Characteristics of McGraw-Hill Ryerson's *Math at Work 12* Program

The *Math at Work 12* program was designed for students and educators using the outcomes and achievement indicators published in *The WNCP Common Curriculum Framework for Grades 10–12 Mathematics, January 2008*. This resource package will support educators and all grade 12 students enrolled in Apprenticeship and Workplace Mathematics Grade 12.

The *Math at Work 12* design is based on current educational philosophy and pedagogy. The instructional design adheres to the principles set out in the WNCP Common Curriculum Framework that include beliefs about students and mathematics learning, the affective domain, mathematical processes, the nature of mathematics learning, and instructional focus. Other considerations include chapter sequence, readability, and layout.

Because concern for teachers and students was paramount, the program was developed around two central questions:

1. How would the instructional design benefit/support students?
2. What would teachers require to support their implementation of the new curriculum?

Pedagogical Approach

The program is based on the philosophy that the focus of student learning is to develop a deeper understanding of mathematics and its connection to student lives, careers, and interests. For that reason, the instructional design is based on the premise that students can, and will, take responsibility for their learning, and that they are active and thoughtful learners. With these beliefs in mind, the resource supports a wide range of student interests and learning styles.

Mathematics: Making Links

Throughout the *Math at Work 12* student resource, students are given the opportunity to see the links between real life and mathematics.

- Every chapter includes a **chapter project** that models mathematics in the real world, engages students' interest, and gives students a meaningful purpose for learning the mathematics presented. The project is designed to engage students by making links between the mathematics in the chapter and students' personal experiences and interests, as well as between mathematics and the real world.
- Most concepts or procedures are introduced in a real-life context.
- A **Career Link** at the beginning of each chapter allows students to see how the math they are learning applies to a career in the real world.
- The visuals throughout the chapter show people performing work related to the math skills in the chapter. Many of these jobs and careers require the processes and skills being developed in the chapter, thus connecting more students to how mathematics may be used in their future lives.
- A **Games and Puzzles** page at the end of each chapter encourages students to use the skills they have learned in a non-threatening, and often entertaining, way.

Procedural Fluency and Conceptual Understanding

The three-part lesson structure in McGraw-Hill Ryerson's *Math at Work 12* program is designed to engage students in learning that develops their conceptual understanding and procedural fluency. The three parts are described below.

1. Explore

- Each exploration is designed to help students build their own understanding of the new concept by working individually and in groups to explore a mathematical concept or procedure.
- The explorations emphasize personal strategies and alternative methods for solving problems.
- **Reflect** questions at the end of each Explore help students to generalize learning about the key concept or methods being investigated.
- **Extend Your Understanding** questions encourage students to bring their understanding to a higher level.

2. On the Job

- Each **On the Job** is an example. Many use common workplace or day-to-day scenarios to demonstrate how to use the concept explored in the Explore. Many include multiple approaches.
- **Your Turn** questions after each On the Job allow students to check their understanding of concepts.
- **Check Your Understanding** questions allow for additional practice. In this question set, **Try It** questions allow students to practise new skills at a basic level; **Apply It** questions include problems in a range of real-world contexts.

3. Work With It

- After a number of related On the Job sections, each with Check Your Understanding questions geared to that particular concept, a **Work With It** section allows students to consolidate their learning in the previous sections by including questions that may require working with a number of the concepts and skills just learned.
- The **Discuss It** questions at the end of this set encourage students to consider and reflect on what they have learned. These questions work best if students discuss them in a group before attempting to answer them.

Problem Solving

Problem solving is central to the McGraw-Hill Ryerson *Math at Work 12* program. Significant emphasis has been placed on incorporating problems that:

- have a range of contexts
- can be solved using different problem-solving strategies

A variety of problem-solving experiences are provided throughout the chapters:

- Each chapter includes a chapter project that allows students to demonstrate their understanding of many of the chapter's outcomes.
- In the Discuss It section, students consider their methods for solving problems. Doing so reinforces thinking and helps students realize that there may be multiple methods for solving a problem.
- A problem provides the focus for learning in the Explore at the beginning of each section, often making use of concrete materials.
- Students extend their understanding of concepts and skills in hands-on **Mini Labs** provided in Chapters 1, 3, and 4.

Differentiating Instruction

Differentiating instruction provides educators with the tools needed to create a learning environment where students are actively involved and working together. Hands-on activities engage students and help to meet their diverse needs. Significant emphasis has been placed on:

- variety — provides opportunities for students to be thoughtful about what and how they learn
- choice — encourages students to develop responsibility by making good personal decisions
- balance — is essential in having students actively involved in their learning. Students' needs are best met when they experience a variety of ways to develop and understand concepts.

Care has been taken in the McGraw-Hill Ryerson *Math at Work 12* program to ensure that all students—including students at risk, English language learners, or students from different cultures—can access the mathematics and experience success.

- The **Get Ready** at the beginning of each chapter serves to activate student knowledge of concepts related to the topics in the chapter.
- Visuals that illustrate how to carry out explorations accompany the instructions, where appropriate.
- Visuals and graphics are paired with questions and content in other strategic locations in the student resource.
- **Key Words** are listed in the chapter opener. When they are first used, they are highlighted in blue and defined in the margin, with the aid of visuals where appropriate.
- Key Words are also defined in the **Glossary**.
- **Tools of the Trade** boxes present interesting career information related to the math or context of the lesson.
- **F.Y.I.** boxes provide literacy information and additional interesting data about some topics.
- **Web Links** refer students to the ***Math at Work 12* Online Learning Centre**, where they can find additional information or activities for specific topics.
- The *Math at Work 12 Teacher's Resource* also provides strategies and blackline master support for accommodating different learning styles, special needs, English language learners, at-risk students, and for students who need a gifted or enriched program.

ASSESSMENT

Teachers are encouraged to assess students on an ongoing basis, using Assessment *as* Learning, Assessment *for* Learning, and Assessment *of* Learning. Through the use of a chapter organizer, Reflect and Extend Your Understanding questions in each exploration, Your Turn questions at the end of each On the Job, a chapter project, chapter review (**Skill Check**), practice test (**Test Yourself**), and games and puzzles, students are encouraged to assess their own progress, to identify their own strengths and weaknesses, and then to consider what they need to do in order to progress. Teachers are encouraged to coach students through this process.

Many opportunities for Assessment *as* Learning and Assessment *for* Learning assist teachers in identifying ways they can facilitate student progress to a higher level of conceptual and procedural understanding and skill development. Assessment *of* Learning further contributes to growth as teachers and students begin to use this summative assessment as a time for communication and reflections about future goals and strategies for improving.

Assessment *as* Learning (Diagnostic)

These assessment tools include student reflection. They are provided throughout the *Math at Work 12* student resource and *Math at Work 12 Teacher's Resource* to assist the teacher in programming by identifying student weaknesses and gaps.

- Reflect questions at the end of each Explore provide early opportunities for students to construct knowledge about the section content. The Extend Your Understanding questions allow them to further that knowledge.
- Get Ready at the beginning of each chapter and **Warm-Up** exercises on BLMs in the *Math at Work 12 Teacher's Resource* provide additional support in identifying and facilitating student learning.
- The suggested assignments, questions, and activities in the **Supporting Learning** column of each assessment box in the *Math at Work 12 Teacher's Resource* address a variety of learner needs specific to the questions or activities used for the assessment.

Assessment *for* Learning (Formative)

Formative assessment tools are provided throughout the *Math at Work 12* student resource and the *Math at Work 12 Teacher's Resource*.

- The **chapter opener** and related discussion activate learning necessary for students' success in the upcoming chapter.
- The Assessment *for* Learning box on the back of the Planning Chart is designed to provide teachers with an opportunity to activate student knowledge and assess the understanding that students should have to begin the chapter.
- The Reflect and Extend Your Understanding questions provide an opportunity to determine students' understanding of concepts through conversations and/or written work.
- The Your Turn questions target key skills of a section.
- Students can use the **Try It** assignments in each On the Job to check their understanding. The **Apply It** questions test their ability to apply what they have learned.
- The Skill Check and Test Yourself provide opportunities to assess knowledge/understanding, applications, communication, mental math, and problem solving.

Assessment *of* Learning (Summative)

Summative assessment is provided in the following ways:

- **Chapter tests** are provided as blackline masters in the *Math at Work 12 Teacher's Resource*.
- The chapter project provides teachers with an opportunity to check whether students have synthesized the concepts and procedures. A generic rubric that can

be used for each chapter project is provided on **Master 1 Project Rubric**. Notes on how to ue the rubric are in the *Math at Work 12 Teacher's Resource*.

Teachers are encouraged to use alternative assessments beyond formal testing. The games and puzzles in some chapters can also be used to assess student understanding of related concepts and skills.

Portfolio Assessment

Student-selected portfolios provide a powerful platform for assessing students' mathematical thinking. Portfolios provide the following benefits:

- help teachers assess students' growth and mathematical understanding
- give insight into students' self-awareness about their own progress
- help parents/guardians understand their teen's growth

Math at Work 12 has many components that provide ideal portfolio items. Including any or all of the following chapter items is a non-threatening, formative way to gain insight into students' progress

- answers to the Reflect questions, which give students early opportunities to construct knowledge about the section content
- answers to the Discuss It questions, which allow students to explore their understanding of the chapter skills and processes
- chapter projects
- student responses to the chapter games and puzzles
- work on any Mini Lab

Master 1 Project Rubric

Master 1 Project Rubric is a generic rubric developed for assessing student work. It highlights the level of development of conceptual and procedural understanding within a particular topic, and provides consistent assessment strategies for multiple approaches and/or for multiple solutions to problems and problem solving. This unique rubric includes

- a Score/Level grade ranging from 1 to 5 (Beginning to Standard of Excellence)
- a Holistic Descriptor for each grade range, describing the level of understanding and communication skills

A copy of Master 1 Project Rubric in each chapter of the teacher resource includes Specific Level Notes, which provide descriptions of each grade range. These notes are meant to represent what the majority of students display. They are by no means exhaustive of all possible solutions. Teachers are encouraged to continually refer to both the specific and holistic pieces of the rubric.

Teachers are encouraged to share the rubric with students early in each project. This will help students become active participants in their own assessment and program planning. Discussing and building the Specific Level Notes with students allows them to engage actively in their learning.

CONCRETE MATERIALS

The McGraw-Hill Ryerson *Math at Work 12* program engages students in a variety of worthwhile mathematical tasks. Where appropriate, concept development in the program begins with students working with concrete materials. Most explorations have students using commonplace materials and conventional mathematical manipulatives in a hands-on approach. After an appropriate number of hands-on opportunities, students move from the pictorial to the symbolic in the On the Jobs, Your Turn, Check Your Understanding, and Work With It exercises.

TECHNOLOGY

Where appropriate, lessons are designed to provide students with the opportunity to develop their skills in the use of various technologies, but not to rely on this technology to think mathematically. Students are also asked to use the Internet to research information about careers related to the mathematics they are doing and to access applets and other online activities.

The student resource provides technology learning that matches technology requirements for curriculum expectations and that deepens students' conceptual understanding.

COOPERATIVE LEARNING

Students learn effectively when they are actively engaged in the process of learning. Most sections of *Math at Work 12* begin with a hands-on activity that fosters this approach. These activities are best done through cooperative learning during which students work together—either with a partner or in a small group of three or four—to complete the activity and develop generalizations about the topic or process. For students who are distance or distributed learners, these explorations can be explored independently, allowing for valuable student-based learning.

Group learning such as this is an important aspect of a constructivist educational approach. It encourages interactions and increases chances for students to communicate and learn from each other.[1]

Teachers' Role—In classrooms or alternative learning environments where students are adept at cooperative learning, the teacher becomes the facilitator, guide, and progress monitor. Until students have reached that level of group cooperation, however, the teacher will need to coach them in how to learn cooperatively. This may include

- making sure that the materials are at hand and directions perfectly clear, so that students know what they are doing before starting group work
- carefully structuring activities so that students can work together
- coaching how to provide peer feedback in a way that allows the listener to hear and attend
- constantly monitoring student progress and providing assistance to groups having problems with either group cooperation or the math at hand
- using a discussion board or other medium to facilitate partner or group work for distance or distributed learners

Group Composition—The size of group may vary from activity to activity. Small-group settings allow students to take risks that they might not take in a whole class.[2] Research suggests that small groups are fertile environments for developing mathematical reasoning.[3]

Results of international studies suggest that groups of mixed ability work well in mathematics classrooms.[4] If your class is new to cooperative learning, you may wish to assign students to groups according to the specific skills of each individual.

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[1] Sternberg, R.J., and W.M. Williams, *Educational Psychology* (Boston, MA: Allyn & Bacon, 2002).

[2] Van De Walle, J., *Elementary and Middle School Mathematics: Teaching Developmentally*, 4th ed. (Boston, MA: Addison Wesley Longman, 2000).

[3] Artzt, A.F., and S. Yaloz-Femia, "Mathematical Reasoning During Small-Group Problem Solving," in L. Stiff and F. Curcio (eds.), *Developing Mathematical Reasoning in Grades K–12* (Reston, VA: National Council of Teachers of Mathematics, 1999), 115–26.

[4] Kilpatrick, J., J. Swafford, and B. Findell, *Adding It Up: Helping Children Learn Mathematics* (Washington, DC: National Academy Press, 2001).

For example, pair a student who is talkative but weak in number sense and numeration with a quiet student who is strong in those areas. Pair a student who is weak in many parts of mathematics but has excellent spatial sense with a stronger mathematics student who has poor spatial sense. In this way, student strengths and weaknesses complement each other, and peers have a better chance of recognizing the value of working together.

Cooperative Learning Skills—When coaching students about cooperative learning, consider task skills and working relationship skills.

Task Skills	Working Relationship Skills
• following directions • communicating information and ideas • seeking clarification • ensuring that others understand • actively listening to others • staying on task	• encouraging others to contribute • acknowledging and responding to the contributions of others • checking for agreement • disagreeing in an agreeable way • mediating disagreements within the group • sharing • showing appreciation for the efforts of others

Discuss common group roles and how group members can use them. Make sure students understand that the same person can play more than one role.

Role	Job	Sample Comment
Leader	• makes sure the group is on task and everyone is participating • pushes group to come to a decision	Let's do this. Can we decide … ? This is what I think we should do …
Recorder	• manages materials • writes down data collected or measurements made	This is what I wrote down. Is that what you mean?
Presenter	• presents the group's results and conclusions	This is what the group thinks …
Organizer	• watches time • keeps on topic • encourages getting the job done	Let's get started. Where should we start? So far we've done the following … Are we on topic? What else do we need to do?
Clarifier	• checks that members understand and agree	Does everyone understand? So, what I hear you saying is … Do you mean that … ?

Types of Groups

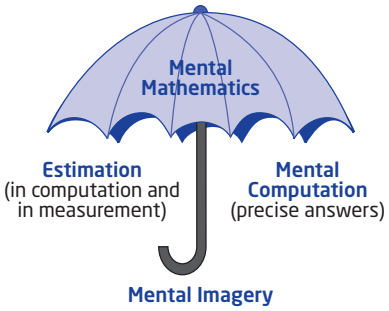
Three group types are commonly used in the mathematics classroom.

Think/Pair/Share—This consists of having students individually think about a concept and then pick a partner to share their ideas. For example, students might work on the Discuss It questions and then choose a partner to discuss the concepts with. Working together, the partners could expand on what they understood individually. In this way, they learn from each other, learn to respect each other's ideas, and learn to listen.

Cooperative Task Group—Task groups of two to four students can work on activities in the investigations at the beginning of each section. As a group, students can share their understanding of what is happening during the activity and how that relates to the mathematics topic, at the same time as they develop group cooperation skills.

Jigsaw—Another common cooperative learning group is called a jigsaw. In this technique, individual group members are responsible for researching and

understanding a specific area of information for a project. Individual students then share what they have learned so that the entire group gets information about all areas being studied.



MENTAL MATHEMATICS

A major goal of mathematics instruction for the twenty-first century is for students to make sense of the mathematics in their lives. The development of all areas of mental mathematics is a major contributor to this comfort and understanding. Mental mathematics is the mental manipulation of knowledge dealing with numbers, shapes, and patterns to solve problems.

Estimation

Estimation refers to the approximate answers for calculations, a very practical skill in today's world. The development of estimation skills helps refine mental computation skills, enhances number sense, and fosters confidence in math abilities, all of which are key in problem solving. Over 80% of out-of-school problem-solving situations involve mental computation and estimation.[5]

Estimation does not mean guessing at answers. Rather, it involves a host of computational strategies that are selected to suit the numbers involved. The goal is to refine these strategies over time with regular practice, so that estimates become more precise. The ultimate goal is for students to estimate automatically and quickly when faced with a calculation. These estimations allow for recognition of errors on calculator displays, provide learners with a strategy for checking the reasonableness of their calculations, and give students a strategy for finding an answer when only an approximation is necessary.

Mental Imagery

Mental imagery in mathematics refers to the images in the mind when one is doing mathematics. It is this mental representation, or conceptual knowledge, that needs to be developed in all areas of mathematics. Capable math students "see" the math and are able to perform mental manoeuvres in order to make connections and solve problems. These images are formed when students manipulate objects, explore numbers and their meanings, and talk about their learning. Students must be encouraged to look into their mind's eye and "think about their thinking."

Mental Computation

Mental computation refers to an operation used to obtain the precise answer for a calculation. Unlike traditional algorithms, which involve one method of calculation for each operation, mental computations include a number of strategies—often in combination with each other—for finding the exact answer. As with estimation, strategies for mental computation develop in quantity and quality over time. A thorough understanding of, and facility with, mental computation allows students to solve complicated multi-step problems without spending needless time figuring out calculations. Students need regular practice in these strategies.

[5] Reys, B. J., and R.E. Reys, "One Point of View: Mental Computation and Computational Estimation—Their Time Has Come," *Arithmetic Teacher* (Vol. 33, No. 7, 1986), 4–5.

Some Points Regarding Mental Mathematics

- The various estimation and mental calculation strategies must be taught and are best developed in context; opportunities must be provided for regular practice of these strategies. Having students share their various strategies is vital, as it provides possible options for classmates to add to their repertoire.
- Key to the development of skills in mental math is the understanding of place value (number sense) and the number operations. This understanding is enhanced when students make mental math a focus as they calculate.
- Mental math strategies are flexible; the student needs to select one that is appropriate for the numbers in the computation. Practice should be in the form of practising the strategy itself, selecting appropriate strategies for a variety of computation examples, and using the strategies in problem-solving situations.
- Sometimes mental math strategies are used in conjunction with paper-and-pencil tasks. The questions are rewritten to make the calculation easier.
- The ultimate goal of mental mathematics is for students to estimate for reasonableness and to look for opportunities to calculate mentally.
- Students need to identify why particular procedures work; they should not be taught computation "tricks" without understanding.

Keep in Mind

Practice in classrooms has traditionally been in the form of asking students to write the answers to questions presented orally. This is particularly challenging for students who are primarily visual learners. Although we are sometimes faced with computations of numbers we cannot see, most often the numbers are written down. This makes it easier to select a strategy. In daily life, we see the numbers when solving written problems (e.g., when checking calculations on a bill or invoice, when determining what to leave for tips, when calculating discounted prices from a price tag). Provide students with mental math practice that is sometimes oral and sometimes visual.