the study of a full curriculum in mathematics. The NCTM (1989) goals for mathematical literacy are that students: learn to value mathematics, become confident in their ability to do mathematics, become mathematical problem solvers, learn to communicate mathematically, and learn to reason mathematically.

What numeracy and literacy integration looks like

PRIME is an example of a language-focused approach to improve the learning and teaching of mathematics. It is based on the four key principles offered below. These are followed by an outline of an integrated lesson that puts these principles into practice.

1. The mathematics classroom provides a comfortable/risk-taking learning environment.

   In order to facilitate learning by all students, teachers must also be perceptive and skilful in analysing the culture of the classroom, looking out for patterns of inequality, dominance and low expectations that are the primary causes of non-participation by many students (NCTM, 1991: 34).

   Certain rules of classroom behaviour involving active participation, listening and mutual respect need to be established and sustained. If learners feel supported and secure, they will be willing to risk using their language resources to make mathematical meaning; if they feel comfortable, they will risk sharing with peers and teachers their ideas about their mathematical work.

2. English is used in the service of learning mathematics, with planned integration of mathematics content and language.

   In the mathematics classroom the focus is on the mathematics and the mathematical tasks the students are engaged in. In the course of these activities, students need to
formulate questions, make conjectures, present solutions, and write for themselves or publicly. Words needed from the mathematical register or the school English register are picked up from peers, the teacher and written and electronic material. In other words, they learn the language of mathematics and of the mathematics classroom because they are immersed and engaged in a mathematical community of inquiry (Lee, 1996, 1997).

3. There are planned opportunities for meaningful, comprehensible interaction in the mathematics classroom (e.g. among peers, students and teachers).

The peer group is a powerful resource to the learner, providing a wide range of models of language use, and the need to communicate offers the learner strong motivation to use language in the mathematics classroom.

Students must talk, with one another as well as in response to the teacher. When the teacher talks most, the flow of ideas and knowledge is primarily from teacher to student. When students make public conjectures and reason with others about mathematics, ideas and knowledge are developed collaboratively, revealing mathematics as constructed by human beings within an intellectual community (NCTM, 1991: 34).

Peer interaction can be organised in multiple ways—small and large cooperative or collaborative groups—and different classroom organisations entail different discourse needs (Slovin, Zenigami & Venenciano, 2005). A classroom that uses a wide variety of peer interaction from whole group to small group organisations allows for the widest range of mathematical discourse. Teacher scaffolding\(^1\) makes explicit the academic register of school. Scaffolding interactions between teacher and student have a significant role in developing content, language and literacy within and across disciplines (Gibbons, 1998). Teacher–student interaction is also part of the ongoing and embedded everyday assessment teachers do in the classroom (e.g. observation and discussion, conferencing, discussions about task work). Such assessment practices help teachers learn about and act on the diverse strengths and needs of each child (Black & Wiliam, 1998; Low, 1999, 2003).
The basics of learning

In classrooms where meaningful interaction occurs, models of language presented are understandable to the learner and provide new ways of constructing and extending mathematics meaning. Learners hear models of literacy that will extend their own language use and meaning making. Such models include scaffolding and recasting strategies in support of language and mathematics learning, and offer students multiple representations of meaning (e.g. experiential, graphs, charts, visual, oral, print, technology) that they can explore, manipulate, and create anew (Calderón & Minaya-Rowe in press; Echevarria et al., 2004; Gibbons, 2002; Low, 1999, 2003).

4. Learners have opportunities to be mathematics ‘problem solvers’ rather than ‘information receivers’.

Students need to have opportunities to be ‘problem posers’ as well. The central activity of problem solving and problem posing in the mathematical community is the cornerstone of the NCTM’s Principles and Standards for School Mathematics (2000). Besides recognising the central role of problem solving (routine, non-routine, open-ended) in all students’ learning, the NCTM recognises its crucial role in the development of mathematics discourse:

The teacher of mathematics should promote classroom discourse in which students … use a variety of tools to reason, make connections, solve problems and communicate; initiate problems and questions; make conjectures and present solutions; explore examples and counter-examples to investigate a conjecture; try to convince themselves and one another of the validity of particular representations, solutions, conjectures, and answers… . (NCTM 1991: 45).

Principles into practice

At the end of this chapter there is an outline of a PRIME lesson, offering an example of a classroom activity that promotes integrated numeracy and literacy learning and is culturally contextualised. As part of a larger unit on comparing quantities, students in this lesson are learning to compare the areas of different types of locally found leaves in preparation for covering/protecting young
plantings in a taro patch. Language resources that teachers model and students apply in carrying out the task are highlighted. Teachers use oral strategies to develop students’ fluency in their use of mathematical language and English. Such fluency requires frequent and deliberate uses of language in mathematics activities. Working orally in groups on problem-solving tasks, such as the one on comparing area, invites students to talk like mathematicians. Extensions of this activity may involve writing and/or visual literacy, where students write and/or illustrate the mathematics they are learning. It is one way for students to learn what constitutes clear, valid mathematical communication.

Bringing together a language and content approach from the field of second language education and a mathematics and language perspective from the field of mathematics education offers a powerful and dynamic way of teaching and learning mathematics in the Pacific. Multiple and planned opportunities to talk and write mathematics within and beyond culturally contextualised tasks is a vital process for student learning. To create these conditions, teachers must develop a deep and substantive knowledge of mathematics, including its register, and of the culture and language of their students. They must use this knowledge to find or develop tasks that are both mathematically sound and culturally contextualised. It is hoped that teachers’ use of an integrated curriculum will begin to create such conditions in the classroom.

**Conclusion**

Using a case study approach, we have provided an example of how the Pacific Regional Integrated Mathematics and English approach can work in the Pacific region. This language-focused approach can be taken to improve the teaching and learning of mathematics. In as many ways as possible, teachers and teacher educators in the fields of English (or vernacular) literacy and mathematics education are encouraged to integrate literacy and numeracy in their work.
The basics of learning

**Task:** Compare the areas of these two leaves.

*This comparison can be set in a context of choosing what type of leaves to use to cover/protect plantings in a Taro patch (where the leaf that covers the biggest area is preferred).*

Is the area (B) of the broad leaf greater than, less than, or equal to the area (T) of the thin leaf?

Or

Which of the following is true?

B > T     B < T     B = T

Are there any conjectures? How can we test our conjectures?

Here is a list of available materials to use in our investigation:

1. Scissors and glue  
2. String and 30 cm. wood ruler  
3. Plastic cubic centimetres  
4. Pennies or one cent coins  
5. Triangle & rhombus pieces from a set of pattern blocks  
6. Square grid paper

Six teams form around the six materials and work on accomplishing the comparison task (testing conjectures, answering the question).

A plenary session follows where each team presents its work and answer to the question. Because the leaves are very close in area, teams may vary on their answers. A discussion follows on the advantages and disadvantages of the different materials and which team’s answer might inspire more confidence.

The materials used by the second team (string and ruler) give rise to some interesting discussions if the team used the string to compare perimeters. The relationship between perimeter and area can become the subject of another lesson. Question: If the perimeter of one leaf is bigger than the other, is its area bigger too?
Teacher draws attention to ‘mathematics talk’ by modeling and encouraging students to use such talk as s/he pushes them to explain their thinking and how they figured out the answer to the question.

**Comparison structures & symbols:**
- is greater than (>)
- is less than (<)
- is equal to (=)

Words and their symbols are written on the board or chart paper and students are encouraged to use them. Other comparative forms using ‘er’ are modeled:

- B is larger than T
- T is smaller than B

**Conjecturing** requires students to make an ‘informed guess.’ In this task, the conjectures describe. For example,

- I think B is larger than T
- T is smaller than B

They have the same area.

Note the use of ‘to be’ and ‘to have’ verb forms. Present tense is used in conjectures of this type. In other tasks, students might need to use an ‘if…then’ form of conjecture.

**Testing conjectures** requires the use of a variety of imperatives:

- Cover the leaf with these coins. Count them.

**Vocabulary** may include, for example, mathematics words in English that have no equivalent in the local language or that translate in two or more ways.

**Collaborating** to complete the task requires students to use language to:

- make polite requests (please pass…)
- take and give turns (Tero, what do you think?)
- clarify (Can you please repeat.)
- questioning (What do we do with the gaps between pennies?)
The basics of learning

Notes

1. **Scaffolding** is the temporary assistance by which a teacher/mentor helps a learner know how to do something, so that the learner will later be able to complete a similar task alone. It is future-oriented: what a child can do with support today, s/he can do alone tomorrow. Vygotsky (1978) suggests that ‘good learning’ is learning that is ahead of actual development. Implications for ELs suggest that rather than simplifying the task to reduce the language load, teachers should instead reflect on the nature of the scaffolding (of language and content) that is being provided for learners to carry out that task.

2. **Recasting** is a strategy used in oral interactions wherein the teacher/mentor corrects and/or paraphrases student speech. Corrective recasts repair form, making speech more literate. Paraphrased recasts address meaning in discourse

References


1. Scaffolding is the temporary assistance by which a teacher/mentor helps a learner know how to do something, so that the learner will later be able to complete a similar task alone. It is future-oriented: what a child can do with support today, s/he can do alone tomorrow. Vygotsky (1978) suggests that ‘good learning’ is learning that is ahead of actual development. Implications for ELs suggest that rather than simplifying the task to reduce the language load, teachers should instead reflect on the nature of the scaffolding (of language and content) that is being provided for learners to carry out that task.

2. Recasting is a strategy used in oral interactions wherein the teacher/mentor corrects and/or paraphrases student speech. Corrective recasts repair form, making speech more literate. Paraphrased recasts address meaning in discourse.

References