

# Improving Mathematics Achievement by Effectively Integrating Technology

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For almost two years now, I have been working with authors from across Canada to develop computer resources to match the content and intent of *The Common Curriculum Framework for K-12 Mathematics* (Alberta Education 1995). Our collective focus has been on the instructional approach and design and the implications for regular classroom use. We have concentrated our initial efforts on the Version 1.0 materials—"getting the instruction" right!

Once we had completed the writing process for the first grade level, my attention turned toward a massive classroom pilot study of the edited and programmed prepublication materials. The critical question we needed to answer was "Will using the computer materials improve student learning in math?" The expense in development costs was now approaching \$2.5 million. This is a reasonable question to ask! I will share the results in the pages which follow.

Before I get ahead of myself, I will set the context. (For those of you who have seen Computer Guided Learning (CGL) demonstrations recently, you might want to skim through the following descriptive paragraphs in Section 1.) In discussing the evolution, the testing of the materials, and implementation issues and potentialities of CGL use, the next question I would like to respond to is "What would teachers be most interested in hearing about?" I have divided the following discussion into the following three major sections which I hope will spark further interest.

## Section 1. What Is CGL?

CGL refers to high-quality world-class CD-ROM materials supported by print resources for teaching and learning mathematics. The primary objective of the partnership agreement between the western provinces and territories with ITP Nelson Canada Publishing is to develop resources for Grades 9-12 that will improve student performance and retention of expected mathematics outcomes.

*The Learning Equation Mathematics 9* is the first level of the CGL materials to be completed under the partnership. It will be available in both Mac and Windows for teachers to use with their students in the 1997-98 school year.

Designed to match *The Common Curriculum Framework for K-12 Mathematics* of expectations for what students know and are able to do in mathematics, CGL development was initiated to support the *Western Canadian Protocol for Collaboration in Basic Education in K-12 Mathematics* (1995, 1996).

CGL is

- correlated to the curriculum,
- fully interactive,
- user friendly, and
- visually appealing.

CGL is designed to put the learner in control of his or her learning by providing superior teaching and learning strategies to match the vision set forth in the NCTM Standards.

## A Commonsense Approach

The pedagogical approach is research-based. It is a commonsense approach that works for teaching and learning math. The instructional components of each lesson incorporate real-world connections to make math more relevant and meaningful for students and build on students' prior knowledge. Each lesson begins with an attention grabber and motivator to address the question "Why do we need to learn this?" This introduction is revisited in the summary where students use the mathematics they have just learned to solve the introductory problem or application.

The tutorial and wealth of examples develop the mathematical concept and lead students to build their understanding. The approach is highly interactive and incorporates diagnostic feedback. It is presented in a logical sequence within a variety of meaningful learning activities for students at different ability levels.

The language of mathematics is reinforced throughout the lessons with features such as vocabulary checks, a built-in glossary and student-response models which incorporate phrases, symbols and math vocabulary.

The practice components include Jeopardy-type board exercises and categories of problems at varying levels of difficulty and complexity. Mini-test banks provide lots of extra practice to meet the individual needs of students.

## CGL Is Courseware

A unique feature of this software is that it is actually *courseware*! CGL is designed to be sensitive to the amount of instructional time available for mathematics instruction in Grade 9 programs. Each of the 56 lessons is intended to average 90 minutes in length; however, that will vary according to the individual needs and abilities of students.

The Math 9 courseware includes seven Explorer lessons that allow students to explore and build their understanding of key mathematical concepts. The Explorers are a result of the creative genius of Ron Blond who is on secondment from his position as math department head with the Edmonton Public School Board.

A second unique feature is the Student Refresher that provides additional examples and exercises to support students when they are away from the computer. This resource contains extra practice for independent study, open-ended writing activities to check for understanding and non-routine problems to apply and extend learning. This part of the CGL package is intended to complement and enrich the integration of mathematical processes through such things as group-learning activities, creating problems and working with concrete materials.

Finally, the Teacher Print Support materials are designed to assist and support teachers in the transition to a more integrated technological approach in their mathematics classrooms.

The teachers resource contains brief descriptions of each lesson on the CD-ROM as well as teacher-intervention strategies and ideas for evaluation, remediation, extension and enrichment. These strategies include learning activities and projects for individuals and groups of students.

## CGL Builds Student Confidence

Students enjoy working at their own pace. They can preview, review and repeat parts of lessons to meet their individual learning needs. They receive immediate feedback as they proceed through the lessons. The feedback varies according to the type of response solicited. Diagnostic feedback has been created by experienced classroom teachers and is often based on clarifying common errors or misconceptions. Generally, feedback provides a hint leading toward a correct response.

A "Help" button is provided in instances where authors feel it is appropriate or where some students may require review or additional support in order to proceed. "Success Tips" usually offer suggestions to build students' confidence or to support independent study and learning. Hidden screens serve as

motivators. A hidden picture is revealed as students work through the "Examples and Practice and Problems" components. These screens may contain related information about the lesson, build an appreciation of mathematics, relate to a real-world application, a math historian or career or even present the option to solve a more challenging problem. The "Self-Check" components of each lesson present students with an opportunity to check their mastery and measure their understanding of the lesson outcome. Students have the opportunity to review the questions, retry incorrect ones and check their answers, and/or see a Sample Solution.

## Section 2. What Do Teachers and Students "Do" When They Use CGL?

### The Paradigm Shift

The use of CGL as the prime mode of delivery of instruction was expected to change the role of the teacher. I believe a critical part of this change involves a conscious effort on the part of teachers to "let go" of some more traditional ways of teaching math. Moving from the "sage on the stage" to the "guide on the side" is a common shift when students are working one-on-one or two-on-two on computers—the teacher's role changes to one of coach, facilitator and mentor!

Using CGL challenges our beliefs about learning. Here are just a few questions and ideas for your personal reflection:

- What does constructivism mean?
- When students are actively engaged in meaningful learning activities, their learning is enhanced.
- Physical interaction and the use of models to demonstrate understanding make a difference in learning and retention.
- Students learn at different rates and in different ways.
- Students require both group- and individual-learning activities.
- Learning is accelerated when motivation is high.
- Time-on-task is directly correlated to mathematics achievement.

Let's turn our attention to the equally important paradigm shift for students using CGL! Students are suddenly actively engaged, talking and helping one another, and interacting in a meaningful way to develop and build their understanding of concepts.

Grade 9 students for the most part do not have a great deal of experience in note-taking, let alone

reflecting on and monitoring their progress and understanding. Simply speaking, they are used to doing what they are told when they are told to do it; they copy down what they are told and so on.

The effective use of CGL parallels planning for effective teaching and, most importantly, creates a positive climate and learning environment by helping the teacher.

- Plan and establish classroom routines and procedures.
- Establish and model clear expectations.

Ask yourself:

- What do I want students to write or record in their notebooks?
- How will I integrate homework and review it?
- How will I monitor the individual learning needs of students?
- What kinds of assessment make sense and are appropriate?

### What Do Pilot Teachers and Students Say?

Although the classroom pilot experience provides some very good suggestions to help other teachers integrate the technology effectively, there is no magic formula that will work for everyone. Teachers will use the resource as they do any others, as part of an approach that will work best for their students and their own comfort levels. There is no one single, right way, but we can learn from the successful practices of others. Here are some comments collected by Theresa Gross, formerly of Calgary Catholic Schools, in qualitative data from classroom interviews in the pilot of *The Learning Equation CGL Math 9* materials.

- The program provides more depth to the concepts (than a textbook). It allows for an internalization of knowledge and greater understanding in the long run.
- Teachers describe their role as manager, facilitator, helper of students (one-to-one)—no longer the principle dispenser of knowledge.
- Students in a CGL class are more actively engaged (involved) in their learning.
- Students say: "It's good to be able to slow down or repeat material I didn't get" and "I like the computer. It explains the work well and I can go at my own speed."

From a former principal's perspective, Jim Beatt, Foothills School Division, observed classes using CGL and made the following comments, comparing them to his observations of regular classes:

- Students in the CGL classes were more focused than students in regular classes. That is, more time was spent on task.

- Students using computers seemed to be more actively engaged in the task presented to them. They worked for much longer periods of time.
- The (CGL) mathematics software involves several activities (listening, reading, manipulating and viewing). If the teacher insists upon student writing as well, the combination is powerful since one actively reinforces the other.
- Students become much more responsible for their own learning as the teacher becomes more of a facilitator.

### Section 3—Why Would You Want to Use CGL?

If we truly want to promote excellence in mathematics education, we must consider adapting to change and using the best tools available. Technology plays a critical role in doing this. Using CGL allows teachers to move in this direction, while being confident they have a resource correlated to the curriculum they are mandated to teach. CGL resource materials, by their very nature, contain more breadth and depth than any other print or software resource available.

Just imagine the potential computers have to improve students' achievement in math when they

- are able to click on a word or math expression when they have forgotten what it means, and get a very specific explanation with an example;
- are asked to accurately input an expression using specific math symbols and notation;
- make a slight error and immediately receive appropriate feedback to move them toward the correct response or solution;
- have more than enough examples at all levels with lots of problem-solving;
- are able to see full solutions to problems to compare with their own work
- have different explanations for a concept, idea or problem;
- see alternative solutions or methods at the click of a button;
- interact in a highly visual environment that is user-controlled; and
- are able to use computer simulations or on-screen concrete materials to manipulate and observe their effects.

A CGL-enhanced program has definite advantages. Let's look at the potential of these features:

- The computer is infinitely patient.
- Learners can know how they are doing something, while they are doing it.

- It can be fun and easy to use.
- Learning at a computer is low risk. (Mistakes are a matter between the individual and the machine.)
- The computer can repeat things over and over without raising its voice!

### Why Might Educators Invest in Courseware?

The members of the Western Canadian Protocol (WCP) are now wrestling with this question. Only one answer begins to provide a solution—*demonstrable improved student performance*. Achieving this objective has been the basis of this WCP joint initiative with ITP Nelson.

### Does It Work?

ITP Nelson tested the material with over 1,000 students from 41 schools in a controlled pilot study, probably the largest study of its type ever undertaken with prepublication material in Canada. Results from an independent evaluation conducted under the direction of George Fitzsimmons of the University of Alberta show students using CGL 9 demonstrated statistically significant improvements in performance when compared with students using authorized texts. Students, both male and female, who used CGL as the main delivery system performed significantly higher on a pre/post test design at all levels of math ability.

### What You Need Before You Start

First, you will need a willingness to change and embrace a new teaching style. Next, you will need access to the computer hardware and a supportive

school environment. Inservice training will be a valuable way to prepare yourself and build a support network. A parent-orientation session or hands-on opportunity could also contribute significantly to the success of your implementation.

With most new things, it takes time to adjust and to find your own comfort level. CGL has many flexible uses. As a teacher, you determine how you will begin, what your students' needs are and what you can manage effectively. Start slowly, taking one step, one year at a time. You can use CGL for whole-class instruction over the entire Grade 9 program or start using parts of CGL for demonstration purposes, remediation, enrichment (when students miss class) and so on. Then try it out, reflect on how it went, modify it for next time and make revisions. Teamwork is a real bonus, too, if you can swing it!

### Visit the CGL Web Site

Why not visit our Web site to order your free Mac or Windows demo CD-ROM at <http://cgl.nelson.com>? See for yourself how CGL is

- easy to use,
- a commonsense approach to math instruction and
- covers topics in-depth.

That's why it works!

### Reference

Alberta Education. *The Common Curriculum Framework for K-12 Mathematics: Western Canadian Protocol for Collaboration in Basic Education*. Edmonton: Author, 1995.