

**Independent review of Education Queensland's  
Curriculum into the Classroom program:  
primary mathematics**

November 30th 2011

**Authors:**

---

Tierney Kennedy:  
Independent mathematics  
Consultant

Leah O'Neill,  
Head of Curriculum

Kylie Devenish  
Practising Teacher

## Contents

1   Executive summary .....	4
1.1 Review overview .....	4
1.2 Review conclusion.....	4
1.3 Recommendations .....	5
2   Introduction.....	6
3   The Australian Curriculum requirements and intent .....	7
3.1 Context and rationale .....	7
3.2 Understanding.....	8
3.3 Fluency .....	9
3.4 Reasoning.....	10
3.5 Problem Solving .....	11
3.6 Questions .....	13
3.7 Situations for Learning .....	13
3.8 Findings .....	14
3.9 Recommendations .....	15
4   Education Queensland requirements for quality teaching and learning .....	16
4.1 Policy documents and requirements .....	16
4.2 Pedagogical principles.....	16
4.3 Assessment principles .....	19
4.4 Recommendations .....	22
5   Sequential development of mathematical ideas .....	23
5.1 Important concepts in mathematical development – the <i>Big Ideas</i> .....	23
5.2 Time allocated to concepts.....	24
5.3 Misconceptions .....	25
5.4 Gaps between current Queensland practices and C2C expectations.....	26
5.5 Recommendations .....	28

6   Numeracy results and NAPLAN recommendations.....	29
6.1 Queensland NAPLAN trends – where we are falling down.....	30
6.2 C2C alignment with NAPLAN trends .....	33
6.3 Recommendations .....	33
7   Conclusions and Recommendations .....	34
8   Appendices .....	36
8.1 Methodology and scope of the review .....	36
8.2 Analysis of verbs in 57 C2C lessons.....	38
8.3 Analysis of focus questions in 57 C2C lessons .....	40
8.2 References .....	41

## 1 | Executive summary

### 1.1 Review overview

In October 2011, the first units of *Curriculum into the Classroom* for primary mathematics (C2C) were released for implementation from January 2012. Education Queensland have announced that C2C is a “comprehensive curriculum package to prepare for the Australian Curriculum”<sup>1</sup> and claimed that it has been developmentally sequenced to maximise student learning.<sup>2</sup> In response to these circumstances, and having consulted in maths curriculum implementation with well over 300 QLD schools over the past five years, we have undertaken a detailed review of the available C2C material. The methodology used for this review can be found in section 8.1.

This review has examined 57 C2C lessons in detail, according to:

1. Whether the C2C program meets the Australian Curriculum requirements; specifically examining the proficiency strands, questions asked and situations for learning (section 3).
2. Whether the C2C program meets the pedagogical and assessment principles inherent within the P-12 Curriculum Framework, the ROADMAP – Dimensions of Teaching and Learning, and the Numeracy Framework for action (section 4).
3. Whether the learning within C2C is developmentally sequenced to maximise student learning, including adequate focus on key mathematical ideas (section 5).
4. Whether C2C addresses Queensland-specific NAPLAN failings (section 6).

The methodology and scope of this review are described in section 8.1.

### 1.2 Review conclusion

Education Queensland is to be commended in attempting to provide support for Queensland teachers implementing the Australian Curriculum in the creation of the Curriculum into the Classroom program. However, analysis in this review indicates a series of critical shortcomings in C2C. These include:

- C2C fails to meet Australian Curriculum requirements for proficiency strands, question types and situations for learning (Section 3)
- C2C fails to meet the pedagogical and assessment principles within the P-12 Curriculum Framework, the ROADMAP: Dimensions of Teaching and Learning, and the Numeracy Framework for Action (Section 4)
- C2C contains both transitional and systemic problems in the sequential development of mathematical ideas, particularly with respect to key mathematical concepts such as place value and fractions, which are likely to lead to major student difficulties with mathematics (Section 5)
- C2C fails to address Queensland-specific difficulties in NAPLAN testing (Section 6)

## 1.3 Recommendations

Detailed recommendations can be found in sections 3.9, 4.4, 5.5, and 6.3 of this report. Major recommendations include an urgent rewrite of the C2C program prior to implementation in January as well as professional development for teachers.

Rewriting of the C2C program should be undertaken prior to implementation, focussing on the following priorities:

- 1.1 Unit plans should devote more time to key mathematical concepts. Under the current C2C program Queensland student face a significant risk of future difficulties in mathematics.
- 1.2 Lesson plans should incorporate problem-based, inquiry or constructivist approaches to introduce new content to students, with a heavy emphasis on unfamiliar problems. These should incorporate existing research on student misconceptions as well as specific strategies for differentiating learning activities.
- 1.3 Questions that assess student understanding should be incorporated at the beginning, during and at the conclusion of each lesson on new content, enabling teachers to determine what students understand, evaluate how successful learning experiences have been and indicate future focus areas. Assessment of student understanding should be continuous.
- 1.4 Unit and lesson plans should incorporate more flexible time each week to enable teachers to cater for the specific learning needs of their students.
- 1.5 Formal assessment items should embed the proficiency strands within them, with deliberate effort to focus on Problem-Solving, Reasoning and Understanding as discussed within the National Mathematics Curriculum: Framing Paper<sup>3</sup>.
- 1.6 Consideration should be given to bridging the gap between current Queensland Curriculum expectations and Australian Curriculum expectations. Expecting students to just catch up without placing sufficient time and emphasis on key mathematical concepts is very likely to lead to significant holes in student understanding for an entire cohort of students. We recommend using problem-based teaching with differentiated instructions for meeting the specific learning needs of individuals within a whole class lesson.

Current research suggests that students placed with high-performing teachers will progress three times as fast as those placed with low-performing teachers.<sup>4</sup> Professional Development should therefore be provided for Teachers and Administrators focusing on:

- 2.1 The proficiency strands: what these mean and *how* to implement them within a classroom situation, with a focus on problem-solving, understanding and reasoning
- 2.2 Finding out what students know, developing activities to extend this understanding, and differentiating learning to meet the needs of students requiring support and extension
- 2.3 Using problem-based approaches to diagnose student misconceptions, and logical questioning techniques to enable students to self-correct their own wrong ideas

## 2 | Introduction

In October 2011, the first units of *Curriculum into the Classroom* for primary mathematics (C2C) were released for implementation from January 2012. Education Queensland have announced that C2C is a “comprehensive curriculum package to prepare for the Australian Curriculum”<sup>5</sup> and claimed that it has been developmentally sequenced to maximise student learning.<sup>6</sup> Indeed, many schools have reported receiving clear instructions for the mandatory adoption of C2C in spite of an agreement between Education Queensland and the Queensland Teachers Union **that “the centrally devised unit plans associated with implementing the Australian Curriculum will not and cannot be mandated”**.<sup>7</sup>

In response to these circumstances, and having consulted in maths curriculum implementation with well over 300 QLD schools over the past five years, we have undertaken a detailed review of the available C2C material. The methodology used for this review can be found in section 8.1.

This review examines how C2C meets the following:

- The Australian Curriculum requirements (section 3)
- Education Queensland's major policy documents regarding quality teaching and learning: The P-12 Curriculum Framework, the ROADMAP: Dimensions of Teaching and Learning, and the Numeracy Framework for Action (section 4)
- Developmental sequencing of mathematical ideas: latest research findings (section 5)
- Queensland-specific areas of weakness in NAPLAN results (section 6)

As appropriate assessment items have not been released for C2C at the time of writing this review, we have used the available materials from the previous version of C2C known as Scribbly Gum when examining assessment (section 4.3).

## 3 | The Australian Curriculum requirements and intent

### 3.1 Context and rationale

The stated focus of the Australian curriculum is on “developing increasingly sophisticated and refined mathematical understanding, fluency, logical reasoning, analytical thought and problem-solving skills.”<sup>8</sup> It is these proficiencies or capabilities that define how students should interact with mathematics in our classrooms and therefore what a good mathematics program should look like.

The Australian Curriculum rationale explains that these capabilities “enable students to respond to familiar and unfamiliar situations by employing mathematical strategies to make informed decisions and solve problems efficiently.”<sup>6</sup> This dual emphasis on familiar and unfamiliar situations is reflected within the proficiency strands. The aim is to ensure “all students benefit from access to the power of mathematical reasoning and learn to apply their mathematical understanding creatively and efficiently... [and] become self-motivated, confident learners through inquiry and active participation in challenging and engaging experiences.”<sup>6</sup>

In order for any program to meet the Australian Curriculum Requirements it must therefore have a similar focus on developing proficiencies, ensuring that students are presented with a range of familiar and unfamiliar situations that require them to make decisions, solve problems, and apply their learning creatively through inquiry and active participation in challenging and engaging experiences.

These requirements may be summarised into the following categories:

- **Programs must focus on** developing (a) Understanding, (b) Fluency, (c) Logical reasoning and analytical thought, (d) Problem-solving skills. These proficiencies should not be added as an after-thought to content, but should instead be the *focus* of any program.
- **Questions must** comprise a range of (e) familiar and unfamiliar situations that require students to make decisions and solve problems.
- **Situations must** (f) require students to apply their mathematical understanding creatively, not just efficiently, and (g) consist of inquiry and active learning experiences that are both challenging and engaging

These requirements must be present in a program for it to truly meet the curriculum requirements as stated clearly in the Australian Curriculum Rationale. The following sections of this report elaborate on the proficiency strands, and examine how C2C meets the requirements for Programs, Questions and Situations as described above.

## 3.2 Understanding

A. What does a program that focuses on developing Understanding look like? What components are required?

The Understanding proficiency strand contains the following description:

“Students build a robust knowledge of adaptable and transferable mathematical concepts. They make connections between related concepts and progressively apply the familiar to develop new ideas. They develop an understanding of the relationship between the ‘why’ and the ‘how’ of mathematics. Students build understanding when they connect related ideas, when they represent concepts in different ways, when they identify commonalities and differences between aspects of content, when they describe their thinking mathematically and when they interpret mathematical information.”<sup>9</sup>

Important phrases that emerge from this paragraph describe what students are expected to do:

1. Adapt and transfer mathematical concepts to new situations
2. Connect related ideas, represent concepts in different ways
3. Identify commonalities and differences in mathematical concepts
4. Describe their own thinking mathematically
5. Interpret mathematical information
6. Apply familiar ideas and concepts to develop new ideas, relating the ‘how’ to the ‘why’ of mathematics

Notice that all of the actions within this passage belong to the students. Teachers do not connect related ideas, **students do**. Students identify commonalities and differences **for themselves**, connect ideas **through their own thinking**, and represent concepts in different ways.

The teacher's job is not to point out connections between ideas and concepts, it is the teachers' job to facilitate the students finding and developing these connections themselves.

**Teachers do not provide the answers, they ask the right questions.**

Questions that are asked to diagnose and build student Understanding are necessarily different to those for Fluency. Understanding questions need to focus on helping the students to make connections, adapt concepts and find similarities and differences between ideas.

Examples might include:

- What do you already know about...? So how could we use this to work out...?
- How is ..... kind of the same as .....? What is different between the ideas?
- If I make this change... is it still the same or is it different now? How do you know?
- Do you think that is always going to be true or is it just this time?
- What is the problem here? Why isn't this working for us? So what else could we try?

- What do you mean by...? Can you show me so that I understand what you mean?
- Which way is the easiest? Are they all going to work or will just some of them work? Why?
- How do you know? How can you be sure?
- Can you see a pattern here? What is it? How are these two things related?

In C2C we find very few of these questions, with most lessons missing the Understanding strand altogether. For example, in a seven lesson sequence to develop Number Sense for year four, only three of the 66 focus questions provided would fit within the Understanding proficiency strand and these were all contained within the opening sequence of a single lesson. In years 1-4 and 7 Understanding questions made up only 29 of the 522 focus questions asked over 41 lessons. This is less than one question per lesson. The average was higher for years 5 and 6 with 1.8 understanding questions asked per lesson over 16 lessons. Full analysis of these questions can be found in Table 2 in section 8.1.

Once a concept has been taught and practised in C2C, students are not generally encouraged to apply their understanding to non-standard questions or new situations to ensure that their learning is transferred. Not only does this represent a significant failing to meet the Understanding proficiency strand, but also teachers' failure to instil Understanding and deal with student misconceptions has serious implications for Queensland NAPLAN results as shown in the 2009 Masters Report.<sup>10</sup>

### 3.3 Fluency

- B. What does a program that focuses on developing Fluency look like? What components are required?

The Fluency proficiency strand contains the following description:

"Students develop skills in choosing appropriate procedures, carrying out procedures flexibly, accurately, efficiently and appropriately, and recalling factual knowledge and concepts readily. Students are fluent when they calculate answers efficiently, when they recognise robust ways of answering questions, when they choose appropriate methods and approximations, when they recall definitions and regularly use facts, and when they can manipulate expressions and equations to find solutions." <sup>ii</sup>

Important phrases that emerge from this paragraph describe what students are expected to do:

1. *Choose* appropriate procedures and approximations
2. Carry out procedures flexibly, accurately, efficiently and appropriately
3. Recall factual knowledge and concepts easily, including definitions and regularly used facts
4. Calculate answers efficiently
5. Recognise robust ways of answering questions
6. Manipulate expressions and equations to find solutions

Fluency within the Australian curriculum emphasises not only factual knowledge, routine questions and efficiency but also the ability of students to be **flexible** and **robust** in their approach to questions - in other words, to be able to select their own approaches to questions and to manipulate the mathematics to suit their needs.

Within C2C, Fluency is given a heavy focus, with opportunities given in almost every lesson to develop content knowledge, and all of the content carefully mapped to the Australian Curriculum. However the approach to content knowledge in C2C differs from ACARA's approach in a subtle, but important way. Factual knowledge, routine questions and efficiency dominate, frequently at the expense of flexibility. In a textual analysis of 57 lessons across grades 1-7 we found that 86% of the actions associated with teachers fit within a traditional teaching approach where teachers demonstrated, modelled or explained particular content to students, followed by time for practice questions that were very similar in nature to that which the teacher had just shown. 78% of the actions associated with students also fit with this traditional teaching model, with this average changing to 81% when a single year 6 lesson was excluded. For the full textual analysis results see Table 1 in section 8.1.

This prescriptive format permeates the program, with students predominantly using the strategy or procedure just demonstrated and very rarely encouraged to choose their own strategy. While teacher modelling routine questions and students practicing procedures are both very important, these alone do not meet the Fluency requirements.

### 3.4 Reasoning

C. What does a program that focuses on developing logical thought and analytical reasoning look like? What components are required?

The Reasoning proficiency strand contains the following description:

"Students develop an increasingly sophisticated capacity for logical thought and actions, such as analysing, proving, evaluating, explaining, inferring, justifying and generalising. Students are reasoning mathematically when they explain their thinking, when they deduce and justify strategies used and conclusions reached, when they adapt the known to the unknown, when they transfer learning from one context to another, when they prove that something is true or false and when they compare and contrast related ideas and explain their choices." <sup>ii</sup>

Important phrases that emerge from this paragraph describe what students are expected to do:

1. Analyse, prove, evaluate, explain, infer, justify and generalise
2. Explain their thinking
3. Deduce and justify strategies used and conclusions reached
4. Adapt the known to the unknown, transferring learning from one context to another
5. Prove that something is true or false
6. Compare and contrast related ideas and explain their choices

Reasoning describes what students **do** rather than what they **know**. It is important to give students adequate opportunities to reason their way through problems, proving and disproving ideas and explaining their thinking in a robust manner. Traditionally in Queensland we have focussed on developing student Communication, which has many similar elements to Reasoning particularly in terms of logical structuring, but without the heavy emphasis on deductions, proofs and the unknown.

Within C2C, an average of only 1.2 Reasoning questions were asked each lesson, across our 57 lesson sample. The vast majority of questions are closed and focus on the answer rather than the underlying mathematical principle or the mathematical processes used to find the answer. Using a year four Number-Sense unit as an example, the only example of Reasoning that we could find was "How do you know?" At no point were the students asked to prove or disprove an idea, to explain their processes or even to show their working.

It would seem reasonable to expect that students who are shown how to solve problems with no requirement to *adapt the known to the unknown* (as done in C2C), would find it more difficult to *analyse, prove, evaluate, explain, infer, justify and generalise* than those who are required to reason their way through a problem to determine a strategy and solution for themselves.

### 3.5 Problem Solving

D. What does a program that focuses on developing problem-solving look like? What components are required?

The Problem-Solving proficiency strand contains the following description:

"Students develop the ability to make choices, interpret, formulate, model and investigate problem situations, and communicate solutions effectively. Students formulate and solve problems when they use mathematics to represent unfamiliar or meaningful situations, when they design investigations and plan their approaches, when they apply their existing strategies to seek solutions, and when they verify that their answers are reasonable." <sup>ii</sup>

Important phrases that emerge from this paragraph describe what students are expected to do:

1. Make choices, interpret, formulate, model and investigate problem situations
2. Communicate their solutions effectively
3. Represent *unfamiliar* situations and meaningful situations
4. Design investigations and plan their approaches
5. Apply existing strategies to seek solutions
6. Verify that their answers are reasonable

The Problem-Solving proficiency strand describes a process in which students must work out how to approach the problem, identify appropriate strategies, try them out, revise their ideas and verify their solutions. Suitable situations for these problems are described firstly as "unfamiliar" and secondly as "meaningful". These situations are an essential part the problem-solving proficiency as only unfamiliar problems require students to "interpret, formulate, model and investigate".

Routine questions disguised as word problems are not *unfamiliar*, and while students require literacy skills to unpack the phrases they have no need to interpret, formulate, model, investigate, design or plan in order to answer a question that they have previously seen. Peter Sullivan recently described problem solving as the process that happens when “students devise their own ways of solving a task that they *have not been taught to do*”.<sup>11</sup>

Throughout our examination of the C2C material presented so far we have found a marked absence of unfamiliar problems. Across the 57 lessons analysed, no unfamiliar problems of any sort were found in grades 4, 5 and 7. Across all 57 lessons only 5% were taken from the Problem-Solving proficiency strand, with the six best Problem-Solving questions all taken from a single Year six lesson on Fractions.

The vast majority of the “problems” that are presented are routine, and any opportunity for creative thinking is lost when these are presented by the teacher and then “solved” with explicit teacher direction. In over 70% of questions students simply practise solving questions similar to the one that has been modelled by the teacher.

One exception to this trend is the year 6 unit on Fractions. This unit consists of three introductory lessons that review previously taught content on equivalent fractions, followed by two lessons that introduce students to addition and subtraction of fractions with different denominators, one lesson on problem-solving and one lesson for review. In this unit only 24% of focus questions provided were routine, whereas all of the other units examined contained 70-85% routine questions. Unfortunately, the majority of non-routine questions are asked in lessons where students were reviewing or applying content that they had previously been taught rather than in the two lessons where new knowledge was being developed. In lessons 4 and 5 when new content is taught (adding and subtracting fractions with different denominators) the pedagogy revert to traditional explanations and practice, with the only focus questions included after content has been taught and practised at the conclusion of lesson 4. In spite of these shortcomings, this unit does remain the only example of where the C2C primary mathematics program meets the requirements for problem-solving in Australian Curriculum.

This predominance of familiar problems also extends to the available assessment items which claim to incorporate the Problem-Solving proficiency. In the available year 6 Scribbly Gum assessment on negative numbers, routine questions written as word problems are the only “problems” given. Students are taught in class about negative numbers, relating these to thermometers and money and reading temperatures from thermometers. In the assessment item students complete very similar questions to those already done in class, but this time they are presented in sentences. As these questions are *familiar* to students, even using the same context as those previously used in class, they in no way require Problem-Solving as described by the proficiency strands. This assessment item is therefore a clear indication that the Problem-Solving proficiency has been completely misinterpreted within the C2C program.

### 3.6 Questions

In any program claiming to meet the Australian Curriculum requirements questions must comprise a range of familiar and unfamiliar situations that require students to make decisions and solve problems.

Questions in C2C can be divided into four categories:

- Familiar questions: those that students have previously experienced and are simply routine or practice questions. These include any questions that are asked about content that the teacher has just demonstrated or explained, revision questions and drill and practice questions.
- Unfamiliar questions for problem-solving: those that require students to work out something that they have not been taught to do
- Reasoning questions: those that focus on the method for solving the question and the analytical processes that took place to work out the answer
- Understanding questions: those that require students to make connections, adapt what they know to a new situation or answer similar content presented in a non-standard manner

When we examined the familiar and unfamiliar focus questions across a sample of 57 lessons from years 1-7 we found 463 questions that fit into these two categories. 426 of these (92%) were familiar, with just 37 (8%) unfamiliar. This gave an average of 0.6 unfamiliar questions asked per lesson (see section 8.1). This is clearly inadequate to meet the need for students to make their own decisions and solve problems.

### 3.7 Situations for Learning

The situations for learning described within the rationale for the Australian curriculum require students to apply their mathematical understanding creatively, not just efficiently, and consist of inquiry and active learning experiences that are both challenging and engaging.

The P-12 curriculum framework produced by Education Queensland states that, *Learning experiences should connect with what students already know and extend that knowledge through **intellectually challenging work**. Activities should be purposeful and relevant, and **stimulate inquiry, action, reflection, and enjoyment**.*<sup>12</sup>

With the exception of one year six lesson on developing a fractions game (lesson 6 Fractions, unit one), we found an absence of creative application of mathematical concepts. The learning experiences within C2C very rarely consist of inquiry and active learning, with student engagement mostly coming through video segments and lower-order thinking games rather than challenging problems. We would argue that this reflects an underlying tendency to keep students entertained in mathematics rather than engaged, and does not meet the requirements from the P-12 curriculum framework as stated above let alone those from the Australian Curriculum.

### 3.8 Findings

The Curriculum into the Classroom program does not adequately meet the Australian curriculum requirements for Fluency in terms of allowing students to choose their own strategies and promoting flexibility that builds a robust knowledge of mathematics.

The Curriculum into the Classroom program does not meet the Australian curriculum requirements for Problem-Solving, Reasoning or Understanding and shows evidence of serious misinterpretation of what these proficiencies mean.

This failure to meet the proficiency strands is related to how the strands are referred to within the C2C program. In the Australian Curriculum, each of the year level outlines contains three or four skill statements giving examples of how each of the proficiency strands relates to specific content statements. These skill statements provide a simple example of how a proficiency strand might look within a specified content area. They are not intended to fully define how Understanding, Reasoning or Problem-Solving might look across a year, but as guiding principles or suggestions of skills, as correspondence with Karl Eccleston (ACARA) has indicated:

*“The statements you are referring to for each year level do not present an exclusive list of skills for teachers to deliver, but instead they are suggestions only of skills in that particular strand and year level.”<sup>13</sup>*

Put simply, the proficiency strands are meant to be embedded in everyday teaching, not addressed only on occasion. They describe normal teaching and learning practice – what students know and do every day - yet instead of embedding the proficiency strands into each lesson, C2C appears to use these simple skill statements as a **complete outline of what is to be expected** for each proficiency strand. Within the units provided, these statements are simply copied and pasted, without further elaborations about where else the proficiency strand is to be used or how it is to be developed within the lesson plans. This major oversight has contributed to the lip-service paid to the proficiency strands within C2C, and ultimate failure of the program to meet the requirements or intent of the Australian Curriculum.

### 3.9 Recommendations

The following recommendations should be taken into consideration prior to implementation of the Curriculum into the Classroom program in January 2012.

- Students need to be encouraged to select their own strategies for answering questions rather than being shown one method to use.
- Students need to be encouraged to explain their solutions, discussing and debating their ideas with peers and proving or disproving mathematical suggestions using logical thought processes. This process can take significant time to develop, so deliberate strategies for building these skills should be embedded within every C2C unit.
- Students should be presented with *many* more unfamiliar problems that require them to work out that which they have not been taught to do. This requires a significant rewrite of the C2C lessons. Alternatively, whole lessons within C2C could be exchanged for problem-based teaching lessons from another source that addresses the same content. We recommend that at least two out of the five lessons in every week require exchanging for inquiry learning experiences in order to adequately meet the Australian Curriculum requirements.
- Focus questions that diagnose student understanding should be included at the beginning of each new topic and cross-referenced to commonly held student misconceptions. Without adequate diagnosis of student misconceptions teachers cannot tailor learning experiences to meet student needs. Lesson plans also need alteration to add the flexibility necessary to enable teachers to deal with these misconceptions rather than simply moving on to the next topic.
- Focus questions that develop student understanding, such as those that help students find patterns, make connections and identify similarities and differences, should be included on multiple occasions within every lesson that introduces new content. This includes asking non-standard questions to extend and deepen student understanding.
- Given the misinterpretation of the proficiency strands within C2C, we recommend professional learning be provided to teachers on these strands and what they look like within a classroom situation. This learning should focus on problem-solving, understanding and reasoning. A simple explanation of the proficiency strands should also be provided to teachers and included within each unit plan.
- The proficiency strands should be embedded within the assessment items for C2C, as discussed within the National Mathematics Curriculum: Framing Paper<sup>14</sup>

## 4 | Education Queensland requirements for quality teaching and learning

### 4.1 Policy documents and requirements

In examining the Curriculum into the Classroom program we must be mindful of Education Queensland's policy documentation on teaching and learning, including the Roadmap's Dimensions for teaching and learning, the Numeracy framework and the P-12 curriculum framework. Each of these policy documents contains guidelines for teaching and learning within Queensland state schools, with particular emphasis on pedagogy and assessment. This review does not have the scope to examine every guideline, so eight key principles regarding **pedagogy** and **assessment** have been selected from these documents for comparison with the principles implicit within C2C.

The following **pedagogical principles** are addressed within this review:

1. Effective teachers start from where the student is at.<sup>15</sup> Teachers must meet learners at their current point of understanding.<sup>16</sup> Learning experiences connect with existing knowledge and skills.<sup>17</sup>
2. Learning involves students in making sense of the world. It is not simply about absorbing information but it is an active process of constructing meaning.<sup>18</sup>
3. Learning experiences promote depth of understanding and are connected, purposeful and challenging.<sup>19</sup>
4. Teaching is about supporting learning and helping students evaluate what they know, extend or renew their knowledge and deepen their understanding.<sup>20</sup>

The following **assessment principles** are addressed within this review:

1. Assessment tasks should be intellectually challenging and authentic.<sup>21</sup>
2. Assessment tasks should support all students in production of a performance of best quality.<sup>22</sup>
3. Assessment should provide all students with the opportunity to demonstrate the extent and depth of their learning.<sup>23</sup>
4. Assessment should inform planning and teaching as well as reporting.<sup>24</sup>

In order for C2C to meet Education Queensland's own policy requirements it must therefore meet these pedagogical and assessment principles.

### 4.2 Pedagogical principles

Teacher pedagogy is critical for student achievement, with teaching quality singled out by the OECD as *"the single biggest in-school influence on student learning"*.<sup>25</sup> Education Queensland's *Dimensions of teaching and learning*, argues that *"the quality of classroom teaching has a profound influence on student learning and achievement."*<sup>26</sup> The 2007 McKinsey Report, which identified features common to the world's top-performing school systems, argues that the quality of an education system simply cannot exceed the quality of its teachers.<sup>27</sup> These findings led the Australian Government to declare

that the first priority for the COAG reform agenda is “*Raising the quality of teaching in our schools*”.<sup>28</sup>

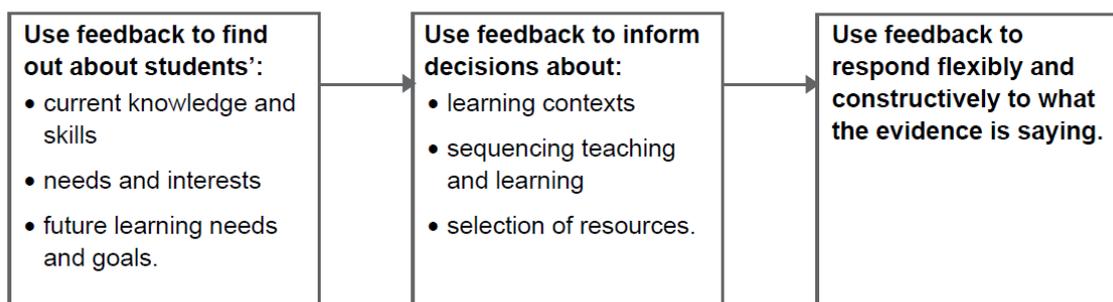
Pedagogy within Curriculum into the Classroom must therefore seek to improve teaching quality. From within the main policy frameworks released by Education Queensland over the past few years, the pedagogical principles listed in section 4.1 have been identified. Each of the pedagogical principles identified previously will be examined in turn.

1. Effective teachers start from where the student is at.<sup>29</sup> Teachers must meet learners at their current point of understanding.<sup>30</sup> Learning experiences connect with existing knowledge and skills.<sup>31</sup>

If effective teaching is to start from where the student is at and teachers are to connect the new knowledge with students' existing knowledge, then new topics necessarily need to begin by finding out what students know and don't know.

The following diagram is taken from page 4 of *THE ROADMAP, Dimensions of Teaching and Learning*, and illustrates the importance that the Roadmap places on starting from where students are at:

**By starting from where students are at:**



Starting from what students know and don't know is a critical underpinning of the *Dimensions of Teaching and Learning*, the *P-12 Curriculum Framework*, and the *Numeracy Framework*. It is perhaps the most important pedagogical principle expounded within these three major Education Queensland policy documents, and therefore needs to underpin the lesson and unit planning from the Curriculum into the Classroom program.

Out of 57 lessons from years 1-7 we found very few times where the teacher was asked to find out what the students knew prior to teaching. In less than one quarter of the lessons from years 4-7 did the teacher even check the students' routine content knowledge prior to teaching, with deep understanding checked in *only two* of the thirty-four lessons. In addition to this, none of the lessons allowed time or flexibility to catch students up who were missing the necessary prior knowledge for the new concept. Very few of the lessons suggested learning experiences for this, or made adjustments for students who required differentiated instruction. None of the lessons suggested what to do if students already understood this concept. This results in a one-size-fits-all teaching approach where all students are taught the same content on the same day regardless of what they understand prior to the lesson, and no time is allocated for catching students up who are falling behind.

To confirm this initial conclusion we examined in detail the teaching of fractions across grades four to seven, which has been identified by Dr Dianne Siemon as one of the Big Ideas in Number<sup>32</sup> and an area of importance in the National Curriculum Framing Paper<sup>33</sup>. Student misconceptions are common in fractional understanding, with many resources dedicated to helping teachers identify them. When examining the fractions sequences, we found that only two of the lessons listed misconceptions, with a single one in each lesson. Only in year seven were teachers referred to First Steps in Mathematics, which deals specifically with student misconceptions. For the rest of the lessons teachers were not provided with any cues regarding potential student misunderstandings on such an important concept.

Curriculum into the Classroom does not provide teachers with cues or with resources to adequately assess what their students know and can do prior to teaching, or resources to deal with student prior knowledge. The program certainly does not encourage teachers to “make no assumptions about prior learning, beginning with what students *currently* know rather than from what they ‘should’ know”.<sup>34</sup> We find that in this aspect C2C fails to meet three key policies from the past five years: the P-12 Curriculum Framework, the Roadmap – Dimensions of Teaching and Learning, and the Numeracy Framework for action.

2. Learning involves students in making sense of the world. It is not simply about absorbing information but it is an active process of constructing meaning.<sup>35</sup>

Active and inquiry learning is a central tenet, not only of the Australian Curriculum, but also of the *P-12 Curriculum Framework*, the *Roadmap – Dimensions of Teaching and Learning*, and the *Numeracy Framework for action*. As stated clearly above, learning is about an active process of constructing meaning rather than simply absorbing information. This view of learning requires that the teacher take a facilitator role and begin asking the right questions rather than simply providing the explanations. It is the students who make sense of the world and actively construct meaning, not the teachers.

In order to bring to light the ideology expressed about teachers and students in the Curriculum into the Classroom Program we conducted a verbal analysis of the action words associated with teachers and students. This critical literacy technique is very useful for showing the assumptions made by authors of a text and the ideology, or world-view, employed within it. For this analysis we carefully examined every action associated with both teachers and students across 57 lessons from years 1 to 7. In this analysis we found 1438 actions belonging to teachers and 1297 actions belonging to students. Once general instructions (such as “have students”) were removed, we found that only 14% of the remaining teacher actions and only 22% of the student actions fit with an inquiry and active learning model. 86% of the teacher actions and 78% of the student actions fit with a more traditional, teacher-directed pedagogy. The full verbal analysis results are presented in Table 1, Section 8.1.

This overwhelming trend was upheld in every unit that we examined across years 1-7. Whenever new content was introduced, teaching became about presenting information to be absorbed rather than about students constructing meaning. The only active or inquiry processes that we could find took place after teacher explanation, drill and practice had been completed.

This pedagogical approach does not encourage students to actively construct meaning, as the investigative process is only used after students have been told what to think, what processes to use, and how to solve questions. Modelling, investigating and trialling are difficult to instigate when students already know the answers to the questions being asked. This aligns much more closely with the assumption that problem-solving can only be used after students have "the basics" rather than the learning and teaching philosophies described in EQ policy.

3. Learning experiences promote depth of understanding and are connected, purposeful and challenging<sup>36</sup>

This principle further elaborates Pedagogical principle 1 (starting from where students are at), and is discussed above. An assessment of C2C's compliance with a requirement to develop deep understanding is presented in section 3.2. Section 3.5 on Problem-Solving examines the lack of challenging problems presented within C2C.

4. Teaching is about supporting learning and helping students evaluate what they know, extend or renew their knowledge and deepen their understanding.<sup>37</sup>

This principle again further elaborates Pedagogical principle 1 (starting from where students are at), and is discussed above. An assessment of C2C's compliance with a requirement to develop deep understanding by evaluating and extending what they already know is presented in section 3.2.

This analysis leads us to conclude that the pedagogical approaches inherent within Curriculum into the Classroom fail to meet the principles underpinning the *Dimensions of Teaching and Learning*, the *P-12 Curriculum Framework*, and the *Numeracy Framework for Action*.

### 4.3 Assessment principles

Assessment is a critical component of any program. The National Mathematics Curriculum Framing Paper explains in paragraph 57 the expectations that each proficiency strand, "will establish the respective achievement standards for the curriculum, and will be used as the basis of national assessments and reporting."<sup>38</sup> The authors also explain that the Fluency strand already has well-established expectations, "so the challenge for the writers will be to define expectations in the other proficiency strands".<sup>39</sup>

In addition to these expectations from the Australian Curriculum, Education Queensland policy documents have described the following principles for assessment to examine:

1. Assessment tasks should be intellectually challenging and authentic <sup>40</sup>
2. Assessment tasks should support all students in production of a performance of best quality <sup>41</sup>
3. Assessment should provide all students with the opportunity to demonstrate the extent and depth of their learning <sup>42</sup>
4. Assessment should inform planning and teaching as well as reporting <sup>43</sup>

Unfortunately at the time of writing this review Curriculum into the Classroom still has very few of the proposed assessment items available for examination. It is therefore difficult to thoroughly review this essential part of teaching and learning. Our critique is therefore limited to the existing Scribbly Gum (fore runner of C2C) assessment items on positive and negative numbers for year six. The proficiency strands identified within this assessment are Problem-Solving and Fluency (refer to sections 3.3 and 3.5 above for discussions of these strands and their requirements).

The Assessment item in question consists of nine main questions, with a total of 42 questions. These 42 questions include:

- 20 questions ask students to fill in a box or insert a word or number on a line
- 10 questions ask students to draw temperatures on an existing diagram of a thermometer
- 6 questions ask students to calculate a temperature that is "warmer than" or "cooler than" a given starting temperature, with four of these asking for a number sentence
- 2 questions ask students for definitions
- 2 questions ask students to explain how they got their answer
- 2 questions ask students to brainstorm and explain how negative numbers are used in real life

Of these 42 questions, none require students to do anything unfamiliar or even to apply known principles to an application question in a different context to what has been given in class. Only two questions ask students for an explanation and two are a simple brainstorming exercise. While these questions are adequate to assess Fluency, none are adequate to assess Problem-Solving as described in section 2.5.

In terms of the four assessment principles above, we find that the questions asked are almost exact copies of those completed in the unit during class. These routine questions are not *intellectually challenging* (1), and this lack of challenging questions directly fails to *provide all students with the opportunity to demonstrate the extent and depth of their learning* (3), and to *support all students in production of a performance of best quality* (2). Students are simply not asked any questions that would prompt them to display the depth of their understanding or even to apply what they have learned to a new context.

The fourth principle listed above is that assessment should inform teaching and learning as well as reporting. As described in section 4.2 above on Pedagogical Principles, assessing student understanding at the beginning of the lesson is simply omitted in most lessons, with teachers generally beginning by reviewing previous concepts using routine, factual-recall questions and then quickly moving on, seemingly assuming that students have developed the Understanding previously.

Unfortunately there is also no flexibility within the lesson or program structure to help students who cannot answer these recall questions as the lesson progresses immediately to the next concept. Passing references are made to First Steps materials, which provide an excellent source of diagnostic tasks to assess student understanding, yet it is very rare that time is allocated within the C2C program to use any of these tasks, and we have yet to identify a time allocation to deal adequately with the findings of the tasks.

We therefore conclude that the Assessment provided so far fails to meet the principles of assessment underpinning the *Dimensions of Teaching and Learning*, the *P-12 Curriculum Framework*, and the *Numeracy Framework for Action*.

## 4.4 Recommendations

The following recommendations should be taken into consideration prior to implementation of the Curriculum into the Classroom program in January 2012.

- Lesson plans within C2C need to begin with finding out what students already know and can do about a topic, and then provide recommendations for teachers based on these findings. Lesson plans that promote a “one size fits all” approach to teaching should be significantly rewritten.
- Lesson plans in which new content is introduced to students should incorporate inquiry and active learning principles and provide students with a challenging question to solve. Exploration of problems should not be relegated to follow-up, but should be the most important part of teaching and learning. Students should be required to actively construct meaning, make connections and identify similarities and differences.
- Unit and lesson plans should incorporate additional time for flexible learning, to allow teachers to respond directly to the different learning needs and prior experiences of their students. Suggestions for how to differentiate, including support and extension activities, should be included and should have time allocated within the program.
- The proficiency strands should be embedded within the assessment items for C2C, as discussed within the National Mathematics Curriculum: Framing paper
- Assessment should not be left until the end of a unit, but should be used at the start of units to diagnose student understanding, during the unit to check that students are progressing and also at the end of the unit to make sure that learning goals have been met. Assessment should be used to inform both teaching and learning rather than just to grade student performance.
- Assessment tasks require a component of intellectual challenge, with the inclusion of problem-solving and understanding questions, rather than only questioning routine content and processes. Intellectual challenge within assessment would allow students to demonstrate the extent of their understanding as well as providing them with an opportunity to produce their best quality work.
- Professional learning for teachers needs to be provided on finding out what students know, developing activities to extend this understanding, and differentiating learning to meet the needs of students requiring support and extension.

The concluding remarks in the Framing Paper for the National Curriculum (paragraph 80) describe these issues succinctly:

*“There will be substantial opportunities and challenges for teacher learning in the implementation of the national mathematics curriculum. Structuring a curriculum in the way that is proposed in this document will create a need for adjustments to some aspects of professional learning for mathematics teachers. In particular the emphasis will be on teachers **understanding the big ideas of mathematics**, as articulated in the curriculum, and then **making active and interactive decisions on ways to teach that curriculum**. This includes greater emphasis on **finding out what the students know**, and also greater emphasis on **ways of adapting activities** to enable access for students experiencing difficulty, and to extend students who may benefit from richer activities. Such emphases are compatible with current approaches to facilitate school- and classroom-based teacher learning.”*<sup>44</sup>  
(emphasis added)

## 5 | Sequential development of mathematical ideas

Within mathematics, “learning for most topics can be considered to occur along a continuum, although not necessarily with development at a regular rate”.<sup>45</sup> This developmental sequence of mathematical ideas underpins much of the recent research in mathematics. In contrast, the goal of the Australian curriculum is not to provide this complete developmental sequence, but to specify only “the major learning goals for each content strand, noting that this is a complex task and is not a feature of most current curriculums.”<sup>46</sup> As the curriculum has been deliberately designed as a way of “thinning-out the crowded curriculum”<sup>47</sup> it is very important for teachers to consider not only the content that is presented, but also the developmental sequence that surrounds this content in order to ensure that deep understanding is achieved.

Curriculum into the Classroom has been promoted by internal correspondence as “developmentally sequenced to maximise student learning”.<sup>48</sup> This claim is therefore carefully examined below in light of the current research on mathematical ideas and learning. In order to achieve this, our review will now consider the following:

1. What key ideas are fundamental to mathematics? What are the implications for programs?
2. How is time allocated for key concepts within C2C?
3. How are student misconceptions for key concepts handled within C2C?
4. What gaps exist between current Queensland expectations and the new Australian Curriculum?  
How does C2C address these gaps?

### 5.1 Important concepts in mathematical development – the *Big Ideas*

In current mathematics research certain key ideas are given more importance than others. This principle has been described by both the National Mathematics Curriculum Framing Paper and the 2008 NMAP report.<sup>49</sup> Important research by Dr Dianne Siemon has identified some of these Big Ideas that are fundamental for students to acquire at certain stages as they form the basis for future conceptual development.

These Big Ideas in Number have been identified as:

**LEVEL 1 – Trusting the count**, developing flexible mental objects for the numbers 0 to 10

**LEVEL 2 – Place-value**, the importance of moving beyond counting by ones, the structure of the base ten numeration system

**LEVEL 3 – Multiplicative thinking**, the key to understanding rational number and developing efficient mental and written computation strategies in later years

**LEVEL 4 – Partitioning**, the missing link in building common fraction and decimal knowledge and confidence

**LEVEL 5 – Proportional reasoning**, extending what is known about multiplication and division beyond rule-based procedures to solve problems involving fractions, decimals, percent, ratio, rate and proportion

**LEVEL 6 – Generalising**, skills and strategies to support equivalence, recognition of number properties and patterns, and the use of algebraic text without which it is impossible to engage in broader curricula expectations at this level<sup>50</sup>

These concepts are critical to develop at certain stages and build on one another. One clear example is shown in The Middle Years Numeracy Research Project (MYNRP, 1999-2001) which concluded that fractions, decimals, [and] multiplicative thinking were among the most common sources of student difficulty from years 5-9.<sup>51</sup> Each of the concepts identified as major difficulties fit within the Big Ideas of Multiplicative thinking, Partitioning and Proportional Reasoning. These concepts within the Number and Algebra strand should be given special emphasis, with extra time allocated to their study and a deliberate focus on developing deep Understanding rather than just Fluency. Student misconceptions form an important part of this focus.

## 5.2 Time allocated to concepts

According to the National Mathematics Curriculum Framing Paper, "The rate of development of the curriculum should enable teachers to extend students in more depth in key topics".<sup>52</sup> Time allocated to key concepts is a critical component for any mathematics approach, particularly in a lesson-by-lesson program such as Curriculum into the Classroom. Development of new content knowledge and deep understanding in the areas identified in section 4.1 above should have proportionally more time devoted to their study than to other areas.

We have found little evidence of consideration being given to the key ideas of mathematics within the C2C program. Below are three examples that highlight some of the problems in the development of the Place Value, Multiplicative Thinking and Proportional Reasoning key concepts:

- Year 1 classes using the current EQ scope and sequence for 2011 will have worked with numbers to 10 only. For these classes, year 2 C2C begins with two lessons on counting patterns to 100 and two lessons on numbers to 100 before immediately moving on to larger numbers. Four lessons on numbers between 11 and 99 is not sufficient time to establish deep understanding of place value for students who have not previously worked with numbers to 100.
- In year 4 C2C, two lessons are spent developing new student knowledge of equivalent fractions and a single lesson is spent working with four-digit numbers (which would not have been covered following the EQ Scope and Sequence for year 3 in 2011). Yet within the same unit two lessons are spent playing with tangrams. This time allocation indicates that C2C considers playing with tangrams as equally important to developing new understanding of equivalent fractions, and more important than introducing students to four-digit place value.
- In year 5 C2C, no lessons in all of term 1 are devoted to place value. Additionally, in a number of lessons students "review" five and six digit numbers during the introduction to the lesson, but these would not have been taught to the students when they were in year 4 using the current EQ scope and sequence.

The problems above can be categorised as either transitional or systemic. Transitional problems, such as inadequate time allocations for introducing new content given the current state of knowledge of Queensland students, will not only create problems for 2012 but has the potential to seriously impact the learning of an entire cohort of students. As noted in section 5.1 above, failure of students to develop deep understanding of key concepts is most common source of student difficulty in mathematics development from years 5-9.<sup>53</sup>

Systemic problems, such as the inadequate amount of time allocated to developing key understandings compared with other less important concepts, seem to be inherent in the Curriculum into the Classroom program. Given the inflexibility of the timing for learning within the C2C program, this lack of foresight is likely to lead to considerable gaps in student understanding and mathematical misconceptions for the foreseeable future.

### 5.3 Misconceptions

Mathematical misconceptions or misunderstandings have been identified as having a serious impact on students' mathematical learning, particularly in relation to the Big Ideas in mathematics.<sup>54</sup> The 2009 Masters Report identified one of the characteristics of highly effective teachers as being "aware of common student misunderstandings and errors and know how to diagnose and address obstacles to further learning".<sup>55</sup> Much of the current mathematical research has revolved around diagnosing and classifying these misconceptions so that teachers can better scaffold learning experiences to meet the needs of their students. In addition to these findings, our own current research indicates that over the past four years approximately 50% of the answers in multiple choice questions in NAPLAN tests are made up of common misconceptions.

Education Queensland currently has access to materials that diagnose student misconceptions through First Steps in Mathematics and through the freely available diagnostic tasks on the Victorian State Government's website. Yet in the Curriculum into the Classroom program very few references are made to student misunderstandings or misconceptions. Very few of the focus questions asked are designed to draw out misconceptions. Where focus questions of this type are included we have often found only a single misconception has been highlighted. In addition to this, C2C fails to make adequate referrals to other materials that could be used to diagnose misunderstandings such as those discussed above, or to include flexible time where teachers could make use of this material of their own initiative.

Another issue is how to approach student misconceptions once they have been identified by teachers. Research has shown that using a constructivist approach to mathematics, where students engage in inquiry and active learning through discussion, can cause students to confront their own misconceptions and reorganise their mathematical understandings to discard wrong ideas.<sup>56</sup> This is one of the major reasons why problem-based teaching should be used before students are shown a strategy to solve a question. According to the National Council on the Teaching of Mathematics, "To find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. Solving problems is not only a goal of learning mathematics but also a major means of doing so."<sup>57</sup> Problem-based approaches are so powerful not only because they enable teachers to diagnose misconceptions before they teach new content, but also because they enable students to self-correct their own wrong ideas, forming a much more robust and deep understanding. These "aha" moments are recognised by teachers as extremely valuable learning experiences.<sup>58</sup>

As discussed in sections 4.2 and 4.3 above, Curriculum into the Classroom shows very little evidence of using inquiry and active learning, and the questions asked of students very rarely diagnose or promote deep understanding. By using traditional approaches to introduce new content and relegating problem-solving to use after students have mastered basic routine questions, C2C misses a valuable opportunity to diagnose misconceptions, and perhaps even more importantly, to create "aha" moments where students reconceptualise their own mathematical understanding.

## 5.4 Gaps between current Queensland practices and C2C expectations

In section 5.2 above some of the gaps between the current Education Queensland Scope and Sequence and the expectations within the Curriculum into the Classroom program were listed. The current Queensland curriculum, produced by the Queensland Studies Authority, is significantly different to the Australian Curriculum. For Queensland students the bar is being raised in terms of Number Concepts (particularly with the introduction of larger numbers at an earlier stage), Fractions (with students expected to use fractions at earlier stages and operate with fractions at much earlier stages), and Geometric Reasoning. This difference in standards has created a fair degree of angst among teachers who we have contact with, who are concerned about how to bridge the gap between their students' current knowledge and that expected by the Australian Curriculum. As discussed in section 5.2, repercussions of this practice are likely to affect the future mathematics success of an entire cohort of students.

The Curriculum into the Classroom program appears to pay little regard to where Queensland students are currently at in terms of either the EQ Scope and Sequence or the Essential Learnings by the QSA, and instead moves only to introducing the new standards set by the Australian Curriculum. Several units begin by "reviewing" content that has never been introduced to students working under the current QLD curriculum documents, and then quickly moving on to more advanced concepts. As there are no strategies given to help students catch up or bridge the current gap, we are very concerned at the long-term effect this approach will have on student learning.

Areas that we have identified of particular concern in unit 1 and 2 of C2C include:

- Place value and the introduction of large whole numbers for years 1-6: For example, current year 1 students focus on numbers only to 10. When they begin year two with C2C, they will spend just four lessons introducing numbers between 11 and 99 before moving on to three digit numbers. In another example, our current year 4s who only learn four digit numbers, will not be introduced to five, six or seven digit numbers, as the C2C year 5 lesson plans simply ask teachers to "review" these as part of the introduction and warm up activities. Again, students are reviewing content that has never previously been introduced.
- Fractional understanding and proportional reasoning: For example, current year three students only cover halves and quarters. When they begin year four with C2C they will "review" what they know about fractions, with examples given in the first lesson plan of seven fifths, before moving straight onto working with equivalent fractions.

We would also caution schools to carefully examine the sections on integers and geometric reasoning for upper primary as these areas have content set at significantly different levels in the Australian Curriculum.

## 5.5 Recommendations

The following recommendations should be taken into consideration prior to implementation of the Curriculum into the Classroom program in January 2012.

- Unit one lessons on Place Value and Fractions need urgent rewriting to place sufficient emphasis on these Big Ideas. Key concepts should have much more time devoted to their study, with less important concepts being used for introductory and play activities.
- C2C needs urgent rewrites to enable students to bridge the gap between current Queensland Curriculum expectations and Australian Curriculum expectations. Expecting students to just catch up without placing sufficient time and emphasis on key mathematical concepts is very likely to lead to significant holes in student understanding. These misconceptions are critically important for stopping student mathematical understanding, and are likely to result in Queensland students slipping further behind those in southern states.
- C2C needs to include diagnostic tasks and questions to enable teachers to diagnose student misconceptions. These are freely available, and the lack of their inclusion is a major oversight in the writing of C2C.
- C2C needs to include explanations for what to do with student misconceptions, and build flexibility into the program to allow teachers time to deal with them. The currently inflexible lesson-by-lesson approach does not provide teachers with any spare time to help students who are struggling with complex or abstract concepts. Similarly, specific strategies, activities and questions should be included for adapting the lessons for students working at different levels.
- C2C needs to use problem-based teaching to introduce new concepts to students to both diagnose and correct student misconceptions, enabling “aha” moments to create rapid student growth in understanding.

## 6 | Numeracy results and NAPLAN recommendations

The tables below are taken directly from the 2010 NAPLAN reports.<sup>59</sup> They clearly show that Queensland has a long way to go to catch up to the southern states in terms of Numeracy.

From page 46, Year 3 Numeracy

Figure 3.N1: Achievement of Year 3 Students in Numeracy, by State and Territory, 2010.



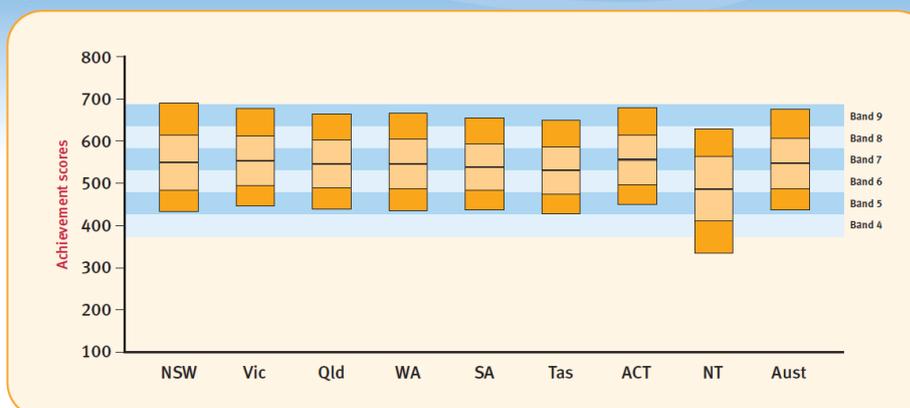
From page 110, Year 5 Numeracy

Figure 5.N1: Achievement of Year 5 Students in Numeracy, by State and Territory, 2010.



From page 174, Year 7 Numeracy

Figure 7.N1: Achievement of Year 7 Students in Numeracy, by State and Territory, 2010.



This section examines how the Curriculum into the Classroom program addresses Queensland-specific NAPLAN issues identified over the past four years as well as recommendations outlined in the 2009 Masters Report.

## 6.1 Queensland NAPLAN trends – where we are falling down

### NAPLAN trends:

The first NAPLAN trend worth examining is that very few routine questions have been present in the tests over the past four years. We have found that the majority of questions involve one or more of the following complications that make them not routine:

- Multiple steps
- Working backwards from an answer to a starting point
- Filling a gap rather than finding an answer
- Additional information that is not important for solving the question is included
- Non-standard representations are used for fractions, shapes and measurement

These questions fit within the Understanding proficiency strand as they require students to make connections between content that is familiar to them and an unfamiliar question or non-standard representation.

A second trend is the prevalence of misconceptions. We have found when examining the possible answers in multiple choice questions that approximately 50% of all answers consist of common student misconceptions. In professional development sessions we often have teachers lament the “unfair” nature of NAPLAN – where the questions seem to be designed to “trick” the students. They often complain that the students simply forgot what they had been taught. We argue that if students had developed deep understandings instead of memorising routine content and skills then they would not be tricked by the misconceptions and distractors in multiple choice questions.

**These two trends indicate a deliberate intention within NAPLAN testing to assess deep student understanding rather than routine content and procedural skills.**

### Queensland data:

Over the past four years Queensland NAPLAN data has revealed some startling trends about the way that we teach in comparison to the rest of Australia. In this section we will discuss trends that we have found and present data that validates the following findings:

1. Queensland does a relatively good job at teaching routine processes and Fluency compared with the rest of Australia
2. Queensland does a comparatively poor job at developing deeper understanding compared with the rest of Australia
3. Queensland does a comparatively poor job at teaching students to approach unfamiliar problems compared with the rest of Australia

It is commonly recognised among teachers that the first five to ten questions in NAPLAN contain considerably more routine, easier questions than the rest of the paper. These questions are good indicators of teachers' ability to impart routine content and skills to students. The further through the test, the harder the questions become. These are not necessarily difficult because of the content involved, but because they ask more non-standard questions that involve deep understanding and problem-solving skills. These questions are better indicators of teachers' ability to impart deep understanding of mathematical concepts and problem solving skills.

Below are graphs that show the differences between the Australian average and Queensland average by question number for 2010, by test item sequence. These have been compiled from raw NAPLAN data. The results have been organised into sequences of 5 questions to better illustrate the trends. Note the obvious decline in Queensland performance compared to the national average as the questions in the test become more unfamiliar.

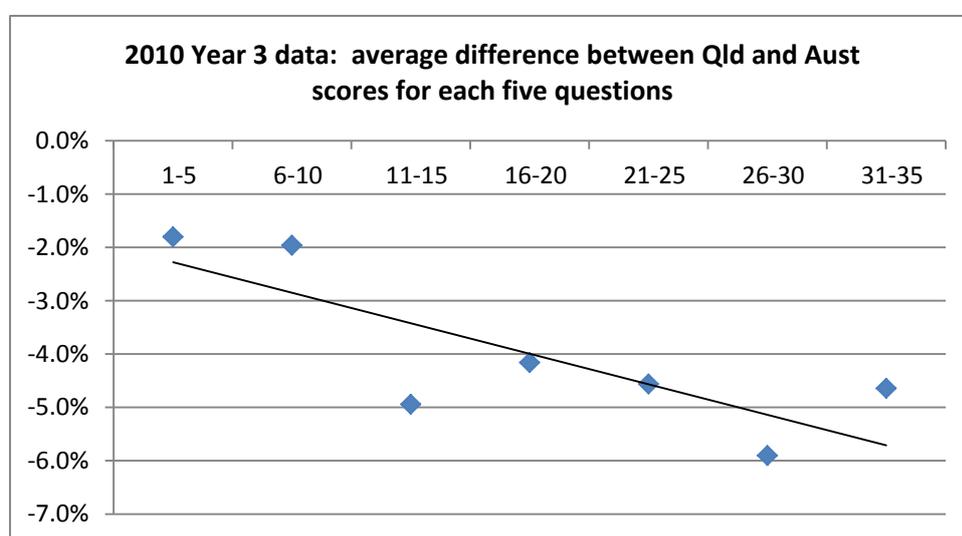


Figure 1: Year 3 results compared to the Australian average by item level for 2010

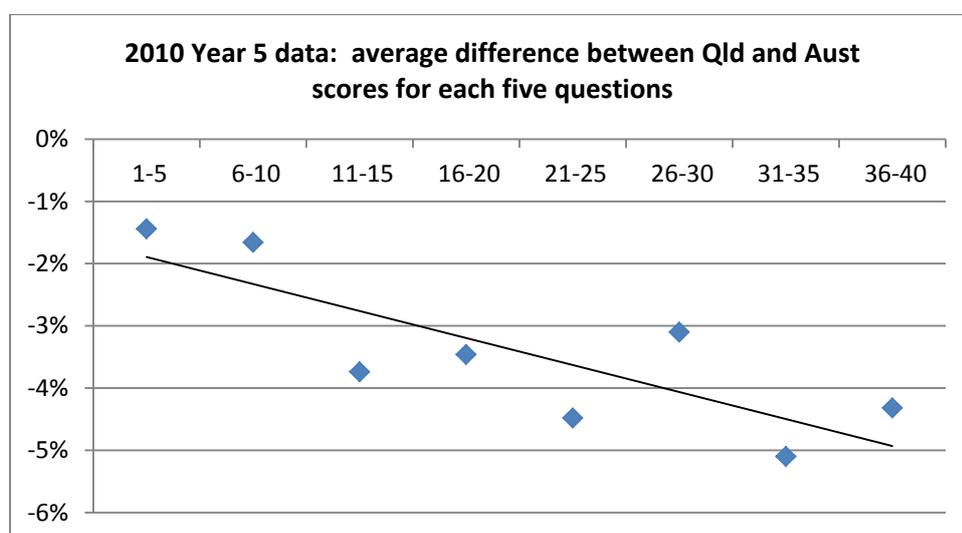


Figure 2: Year 5 results compared to the Australian average by item level for 2010

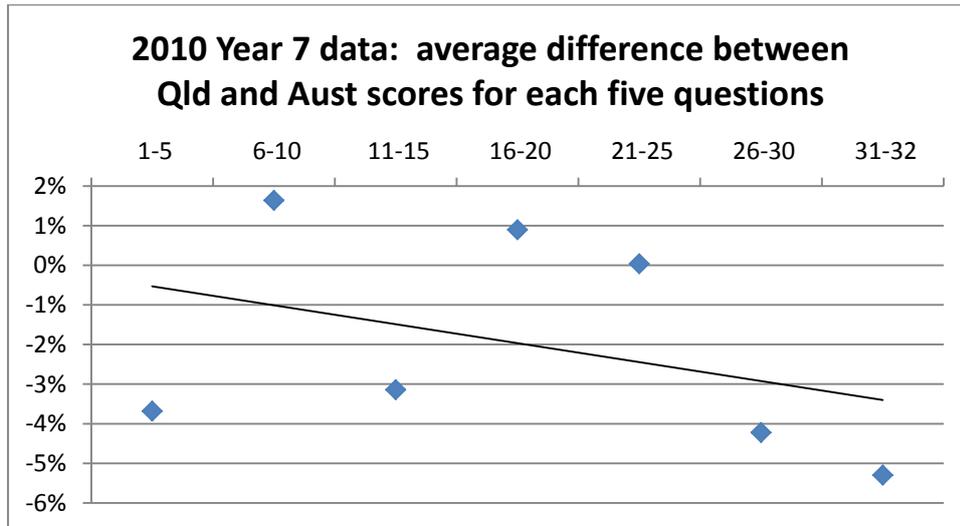


Figure 3: Year 7 results compared to the Australian average by item level for 2010 (non-calculator)

The following graph shows the average difference between the Queensland and Australian scores for the first 10 and last 10 questions for years 3, 5 and 7 during 2010 and 2011.

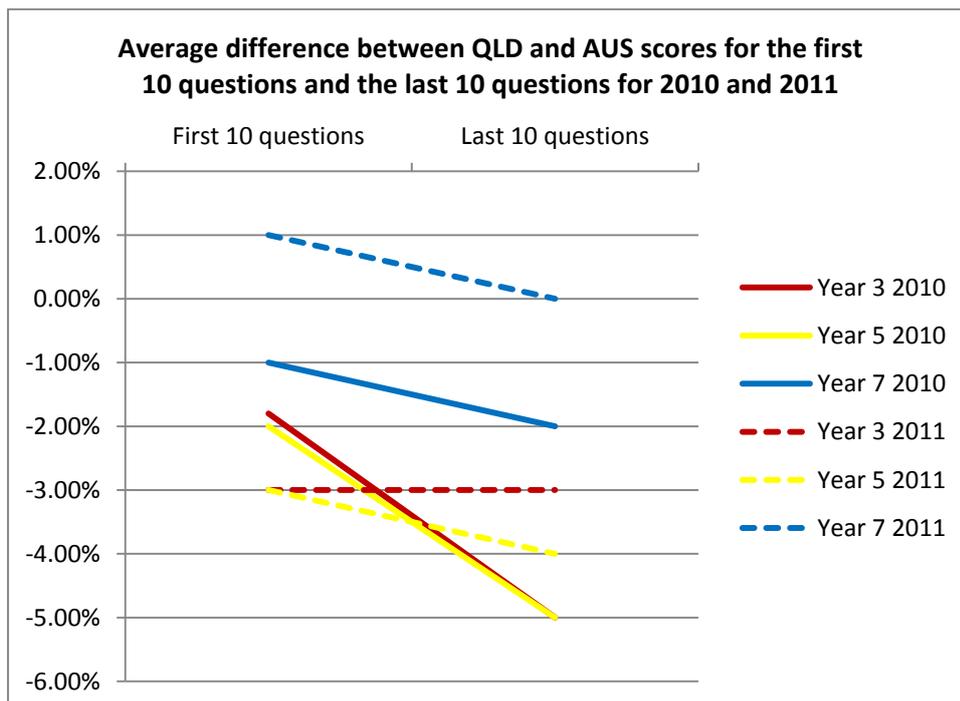


Figure 4: Year 3, 5 and 7 Queensland results compared to the Australian average for the first and last 10 items during 2010 and 2011

This analysis illustrates that Queensland students perform consistently higher at the first 10 questions than the last 10 questions when compared to the average performance for students across Australia. For the past two years this means that Queensland raw scores have been 1.6% below the national average for the first 10 questions, but have been 3.2% below the national average for the last 10 questions. This is a clear indication that teachers in Queensland are

comparatively stronger at teaching routine content and procedures and comparatively weaker at developing the deep understanding needed to deal with unfamiliar and non-standard problems. Unfortunately as most of NAPLAN consists of unfamiliar or non-standard problems this trend does not serve our students well. It also raises the question of the validity of comparing the League table results of the 1960s and 1970s with current Queensland performance on NAPLAN tests as these appear to have been designed to assess completely different things.

## 6.2 C2C alignment with NAPLAN trends

In our analysis of C2C we found a heavy emphasis on Fluency, and very little emphasis on developing deep understanding or problem-solving. This approach is likely to maintain Queensland's current relatively high performance for the first 10 questions, but is unlikely to improve our relatively low performance past these initial items. It is difficult for students to learn how to approach unfamiliar problems if they are rarely given any opportunity to solve these during class time.

Another difficulty that Queensland students will face is that C2C uses very few diagnostic tasks and rarely refers to student misconceptions. As misconceptions commonly form 50% of all of the possible choices for multiple choice questions, failing to adequately diagnose and deal with these is a major oversight in the Curriculum into the Classroom program.

## 6.3 Recommendations

The following recommendations should be taken into consideration prior to implementation of the Curriculum into the Classroom program in January 2012.

- Programs such as C2C should place a much heavier focus on presenting unfamiliar and non-standard problems so that students are not facing these for the first time during NAPLAN testing.
- Diagnostic tasks that uncover student misconceptions, and constructivist tasks that enable students to self-correct their own wrong ideas should be used whenever new content is introduced. These help students to develop the deep understanding necessary to improve Queensland's current NAPLAN performance.

In addition to these recommendations in relation to C2C, we offer the following recommendation with regards to analysis of NAPLAN data:

- Research into NAPLAN trends should focus more heavily on the type of question and thinking required rather than the content in each question. This would illustrate state-wide trends that are heavily influenced by current standard teaching practices and could indicate future directions for system-wide approaches to ensure effective teaching and learning takes place.

## 7 | Conclusions and Recommendations

Education Queensland is to be commended in attempting to provide support for Queensland teachers implementing the Australian Curriculum in the creation of the Curriculum into the Classroom program. However, critical analysis in this review indicates a series of significant shortcomings in C2C. These include:

- C2C fails to meet Australian Curriculum requirements for proficiency strands, question types and situations for learning (Section 3)
- C2C fails to meet the pedagogical and assessment principles within the P-12 Curriculum Framework, the ROADMAP: Dimensions of Teaching and Learning, and the Numeracy Framework for Action (Section 4)
- C2C contains both transitional and systemic problems in the sequential development of mathematical ideas, particularly with respect to key mathematical concepts such as place value and fractions, which are likely to lead to major student difficulties with mathematics (Section 5)
- C2C fails to address Queensland-specific difficulties in NAPLAN testing (Section 6)

The following major recommendations should be taken into consideration prior to implementation of the Curriculum into the Classroom program in January 2012:

- 2 Urgent rewrites of the C2C program should consider the following:
  - 2.1 Unit plans should devote comparatively more time to key mathematical concepts, such as the Big Ideas in number identified by Dr Dianne Siemon. These important concepts include: trusting the count, place value, partitioning, multiplicative thinking, proportional reasoning and generalising<sup>60</sup>. Current time allocations require urgent revision with respect to developing these key concepts as under the C2C program Queensland students face a significant risk of future difficulties in mathematics.
  - 2.2 Lesson plans should incorporate problem-based, inquiry or constructivist approaches to introduce new content to students, with a heavy emphasis on unfamiliar problems. Lessons should begin with focus questions to diagnose student understanding, specifically looking for student misconceptions, and include suggestions for how to proceed based on student responses. Lesson plans should provide suggestions for differentiating the learning experiences based on student understanding of the topic. Such suggestions need to be specific to the content of the lesson, so that teachers can use the one lesson to meet the needs of different learners. Problem-based or constructivist approaches should enable teachers to both find student misconceptions, and encourage students to self-correct their own thinking resulting in powerful "aha" moments. These approaches would enable C2C to meet the Australian Curriculum requirements as well as implementing the pedagogical principles within major Education Queensland policy documents, and would likely result in NAPLAN improvements for Queensland students.
  - 2.3 Questions that assess student understanding should be incorporated at the beginning, during and at the conclusion of each lesson on new content, enabling teachers to determine what students understand, evaluate how successful learning experiences have been and indicate future focus areas. Assessment of student understanding should be continuous.

- 2.4 Unit and lesson plans should incorporate more flexible time each week to enable teachers to cater for the specific learning needs of their students.
  - 2.5 Formal assessment items should embed the proficiency strands within them, with deliberate effort to focus on Problem-Solving, Reasoning and Understanding as discussed within the National Mathematics Curriculum: Framing Paper<sup>61</sup>. These items should provide an element of intellectual challenge, support students to present their best work, and provide students with an opportunity to demonstrate both the extent and depth of their learning.
  - 2.6 Consideration should be given to bridging the gap between current Queensland Curriculum expectations and Australian Curriculum expectations. Expecting students to just catch up without placing sufficient time and emphasis on key mathematical concepts is very likely to lead to significant holes in student understanding for an entire cohort of students. We recommend using problem-based teaching with differentiated instructions for meeting the specific learning needs of individuals within a whole class lesson.
- 
- 3.0 Current research suggests that students placed with high-performing teachers will progress three times as fast as those placed with low-performing teachers.<sup>62</sup> Professional Development should therefore be provided for Teachers and Administrators focusing on:
    - 3.1 The proficiency strands: what these mean and *how* to implement them within a classroom situation, with a focus on problem-solving, understanding and reasoning
    - 3.2 Finding out what students know, developing activities to extend this understanding, and differentiating learning to meet the needs of students requiring support and extension
    - 3.3 Using problem-based approaches to diagnose student misconceptions, and logical questioning techniques to enable students to self-correct their own wrong ideas

## 8 | Appendices

### 8.1 Methodology and scope of the review

This review focuses on examining a selection 57 lesson plans across years 1-7, from whole sequences within unit one of the Curriculum into the Classroom program available during October and November 2011. The majority of the lessons examined were from the Number and Algebra strand, with most relating to basic operations, place value and fractions. Additional informal analysis was conducted for all other sequences for units 1 and 2 from years 1-7 to check for consistency with our preliminary findings using: the Australian Curriculum proficiency strands as described in section 3, the principles of pedagogy and assessment identified in section 4, and sequential development of mathematical ideas as described in section 5.

The 57 lessons examined in detail for this review comprise the following sequences:

- Year 1: Time and Number (4 lessons), Addition and Subtraction (9 lessons)
- Year 2: Addition and Subtraction (9 lessons)
- Year 3: Number and Place Value (5 lessons)
- Year 4: Number Sense (7 lessons)
- Year 5: Fractions and Decimals (4 lessons), Addition and Subtraction (5 lessons)
- Year 6: Fractions (7 lessons)
- Year 7: Fractions, decimals and percentage (7 lessons)

Detailed analysis of all of the 57 lessons included the following:

1. A textual analysis of the action words associated with teachers and students in all of the lesson plans, following critical literacy procedures to illuminate the ideology of the program (see section 8.2 for a full description and results).
2. An analysis of the focus questions in each of the lesson plans was conducted, classifying each question according to the proficiency strands (see descriptions in section 3) as (1) routine content or procedures, (2) unfamiliar or problem-solving, (3) diagnosing or developing deep understanding, or (4) reasoning (see section 8.3 for the results).
3. Analysis of every question asked within the resources provided for years 1-3 from within the selected 57 lessons, classifying each using the sections in point two above and incorporating the results into Table 2, section 8.3.
4. Identification of all diagnostic questions or tasks used to assess student understanding prior to teaching a concept, as well as all references to student misconceptions and references to tasks or resources used to diagnose these.
5. Identification of all strategies for differentiation within the lesson plans.
6. Examination of the time allocation for lessons within each unit, considering the importance of the key mathematical concepts identified as Big Ideas in Number by Dr Dianne Siemon.
7. Examination of the content assumed as prior knowledge, or identified as being "reviewed" within each lesson plan, with reference to both the Essential Learnings (ELs) by the Queensland Studies Authority and the Scope and Sequence by Education Queensland. Content "reviewed" in year 5 C2C units 1 and 2 for implementation in 2012 should have been previously covered during 2011 in year 4 ELs or Scope and Sequence.

Analysis of the sample assessment from the year 6 Scribbly Gum unit on positive and negative numbers:

1. Examination and classification of each question according to the proficiency strands.
2. Examination of the content and context of each question with regards to its previous presentation within the lesson plans.

Analysis of raw NAPLAN data from 2010 and 2011 was conducted using the following:

1. Calculate the difference between the Queensland and Australian student scores for each item, and look for trends in how Queensland performs compared to the Australian averages.
2. Calculate the average difference between Queensland and Australian student scores for the first 10 and the last 10 questions .
3. Ask teachers in professional development sessions during 2010 and 2011 to identify misconceptions in the multiple choice questions for NAPLAN tests across years 3, 5, 7 and 9 for 2009, 2010 and 2011. Teachers in each professional development session found at least 50% of the answers for multiple choice questions contained possible misconceptions. Further, more formal analysis of the prevalence of misconceptions was conducted for the year 3 and 5 2010 NAPLAN test by the authors of this paper to confirm these findings. For year 3, out of 35 questions, 27 were multiple-choice format. Out of 108 possible answers, we identified 56 likely misconceptions. For year 5, out of 40 questions 28 were multiple-choice format. Out of 112 possible answers, 53 were misconceptions. This gives a total of 109/220 answers as misconceptions, or approximately 50%.

## 8.2 Analysis of verbs in 57 C2C lessons

To conduct the textual analysis, each action word was listed as either a teacher or student action, and classified as either following problem-based (constructivist or inquiry learning) principles or as following traditional explanation and practice models.

Please see the two examples given below:

Example 1: from Number Sense lesson 3 from year 4 Unit 1<sup>63</sup>

**Write** 5-digit numbers without the space (e.g. 52694) on the whiteboard to **demonstrate** how much harder the numbers are to **read**.

**Write** 5-digit numbers on the whiteboard or on a place value mat (e.g. 26 231, 48 926 and 31 605). **Explain** how to read 5-digit numbers (including with internal zeros). 48 926 is not **read** as 4 ten thousand, 8 thousand, 9 hundred and twenty-six. When **reading** 5-digit numbers, **say** the number in the house and then the house name (e.g. 48 thousand, 9 hundred and twenty-six).

**Discuss** the 5-digit numbers.

Teacher actions: write (2), demonstrate (1), explain (1), read (3), say (1), and discuss\* (1)

Student actions: discuss\* (1)

\*Discuss implies an action for both teachers and students

All of these actions fit within a traditional framework rather than a problem-based framework, as none challenge students to think deeper than they have been shown.

Example 2: from Fractions lesson 6 from year 6 Unit 1<sup>64</sup>

In small groups, students:

- **experiment** with concrete materials to **create** an addition and/or subtraction question to **match** each answer; **encourage** students to **create** more than one question for each answer and to **use** fractions with easily related denominators where possible
- **write** their questions on the blank question cards
- **ask** a classmate to **test** their questions to **make sure they reach** the same answer as the answer card

Teacher actions: encourage\* (1)

Student actions: experiment (1), create (2), match (1), encourage\* (1), use (1), write (1), ask (1), test (1), make sure they reach (1)

\*Encourage implies an action that could be meant for either teacher or students

All of these actions fit within a problem-based framework as they challenge students to work out something that they don't yet know.

Full results of the textual analysis can be found in Table 1 below.

Table 1: Actions attributed to teachers and students in 57 lessons from Curriculum into the Classroom

Actions analysis results	Grade 1 (13 lessons) %	Grade 2 (9 lessons) %	Grade 3 (5 lessons) %	Grade 4 (7 lessons) %	Grade 5 (9 lessons) %	Grade 6 (7 lessons) %	Grade 7 (7 lessons) %	Average number per lesson across all grades	Average percentage across all grades
Total teacher actions	305	286	170	126	258	154	139	25.2	
Total teacher actions, less common actions between students and teachers and general instructions	215	194	125	104	210	149	110	19.4	
Teacher actions that fit with a traditional teaching model (such as demonstrating, explaining, asking students to do something that they have just seen)	195	164	105	87	178	127	97	16.7	86%
Teacher actions that fit with an enquiry model (such as checking for understanding, asking students to explore, extending understanding)	20	30	20	17	32	22	13	2.7	14%
	91%	85%	84%	84%	85%	85%	88%		
	9%	15%	16%	16%	15%	15%	12%		
Total student actions	468	251	144	81	130	112	111	22.8	
Total student actions, less common actions between students and teachers and general instructions	368	196	110	65	115	112	111	18.9	
Student actions that fit with a traditional teaching model (such as being asking students to do something that they have just seen)	333	177	77	53	82	75	82	15.4	78%
Student actions that fit with an enquiry model (such as exploring and experimenting, making generalisations and looking for patterns)	35	22	33	12	33	37	29	3.5	22%
	90%	90%	90%	70%	71%	67%	74%		
	10%	11%	11%	30%	29%	33%	26%		

### 8.3 Analysis of focus questions in 57 C2C lessons

Actions analysis results	Grade 1 - 13 lessons	Grade 2 - 9 lessons	Grade 3 - 5 lessons	Grade 4 - 7 lessons	Grade 4 - 7 lessons	Grade 5 - 9 lessons	Grade 6 - 7 lessons	Grade 7 - 7 lessons	Grade 7 - 7 lessons	Average number per lesson across all grades	Average percentage across all grades
Total number of focus questions	154	171	102	66	66	80	41	29	29	11.3	
Routine questions, similar to those that the student has seen before.	127	134	78	56	56	56	10	21	21	8.5	70%
Unfamiliar questions for problem-solving	9	12	10			0	6	0	0	0.6	5%
Reasoning or communicating questions	11	15	9	7	7	7	13	4	4	1.2	13%
Understanding questions	7	10	5	3	3	17	12	4	4	1.0	12%

Table 2: Analysis of focus questions by proficiency strand in 57 lessons from Curriculum into the Classroom

## 8.2 References

- <sup>1</sup> <http://education.qld.gov.au/projects/educationviews/news-views/2011/oct/united-in-pursuit-c2c.html>
- <sup>2</sup> Private correspondence to Tierney Kennedy received from a Principal, containing the exact wording of an email sent from an Assistant Regional Director to all of the Principals within the district. October 2011.
- <sup>3</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>4</sup> Barber, M. & Mourshed, M. (2007). *How the world's best-performing school systems come out on top*. London: McKinsey & Company.
- <sup>5</sup> <http://education.qld.gov.au/projects/educationviews/news-views/2011/oct/united-in-pursuit-c2c.html>
- <sup>6</sup> Private correspondence to Tierney Kennedy received from a Principal, containing the exact wording of an email sent from an Assistant Regional Director to all of the Principals within the district. October 2011.
- <sup>7</sup> [www.etaq.org.au/?p=626](http://www.etaq.org.au/?p=626)
- <sup>i</sup> <http://www.australiancurriculum.edu.au/Mathematics/Rationale>
- <sup>ii</sup> <http://www.australiancurriculum.edu.au/Mathematics/Content-structure>
- <sup>10</sup> Masters, G. (2009). A shared challenge: Improving literacy, numeracy and science learning in Queensland primary schools. Retrieved from <http://education.qld.gov.au/mastersreview/pdfs/final-reportmasters.pdf>.
- <sup>11</sup> Peter Sullivan, Numeracy pedagogy: What works and why,  
found at: [http://www.nlnw.sa.edu.au/files/links/SA\\_numeracy\\_201\\_1.pdf](http://www.nlnw.sa.edu.au/files/links/SA_numeracy_201_1.pdf)
- <sup>12</sup> <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>13</sup> Email from ACARA to Leah O'Neill in response to a question
- <sup>14</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>15</sup> THE ROADMAP, Dimensions of Teaching and Learning, Teaching and Learning Branch, Education Queensland, Found at: [http://www.learningplace.com.au/uploads/documents/store/doc\\_750\\_3009\\_Dimensions\\_of\\_teaching\\_and\\_learning.pdf](http://www.learningplace.com.au/uploads/documents/store/doc_750_3009_Dimensions_of_teaching_and_learning.pdf)
- <sup>16</sup> Numeracy: Lifelong Confidence with Mathematics – Framework for Action 2007–2010, page 5, Teacher pedagogy;  
Found at: <http://education.qld.gov.au/curriculum/area/literacy/docs/numeracy.pdf>
- <sup>17</sup> P-12 Curriculum Framework 2007-2010;  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>18</sup> THE ROADMAP, Dimensions of Teaching and Learning, Teaching and Learning Branch, Education Queensland, Found at: [http://www.learningplace.com.au/uploads/documents/store/doc\\_750\\_3009\\_Dimensions\\_of\\_teaching\\_and\\_learning.pdf](http://www.learningplace.com.au/uploads/documents/store/doc_750_3009_Dimensions_of_teaching_and_learning.pdf)
- <sup>19</sup> P-12 Curriculum Framework 2007-2010; Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>20</sup> THE ROADMAP, Dimensions of Teaching and Learning, Teaching and Learning Branch, Education Queensland, Found at: [http://www.learningplace.com.au/uploads/documents/store/doc\\_750\\_3009\\_Dimensions\\_of\\_teaching\\_and\\_learning.pdf](http://www.learningplace.com.au/uploads/documents/store/doc_750_3009_Dimensions_of_teaching_and_learning.pdf)
- <sup>21</sup> Found at <http://education.qld.gov.au/curriculum/assessment/docs/design-decisions.pdf>
- <sup>22</sup> Found at <http://education.qld.gov.au/curriculum/assessment/docs/design-decisions.pdf>
- <sup>23</sup> P-12 Curriculum Framework 2007-2010;  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>

- 
- <sup>24</sup> P-12 Curriculum Framework 2007-2010;  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>25</sup> Building a High-Quality Teaching profession; Remarks by Angel Gurría, OECD Secretary-General; New York, 17 March 2011  
Found at [http://www.oecd.org/document/53/0,3746,en\\_21571361\\_44315115\\_47386549\\_1\\_1\\_1\\_1,00.html](http://www.oecd.org/document/53/0,3746,en_21571361_44315115_47386549_1_1_1_1,00.html)
- <sup>26</sup> P-12 Curriculum Framework 2007-2010; page 1;  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>27</sup> Barber, M. & Mourshed, M. *How the World's Best Performing School Systems Come Out on Top*, McKinsey and Company, 2007.
- <sup>28</sup> Quality Education: The case for an Education Revolution in our Schools; COAG, Kevin Rudd 27 August 2008  
Found at: [www.deewr.gov.au](http://www.deewr.gov.au)
- <sup>29</sup> THE ROADMAP, Dimensions of Teaching and Learning, Teaching and Learning Branch, Education Queensland, Found at: [http://www.learningplace.com.au/uploads/documents/store/doc\\_750\\_3009\\_Dimensions\\_of\\_teaching\\_and\\_learning.pdf](http://www.learningplace.com.au/uploads/documents/store/doc_750_3009_Dimensions_of_teaching_and_learning.pdf)
- <sup>30</sup> *Numeracy: Lifelong Confidence with Mathematics – Framework for Action 2007–2010*, page 5, Teacher pedagogy; Found at: <http://education.qld.gov.au/curriculum/area/literacy/docs/numeracy.pdf>
- <sup>31</sup> P-12 Curriculum Framework 2007-2010;  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>32</sup> Developing the Big Ideas in Number, Dianne Siemon, RMIT University, Department of Education Victoria,  
Found at: <http://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/devbigideas.pdf>
- <sup>33</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board (p.8)  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>34</sup> P-12 Curriculum Framework 2007-2010; p10  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>35</sup> THE ROADMAP, Dimensions of Teaching and Learning, Teaching and Learning Branch, Education Queensland, Found at: [http://www.learningplace.com.au/uploads/documents/store/doc\\_750\\_3009\\_Dimensions\\_of\\_teaching\\_and\\_learning.pdf](http://www.learningplace.com.au/uploads/documents/store/doc_750_3009_Dimensions_of_teaching_and_learning.pdf)
- <sup>36</sup> P-12 Curriculum Framework 2007-2010;  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>37</sup> THE ROADMAP, Dimensions of Teaching and Learning, Teaching and Learning Branch, Education Queensland, Found at: [http://www.learningplace.com.au/uploads/documents/store/doc\\_750\\_3009\\_Dimensions\\_of\\_teaching\\_and\\_learning.pdf](http://www.learningplace.com.au/uploads/documents/store/doc_750_3009_Dimensions_of_teaching_and_learning.pdf)
- <sup>38</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board (p.10)  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>39</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board (p.11)  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>40</sup> Found at <http://education.qld.gov.au/curriculum/assessment/docs/design-decisions.pdf>
- <sup>41</sup> Found at <http://education.qld.gov.au/curriculum/assessment/docs/design-decisions.pdf>
- <sup>42</sup> P-12 Curriculum Framework 2007-2010;  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>43</sup> P-12 Curriculum Framework 2007-2010;  
Found at <http://education.qld.gov.au/curriculum/framework/p-12/docs/p-12-policy.pdf>
- <sup>44</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board (p.15)  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)

- 
- <sup>45</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board (p.8)  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>46</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board (p.8)  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>47</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board (p.8)  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>48</sup> Private correspondence to Tierney Kennedy received from a Principal, containing the exact wording of an email sent from an Assistant Regional Director to all of the Principals within the district
- <sup>49</sup> National Mathematics Advisory Panel (2008). Final Report: US Department of Education
- <sup>50</sup> Professional Development notes by Dianne Siemon found at:  
<http://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/vlnsdisiemonnailbigideas.pdf> (slide 34)
- <sup>51</sup> Siemon, D., Virgona, J. & Corneille, K. (2001) Final Report of Middle Years Numeracy Research Project 1999-2001, RMIT University: Melbourne
- <sup>52</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board (p.8)  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>53</sup> Siemon, D., Virgona, J. & Corneille, K. (2001) Final Report of Middle Years Numeracy Research Project 1999-2001, RMIT University: Melbourne
- <sup>54</sup> Department of Education and Early Childhood Development, State Government of Victoria; Found at:  
<http://www.education.vic.gov.au/studentlearning/teachingresources/maths/common/default.htm>
- <sup>55</sup> Masters, G. (2009). A shared challenge: Improving literacy, numeracy and science learning in Queensland primary schools. Retrieved from <http://education.qld.gov.au/mastersreview/pdfs/final-reportmasters.pdf>. Page 5
- <sup>56</sup> Ryan, J., & Williams, J. (2000). *Mathematical discussions with children: Exploring methods and misconceptions as a teaching strategy*. Manchester: Centre for Mathematics Education: University of Manchester.
- <sup>57</sup> Guiding principles for mathematics curriculum and assessment; National Council of Teachers of Mathematics (page 2)  
Found at: [http://www.nctm.org/uploadedFiles/Math\\_Standards/NCTM%20Guiding%20Principles%206209.pdf](http://www.nctm.org/uploadedFiles/Math_Standards/NCTM%20Guiding%20Principles%206209.pdf)
- <sup>58</sup> AHA!: the *effect* and *affect* of mathematical discovery on undergraduate mathematics students; Peter Liljedahl; Simon Fraser University. Found at: [http://www.icme-organisers.dk/tsg03/TSG3\\_Liljedahl.pdf](http://www.icme-organisers.dk/tsg03/TSG3_Liljedahl.pdf)
- <sup>59</sup> National Assessment Program, Literacy and Numeracy Achievement in Reading, Writing, Language Conventions and Numeracy; National Report for 2010; Australian Curriculum, Assessment and Reporting Authority  
Found at: [http://www.nap.edu.au/Documents/National%20Report/NAPLAN\\_2010\\_National\\_Report.pdf](http://www.nap.edu.au/Documents/National%20Report/NAPLAN_2010_National_Report.pdf)
- <sup>60</sup> Professional Development notes by Dianne Siemon found at:  
<http://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/vlnsdisiemonnailbigideas.pdf> (slide 34)
- <sup>61</sup> National Mathematics Curriculum: Framing paper (2008), National Curriculum Board  
Found at: [http://www.ncb.org.au/verve/resources/National\\_Mathematics\\_Curriculum\\_-\\_Framing\\_Paper.pdf](http://www.ncb.org.au/verve/resources/National_Mathematics_Curriculum_-_Framing_Paper.pdf)
- <sup>62</sup> Barber, M. & Mourshed, M. (2007). *How the world's best-performing school systems come out on top*. London: McKinsey & Company.
- <sup>63</sup> Curriculum into the Classroom (2011), Mathematics Year 4 Unit 1, Number sense, Lesson 3; Department of Education and Training Queensland, Curriculum Division
- <sup>64</sup> *Curriculum into the Classroom* (2011), Mathematics Year 6 Unit 1, Fractions, Lesson 6; Department of Education and Training Queensland, Curriculum Division