Mental Math
Mental Computation
Grade 2

Draft — September 2006

NOVA SCOTIA
Education
English Program Services

Acknowledgements

The Department of Education gratefully acknowledges the contributions of the following individuals to the preparation of the *Mental Math* booklets:

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Introduction

Definitions

It is important to clarify the definitions used around mental math. Mental math in Nova Scotia refers to the entire program of mental math and estimation across all strands. It is important to incorporate some aspect of mental math into your mathematics planning everyday, although the time spent each day may vary. While the *Time to Learn* document requires 5 minutes per day, there will be days, especially when introducing strategies, when more time will be needed. Other times, such as when reinforcing a strategy, it may not take 5 minutes to do the practice exercises and discuss the strategies and answers.

While there are many aspects to mental math, this booklet, *Mental Computation*, deals with fact learning, mental calculations, and computational estimation — mental math found in General Curriculum Outcome (GCO) B. Therefore, teachers must also remember to incorporate mental math strategies from the six other GCOs into their yearly plans for Mental Math, for example, measurement estimation, quantity estimation, patterns and spatial sense. For more information on these and other strategies see *Elementary and Middle School Mathematics: Teaching Developmentally* by John A. Van de Walle.

For the purpose of this booklet, fact learning will refer to the acquisition of the 100 number facts relating the single digits 0 to 9 for each of the four operations. When students know these facts, they can quickly retrieve them from memory (usually in 3 seconds or less). Ideally, through practice over time, students will achieve automaticity; that is, they will abandon the use of strategies and give instant recall. Computational estimation refers to using strategies to get approximate answers by doing calculations in one's head, while mental calculations refer to using strategies to get exact answers by doing all the calculations in one's head.

While we have defined each term separately, this does not suggest that the three terms are totally separable. Initially, students develop and use strategies to get quick recall of the facts. These strategies and the facts themselves are the foundations for the development of other mental calculation strategies. When the facts are automatic, students are no longer employing strategies to retrieve them from memory. In turn, the facts and mental calculation strategies are the foundations for estimation. Attempts at computational estimation are often thwarted by the lack of knowledge of the related facts and mental calculation strategies.

Rationale

In modern society, the development of mental computation skills needs to be a major goal of any mathematical program for two major reasons. First of all, in their day-to-day activities, most people's calculation needs can be met by having well developed mental computational processes. Secondly, while technology has replaced paper-and-pencil as the major tool for complex computations, people need to have well developed mental strategies to be alert to the reasonableness of answers generated by technology.

Besides being the foundation of the development of number and operation sense, fact learning itself is critical to the overall development of mathematics. Mathematics is about patterns and relationships and many of these patterns and relationships are numerical. Without a command of the basic relationships among numbers (facts), it is very difficult to detect these patterns and relationships. As well, nothing empowers students with confidence and flexibility of thinking more than a command of the number facts.

It is important to establish a rational for mental math. While it is true that many computations that require exact answers are now done on calculators, it is important that students have the necessary skills to judge the reasonableness of those answers. This is also true for computations students will do using pencil-and-paper strategies. Furthermore, many computations in their daily lives will not require exact answers. (e.g., If three pens each cost $1.90, can I buy them if I have $5.00?) Students will also encounter computations in their daily lives for which they can get exact answers quickly in their heads. (e.g., What is the cost of three pens that each cost $3.00?)

The Implementation of Mental Computational Strategies

General Approach

In general, a strategy should be introduced in isolation from other strategies, a variety of different reinforcement activities should be provided until it is mastered, the strategy should be assessed in a variety of ways, and then it should be combined with other previously learned strategies.

Introducing a Strategy

The approach to highlighting a mental computational strategy is to give the students an example of a computation for which the strategy would be useful to see if any of the students already can apply the strategy. If so, the student(s) can explain the strategy to the class with your help. If not, you could share the strategy yourself. The explanation of a strategy should include anything that will help students see the pattern and logic of the strategy, be that concrete materials, visuals, and/or contexts. The introduction should also include explicit modeling of the mental processes used to carry out the strategy, and explicit discussion of the situations for which the strategy is most appropriate and efficient. The logic of the strategy should be well understood before it is reinforced. (Often it would also be appropriate to show when the strategy would not be appropriate as well as when it would be appropriate.)

Reinforcement

Each strategy for building mental computational skills should be practised in isolation until students can give correct solutions in a reasonable time frame. Students must understand the logic of the strategy, recognize when it is appropriate, and explain the strategy. The amount of time spent on each strategy should be determined by the students' abilities and previous experiences.

The reinforcement activities for a strategy should be varied in type and should focus as much on the discussion of how students obtained their answers as on the answers themselves. The reinforcement activities should be structured to insure maximum participation. Time frames should be generous at first and be narrowed as students internalize the strategy. Student participation should be monitored and their progress assessed in a variety of ways to help determine how long should be spent on a strategy.

After you are confident that most of the students have internalized the strategy, you need to help them integrate it with other strategies they have developed. You can do this by providing activities that includes a mix of number expressions, for which this strategy and others would apply. You should have the students complete the activities and discuss the strategy/strategies that could be used; or you should have students match the number expressions included in the activity to a list of strategies, and discuss the attributes of the number expressions that prompted them to make the matches.

Assessment

Your assessments of mental math and estimation strategies should take a variety of forms. In addition to the traditional quizzes that involve students recording answers to questions that you give one-at-a-time in a certain time frame, you should also record any observations you make during the reinforcements, ask the students for oral responses and explanations, and have them explain strategies in writing. Individual interviews can provide you with many insights into a student's thinking, especially in situations where pencil-and-paper responses are weak.

Assessments, regardless of their form, should shed light on students' abilities to compute efficiently and accurately, to select appropriate strategies, and to explain their thinking.

Response Time

Response time is an effective way for teachers to see if students can use the mental math and estimation strategies efficiently and to determine if students have automaticity of their facts.

For the facts, your goal is to get a response in 3-seconds or less. You would give students more time than this in the initial strategy reinforcement activities, and reduce the time as the students become more proficient applying the strategy until the 3-second goal is reached. In subsequent grades when the facts are extended to 10s, 100s and 1000s, a 3-second response should also be the expectation.

In early grades, the 3-second response goal is a guideline for the teacher and does not need to be shared with the students if it will cause undue anxiety.

With other mental computational strategies, you should allow 5 to 10 seconds, depending upon the complexity of the mental activity required. Again, in the initial application of the strategies, you would allow as much time as needed to insure success, and gradually decrease the wait time until students attain solutions in a reasonable time frame.

A. Addition — Fact Learning

Facts and the Fact Learning Strategies

At the beginning of grade two, it is important to review addition and subtraction facts and strategies to 10 before learning addition and subtraction facts and strategies to 18. Some of these strategies have been addressed in grade 1. Students are expected to be able to recall facts to ten with a three-second response by mid-year and to recall facts to eighteen with a three-second response by the end of grade two.

"Plus 1"

For any fact involving + 1, direct students to ask for the next number.

For example: 7 + 1 or 1 + 7 is asking for the number after 7. An addition table and a number line are useful to help students *visualize* addition facts using this strategy.

Examples of Some Practice Items

Some practice items for numbers in the 1s are:

2 + 1 =	6 + 1 =	1 + 4 =
1 + 8 =	1 + 9 =	8 + 1 =

"Plus 2"

For any number involving + 2, direct students to think of *skip counting* by 2's or to ask for the next even or odd number.

For example: 6 + 2 is skip counting by 2 after 6 *or* asking for the next even number after 6 to get 8. An addition table is useful to help students visualize addition facts using this strategy.

Examples of Some Practice Items

Some practice items for numbers in the 1s are:

1 + 2 =	2 + 7 =	2 + 5 =
3 + 2 =	2 + 2 =	9 + 2 =

Doubles

There are only ten doubles from 0 + 0 to 9 + 9. They are a powerful strategy to use when learning number facts.

Relating doubles to real-life contexts is suggested; 5 + 5 is the number of fingers on two hands; or 4 + 4 is the number of wheels on two cars; 6 + 6 is the egg carton double. Students might suggest other real-life contexts to relate this to language arts.

Dot pictures set up in double frames (similar to dominoes, but based on the more familiar dot patterns found on number cubes) give students a way to visualize the combinations in their minds.

Examples

Review the basic double facts by using the double-frame dot pictures and modelling the following oral response.

Say "3 + 3 is double three or 3 plus 3 equals 6".

Examples of Some Practice Items

4 + 4 =	6 + 6 =	8 + 8 =
1 + 1 =	4 + 4 =	3 + 3 =
5 + 5 =	7 + 7 =	2 + 2 =
0 + 0 =	9 + 9 =	

Near-Doubles (1-Aparts) Facts

The near-doubles are also called the "doubles plus one" facts and include all combinations where one addend is one more than the other. The strategy is to double **the smaller number** and **add one**.

Examples

6 + 7 is (6 + 6) + 1.

Dot pictures set up in double frames, (similar to dominoes, but based on the more familiar dot patterns found on number cubes) and showing 1 more dot added to one of the frames can be used to teach this strategy. Students are directed to look for the double using the dot configuration; to identify how many more, then add 1 more. For example: 3 + 4 = 3 + 3 = 6 and 1 more makes 7.

Review this strategy for near-doubles facts, using the double-frame dot pictures, modelling the following oral response:

Say "5 + 6 is double 5 and add 1 or 10 + 1 = 11"

Examples of Some Practice Items

Some practice items for numbers in the 1s are:

8 + 9 =	2 + 3 =	2 + 1 =
7 + 8 =	3 + 4 =	5 + 4 =

Doubles Plus 2 (2- Apart) Facts

For addends that differ by 2, such as 3 + 5, 4 + 6 or 5 + 7, there are two possible strategies, each depending on knowledge of doubles. One strategy is "doubling the smaller number plus 2." This strategy can be taught using the dot picture frames described in the "near-doubles (1-Apart)" strategy, adding 2 more dots to one part of the frames. Students are directed to look for the double using the dot configurations; to identify how many more; then add 2 more.

Examples

3 + 5 = 6 (double 3) + 2 = 8

Review this strategy for "double plus 2" using the dot picture frames, modelling the following oral response:

Say: "3 + 5 is 6 add 2; and 6 + 2 is 8."

Examples of Some Practice Items

Some practice items for numbers in the 1s are:

4 + 6 =	7 + 5 =	5 + 3 =
5 + 7 =	3 + 5 =	6 + 4 =
6 + 8 =	7 + 9 =	9 + 7 =

Plus or Minus 0 "No Change"

Nineteen facts have zero as one of the addends. Though such problems are generally easy, some students over-generalize the idea that "plus makes numbers bigger" or "minus makes numbers smaller". Instead of making arbitrary-sounding rules about adding or subtracting zero, use story problems involving zero to build understanding. For example: Joe bought 2 fruit roll-ups on Monday. On Tuesday, he bought 0. How many fruit roll-ups did Joe buy altogether?

In the discussion of these word problems, use drawings that show two parts with one part empty.

Examples of Some Practice Items

Some practice examples for adding and subtracting with 0 are:

5 + 0 =	4 + 0 =	6 – 0 =	7 – 0 =
2 + 0 =	0 + 9 =	1 - 0 =	4 – 0 =
0 + 6 =	10 + 0 =	8 – 0 =	3 – 0 =

Make 10 Using Ten Frames

Ten is the basis of our number system and plays a key role in many of the mental math strategies students will be learning. Because of this, students need to be very familiar with combinations that add to make ten.

Students have had extensive experience in grade one using ten-frames to learn the facts for 10. One activity involves having students use individual ten-frames and counters to find "special 10" numbers. For example, have students put 6 counters on the empty ten-frame (1 row of 5 counters on the top of the frame and 1 counter on the bottom row). This leaves 4 boxes on the ten-frame empty for a total of 6 + 4 or 10.

Example

This activity can be used to identify all of the addition facts for 10.

Students can be asked to visualize a ten-frame in their minds. Tell them that you are going to put imaginary counters into their imaginary ten-frame. As you state the number of counters you have put in the ten-frame, the students are to write the number of empty boxes.

You Say	Students Write	You Say	Students Write
7	3	9	1
4	6	0	10
5	5	7	3
8	2	6	4

Make 10

The strategy for these facts is to build onto the 8 or 9 up to 10 and then add on the rest.

Example

(i) For example: For 9 + 3 think: 9 + 1 (from the 3) is 10, and 10 + 2 (the other part of the 3) is 12 or 9 + 3 = (9 + 1) +2 = 10 + 2 = 12

Ten frames may be used to help students understand facts with 8 or 9 to make 10.

Using the ten-frame, place 9 counters on the frame. Ask, "How many counters are in the frame? " (9) Place 3 loose counters just below the ten-frame, pointing out that the addition combination now shown is 9 + 3. Move 1 of the 3 loose counters into the empty box of the ten-frame. Ask, "What addition combination is shown now?" (10 + 2) What is the total? (12)".

(ii) The above "make 10" strategy can be extended to facts involving 7.

For example: For 7 + 4, think: 7 and 3 (from the 4) is 10, and 10 + 1 (the other part of the 4) is 11 or 7 + 4 = (7 + 3) + 1 =10 + 1 = 11.

Examples of Some Practice Items

(i) Some practice items for adding with 8 or 9 using the ten-frame are:

9 + 4 =	9 + 6 =	8 + 4 =
5 + 9 =	6 + 8 =	8 + 6 =
8 + 5 =	3 + 9 =	7 + 9 =

(ii) Some practice items for adding with 7 using the ten-frame are:

7 + 5 =	7 + 6 =	7 + 7 =
8 + 7 =	3 + 7 =	9 + 7 =

Addition — Mental Calculations

Counting On

When presented with a number combination, for example 2 + 6, students are directed to start with the larger number and to *COUNT ON* the amounts of the smaller number (six, *SEVEN, EIGHT*). Number cards showing numbers from which the students "count on" and counters to demonstrate the "counting on" are useful materials to use to teach this strategy. An addition table or a hundreds chart is also useful to help students *visualize* relationships.

Examples of Some Practice Items

Some practice items for numbers in the 1s are:

7 + 3 =	1 + 8 =	4 + 2 =
3 + 6 =	5 + 2 =	2 + 7 =
8 + 2 =	7 + 1 =	3 + 8 =
1 + 5 =	5 + 3 =	2 + 6 =
1 + 9 =	1 + 6 =	2 + 9 =
3 + 9 =		

Some practice items for numbers in the 10s are:

43 + 3 =	2 + 47 =	3 + 45 =
2 + 51 =	26 +3 =	58 + 1 =

Ten and "Some More"

The mental math strategy presented here is adding 10 (or a multiple of 10) to a single number, example 10 + 4.

Examples

(i) 2-Part Mat

To solve 10 + 4, use a simple two-part mat. (An example of a 2-part mat is needed). Count out 10 counters to put on one side. Next put 4 counters on the other side. Together count all of the counters by ones. Chant the combination, "Ten and four is fourteen". Repeat with other numbers but without changing the 10 side of the mat. Students should realize that they do not need to recount the ten side of the mat. Instead, they will count on from ten.

(ii) Two ten-frames can be used to do this activity instead of the 2-part mat.

The strategy of "Ten and Some More" may be extended to adding larger numbers by using two or more ten-frames. For example: 28 + 4 would be represented with three ten-frames containing 28 counters plus 4 loose counters. Ask, "How many counters are needed to fill the third frame?' (2), then add those counters to the third frame. Ask, "How many counters are there altogether?" Record 30 + 2 = 32.

Examples of Some Practice Items

(i) Some practice items are:

10 + 2 =	3 + 10 =	10 + 5 =
10 + 5 =	10 + 6 =	10 + 9 =
10 + 1 =	8 + 10 =	7 + 10 =

(ii) Some practice items:

27 + 6 =	57 + 5 =	37 + 8 =
15 + 9 =	68 + 7 =	87 + 9 =

Using Addition Facts for 10s

This strategy applies to calculations involving the addition of two numbers in that are multiples of 10. Students will use their knowledge of basic facts to solve these problems.

Doubles

Examples

If you know that 6 + 6 = 12, then applying the doubles strategy to adding numbers in the 10s, you know

60 + 60 = 120.

Examples of Some Practice Items

Some practice items for numbers in the 10s are:

40 + 40 =	20 + 20 =	30 + 30 =
50 + 50 =	70 + 70 =	90 + 90 =
80 + 80 =	10 + 10 =	

Near-Doubles (1-Aparts) Facts

Examples

If you know that 2 + 3 = 5, then applying the " near-doubles plus" strategy to adding numbers in the 10's, you know that 20 + 30 is (20 + 20) + 10 = 50. Say "20 + 30 is double 20 and add 10; 40 + 10 is 50."

Examples of Some Practice Items

Some practice items for numbers in the 10s are:

30 + 40 =	70 + 80 =	50 + 60 =
10 + 20 =	60 + 70 =	
50 + 40 =	80 + 90 =	

Doubles Plus 2 (2- Apart) Facts

Examples

If you know that 3 + 5 = 8, then applying the "near-doubles plus 2" strategy to adding numbers in the 10's, you know 30 + 50 is (30 + 30) +20 = 80.

Say "30 + 50 is double 30 and add 20; 60 + 20 is 80.

Examples of Some Practice Items

Some practice items for numbers in the 10s are:

40 + 60 =	60 + 40 =	60 + 80 =
70 + 90 =	50 + 70 =	70 + 50 =
50 + 30 =	90 + 70 =	

Quick Addition — No Regrouping

After students have worked extensively with base ten materials to model the addition of two 2-digit numbers, with and without regrouping, they can learn "quick addition" as an addition strategy for solving problems with no regrouping.

Example

For example: For 56 + 23, simply record, starting at the front end, 79.

Examples of Some Practice Items

Here are some items examples for numbers in the 10s.

71 + 12 =	63 + 33 =	44 + 53 =
37 + 51 =	15 + 62 =	66 + 23 =

Front End Addition

Front end addition is a good beginning strategy for addition (or subtraction). This strategy involves adding the highest place values and then adding the sums of the next place value(s).

For example: To solve 46 + 38, use base ten materials to model the numbers. Point out that to add 46 and 38, we can join the tens (7 tens) and the ones (14 ones), and rename the sum.

Therefore, 46 + 38 = 70 + 14 = 84.

Examples of Some Practice Items

Some practice items are:

74 + 8 =	53 + 9 =
15 + 16 =	45 + 7 =
74 + 19 =	

Finding Compatibles

This strategy for addition involves looking for pairs of numbers that add to powers of ten (10 or 100) to make the addition easier.

Example

For example: For 3 + 8 + 7, think: 3 + 7 is 10 plus 8 is 10 + 8 = 18.

Examples of Some Practice Items

Some items of applying this strategy to numbers in the 1s are:

6 + 9 + 4 =

2 + 3 + 8 =

4 + 6 + 2 =

1 + 9 + 5 =

5 + 6 + 5 =

Compensation

This strategy for addition involves changing one number to a ten; carrying out the addition and then adjusting the answer to compensate for the original change. This strategy is useful when one of the numbers ends in 8 or 9.

Example

For example: For 7 plus 9, think: 7 plus 10 is 17, but I added one too many; so, I subtract one from 17 to get 16 or 7 + 9 = (7 + 10) – 1 = 16

Examples of Some Practice Items

Some items of applying this strategy to numbers in the 1s are:

2 + 9 =	5 + 8 =	9 + 6 =
3 + 9 =	9 + 5 =	8 + 3 =
9 + 4 =	8 + 7 =	7 + 8 =

B. Subtraction — Fact Learning

Facts and the Fact Learning Strategies

Due to the use of addition facts in the subtraction strategies it is important that you ensure students have reach a reasonable response time in all addition facts before moving on to subtraction facts. The main strategy for Subtraction at this level is to 'think addition'.

First, review the subtraction facts and the fact learning strategies from grade 1. Then apply to subtraction facts to 18.

Doubles

This strategy uses the addition double facts to help find the answers to related subtraction combinations.

Examples

(i) For example: For 12 – 6, think; 6 plus what makes 12? 6 + 6 = 12, so 12 – 6 = 6

(ii) If you know that 8 – 4 = 4, then 80 – 40 = 40

Examples of Some Practice Items

(i) Some practice items are:

10 – 5 =	6 – 3 =	14 – 7 =
16 – 8 =	8 – 4 =	18 – 9 =

(ii) Here are some practice items for numbers in the tens:

60 – 30 =	100 – 50 =	20 – 10 =
120 – 60 =	180 – 90 =	140 – 70 =

Near-Doubles (1-Apart) Facts

Note: This strategy also uses the addition double facts and near-double facts to help find the answers to related subtraction combinations. When the part being subtracted is close to half of the total, we can think of an addition double fact, and then adjust it by 1 to find the answer.

Example

(i) For example: For 9 – 4, think: 4 plus 4 =8, 4 + 5 = 9, so 9 – 4 = 5

(ii) If you know that 9 – 4 = 5, then for 90 – 40, think; 40 plus 40 = 80; 40 + 50 = 90, so 90 – 40 = 50

Examples of Some Practice Items

(i) Some practice items are:

13 – 6 =	11 – 5 =	15 – 7 =
17 – 8 =	7 – 3 =	16 – 7 =

(ii) Some practice items are:

70 – 30 =	50 – 20 =	130 – 60 =
110 – 50 =	150 – 70 =	170 – 80 =

Subtraction — Mental Calculation

Using "Think Addition" in Subtraction

This strategy demonstrates how students can use their knowledge of addition facts to find the answers to subtraction equations. Students will be able to look at a subtraction fact such as 9 – 4, and think "4 plus what equals 9?" and determine the missing part.

Examples of Some Practice Items

Some practice items are:

10 – 4 = __ (4 plus what equals 10?)	8 – 2 = __ (2 plus what equals 8?)
8 – 5 = __	10 – 3 = __
9 – 3 = __	6 – 4 = __

Some practice examples are:

80 – 20 = __ (20 plus what equals 80?)	60 – 40 = __ (40 plus what equals 60?)
90 – 30 = __	80 – 50 = __
100 – 30 = __	70 – 40 = __

Using Subtraction Facts for 10s

Note: This strategy applies to calculations involving the subtraction of two numbers in the tens with only one non-zero digit in each number. The strategy involves subtracting the single non-zero digits as if they were the single-digit subtraction facts.

Example

For example: If we know that 8 – 3 = 5, then for 80 – 30, think: 8 tens subtract 3 tens is 5 tens, or 50.

Examples of Some Practice Items

Some practice items for numbers in the 10s are:

90 – 10 =	60 – 30 =	70 – 60 =
30 –20 =	20 – 10 =	80 – 30 =

Addition and Subtraction — Computational Estimation

Front End

This strategy involves combining only the values in the highest place value to get a "ball-park figure". Such estimates are adequate in many circumstances.

Examples of Some Practice Items

Some practice items for estimating addition of numbers in the 10s are:

For example: To estimate 43 = 54, think: 40 + 50 is 90.

62 + 31 =	44 + 23 =	73 + 12 =
54 + 33 =	71 + 14 =	21 + 43 =
13 + 82 =	34 + 42 =	12 + 51 =

Some practice items for estimating subtraction of numbers in the 10's are:

For example: To estimate 92 – 53, think: 90 subtract 50 is 40.

93 – 62 =	64 – 23 =	81 – 54 =
72 – 33 =	54 – 21=	91 – 42 =
43 – 12 =	32 – 23 =	84 – 61 =

Rounding

This strategy involves rounding each number to the highest, or the highest two, place values and adding the rounded numbers.

Examples

For example to estimate 27 + 31, think: 27 rounds to 30 and 31 rounds to 30, so 30 plus 30 is 60.

For example to estimate 87 – 32, think: 87 rounds to 90 and 32 rounds to 30, so 90 subtract 30 is 60.

Examples of Some Practice Items

Some practice items for rounding addition of numbers in the 10s are:

48 + 23 =	34 + 59 =
61 + 48 =	18 + 22 =
97 + 12 =	14 + 32 =
28 + 57 =	41 + 34 =

Some practice items for rounding subtraction of numbers in the 10s are:

57 – 14 =	84 – 9 =	82 – 59 =
36 – 22 =	43 – 8 =	54 – 18 =
68 – 34 =	99 – 47 =	93 – 12 =