

Numeracy Teaching across the Curriculum in Queensland:

Resources for Teachers

September 2015



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0. Background

The Queensland College of Teachers initiated this project to enhance the teaching of numeracy across the curriculum in Queensland schools (both primary and secondary) by developing and making readily available, via the QCT website, user-friendly resources for practising teachers and pre-service teachers on the teaching of numeracy. The project builds on the work undertaken for the Board of Teacher Registration (BTR) in 2005 and reported in *Numeracy in Teacher Education: The Way Forward in the 21st Century* (http://www.qct.edu.au/Publications/BTR/BTR_NumeracyReport2005.pdf).

The project delivered:

1. A literature review of national and international good practice in teaching numeracy in schools, identifying key features of what works and why;
2. An audit of existing material available to Queensland schools/teachers on the teaching of numeracy;
3. An analysis of gaps and areas where Queensland classroom teachers would benefit from further or new resources;
4. A set of video vignettes illustrating good practice in numeracy teaching, capturing teachers identifying and explicitly teaching numeracy concepts in different year levels and subjects, especially subjects other than mathematics, and short interviews with the featured teachers.

This report is structured around these four deliverables.

The final set of video resources is available on the QCT ClassMovies website at <http://www.classmoviestv.com/qctuq>.

1. Literature Review: Numeracy Across the Curriculum

Numeracy is a term used to identify knowledge, skills and practices related to the use of mathematics in non-mathematical contexts and, in particular, to the use of mathematics in work, home and civic life. While the name numeracy is used in many English-speaking countries, such as the UK, Canada, South Africa, Australia and New Zealand; elsewhere other expressions, such as mathematical literacy or quantitative literacy, are employed when discussing the ability to use mathematics in real world contexts. Arguments for the development of students' mathematical capabilities as an important goal of schooling date back to at least 1944, when a post-war Commission of the National Council of Teachers of Mathematics (NCTM) in the USA took the position that schools were responsible for mathematical literacy for all who could possibly achieve it (NCTM, 1970). Since that time, the issue of how people *use* the mathematics they learn in school has remained a point of discussion for schools, education systems and policy makers (e.g., Ministry of Education, 1959; Cockcroft, 1982; Steen, 2001). Increasing national and international focus on numeracy, as part of schooling and beyond, is evident in the emergence of a number of testing regimes aimed at specific populations. Such regimes include, for example the: National Assessment Program – Literacy and Numeracy (NAPLAN); Programme for International Student Assessment (PISA); Programme for the International Assessment of Adult Competencies (PIAAC).

1.1 Definitions of numeracy

The term *numeracy* was first introduced in the UK by the Crowther Report (Ministry of Education, 1959) and was defined as the mirror image of literacy, but involving quantitative thinking. Another early definition proposed by the Cockcroft Report (1982) described “being numerate” as possessing an at-homeness with numbers and an ability to use mathematical skills to cope confidently with the practical demands of everyday life. In developing a more detailed description of the use of mathematics to meet the demands of work, home and civic life, Steen (2001) identified seven dimensions of numeracy (using the term mathematical literacy): confidence with mathematics; appreciation of the nature and history of mathematics and its significance for understanding issues in the public realm; logical thinking and decision-making; use of mathematics to solve practical everyday problems in different contexts; number sense and symbol sense; reasoning with data; and the ability to draw on a range of prerequisite mathematical knowledge and tools.

Internationally, definitions of numeracy vary across mathematics curriculum documents, standards frameworks, and assessment regimes. However, the OECD's (2010) PISA program description of mathematical literacy has gained broad acceptance:

Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals in recognising the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens. (OECD, 2013, p. 25)

Thus, a numerate person requires more than basic mathematical skills. They must also be disposed to using mathematical skills adaptively and strategically in order to deal with mathematically relevant situations across the range of non-mathematical contexts that can be encountered in private and public life. Additionally, the contemporary world demands of a

numerate person the capacity to exercise evidence-based critical judgment and decision-making (Geiger, Goos & Dole, 2014a).

1.2 Numeracy within the Australian context

In Australia, numeracy has been interpreted in a broad sense – similar to the OECD definition of mathematical literacy. A widely accepted definition was developed from a national conference on numeracy convened by the Australian Association of Mathematics Teachers in 1997. This definition states that to be numerate “is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life” (Australian Association of Mathematics Teachers, 1997, p. 15).

The notion of numeracy as an important goal for schooling was confirmed through a national numeracy review (COAG, 2008) that also promoted the view that the development of students’ numeracy requires a cross-curricular commitment by schools and systems. This review recommended that:

...all systems and schools recognise that, while mathematics can be taught in the context of mathematics lessons, the development of numeracy requires experience in the use of mathematics beyond the mathematics classroom, and hence requires an across the curriculum commitment. (COAG, 2008, p. 7)

Further, numeracy has been identified as one of seven General Capabilities embedded in the Australian Curriculum. Numeracy is described within each subject curriculum document via the following statement:

Students become numerate as they develop the knowledge and skills to use mathematics confidently across all learning areas at school and in their lives more broadly. Numeracy involves students in recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully. (Australian Curriculum, Assessment and Reporting Authority, 2014, p. 13)

This statement is elaborated upon through additional subject specific numeracy statements within each learning area document.

1.3 Facets of numeracy

The intrinsic usefulness of mathematics means that it provides a way of thinking about and living in the world. But people in different societies and cultures value and use mathematics in different ways, and this gives rise to different emphases in what numeracy means (Jablonka, 2003). Alternative ways of talking about numeracy include *mathemacy* (Skovsmose, 1994), *matheracy* (D'Ambrosio, 2003), and *critical mathematical numeracy* (Frankenstein, 2010). Numeracy related ideas are also associated with specific discipline knowledge, as is the case of *financial literacy* and *statistical literacy*. Zevenbergen (2004) has noted the importance of digital technologies in supporting numeracy, while other researchers have introduced the idea of *techno-mathematical literacies* to describe the new competencies that are needed in a technologically saturated world (Hoyles, Noss, Kent, & Bakker, 2010).

1.4 Numeracy across the curriculum

Internationally, numeracy (or mathematical literacy) is considered to be an important outcome of schooling; however, there is little agreement on how to develop numeracy capabilities in students. In many educational jurisdictions, it is expected that numeracy should be developed within mathematics courses and so becoming numerate is seen as an outcome of mathematics instruction. However, Steen (2001) argues instead that students must engage with tasks that

demand the use of mathematics in all school subjects, not just mathematics. Others have provided illustrations of what this might look like in a school context. Kissane (2012), for example, provides a summary of numeracy related projects in Australia, including the *Numeracy across the curriculum* project (Hogan, Van Wyke, & Murcia, 2004) and *Numeracy: Families working it out together* (DEST, 2003). He also provides examples of numeracy tasks in curriculum areas other than mathematics, pointing out that both demands and opportunities exist and that teachers need to make connections between numeracy and the curriculum area, even when it is not explicit in the curriculum.

Making numeracy connections across the school curriculum is more or less difficult depending on how the curriculum is organised (Goos & Askin, 2005). At one extreme are subject-centred approaches, which focus on maintaining the specific knowledge and practices of one discipline, and at the other extreme are curricula that integrate a range of discipline specific skills and ways of reasoning in order to tackle real world problems. There are many challenges associated with designing an integrated curriculum, not only in working out the practicalities of combining the separate subject areas but also in helping teachers think differently about where the subject boundaries lie and what counts as valued knowledge (Wallace, Sheffield, Rennie, & Venville, 2007). Nevertheless, examples do exist where fully integrated curriculum practices have been successful in some schools (Lingard, Ladwig, Luke, Mills, Hayes, & Gore 2001).

Research into such “across the curriculum” approaches is emerging and, in the case of numeracy, approaches appear to fall into two broad categories: (1) interdisciplinary inquiry that combines two or more disciplines into a single program; and (2) deliberate, mindful planning that takes advantage of the distinctive numeracy demands and opportunities in school subjects other than mathematics.

Interdisciplinary inquiry

Interdisciplinary inquiry refers to tasks, teaching programs or approaches to instruction that connect two or more academic disciplines. For example, Nikitina (2006) presents interdisciplinary teaching and learning as a continuum that can range from no connection at all between disciplines through to total integration into a single (perhaps unique) subject. While some researchers argue that integrating teaching and learning across disciplines offers greater possibilities for engaging adolescent learners (e.g., Venville, Wallace, Rennie, & Malone, 2002), the practice brings with it challenges that educational institutions often struggle to address when attempting to move away from existing discipline-based approaches. These challenges include the structure of schooling, much of which is designed to protect disciplinary interests, and factors such as discipline-based teacher education, assessment, and parental preferences for a traditional discipline-based curriculum that contribute to maintaining the status quo. Because of these limitations, some people argue against integration and assert that ideas like numeracy should be considered “educational by-product[s] ... [that results from] ... studying mathematics, physics, chemistry, biology, business studies and various other subjects in which numbers and mathematics concepts find application” (Lee, 2009, p. 218). Nevertheless, there are studies that document the successful implementation of programs based on intentional interdisciplinary inquiry.

In reporting on a large trans-national educational program – the Common Problem Solving Strategies as Links Between Mathematics and Science (COMPASS) project – Maass, Garcia, Mousoulides and Wake (2013) argue that it is only in the world of school that applying knowledge to solve problems is connected to a single “academic” discipline. In the real world, people use interdisciplinary knowledge to deal with problematic situations. Maass et al. observe that in many countries curriculum documents encourage interdisciplinary learning,

but they also note that many factors remain obstacles to the implementation of this approach. These obstacles include the high degree of organisational work required of teachers, the single discipline training of most teachers and the limited number of resources available to support learning across the curriculum. Maass et al. claim to have addressed these challenges by bringing together mathematics and science learning within the COMPASS project. The project leaders were experts in the fields of interdisciplinary tasks, real-life-based tasks, modelling tasks, ICT mediated tasks, and the design and implementation of teacher professional learning programs. Interdisciplinary tasks were designed for completion over a period of six to eight lessons. These researchers report that, as a result of the program, teaching changed to a more student-centred and application-oriented approach. Teachers and students indicated that the project materials were relevant, interesting and motivating; however, opinion was divided on the appropriateness of inquiry based learning for day-to-day teaching.

In a discussion of the multidisciplinary nature of numeracy (referred to as quantitative literacy), Miller (2010) stresses the importance of developing students' capacities to effectively communicate the results of problems that are solved using mathematics. She argues that the ability to communicate the solution to a problem, after interpreting the result of calculations and checking the viability of the proposed solution within its original real world context, is as important a skill as the capability to complete the calculations. This ability draws on learning in mathematics, English, and the substantive disciplines (e.g., science, history). In her view, mathematics provides calculations, quantitative reasoning and units; English provides expository writing skills, vocabulary, and analogies and metaphors; and the substantive disciplines provide issues, topics and context.

Miller (2010) provides examples that illustrate the need for students to draw on skills that are generally developed in English when writing about quantitative phenomena. When comparing magnitude and direction, for example, vocabulary is important. Words such as "plummeted" provide a sense of both magnitude and direction; the adverbs "modestly" and "rapidly" can convey the same direction but different rates; analogies such as "J-shaped" convey a verbal picture. In addition, English skills can be applied to organising writing for a science report or political essay by adapting the standard essay structure. Miller concludes that to communicate numeric facts and patterns effectively, students must be taught to use skills and capacities they learn in other discipline areas and that an avenue for achieving this aim is the development of cross-disciplinary assessment tasks.

Ward (2005) reports on her use of children's literature to promote more effective teaching in mathematics and the social sciences within a pre-service teacher education program. She argues that using children's literature in K-8 classes promotes students' mathematical development by providing a bridge "to connect the abstract, symbolic language of mathematics with their own personal world" (p. 133). In a similar vein to Miller (2010), Ward contends that integrating mathematics and literature enables students to "gain experience with solving word problems couched in familiar stories and thus avoid struggling with unfamiliar vocabulary" (p. 134). This view is supported through examples in which children's literature is used to enhance students' learning within social studies, geography and English poetry.

The Archimath Programme (Soygenis & Erktin, 2010) is an example of another attempt to foster numeracy development through the combination of different disciplines, in this case architecture and mathematics. This program was an innovative course in technology and design education aimed at elementary students (Years 4 to 8). The goal of the course was to develop student awareness of the built environment, to initiate an effort to improve it, and to illustrate to students the utility of mathematics in the real world. The course designers aimed

to leverage off concepts common to both architecture and mathematics, such as space, proportion, and measurement. Several pilot schools in Istanbul were involved in the implementation of the program, which consisted of eight one-hour lessons that were additional to students' normal mathematics classes. Analysis of students' responses to activity sheets revealed they struggled with representing three-dimensional objects and had little knowledge of the built environment. However, they were capable users of the mathematics associated with area and perimeter but were challenged by tasks that required the use of scale. Teachers' reports on student performance and assistant teachers' field notes indicated that initially students had little idea about the nature of architecture or what an architect did; however, it was also noted that students developed a greater concern for the built environment as the program progressed. An evaluation of a pre- and post-course attitude survey revealed that there appeared to be greater awareness of the built environment among students after the program.

Taking advantage of numeracy demands and opportunities in subjects other than mathematics

Numeracy can also be addressed across the curriculum by attending to numeracy demands and opportunities as they emerge when teaching subjects other than mathematics. This does not mean that teachers in other subjects should be required to be expert teachers of mathematics. It does mean that teachers need to be familiar with the inherent numeracy demands of their subject, can recognise a numeracy opportunity when it arises, and have the disposition and pedagogical skill to take advantage of such opportunities. The studies discussed in this section demonstrate that such opportunities arise in a wide range of subjects at primary, secondary, and tertiary levels.

An inclination to use quantitative skills and sensitivity towards how and where to implement these skills are identified by Quinnell, Thompson, and LeBard (2013) as vital elements for learning to think and work scientifically. They argue that a disabling anxiety related to the use of numerical skills or an inability to transfer mathematical competencies across disciplines into a science based context are major limiting factors in tertiary students' appropriation of the processes of scientific inquiry. Quinnell et al. propose a model for science pedagogy that maps the points where students become disengaged with science, and these also coincide with increased reliance of the scientific process on numeracy skills. Thus, they conclude, approaches aimed at improving the quantitative skills of science students should not focus on basic mathematical skills and routines alone but also on students' confidence and opportunity to use these skills in more complex situations.

Numeracy is also seen to have an important role within the social sciences as the ability to interpret numerical and graphical data is a vital aspect of critical and thoughtful citizenship. Crowe (2010), for example, argues that in the case of social studies such skills must be developed within the subject itself as school mathematics instruction does not always foster students' capabilities to "make reasonable judgments of and inferences from information presented to them" (p. 105). In order to make these judgments and inferences students must be capable of interpreting raw numeric data, discerning the meaning of percentages in a specific context, understanding the meaning and implications of an average, and interpreting graphs and charts. Examples of how these skills are important to the study of social studies include:

1. Raw numeric data – Understanding how the simplification of raw numbers with words can be misleading.
2. Percentages – Understanding how percentages can be used to mask great differences or overstate small ones.
3. Average – Understanding the difference between mean, median and mode.

4. Graphs and charts – Understanding the importance of labels, purpose and scale.

These understandings will empower students to ask questions of the data and look beyond superficial interpretations, supporting the learning of social studies through the use of mathematics in real world contexts.

Lake (2002) offers a five-step method, based on an adaptation of the SOLO taxonomy, to foster deeper learning in social studies. He contends that this method makes “explicit the expectations and mechanisms for the interpretations of relevant information and provid[es] opportunities for the active development of those skills” (p. 6). In this approach, analysis starts with the context (the what). The next step (the point), focuses attention on notable data points (e.g., range, maximum, minimum, outliers). In the third step (trends), students look for relationships within a single data set. The analysis here is qualitative and then quantitative, if the latter is needed. In the next step (relation), students interrelate the data from more than one data set. The final step (meaning) requires students to interpret the data and possibly evaluate the validity and reliability of the data. Lake describes the ability to interpret and evaluate the data in this manner as indicative of students who have a deep understanding of issues related to social studies.

Philips (2002) observes that the introduction of the *Numeracy across the Curriculum* strand of England’s Key Stage 3 Strategy has sometimes been interpreted as requiring history teachers to teach mathematics in history, for example by asking students to draw a pie chart of a day in the life of a monk. This activity focuses on the task of drawing the pie chart but has no relationship to any historical question. He argues, however, that mathematics should be seen as a tool to aid historical understanding. He offers a number of examples where mathematics is used to enrich students’ understandings of historical events and concepts, such as calculating the cost of ammunition during World War 2 to illustrate the effect of the war on the British economy or the use of data to highlight financial implications of the slave trade.

In responding to a perceived lack of numeracy skills among students in a microeconomic theory course at tertiary level, O’Neill and Flynn (2013) introduced an increased emphasis on quantitative reasoning. Their approach included three elements – logical thinking, making decisions, and mathematics in context – which they attempted to integrate into instruction by focusing on three procedures – working with graphs, creating mathematical models, and explaining the results and meaning of quantitative results. Students’ pre- and post-course responses to a survey instrument designed to ascertain attitudes to quantitative reasoning indicated an improvement in attitudes to using quantitative reasoning relevant to an economics context. Further, there was also moderate improvement in students’ attitudes towards using quantitative reasoning in a non-economics context.

Hogan (2000) argues that being numerate requires a blend of three different types of knowledge:

1. *Mathematical* – understanding mathematical ideas and techniques
2. *Contextual* – capacity to link and use mathematics in life situations
3. *Strategic* – ability to identify key features of a problem in order to make an appropriate choice of mathematics relevant to a situation and recognise the limitations of results.

The use of these types of knowledge is dependent on factors such as an individual’s familiarity with a situation, the specific organisational demands of the situation, and the level of generality at which a problem needs to be solved. Thus, individuals may use different blends of knowledge types in responding to a problem.

In addition, a numerate person must be able to take on three types of roles:

1. The fluent operator - Being (becoming) a fluent user of mathematics in familiar settings
2. The learner - Having (developing) a capacity for the deliberate use of mathematics to learn
3. The critical mathematician - Having (developing) a capacity to be critical of the mathematics chosen and used.

Individuals must be able to assume these roles at different levels and degrees to deal with different situations or the same situation in different ways.

This framework was used as the foundation for a project that investigated the demands and opportunities in teaching numeracy across the curriculum (Thornton & Hogan, 2003). The findings of this project suggest that teachers can deliberately plan for numeracy teaching provided such activity is prioritised. They conclude that a numeracy-oriented approach to teaching across the curriculum develops students' capacity to become numerate and also enriches students' learning in other areas of the curriculum.

In a series of research and development projects, Goos and colleagues investigated the effectiveness of a teacher professional learning program aimed at enhancing numeracy teaching practice across a range of disciplines (e.g., Geiger, Goos, Dole, Forgasz, & Bennison, 2013; Goos, Geiger, & Dole, 2011, Goos, Geiger & Dole, 2014). This program was based on a multi-faceted model of numeracy and involved teachers at both primary and secondary school levels. The numeracy model (Figure 1) incorporates the four dimensions of *contexts*, *mathematical knowledge*, *tools*, and *dispositions* that are embedded in a *critical orientation* to using mathematics.

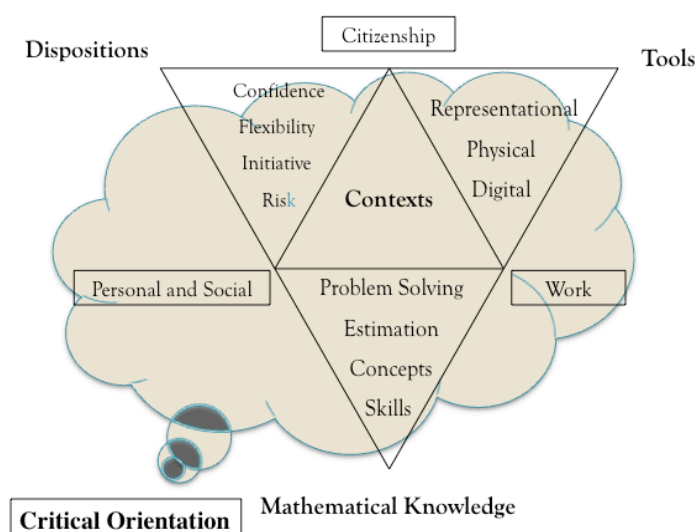


Figure 1. A model for numeracy in the 21st century (Goos, Geiger, & Dole, 2014)

These dimensions are described more fully in other publications (e.g., Geiger, Goos, & Dole, 2014b), but are summarised in Table 1.

Table 1

Descriptions of the dimensions and critical orientation of the numeracy model

Mathematical knowledge	Mathematical concepts and skills; problem solving strategies; estimation capacities.
Contexts	Capacity to use mathematical knowledge in a range of contexts, both within schools and beyond school settings.
Dispositions	Confidence and willingness to use mathematical approaches to engage with life-related tasks; preparedness to make flexible and adaptive use of mathematical knowledge.
Tools	Use of material (models, measuring instruments), representational (symbol systems, graphs, maps, diagrams, drawings, tables) and digital (computers, software, calculators, internet) tools to mediate and shape thinking.
Critical orientation	Use of mathematical information to: make decisions and judgements; add support to arguments; challenge an argument or position.

The model represents a synthesis of research related to effective numeracy practice and was constructed as an accessible instrument for the purpose of teachers' planning and reflection. This model has been validated in earlier work when used as a framework for auditing mathematics curriculum designs (Goos, Geiger & Dole, 2012), analysing teachers' attempts to design for the teaching of numeracy across the curriculum (Goos, Geiger & Dole, 2011), mapping teachers' learning trajectories in effective numeracy pedagogy (Geiger, Goos & Dole, 2011), gauging students' perspectives on their numeracy learning (Geiger, Goos & Dole, 2014a), and using digital tools to enhance numeracy teaching and learning across the curriculum (Geiger, Goos & Dole, 2014b).

1.5 Summary of literature review

Numeracy has been a national educational priority in Australia for over a decade and remains on the educational agenda because numerate citizens are able to participate and function more fully in society. Thus, numeracy must be seen as a basic right to be fostered through schooling and beyond. The concept of numeracy across the curriculum, however, is relatively new and so research into how best to promote numeracy capabilities is only beginning to emerge. Two approaches are evident in the literature. One is based on interdisciplinary inquiry that aims to integrate mathematics with other subjects, and the other leaves the separate disciplines intact and instead encourages teachers to identify subject-specific numeracy demands and opportunities. Both approaches have their challenges. However, it seems that the latter approach would be more feasible for teachers to implement because it avoids the well-documented problems of curriculum integration.

2. Audit of Existing Resources

2.1 Audit methodology

Because the Australian Curriculum maintains strong boundaries between subjects rather than promoting interdisciplinary inquiry, the framework for the resource audit was aligned with the second conceptualisation of numeracy described above – based on identifying the numeracy demands and opportunities in subjects other than mathematics. We were interested in ways in which existing resources supported teachers’ understanding and enactment of numeracy across the curriculum, and so we constructed an audit framework that captured these qualities. The framework consists of statements sourced from the Numeracy Standards for Graduate Teachers published by the Board of Teacher Registration (2005). Although these Numeracy Standards pre-date the Australian Professional Standards for Teachers (AITSL, 2014a), they have a similar organisational structure in describing Professional Knowledge, Practice and Engagement/Attributes but with explicit reference to numeracy.

The resources audit framework is shown in Figure 2, with the numbering in brackets after each statement indicating links to the Australian Professional Standards for Teachers (AITSL, 2014).

Numeracy standards in subjects other than mathematics (BTR, 2005) For teachers of disciplines other than mathematics: this includes specialist teachers in the early years and primary years, as well as teachers of curriculum areas other than mathematics in the middle years and senior years.	
2.1 Professional knowledge	
Students	
2.1.1	Recognise the numeracy knowledge and experiences that learners bring to their classrooms [1.3]
2.1.2	Understand the diversity of numeracy needs of learners [1.5]
Numeracy	
2.1.3	Understand the pervasive nature of numeracy and its role in everyday situations
2.1.4	Understand the meaning of numeracy within their curriculum area [2.1]
2.1.5	Recognise numeracy learning opportunities and demands within their curriculum area [2.3]
Students’ numeracy learning	
2.1.6	Demonstrate knowledge of a range of appropriate resources and strategies to support students’ numeracy learning in their curriculum area [3.3]
2.2 Professional attributes	
Personal attributes	
2.2.1	Display a positive disposition to supporting students’ numeracy learning within their curriculum area [3.5]
2.2.2	Recognise that all students can be numerate [3.1]
2.2.3	Exhibit high expectations of their students’ numeracy development [3.1]
2.2.4	Exhibit a satisfactory level of personal numeracy competence for teaching [2.1]
Personal professional development	
2.2.5	Demonstrate a commitment to continual enhancement of personal numeracy knowledge [6.2]
2.2.6	Exhibit a commitment to ongoing improvement of their teaching strategies to support students’ numeracy learning [6.4]
2.2.7	Demonstrate a commitment to collaborating with specialist teachers of mathematics to enhance their own numeracy learning and numeracy teaching strategies [6.1]

Community responsibility	
2.2.8	Develop and communicate informed perspectives of numeracy within and beyond the school [7.4]
2.3 Professional practice	
Learning environment	
2.3.1	Promote active engagement in numeracy learning within their own curriculum context [4.1]
2.3.2	Establish a supportive and challenging learning environment that values numeracy learning [3.1]
Planning	
2.3.3	Take advantage of numeracy learning opportunities when planning within their own curriculum context [3.4][3.2]
2.3.4	Display willingness to work with specialist teachers of mathematics in planning numeracy learning experiences [6.2][6.2]
2.3.5	Determine students' learning needs in numeracy to inform planning and implementation of learning experiences [2.5][3.2]
Teaching	
2.3.6	Demonstrate effective teaching strategies for integrating numeracy learning within their own curriculum context [3.3]
2.3.7	Model ways of dealing with numeracy demands of their curriculum area [2.1]
Assessment	
2.3.8	Provide all students with opportunities to demonstrate numeracy knowledge within their curriculum area [5.1]

Figure 2. Framework for resources audit

2.2 Audit findings

The full results of the audit are presented in the Appendix, with key findings discussed in this section drawing on a research paper presented at the 39th conference of the International Group for the Psychology of Mathematics Education (Goos, Geiger, & Bennison, 2015).

Although the BTR Numeracy Standards comprise 22 statements, four are especially pertinent for the audit framework because they refer to understanding (Professional Knowledge) and enactment (Professional Practice) of numeracy across the curriculum (Figure 3). For the purposes of the audit, they were preceded by the sentence stem “How might this resource help teachers to ...?”

Professional Knowledge

PK1: Understand the meaning of numeracy within their curriculum areas.

PK2: Recognise numeracy learning opportunities and demands within curriculum areas.

Professional Practice: Planning

PPP: Take advantage of numeracy learning opportunities within their curriculum context.

Professional Practice: Teaching

PPT: Demonstrate effective teaching strategies for integrating numeracy learning within their own curriculum context.

Figure 3. Key numeracy statements for the resources audit

The main targets in our search for numeracy resources were those that are (1) readily accessible to Australian teachers and (2) endorsed or produced by the authorities responsible for the Australian Curriculum or the Australian Professional Standards for Teachers, or by teacher professional associations. These included the following sources:

1. the numeracy statements for all non-mathematics subjects in the Australian Curriculum: the Arts, English, Science, History, Geography, Economics and Business, Civics and Citizenship, Health and Physical Education, and Technology (ACARA, 2014b);
2. the *Illustrations of Practice* that accompany the Australian Professional Standards for Teachers – an online professional development package comprising video clips of classrooms, teacher interviews, and discussion questions (AITSL, 2014b);
3. the government-endorsed repository of digital resources mapped to the Australian Curriculum and available via Scootle (<http://www.scootle.edu.au>);
4. teacher professional journals in mathematics and non-mathematics subjects.

Numeracy statements in the Australian Curriculum

The first source of numeracy resources was the numeracy statements in each of the Australian Curriculum documents. These statements could help teachers to understand the meaning of numeracy within their curriculum area (PK1). For example, in Geography, the numeracy statement explains that students “investigate...the effects of location and distance, spatial distributions and the organisation and management of space within places”.

Illustrations of Practice

The second source of numeracy resources was found to provide little assistance in understanding and enacting numeracy across the curriculum. Only two of the 325 *Illustrations of Practice* were related to numeracy, and only one of these (titled *Embedding mathematics in everything*, see Figure 4) connected mathematics to non-mathematical contexts – but in the form of extra-curricular activities rather than other school subjects. Because this resource illustrates a particular teacher’s planning practices as well as his understanding of numeracy and demonstration of effective teaching strategies, it might help teachers develop professional knowledge and practice in all of the ways identified in the audit framework (PK1, PK2, PPP, PPT).

This teacher works closely with other staff to link mathematics learning to students’ experiences. He encourages a collaborative, inquiry-based approach to teaching mathematics, modelling the use of questioning to encourage the use of problem solving with other staff and students. An activity that allows for mathematical investigation, is facilitated by a parent who has an engineering background. The parent visits the school to teach students how to design and construct see-saws using Lego.

Figure 4. Summary of Embedding mathematics in everything

Scootle

For the third source, a search of Scootle using the term “numeracy” returned 235 resources, almost all of which were related to the teaching of mathematics rather than numeracy across the curriculum. Seventeen numeracy resources were identified, all of which were judged to have the potential to help teachers understand the meaning of numeracy within a particular curriculum area (PK1) and, if implemented as directed, to help teachers demonstrate effective teaching strategies for integrating numeracy learning in this curriculum context (PPT). For example, a unit of work in the science curriculum, on plants, included activities involving measurement of plant growth, development of a scale for a cross section diagram, and the collection and representation of data in tables and graphs.

Teacher professional journals

The fourth source of numeracy resources was teacher professional journals. A search of 17 journals aimed at teachers of science, English, mathematics, computing, health and physical education, English as a second language, modern languages, geography, art, history, and music, as well as more general journals focusing on early childhood or middle years education, found only 15 articles on the teaching of numeracy across the curriculum. Eleven of these were published in mathematics teacher journals, which are unlikely to be read by teachers of other subjects looking for help in understanding (PK1 and PK2) and enacting (PPP and PPT) numeracy in their own curriculum contexts.

2.3 Summary of resources audit

An audit of existing resources available to Australian teachers found very few resources to support teachers' understanding and enactment of numeracy across the curriculum. Most resources that were found did offer some explanation or examples that could enhance teachers' understanding of the meaning of numeracy in their own curriculum context, and many also provided "ready-made" activities for integrating numeracy into the teaching of subjects other than mathematics. However, almost none addressed the need for teachers to recognise and take advantage of the numeracy learning demands and opportunities within the subjects they teach as part of their curriculum planning and pedagogical practice.

While we cannot claim that our numeracy resource audit identified every resource available to Australian teachers, its findings highlighted important gaps. In particular, it seems unlikely that teachers will be able to embed numeracy across the school curriculum without structured assistance in learning how to "see" the numeracy demands and opportunities in all the subjects they might teach.

3. Gap Analysis

The audit of existing resources enabled initial identification of gaps where Queensland teachers might benefit from new resources. The audit findings informed consultation with the following relevant stakeholder groups:

- Queensland Government Department of Education and Training (DET);
- Brisbane Catholic Education (BCE);
- Independent Schools Queensland (ISQ);
- Teacher professional associations: Queensland Association of Mathematics Teachers, Science Teachers' Association of Queensland, Queensland History Teachers' Association.

3.1 Gap analysis methodology

Semi-structured interviews were conducted with relevant staff from stakeholder groups, using the following question prompts:

Existing material to support numeracy across the curriculum

1. What resources are currently available to teachers within your school system to support numeracy learning across the curriculum?
 - Advice
 - Policies
 - Guidelines
 - Resources

Development of teacher resources

2. What resources are needed to support teachers to promote numeracy learning through the subjects they teach?
 - Documents
 - Classroom vignettes
 - Teaching and learning materials

Responses were mapped against the BTR (2005) Numeracy Standards in the domains of Professional Knowledge, Professional Attributes, and Professional Practice.

3.2 Gap analysis findings

Professional knowledge

Literacy, rather than numeracy, is a current focus for the Queensland Department of Education and Training. *Curriculum to Classroom* (C2C) lessons in some curriculum areas have links to numeracy provided at the end of each lesson. The Department's Numeracy Framework is no longer in use, but resources prepared in the past are still available on the Learning Place (<http://education.qld.gov.au/learningplace/>). Independent Schools Queensland has a Literacy and Numeracy Coaching Academy. Coaches are based in schools and assist teachers to see the numeracy links in their subject areas. The main challenge is to change teachers' understanding of what numeracy is, and how it differs from mathematics.

Similarly to Queensland DET, numeracy is not currently a strategic focus for Brisbane Catholic Education. Nevertheless, BCE officers continue to develop numeracy resources based on the numeracy model developed by Goos and colleagues, who worked with BCE in previous projects. The approach taken is thus to identify the numeracy demands in the

curriculum areas, with a focus on curriculum planning. Resources developed are made available to all BCE teachers via a systemic intranet. Interest in numeracy is expected to rise again due to pressures to improve NAPLAN results in schools.

Professional attributes

The ISQ Coaching Academy demonstrates a commitment by the independent sector to aim for continuing improvement of numeracy teaching strategies. In Brisbane Catholic Education, the numeracy workshops delivered by BCE officers are regarded as effective in helping teachers to develop their own numeracy skills and dispositions.

Professional practice

The representative of Queensland DET expressed a view that helping teachers to find the numeracy in their own curriculum areas would be a useful approach. The ISQ representative made the same point, suggesting that the most helpful resources might be videos showing lesson examples or teachers working together in collaborative planning sessions. In other words, providing teachers with a process or framework for embedding numeracy in the subjects they teach could be more effective than lists of teaching resources or a large number of lesson videos. This is the approach taken by BCE, where workshops introduce teachers to the numeracy model (see Figure 1) and focus on curriculum planning.

Teacher professional associations

Only the Queensland Association of Mathematics Teachers claimed a focus on numeracy, but the extent of this focus was in the articles published in the association's journal. There was no current emphasis on professional development workshops to assist mathematics teachers to see the difference between mathematics and numeracy. The science and history teachers' associations likewise admitted no current focus on numeracy in their own disciplines, but acknowledged both the need and a willingness to provide this emphasis.

3.3 Summary of gap analysis

Of the three education sectors, only Brisbane Catholic Education was taking a systematic approach to developing teachers' capacity to recognise the numeracy demands of the subjects they teach and to plan for embedding numeracy across the curriculum. Representatives of all sectors were of the view that "how-to" resources, supplemented by high quality video exemplars of lessons, were likely to be more useful than ready-made lessons or tasks. There appears to be little impetus in the discipline-based teacher professional associations for cross-curricular numeracy development, which perhaps is not surprising when these associations are characterised by strong disciplinary identities and boundaries.

The gap analysis complemented the findings of the resources audit, and so the next stage of the project translated the numeracy model we developed in previous studies (Figure 1) into a design framework to support teachers in selecting, adapting, and creating resources for embedding numeracy across the curriculum.

4. Video Vignettes

Six videos were developed: four illustrating how teachers are embedding numeracy in the subjects they teach, one showing teachers discussing how they established a numeracy committee within their school, and one in the form of a voice over PowerPoint presentation that explains the numeracy model. Each video is accompanied by discussion questions that are designed to engage the viewer with the numeracy model, for example, as the underlying design for the lesson (see Figure 5).

Ethical clearance for the project was obtained from The University of Queensland, Australian Catholic University, the Queensland Department of Education and Training, and Brisbane Catholic Education. All participants, together with students' parents or caregivers, gave informed consent for the videos to be published on the QCT website.

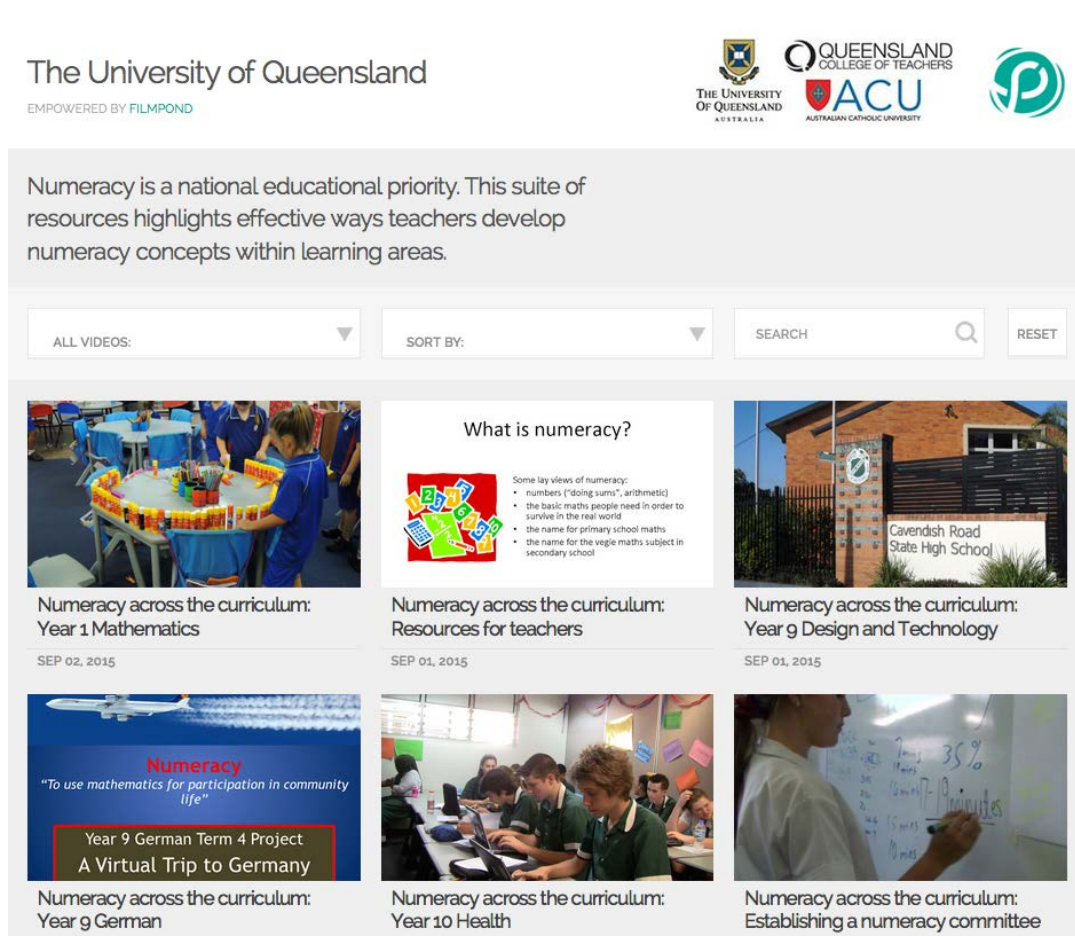


Figure 5. Landing page for QCT ClassMovies site

Synopses and credits for the videos are provided below.

4.1 Numeracy across the curriculum: Resources for teachers

Professor Merrilyn Goos is Head of the School of Education at The University of Queensland and has worked in mathematics education for 25 years. This resource provides a model for exploring and teaching numeracy within your curriculum area. This ClassMovie's editor was Maxwell Gillon.

- a) How does this resource help you to understand the pervasive nature of numeracy and its role in everyday situations?
- b) How does this resource help you to understand the meaning of numeracy in your curriculum area?

4.2 Numeracy across the curriculum: Year 1 Mathematics

Using an inquiry learning approach, Bec O'Connor from St Peter's Catholic Primary School explores measurement with her Year 1 students. This ClassMovie's editor was Maxwell Gillon.

- c) What teaching strategies have you found to be effective for integrating numeracy learning within your curriculum area?
- d) What strategies do you use to provide all students with opportunities to demonstrate and assess numeracy knowledge within your curriculum area?

4.3 Numeracy across the curriculum: Year 9 Design and Technology

Don Markovic from Cavendish Road State High School demonstrates ways he incorporates numeracy into his subject area. This ClassMovie's editor was Daphne Potter.

- e) What resources and strategies do you use to support students' numeracy learning in your curriculum area?
- f) What approaches do you use to enhance your own personal numeracy knowledge?

4.4 Numeracy across the curriculum: Year 9 German

Vicki Dunn is a German teacher at Cavendish Road State High School. See how she incorporated numeracy into a unit on planning a trip to Germany. This ClassMovie's editor was Aziz Yawary.

- g) How do you identify the numeracy learning opportunities and demands in your curriculum area?
- h) How do you determine students' learning needs in numeracy to inform planning and implementation of learning experiences?

4.5 Numeracy across the curriculum: Year 10 Health

Nicole Coutts from Cavendish Road State High School describes an action research project her Year 10 students completed on improving resilience and the numeracy opportunities that arose along the way. This ClassMovie's editor was Aziz Yawary.

- i) How does this resource help you to take advantage of numeracy learning opportunities when planning within your own curriculum area?
- j) Numerate practice involves using tools, what tools are used in your curriculum area to enhance and develop numeracy skills?

4.6 Numeracy across the curriculum: Establishing a numeracy committee

Sarah Gray and Terry Moran describe how they established a numeracy committee within their school, Cavendish Road State High School. This ClassMovie's editor was Daphne Potter.

- k) How does this resource help you to establish a supportive and challenging learning environment that values numeracy learning?
- l) How can you develop and communicate informed perspectives of numeracy within and beyond the school?

5. Concluding Comments

This project delivers research-based resources and design frameworks to assist teachers in developing their students' numeracy in all curriculum areas. In doing so, the project contributes to the professional development of both pre-service and practising teachers by resourcing the curriculum frameworks and professional standards that help shape their practice. The project's outcomes align with Standard 2, *Know the content and how to teach it*, of the Australian Professional Standards for Teachers, and provide a link between Focus areas 2.1 *Content and teaching strategies of the teaching area* and 2.5 *Literacy and numeracy strategies*. The outcomes also provide some guidance to teachers in embedding numeracy as a general capability across the Australian Curriculum.

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Appendix: Resources audit

National

ACARA: *The Australian Curriculum*

This resource addresses some aspects of Professional Knowledge but does not assist teachers to develop Professional Attributes or Professional Practice. The resource helps teachers to understand the meaning of numeracy in their curriculum area (Standard 2.1.4) and identify demands of numeracy within this curriculum area (part of Standard 2.1.5); however, numeracy learning opportunities are not identified (see for example Goos, Dole and Geiger, 2010). The resource does provide links to Scootle (by viewing details of curriculum elements, e.g., ACHS148).

Resource	Notes	Connection to standards	Level of schooling	School subject area
Numeracy in the Arts	- Combine dance movements to create sequences or sequences to create sections. - Decide where to place actors in a performance space. - Analyse audience responses to a media artwork. - Compose a film score or music to accompany dance or drama. - Explore concepts such as space, proportion and repetition in visual arts.	2.1.4, 2.1.5 Professional knowledge	NA	Arts
Numeracy in English	- Interpreting, analysing and creating texts involving quantitative and spatial information such as percentages and statistics, numbers, measurements and directions. - When responding to or creating texts that present issues or arguments based on data, students identify, analyse and synthesise numerical information using that understanding to discuss the credibility of sources.	2.1.4, 2.1.5 Professional knowledge	NA	English
Numeracy in Science	- Practical measurement and the collection, representation and interpretation of data from investigations. - Measurement, first using informal units then formal units. Later they consider issues of uncertainty and reliability in measurement. - As students progress, they collect both qualitative and quantitative data, which is analysed and represented in graphical forms. - Students learn data analysis skills, including identifying trends and patterns from numerical data and graphs. - In later years, numeracy demands include the statistical analysis of data, including issues relating to accuracy, and linear mathematical relationships to calculate and predict values.	2.1.4, 2.1.5 Professional knowledge	NA	Science
Numeracy in History	- Interpret historical events and developments. Students learn to analyse numerical data to make meaning of the past, for example to understand cause and effect, and continuity and change. - Students learn to use scaled timelines, including those involving negative and positive numbers, as well as calendars and dates to recall information on topics of historical significance and to illustrate the passing of time.	2.1.4, 2.1.5 Professional knowledge	NA	History
Numeracy in Geography	Investigate concepts fundamental to geography, for example, the effects of location and distance, spatial distributions and the	2.1.4, 2.1.5 Professional	NA	Geography

	organisation and management of space within places. • They apply numeracy skills in geographical analysis by counting and measuring, constructing and interpreting tables and graphs, calculating and interpreting statistics and using statistical analysis to test relationships between variables. • In constructing and interpreting maps, students work with numerical concepts of grids, scale, distance, area and projections.	knowledge		
Numeracy in Economics and Business	• Principles of financial management, and to make informed financial and business decisions. • They apply their numeracy knowledge and skills to display, interpret and analyse economics and business data, draw conclusions, make predictions and forecast outcomes.	2.1.4, 2.1.5 Professional knowledge	NA	Economics and Business
Numeracy in civics and citizenship	• Analyse, interpret and present information in numerical and graphical form. • This includes investigating the voting process, researching and using statistics on civics and citizenship topics and issues, conducting surveys among community members and representing findings in graphs and charts.	2.1.4, 2.1.5 Professional knowledge	NA	Civics and citizenship
Numeracy in HPE	• Calculation, estimation and measurement to collect and make sense of information related to, for example, nutrition, fitness, navigation in the outdoors or various skill performances. • They use spatial reasoning in movement activities and in developing concepts and strategies for individual and team sports or recreational pursuits. • Students interpret and analyse health and physical activity information using statistical reasoning, identifying patterns and relationships in data to consider trends, draw conclusions, make predictions and inform health behaviour and practices.	2.1.4, 2.1.5 Professional knowledge	NA	HPE
Numeracy in technology	• Calculate, measure and estimate; interpret and draw conclusions from statistics; measure and record throughout the process of generating ideas; develop, refine and test concepts; and cost and sequence when making products and managing projects. • In using software, materials, tools and equipment, students work with the concepts of number, geometry, scale, proportion, measurement and volume. • They use three-dimensional models, create accurate technical drawings, work with digital models and use computational thinking in decision-making processes when designing and creating best-fit solutions.	2.1.4, 2.1.5 Professional knowledge	NA	Technology

Gaps		• Professional knowledge: 2.1.1, 2.1.2, 2.1.3, 2.1.6 • Professional attributes: 2.2.1-8 • Professional practice: 2.3.1-8	All year levels	Nil
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AITSL: Illustrations of Practice

This resource helps teachers identify sources of numeracy within their subject area. Some of the examples show teachers how they can develop their own numeracy competence. Some of the illustrations may help some teachers think about numeracy learning opportunities within their curriculum context.

Resource	Notes	Connection to standards	Level of schooling	School subject area
Literacy and numeracy strategies (Graduate) http://www.aitsl.edu.au/australian-professional-standards-for-teachers/illustrations-of-practice/detail?id=IOP00277	No numeracy strategies shown or discussed in the illustration	Nil	Primary	Nil
Embedding mathematics in everything (Lead) http://www.aitsl.edu.au/australian-professional-standards-for-teachers/illustrations-of-practice/detail?id=IOP00325	Seeing the mathematics in extra-curricular activities: chess games & robotics program. Collaborative approach amongst staff discussing student's 'numeracy/maths' progress through observation sheets and discussions with teacher and maths coordinator. Collect assessment – portfolio pieces, tests.	2.1.3, 2.2.5, 2.2.6, 2.2.7, 2.2.8, 2.3.2, 2.3.4 Professional knowledge, attributes & practice	Early childhood: Prep, 1, 2	(Extra-curricular activities)
Gaps		• Professional knowledge: 2.1.1, 2.1.1, 2.1.4, 2.1.5, 2.1.6 • Professional attributes: 2.2.1, 2.2.2, 2.2.3, 2.2.4 • Professional practice: 2.3.1, 2.3.3, 2.3.5, 2.3.6, 2.3.7, 2.3.8	Years 5-12	All subjects

SCOOTLE

Used search term ‘numeracy’. This yielded 235 results but most of the results were ‘mathematics’. Others were related to using NAPLAN data.

The resource addressed some aspects of Professional Knowledge (Standard 2.1.4, and Standard 2.1.5) but did not address Professional Attributes or Professional Practice.

Most of the resources found on numeracy only identified the numeracy knowledge in this particular resource. It doesn’t really help teachers develop their own numeracy competence, nor does it help teachers plan their own lessons to include numeracy.

Resource	Notes	Connection to standards	Level of schooling	School subject area
Unit: Primary connections: Spot the difference (Australian Academy of Science)	Students: - collaboratively use tables to organise data - interpret tables to compare observed changes	2.1.4, 2.1.5 Professional knowledge – through identifying ways in which numeracy is used in this subject area.	Primary: 1	Chemical science
Unit: Primary connections: Up, down, all around (Australian Academy of Science)	Students: collect, interpret and represent data about observable changes to a garden.	2.1.4, 2.1.5 Professional knowledge	Primary: 1	Earth and space sciences
Unit: Primary connections: Smooth moves (Australian Academy of Science)	Students: - collect, represent and interpret data through tables and graphs - measure distances objects move when subject to different-sized forces - use force-arrow diagrams to indicate size and direction of forces in everyday examples.	2.1.4, 2.1.5 Professional knowledge	Primary: 4	Physical science
Unit: Primary connections: Plants in action (Australian Academy of Science)	These include practical measurement and the collection, representation and interpretation of data. Students: - measure plant growth - draw a scale for cross section diagram - collect and represent data in tables - collect data and represent data in simple graphs - create a timeline of seed germination.	2.1.4, 2.1.5 Professional knowledge	Primary: 4	Biological science
Teacher resource: Gapminder world (The Gapminder Foundation)	World data and statistics displayed on tables and graphs.	2.3.3, 2.3.6 Professional practice	All year levels	Geography
Teacher resource: Liveability and sustainable living (Geography Teacher Resource)	Involves numeracy without explicitly naming it in the resource. E.g. using maps and statistics to teach the unit		Year 7	Geography

Learning object: Hebat! My things: shapes and sizes (Curriculum Corporation The Learning Federation)	Learning shapes and sizes in Indonesian. Includes vocabulary & situations for measurements. Similar learning object for Japanese, Italian, French languages, etc.	2.1.4, 2.1.5 Professional knowledge	Prep-8	LOTE
Learning object: Found art: outback (Education Services Australia Ltd)	Create a design using objects found in a woolshed. Construct displays, including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies. Identifying the best methods of presenting data to illustrate the results of investigations and justifying the choice of representations.	2.1.4, 2.1.5 Professional knowledge	7, 8, 9	Arts, Technology
Video clip: Charles Perkins, Freedom Ride, 1999 (National Film and Sound Archive (NFSA))	Use chronological sequencing to demonstrate the relationship between events and developments in different periods and places. Using interactive timelines to explore the various manifestations or effects of an event in different geographical locations. Examining population data.	2.1.4, 2.1.5 Professional knowledge	6 & 10	History
Unit of work: Probability and pancakes (Global Education)	Kenyan village tale, 'Mama Panya's Pancakes'. Student activities include considering probability, locating Kenya, calculating amounts, cost, and the results of sharing, predicting, and matching pancake recipes to their countries of origin.	2.1.4, 2.1.5 Professional knowledge	Primary: 3, 4	English, Geography and Mathematics
Water for life (Global Education)	The activities include discussion, presentations, making lists, mapping water sources, estimating quantities, responding to photographs, creating mind maps, and reading and creating texts.	2.1.4, 2.1.5 Professional knowledge	F-2	English, mathematics and science
Measuring Millennium Development Goals progress (Global Education)	Student activities include calculating and ordering fractions, percentages, decimals and ratios; completing tables; and comparing progress against the MDG targets and among geographical regions.	2.1.4, 2.1.5 Professional knowledge	7-10	Geography, Mathematics
Data representation and interpretation - years 9 and 10 (Asia Education Foundation)	The resource encourages students to compare the climates of cities in the Asia region, to identify and contrast climate patterns.	2.1.4, 2.1.5 Professional knowledge	9-10	Geography, Mathematics
Dairy: Jenny the Jersey cow (The Australian Association of Mathematics Teachers Inc (AAMT))	There are several resources produced by AAMT for integrating a range of subjects with mathematics for all year levels. Jenny the Jersey cow is one example of these.	2.1.4, 2.1.5 Professional knowledge	7	Mathematics, Technology
Teacher resource: Fieldwork techniques (Australian Association for Environmental Education Inc.)	Here a specialist fieldwork teacher in an environmental education centre demonstrates to his peers how the cross curriculum Sustainability priority can be applied to the Mathematics Year 8 curriculum.	2.1.4, 2.1.5 Professional knowledge	8	Science, Mathematics
Teacher resource: An integrated	The teacher uses an integrated planning approach to link content from	2.1.4, 2.1.5	F-10	English, Science,

approach (Australian Curriculum, Assessment and Reporting Authority (ACARA))	English and science across the primary year levels. In this video, the teacher makes deliberate connections between her English and science lessons as well as her students' own experiences, including a recent class excursion. Students observe qualitatively how speed is affected by the size of a force.	Professional knowledge		
Inspirations: going green (Global Rock Challenge Holdings Pty Ltd)	The resource presents a case study of a sustainably designed primary school and the students' involvement in managing the resources such as measuring rainfall on a day-to-day basis and considering timescales for regeneration of resources.	2.1.4, 2.1.5 Professional knowledge	F-10	Science
Gaps		- Professional knowledge: 2.1.1, 2.1.2, 2.1.3, 2.1.6 - Professional attributes: 2.2.1-8 - Professional practice: 2.3.1-8	Years 11, 12	Economics & Business, Civics and citizenship, HPE
Australian teacher journals and professional teaching associations Apart for a small number of articles published in mathematics teacher journals, there are virtually no resources to support teachers in embedding numeracy into the subjects they teach in Australian teacher journals published by professional teaching associations.				
Resource	Notes	Connection to standards	Level of schooling	School subject area
<i>Teaching Science</i> Australian Science Teachers Association	Brown, N. Watson, J. & Wright, S. (2011). Science and numeracy in the Australian Curriculum: measurement activities for the middle years. <i>Teaching Science</i>, 57(1), 50-58. . (Only one article in 11 years of issues addresses numeracy across the curriculum).	2.1.4, 2.1.5 Professional knowledge	Middle years	Science
<i>English in Australia</i> Australian Association for the Teaching of English Inc.	Nil	NA	NA	NA
<i>Australian Journal of Language and Literacy (AJLL)</i> Australian Literacy Educators' Association (ALEA)	Nil – term 'numeracy' mentioned in context of NAPLAN	NA	NA	NA
<i>The Australian Mathematics Teacher (AMT)</i> These resources would tend to be accessed only by mathematics teachers. <i>Australian Primary Mathematics Classroom (APMC)</i> These resources would tend to be	- Cooper, C., Dole, S., Geiger, V., & Goos, M. (2012). Numeracy in society and environment. <i>The Australian Mathematics Teacher</i>, 68(1), 16-20. - Gazzard, J. (2004). Asia Counts - Secondary: Numeracy and Studies of Asia [Book Review]. <i>The Australian Mathematics Teacher</i>, 60(1), 25. - Gough, J. (2007). Make Your School's Numeracy - Across-the-curriculum Policy. <i>The Australian Mathematics Teacher</i>, 63(3), 31-39.	Various connections to the standards throughout the papers	3-7 Secondary 6	SOSE Asian Studies/ Mathematics Visual Arts

accessed only by primary teachers. Some resources here would be useful for secondary teachers of disciplines other than mathematics. Australian Association of Mathematics Teachers Inc (AAMT)	- Goos, M., Dole, S., & Geiger, V. (2012). Numeracy across the curriculum. <i>The Australian Mathematics Teacher</i>, 68(1), 3-7. - Hogan, J. (2012). Mathematics and numeracy: Is there a difference? <i>The Australian Mathematics Teacher</i>, 68(4), 8-11. - Numeracy Across the Curriculum Project Team. (2004). An Investigation into Student Numeracy across the Curriculum. <i>Australian Primary Mathematics Classroom</i>, 9(4), 30-34. - Perso, T. (2006). Teachers of Mathematics or Numeracy? <i>The Australian Mathematics Teacher</i>, 62(2), 36-40. - Peters, C., Geiger, V., Goos, M., & Dole, S. (2012). Numeracy in health and physical education. <i>The Australian Mathematics Teacher</i>, 68(1), 21-27. - Wade, P., Gervasoni, A., McQuade, C., & Smith, C. (2013). Launching confident numerate learners. <i>The Australian Mathematics Teacher</i>, 69(3), 26-32. - Willis, K., Geiger, V., Goos, M., & Dole, S. (2012). Numeracy for what's in the news and building an expressway. <i>The Australian Mathematics Teacher</i>, 68(1), 9-15. - White, P., Mitchelmore, M., Wilson, S. & Farraghar, R. (2004) critical numeracy and abstraction, <i>APMC</i>, 14(1), 4-8.		NA NA NA NA 8 7, 8 8, 9 NA	NA NA NA NA HPE Mathematics English NA
<i>Australian Educational Computing</i> Australian Council for Computers in Education (ACCE)	Nil	NA	NA	NA
<i>Professional Educator</i> (Australian College of Educators)	Nil (Many articles for literacy)	NA	NA	NA
<i>Asia-Pacific Journal of Health, Sport & Physical Education</i> Australian Council for Health, Physical Education and Recreation Inc (ACHPER)	Nil	NA	NA	NA
<i>ACHPER Australia Healthy Lifestyles Journal</i> Australian Council for Health, Physical Education and Recreation Inc (ACHPER)	Nil	NA	NA	NA
TESOL in Context Australian Council of TESOL Associations (ACTA)	Nil (Some articles for literacy and NAPLAN)	NA	NA	NA

<i>Babel</i> Australian Federation of Modern Language Teachers Associations (AFMLTA)	Nil	NA	NA	NA
<i>Geographical Education</i> Australian Geography Teachers Association (AGTA)	Nil	NA	NA	NA
<i>Australian Art Education</i> Art Education Australia (AEA)	Nil	NA	NA	NA
<i>Australian Journal of Music Education</i> Australian Society for Music Education (ASME)	Nil (Some articles on literacy)	NA	NA	NA
<i>Australasian Journal of Early Childhood</i> Early Childhood Australia (ECA)	- Muir, T. (2012). It's in the bag: Parental involvement in a numeracy at-home program. <i>Australasian Journal of Early Childhood</i>, 37(2), 27-33. - Kritzer, K. (2012). Building foundations for numeracy: A qualitative analysis of the basic concept knowledge demonstrated by young deaf children. <i>Australasian Journal of Early Childhood</i>, 37(2), 106-112. (Many articles on literacy)	2.2.8, 2.3.2 Professional attributes	Early childhood years 1, 2	Mathematics
<i>The History Teacher</i> History Teachers' Association of Australia (HTAA)	Nil	NA	NA	NA
<i>The Australian Journal of Middle Schooling</i> Adolescent Success! (Formerly Middle Years of Schooling Association (MYSA))	Carter, M., Hipwell, P., & Quinnell, L. (2012). A picture is worth a thousand words: an approach to learning about visuals. <i>Australian Journal of Middle Schooling</i>, 12(2), 4-15. (General articles on literacy and numeracy)	NA	Middle years 6, 7, 8	NA
Gaps		- Professional knowledge: 2.1.1-3, 2.1.6 - Professional attributes: 2.2.1-8 - Professional practice: 2.3.1-8	3, 4, 5, 9-12	There is very limited support in teaching journals for embedding numeracy across the curriculum.

Websites				
Resource	Notes	Connection to standards	Level of schooling	School subject area
The Australian National Schools Network: Numeracy across the curriculum, 2004 http://www.ansn.edu.au/sites/default/files/articles/snapshot1_july04.pdf	Describes 'A Numeracy Framework' Willis & Hogan (2000). This resource is not easily accessible to teachers. However, it provides useful information on the meaning of numeracy and the difference between mathematics and numeracy. Teacher professional learning is discussed in terms of using Research circles and conducting a Numeracy Audit.	2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6 Professional knowledge 2.2.1, 2.2.2, 2.2.3, 2.2.6, 2.2.8 Professional attributes 2.3.1, 2.3.2, 2.3.6 Professional practice	NA	NA
Redgum Consulting http://www.redgumconsulting.com.au/homenumeracy.html	See above	2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6 Professional knowledge 2.2.1, 2.2.2, 2.2.3, 2.2.6, 2.2.8 Professional attributes 2.3.1, 2.3.2, 2.3.6 Professional practice	NA	NA
Numeracy in the Home: Children's Access to Kindergarten - Dr Thelma Perso (NT Department of Education and Training) http://www.nlnw.nsw.edu.au/videos09/lo_Perso/lo_Perso_00.htm	Provides contexts for around the home for parents to help their children to become numerate. Ideas for ECT to talk to parents about.	2.1.3 Professional knowledge	Early childhood	NA
Critical Numeracy in Context - Dr Jane Watson http://www.nlnw.nsw.edu.au/videos08/critical_numeracy/index.html	A video that provides a framework for critical numeracy.	2.1.3 Professional knowledge	NA	NA
Numeracy in the News http://simerr.educ.utas.edu.au/numeracy/default.html	This website aims to help teachers develop teaching and learning strategies to build students' critical numeracy - their ability to think discerningly about the way mathematical concepts are used in everyday contexts such as the news.	Professional knowledge 2.1.1-2.1.5 Professional	Can be applied to all year levels	Can be applied to all subjects

		practice 2.3.1-2.3.3		
AC History Units http://www.achistoryunits.edu.au/	There are 8 units developed by the History Teachers' Association of Australia for various year levels. These units contain limited information about numeracy in the context of each unit.	Professional knowledge 2.1.5	2, 4, 6-10	History
Gaps		• Professional attributes: 2.2.4-5, 2.2.7 • Professional practice: 2.3.4-5, 2.3.7-8	4-12	There is very limited support available on websites for embedding numeracy across the curriculum.

Conferences				
Resource	Notes	Connection to standards	Level of schooling	School subject area
Australian Curriculum Studies Association: 2003 Curriculum Conference	Thornton, S., & Hogan, J. (2003). Numeracy across the curriculum: Demands and Opportunities. <i>Paper 009 Australian Curriculum Studies Association Inc.</i>, 117-129. Retrieved from http://www.acsa.edu.au/pages/images/thornton_-_numeracy_across_the_curriculum.pdf	2.1.1, 2.1.2, 2.1.3, 2.1.5 Professional knowledge 2.2.2, 2.2.5 Professional attributes 2.3.1, 2.3.2, 2.3.7 Professional practice	NA	NA
National Numeracy Conference 2002 “Springboards into Numeracy”	- Stoessiger, R. (2002). An introduction to critical numeracy. <i>Proceedings of the National Numeracy Conference</i>, 47-51. Retrieved from http://www.aamt.edu.au/Professional-reading/Numeracy - McCarthy, J. (2002). Connecting numeracy across the curriculum. <i>Proceedings of the National Numeracy Conference</i>, p.101-7. Retrieved from http://www.aamt.edu.au/Professional-reading/Numeracy - Mobey, P. (2002). Motivation and enjoyment through numeracy across the curriculum - There may be others	2.1.1, 2.1.2, 2.1.3 Professional knowledge 2.2.8 Professional attributes 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.1.6 Professional knowledge 2.2.1, 2.2.2, 2.2.4, 2.2.6, 2.2.8 Professional attributes 2.3.5, 2.3.6 Professional practice	NA 10	NA Mathematics, SOSE
Gaps		- Professional attributes: 2.2.3, 2.2.7 - Professional practice: 2.3.3, 2.3.4, 2.3.8	P-9, 11, 12	All except SOSE

States and Territories

QLD resources

Department of Education, Training and Employment & Queensland Curriculum and Assessment Authority

These resources address some aspects of Professional Knowledge and Professional Practice by helping teachers identify sources of numeracy within their subject area, but the resources do not address Professional Attributes.

Resource	Notes	Connection to standards	Level of schooling	School subject area
QSA P-10 numeracy example short assessments http://www.qsa.qld.edu.au/17930.html				
English Prep numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/rep_num_esa_english.pdf Counting rhyme	- Calculating and estimating: Indicate the ordinal position in a sequence as first, second, third. - Match, copy and write familiar numerals and connect number names, numerals and quantities to 10 and beyond. - Identify the word zero with its quantity and numeral - Using measurement: Arrange aspects of daily routines in sequence.	2.1.2, 2.1.4, 2.1.5, 2.3.8 Professional knowledge & Professional practice	Prep	English
Technology Year 1 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/yr1_num_esa_technology.pdf Patterns in jewellery	Describe, create and extend increasing and decreasing patterns using skip counting and describe the rules used.	2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.3.7, 2.3.8 Professional knowledge & Professional practice	1	Technology
The Arts Year 2 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/yr2_num_esa_the_arts.pdf Using line and 2D shapes	- Visualise and describe key features of 3D models, counting faces, corners and edges. - Describe straight and curved lines, and draw 2D shapes (triangles, kites, rhombuses, circles, rectangles including squares) with and without technologies.	2.1.4, 2.1.5, 2.1.6, 2.3.8 Professional knowledge & Professional practice	2	Visual Arts
The Arts Year 4 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/yr4_num_esa_the_arts.pdf Responding to artworks	- Compare angles and classify them as equal to, greater than or less than a right angle. - Create symmetrical patterns, pictures and shapes, identifying the use of angles, with and without technologies	2.1.4, 2.1.5, 2.1.6, 2.3.8 Professional knowledge & Professional practice	4	Visual Arts
Science Year 5 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/	Represent and interpret data by: posing questions and collecting categorical or numerical data by observation or survey	2.1.4, 2.1.5, 2.1.6, 2.3.8 Professional knowledge &	5	Science

p_10/yr5_num_ea_science.pdf How to track rotation of Earth	- constructing column graphs, dot plots and tables, appropriate for the data type, with and without technologies, and justifying the choice of representation - comparing different data sets and identifying patterns and trends.	Professional practice		
HPE Year 6 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/yr6_num_ea_hpe.pdf Problem-solving using nutritional panels	- Select and combine mental strategies and written procedures with and without technologies. - Justify the method/s used. - Represent and solve problems involving the four operations	2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.3.7, 2.3.8 Professional knowledge & Professional practice	6	HPE
Arts Year 9 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/yr9_num_ea_visarts.pdf Transferring an image to a different size	Use the properties of similarity and ratio to solve problems involving enlargement and transformation	2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.3.7, 2.3.8 Professional knowledge & Professional practice	9	Visual Arts
HPE Year 10 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/yr10_num_ea_hpe.pdf Road safety & crash stats	- Use graphs and equations to analyse and illustrate proportional relationships. - Evaluate statistical reports by linking claims to displays, statistics and representative data.	2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.3.7, 2.3.8 Professional knowledge & Professional practice	10	HPE
Science Year 10 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/yr10_num_ea_science.pdf Big bang calculations	- Identify preferred mental and written strategies, select and use definitions, rules, representations and estimates, with and without technologies in calculations involving complex data and contexts. - Explain the method/s. - Use very small and large time scales and intervals to solve problems	2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.3.7, 2.3.8 Professional knowledge & Professional practice	10	Earth and space science
English Year 10 numeracy example short assessments http://www.qsa.qld.edu.au/downloads/p_10/yr10_num_ea_english.pdf Evaluating advertisements	Evaluate statistical reports by linking claims to displays, statistics and representative data.	2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.3.7, 2.3.8 Professional knowledge & Professional practice	10	English
NSW NSW Department of Education and Communities & Board of Studies NSW Difficult to find resources of numeracy across the curriculum or policies currently being used.				
Numeracy K-12 Policy https://www.det.nsw.edu.au/policies/curriculum/schools/numeracy/PD20070365.shtml?query=numeracy	Unclear if documents are still current.	Nil	NA	NA
Syllabus documents 2003 available	Some syllabuses have a short paragraph on numeracy identifying	2.1.4	NA	NA

online	numeracy skills in that subject.			
Teaching numeracy in PDHPE http://www.curriculumsupport.education.nsw.gov.au/secondary/pdhpe/crosscurriculum/numeracy/index.htm	Unit ideas: - Dietary requirements of adolescents - Locating health services in the community - Predicting potential likelihood of harm - Analysing performance results	2.3.6	7-10	PDHPE (Personal development, health and physical education)
In other documents from BOS NSW 'numeracy' is used to mean 'mathematics'		Nil	NA	NA
VIC Department of Education and Early Childhood Development & Victorian Curriculum and Assessment Authority Difficult to find resources of numeracy across the curriculum or policies currently being used.				
Victorian Curriculum and Assessment Authority: AusVELS	The word 'numeracy' is mentioned in mathematics and in ICT but no elaboration about what 'numeracy' means in those contexts.	Nil	NA	NA
F-10 curriculum planning and reporting guidelines http://www.vcaa.vic.edu.au/documents/auscurric/f-10curriculumplanningreporting.pdf Document explaining AusVELS.	"There is considerable research that sets out the importance of the teaching of literacy and numeracy and ICT in the context of the different learning areas. It is therefore both appropriate and necessary that the literacy, numeracy and ICT requirements for each discipline be embedded in the curriculum of each discipline." (There is no guidance for teachers on how to embed numeracy across the curriculum.)	Nil	NA	NA
Numeracy teaching within domains https://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/numeracyteachdomains.pdf	Raise awareness of numeracy demands within identified VELs domains. Very similar to the descriptions in the Australian Curriculum (see above).	Professional knowledge	NA	NA
TAS The Department of Education Tasmania Difficult to find resources of numeracy across the curriculum or policies currently being used.				
Tasmanian Catholic Education Curriculum http://curriculum.catholic.tas.edu.au/GeneralCapabilities/Pdf/Numeracy	Links to the Australian Curriculum description of numeracy across the curriculum.	Professional knowledge	NA	NA
SA Department for Education and Child Development & South Australian Certificate of Education Difficult to find resources of numeracy across the curriculum or policies currently being used.				
Dept for education and child development	Links to the Australian Curriculum description of numeracy across the curriculum.	Professional knowledge	NA	NA
School numeracy audit http://www.decd.sa.gov.au/numeracy/f	Focuses on 'mathematics' rather than 'numeracy' though some good prompt questions.	NA	NA	NA

iles/links/num1_2_school_numeracy_aud.pdf				
WA Department of Education & School Curriculum and Standards Authority Difficult to find resources of numeracy across the curriculum or policies currently being used.				
WA Dept of Education	Descriptions across subject areas very similar to descriptions in the Australian Curriculum (see above).	Professional knowledge	NA	NA
NT Department of Education & NT Board of Studies Difficult to find resources of numeracy across the curriculum or policies currently being used.				
NT Dept of Education	Descriptions across subject areas very similar to descriptions in the Australian Curriculum (see above).	Professional knowledge	NA	NA
Gaps		Professional knowledge: 2.1.1 Professional attributes: 2.2.1-8 Professional practice: 2.3.1-5	Years 11, 12	History, Geography, Languages, Economics and Business, Civics and Citizenship
International resources				
Resource	Notes	Connection to standards	Level of schooling	School subject area
Education Scotland http://www.educationscotland.gov.uk/sharingpractice/i/inthedoghouse/introduction.asp?strReferringChannel=learningteachingandassessment&strReferringPageID=tcm:4-628498-64	This website offers many teacher resources and units for teaching numeracy across the curriculum. One example is given below: “In the dog house” - Making a dog kennel http://www.educationscotland.gov.uk/sharingpractice/i/inthedoghouse/im pactandnextsteps.asp?strReferringChannel=learningteachingandassessment&strReferringPageID=tcm:4-628498-64 - Identified aspects of numeracy in this task. - Ideas for working with colleagues. - Used prompt questions to help teachers consider how else they could embed numeracy in other areas of their subject.	Professional knowledge, attributes & practice	Secondary	Mathematics, craft design & technology
Numeracy across the curriculum Wales https://hwb.wales.gov.uk/cms/hwbcontent/Shared%20Documents/vtc/2012-13/20032013/numeracy-across-the-curriculum-wales/eng/index-04.html	This website offers many teacher resources and units for teaching numeracy across the curriculum. One example is given below: “Flood risk! Rainfall and surface water flow” https://hwb.wales.gov.uk/cms/hwbcontent/Shared%20Documents/vtc/2008-09/esdgc/dwr-cymru-2/index.html	Professional knowledge	Reception (Prep) to Yr 9 Year 8	Geography, Science

Existing resources address mainly Professional Knowledge (especially Standards 2.1.4 and 2.1.5) with very little attention paid to Professional Attributes and Professional Practice. Very few resources exist to help teachers to “take advantage of numeracy learning opportunities when planning within their own curriculum context” (Standard 2.3.3). Resources that assist teachers to develop this capacity need to help teachers to develop a *broad personal conception of numeracy* (Numeracy model), *identify* the numeracy learning opportunities within their curriculum context and *design* appropriate learning activities.