

Math Team Term Project

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Teaching and Learning in the Digital Age

Using ICT in the Classroom:
Helping Students Learn Mathematics

“We have to teach today's mathematics to today's children, always with a view to their future,” (D’Ambrosio, 1999)

Defining Math as a Discipline

As a discipline, mathematics has an impressive range of fields. A basic skill such as number recognition is a foundation for specific focuses such as acoustics and wave propagation (<http://www.math.rpi.edu/AMR/appmath.html>, N.D.). As mathematics can be applied to many other academic disciplines, one very important aspect of what it takes to learn and understand math is transferable to every other discipline across any curriculum: problem solving. This skill is at the forefront of activities in the realm of mathematics, and will be discussed later in this paper. With that being said, math as a discipline separates away from other scholastic disciplines in many ways. The language used to describe math is one of numbers; one that is understood by the majority of the global community. Within mathematics, most problems have globally agreed upon answers that are solved by using globally agreed upon methods. That is a luxury that some disciplines do have, such as history and writing. There are arguments within history that may never be solved; persuading human beings as to the causality of certain events cannot even be done with proven facts (for example, who proved the facts to be true or not, and where did that person get their information?—That question alone is riddled with potential problems because of inherent global politics). In the context of literature, there are many different meanings as to what is considered quality. Even science has its opponents; to many the Big Bang Theory is just a theory, and the theory of evolution of the human species is considered highly blasphemous to many religious people around the world. In a manner of speaking, mathematics is a discipline that is neat and tidy in comparison to the other disciplines.

When it comes to ICT and math, separating the two does not make any sense. Tools that assist people in solving problems are widely accepted around the world in a variety of contexts. For example, buildings constructed today begin with a design made by someone (building designer or architect) with a computer. If the design passes all the necessary codes, then construction may proceed. Construction begins with a survey team that uses sights (lasers) and levels to plot out a foundation. To finish my example in a

concise manner, the building is erected with the use of heavy construction machinery and computerized tools to make sure everything is done right. This is just one example of many that proves the value of ICT as tools to help humans with their daily endeavors.

Why then is there a struggle to bring ICT into the math classroom to help learners further their skills in solving problems? Mathematics is a discipline that deals with numbers, and the multiple ways numbers play a role in our lives. The language of computers is a binary language; 0's and 1's rule the land. Using ICT in the classroom as a tool to help teach and learn math is a method that can greatly enhance students' skills in problems solving.

ICT and Standards

In classrooms around the country an increased emphasis is being placed on achieving standards through standardized testing. The stakes are very high, with most of the concerns being that schools will lose funding (and student enrollment) for not meeting Adequate Yearly Progress (AYP) set in place by the federal government. While this is not a very appetizing thought, one must wonder, "What about the concern for the education of the children?" The face of No Child Left Behind is smiling, with promises of holding schools accountable for not properly educating their students. However, the assessments for these schools as to whether they are doing their job (standardized testing for every grade level every year), is a method that pushes education towards teaching students how to pass a test, rather than disseminate to them knowledge that can help further their ability to lead a productive and educated life. With this in mind, I want to talk about the use of ICT in the classroom. More specifically, the use of ICT to help teach students mathematics in a way that will not only lead to the passing of standardized tests, but will also give them skills with using tools that will help them in their endeavors for the rest of their life.

The national math standards, as set by the National Council of Teachers of Mathematics (NCTM), give an overview as to what students need to know by the end of their 12th grade year (<http://standards.nctm.org/document/chapter5>).

Number and Operations

- Understand numbers, ways of representing numbers, relationships among numbers, and number systems
- Understand meanings of operations and how they relate to one another
- Compute fluently and make reasonable estimates

Algebra

- Understand patterns, relations, and functions
- Represent and analyze mathematical situations and structures using algebraic symbols
- Use mathematical models to represent and understand quantitative relationships
- Analyze change in various contexts

Geometry

- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships
- Specify locations and describe spatial relationships using coordinate geometry and other representational systems

- Apply transformations and use symmetry to analyze mathematical situations
- Use visualization, spatial reasoning, and geometric modeling to solve problems

Measurement

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements

Data Analysis and Probability

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- Select and use appropriate statistical methods to analyze data
- Develop and evaluate inferences and predictions that are based on data
- Understand and apply basic concepts of probability

Problem Solving

- build new mathematical knowledge through problem solving;
- solve problems that arise in mathematics and in other contexts;
- apply and adapt a variety of appropriate strategies to solve problems;
- monitor and reflect on the process of mathematical problem solving.

Reasoning and Proof

- recognize reasoning and proof as fundamental aspects of mathematics;
- make and investigate mathematical conjectures;
- develop and evaluate mathematical arguments and proofs;
- select and use various types of reasoning and methods of proof.

Communication

- organize and consolidate their mathematical thinking through communication;
- communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- analyze and evaluate the mathematical thinking and strategies of others;
- use the language of mathematics to express mathematical ideas precisely.

Connections

- recognize and use connections among mathematical ideas;
- understand how mathematical ideas interconnect and build on one another to produce coherent whole;
- recognize and apply mathematics in contexts outside of mathematics.

Representation

- create and use representations to organize, record, and communicate mathematical ideas;
- select, apply, and translate among mathematical representations to solve problems;
- use representations to model and interpret physical, social, and mathematical phenomena.

Each aspect of these standards can be achieved in a manner that uses forms of ICT in the classroom to help students learn and teachers teach.

“They will need a mathematics of keys and keyboards, of scanning machines, and of making decisions about optimal strategies. They need critical intelligence, curiosity,” (D’Ambrosio, 1999)

The standards for technology use in the classroom as set by the International Society for Technology in the Classroom (ISTE) are described as NETS (National Education Technology Standards). Prior to the 12th grade, students will be expected to demonstrate knowledge in using technology as follows (<http://cnets.iste.org/currstands/cstands-netss.html>, 2004):

1. Identify capabilities and limitations of contemporary and emerging technology resources and assess the potential of these systems and services to address personal, lifelong learning, and workplace needs. (2)
2. Make informed choices among technology systems, resources, and services. (1, 2)
3. Analyze advantages and disadvantages of widespread use and reliance on technology in the workplace and in society as a whole. (2)
4. Demonstrate and advocate for legal and ethical behaviors among peers, family, and community regarding the use of technology and information. (2)
5. Use technology tools and resources for managing and communicating personal/professional information (e.g., finances, schedules, addresses, purchases, correspondence). (3, 4)
6. Evaluate technology-based options, including distance and distributed education, for lifelong learning. (5)
7. Routinely and efficiently use online information resources to meet needs for collaboration, research, publication, communication, and productivity. (4, 5, 6)
8. Select and apply technology tools for research, information analysis, problem solving, and decision making in content learning. (4, 5)
9. Investigate and apply expert systems, intelligent agents, and simulations in real-world situations. (3, 5, 6)
10. Collaborate with peers, experts, and others to contribute to a content-related knowledge base by using technology to compile, synthesize, produce, and disseminate information, models, and other creative works. (4, 5, 6)

As one can see, the standards become pretty rigorous in the usage of technology, so it would be of interest for a teacher to integrate ICT in as many fields as possible, math being an easy match.

Problem Solving, Expertise, and Maturity

When people encounter a problem, it is either solved or not solved. The circumstances that lead to either of those categories can be widely varied. A person may give up on the problem after attempting to solve it, or maybe the attempt is not even made, and the problem is ignored. Perhaps the amount of resources needed to solve the problem are not available or are eventually exhausted (human or otherwise). Being successful in a problem solving situation can be achieved in a multitude of ways as well. In order for this to happen, there are some essential components that need to be fulfilled.

In Dr. Dave Moursund's book, *Brief Introduction to Roles of Computers in Problem Solving*, he defines parameters of whether a problem exists or not, and what it will take to solve it. First, the problem must be clearly defined. Once the problem is known, then a clear goal must be established. From there, a set of resources will need to be identified, accessed, and used towards achieving the desired goal situation. Lastly, the person attempting to solve the problem must be sincerely invested in solving the problem; the person must care about solving the problem enough to devote resources such as time, money, and energy towards the end goal (Moursund, 2004). In my opinion, the fulfillment of the motivation requirement is the most important to solving a problem, given that the problem is defined (however, motivation can be a powerful factor for discovery of an elusive problem). In many cases, motivation can make irrelevant limitations of resources. If a person is serious and dedicated to solving a problem, that person will make every attempt to gain the resources and tools to help him/her.

Maturity plays a big part in the motivation factor, whereas a person who has a high level of maturity in any given content area is likely to have the motivation to seek a solution to a given problem. Possessing a high level of discipline maturity also means that a person has skills in identifying what questions need to be asked, and what strategies will work best towards solving a specific problem (Moursund, 2004). A person who has a low level of expertise in specific math content may have a high level of maturity in that they look at problems from a 'can do' problem solving point of view. A person with a high level of content maturity is less likely to give up on a problem, using as many different resources that can be accessed to achieve success. With each experience in solving a problem, more expertise is gained, both in content, and problem solving skills. Maturity is then reinforced when a difficult problem is solved through diligence and persistence regardless of roadblocks encountered.

Essentially, gaining expertise within any discipline is directly correlated with the amount of experiences in that discipline, the majority of which need to be successful. On the other hand, one may gain invaluable expertise in a discipline through failure; knowing what not to do is highly important. This sub-set of experiences (failures) can lead to surmounting frustration, but it can also bring about an elevated maturity level within the discipline, that can also be translated across disciplines.

How does ICT Affect the Teaching of Mathematical Concepts?

ICT affects all areas of teaching math, including curriculum content, instruction, and assessment. The order of the concepts we teach in math are affected by ICT as well. With the use of tools such as calculators, children can basically skip the lower-order rote memory skills like memorizing addition and other facts. Students are able to use the calculators to do that "thinking" for them, while they move onto higher-order thinking skills like the relationships among numbers and operations, and the meaning of those relationships, and how that transfers into their daily lives and other content areas. In this and many other ways, ICT facilitates the learning of concrete operational skills at a younger age.

Curriculum content is affected in that students are now learning the skills and processes involved in making appropriate use of ICT within math. When making use of a calculator, they are learning the functions of the buttons, and when they are useful in relationship to their task or problem-solving process. Integrating the use of mathematical

computer software and programs also demands that students are familiar with the human-computer interface. They need to at least learn basic skills for navigating on the web, keyboarding, and using the program or software.

ICT affects the instruction of math because its integration lends itself to the facilitation of guided and independent learning. Making use of CD ROM programs allows the teacher to give a some instruction, including modeling how to use the program, then students are able to do some independent work with the CD ROM while the teacher guides them. Here, students can be receiving feedback both from the teacher, and the program. This works similarly with free programs off the Internet such as Kid's Place, (Education Place, 2001). Independent learning is also more easily facilitated with the use of ICT. Students are able to tap into their personal interests and motivations using sites like Fun Brain. This is a website designed to give students an opportunity to develop and practice their math skills in an interactive environment. With this and many other programs, students can engage in independent learning while the teacher "floats" around the room, providing individual help and instruction. Students can also use the web to facilitate research and learning in situations where the teacher is not present.

Peer teaching can also be done in an ICT integrated classroom. This can be done one-on-one, or in a very small group. Students can work together within their same grade or with a partners across grade levels. Generally, however, it is the "expert" of the students involved who gain the most out of the experience. With peer teaching students can work side by side using ICT math programs like Math Brain, (Math Brain, 2004), one student guiding and teaching the other. This increases academic skills, reinforces social behaviors and appropriate use of ICT, and strengthens peer relationships.

Making Use of ICT-Making Use of the Mind

The use of ICT equipment, programs and resources can assist students in their lower-order thinking skills and tasks. As mentioned earlier, with the use of tools such as a calculator, students can concentrate on higher-order skills, while the calculator does the lower-order thinking for them. Projectors can be used in the classroom to display information to the whole group and store information on a screen. In this way, students do not need to remember formulas or steps to follow; it is all available for them to look at on the screen.

There are a variety of programs available on the web for students to practice some of their lower-order math skills. Project Interactive, (Elementary Topics, 2004) is a site where students can practice their skills in a drill format. They may choose their grade level and skill they want to practice, and work independently at their own level. Kid's Place, (Education Place, 2001) is run through the Houghton Mifflin textbook company, and is also a great resource for students. They can practice some lower-order skills and assess their math knowledge. Brainteasers and test taking tips are also available here for students. This is helpful in facilitating formative assessments such as self-assessment.

Resources designed especially for students are available free on the web. Ask Dr. Math, (Ask Dr. Math, 2004) is a site where students can go to search frequently asked questions. It is organized into subgroups including arithmetic, geometry, puzzles, measurement, etc... Students can also submit their own questions to "Dr. Math". Using

this site decreases student wait time when they have a question and the teacher is busy or is helping other students. Children learn to become self-starter and independent learners, instilling the value of life long learning and independence.

We can look at Bloom's Taxonomy to help us think about how ICT can specifically help students in their ways of thinking and problem solving (<http://www.coun.uvic.ca/learn/program/hndouts/bloom.html>, 2003).

Knowledge

- observation and recall of information
- knowledge of dates, events, places
- knowledge of major ideas
- mastery of subject matter
- *Question Cues:*
list, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.

Comprehension

- understanding information
- grasp meaning
- translate knowledge into new context
- interpret facts, compare, contrast
- order, group, infer causes
- predict consequences
- *Question Cues:*
summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend

Application

- use information
- use methods, concepts, theories in new situations
- solve problems using required skills or knowledge
- *Questions Cues:*
apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover

Analysis

- seeing patterns

- organization of parts
- recognition of hidden meanings
- identification of components
- *Question Cues:*
analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer

Synthesis

- use old ideas to create new ones
- generalize from given facts
- relate knowledge from several areas
- predict, draw conclusions
- *Question Cues:*
combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what if?, compose, formulate, prepare, generalize, rewrite

Evaluation

- compare and discriminate between ideas
- assess value of theories, presentations
- make choices based on reasoned argument
- verify value of evidence
- recognize subjectivity
- *Question Cues*
assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize

“It impoverishes mathematics to restrict it to purely manipulative techniques and utilitarian purposes,”(D’Ambrosio, 1999)

Within the taxonomy, to ‘know’ something is to simply memorize (for a time, at least) information, and then repeat the information when prompted. That in itself is a job all forms of computers were made to do. Comprehension starts to bring understanding and meaning into a situation. Some computers can do this, a spreadsheet program bring to the user meaning of a list of numbers. Application is being done when new information is being used to solve new problems. Technical programs such as AutoCAD, which is a program used by architects to create virtual models of their designs, are given information from users to create models. Analysis of information to find patterns in data is done by computers in such ways as testing RAM for flaws (a process that a human could not do without the use of a computer. Synthesis and evaluation processes are types of thinking that is done by very specific computer programs, usually in the fields of science and medicine. Highly controversial right now is the use of human stem cells in research, in which computers are used as tools by humans to evaluate what parts of DNA can be replicated to become specified organs and living tissues.

In this taxonomy, levels of thinking go from a lower order of thinking to a higher order (Moursund, 2004). Both methods of thinking are required in problem solving, and this is where ICT plays a crucial part. When students are expected to memorize times tables (which is a very practical skill to have) they are practicing a lower order form of thinking. This practice is good. However, when the activity turns to more advanced, or higher order problems, in which the students are expected to solve word problems or multi-function equations, in many cases the students are expected to perform calculations in their head, or with pencil and paper. These lower order/higher order problems allow for the lower order processing to be done on a calculator, giving the student time and brainpower to work on higher order problem solving.

Moving throughout the levels of thinking is something that good problem solvers do; movement that is made more easily and effectively when ICT is used as a tool (almost a teammate) to process information that is relevant to the solving of the problem, leaving the learner to process the information not easily dealt with by the tool.

Accommodations/Modifications in Special Education

“Education is concerned with each individual reaching his or her maximum capabilities and, at the same time, learning about their assimilation into societal life,” (D’Ambrosio, 1999)

The use of ICT in mathematics offers many opportunities for students with special needs. In some ways ICT can help “level the playing field”, especially for those students with more physically limiting disabilities. In other ways, the integration of ICT helps to differentiate instruction, and tailors lessons and activities to students’ specific interests and learning needs. There is a wide variety of ICT equipment, resources and programs available for teachers and students to utilize in the study and teaching of mathematics at the elementary level. Equipment such as personal computers, headphones, enlarged calculators and keyboards, Braille printers, and even text to speech devices can assist a diverse population of special needs students in the classroom.

As pointed out in *Brief Introduction to the Roles of Computers in Problem Solving*, “LD students experience difficulty in learning computation, math problem solving, and other math at the earliest grade levels and continuing throughout their schooling,” (Moursund et al, 2004) With the use of ICT, students with learning disabilities can use calculators or other resources and devices to do much of the lower-order thinking for them, while they focus on developing more higher order skills, like how the numbers relate to each other, and what that means. In effect those students who are stuck and struggling at that lower level can move on with the rest of the class, or at least have much of the frustration relieved. EASI (Math and Science Resources) is a website designed to help teachers better adapt their lessons and classroom structure to the needs of students with disabilities. Included on this site are tips for instruction, research on classroom design, and much more. Other sites, like AT for Blind Students, (Math and Computers, 2002), offer links to assistive technologies to use in the classroom for students with disabilities like visual impairments and blindness.

References

Assistive Technology Training Online Project, (2002). Math and computers. Retrieved Nov. 18, 2004, from AT for Blind Students: Math and Computers Web site: <http://atto.buffalo.edu/registered/ATBasics/Populations/Blind/math.php>.

This offers a variety of links to assistive technologies available for students with visual impairments or blindness.

D'Ambrosio, U. (1999). Literacy, matheracy, and technocracy: a trivium for today. *Mathematical Thinking and Learning*, 1(2), 131- 153.

This article discusses the history of mathematics, as well as how math relates to technology and today's society. It looks at the goals of the educational system, and ideas for a new curriculum.

Equal Access to Software and Information, (n.d.). Math and science resources. retrieved Nov. 18, 2004, from EASI Homepage Web site: <http://www.rit.edu/~easi/easisem.htm>.

This has resources to help teacher better adapt their lessons and classroom to the needs of students with disabilities. There are tips for instruction, research on classroom set up, and much more

Houghton Mifflin, (2001). Education place. Retrieved Nov. 22, 2004, from Kid's Place Houghton Mifflin Mathematics Web site: <http://www.eduplace.com/kids/mhm/>.

This is run through the Houghton Mifflin text book company, but it is a great place to have kids go to practice their skills or assess their math knowledge. There are also brain teasers and test taking tips available.

Math Forum, (2004). Ask dr. math. Retrieved Nov. 18, 2004, from The Math Forum- Ask Dr. Math Web site: <http://mathforum.org/dr.math/>.

Here students can search frequently asked questions in math. It is organized by subgroups such as arithmetic, geometry, puzzles, measurement, etc... Students can also submit their own questions to "Dr. Math".

Moursund, D. (2004). *Brief introduction to the roles computers in problem solving*. Eugene, OR: .

This book is available free online at Dr. Moursund's website. It discusses theories and strategies for problem solving, and the ways in which computers can facilitate this.

Pearson Education Inc., (2004). Math brain. Retrieved Nov. 11, 2004, from Fun Brain Web site: <http://www.funbrain.com/brain/MathBrain/MathBrain.html>.

This site is filled with a variety of interactive math games for elementary students. The graphics and animations are beautiful, and it is very easy to use.

Shodor Education Foundation Inc. (2004). Elementary topics. Retrieved Nov. 18, 2004, from Project Interactive for Elementary Math Topics Web site: <http://www.shodor.org/interactivate/elementary/index.html>.

Students can choose from a variety of programs available on this site to practice their math skills. Good for grades K-5

Applied Math Resources (N.D.). *Applied math resources*. Retrieved Nov. 23, 2004, from Applied Math Resources. Website: <http://www.math.rpi.edu/AMR/appmath.html>

This site has a database of mathematical disciplines in which to search for schools that deal specifically with the discipline chosen in the database. The school websites offer information on their courses as well as research in specific math disciplines done by personages at the school.

ISTE (2004). *Curriculum and content standards*. Retrieved November 25, 2004, from ISTE NETS for Students. Website: <http://cnets.iste.org/currstands/cstands-netss.html>

ISTE is a website dedicated to providing content standards in technology use for students, teachers, and administrators alike. Within the website are lesson plans and resources for students, teachers, and administrators

Learning Skills Program (2004). *Bloom's taxonomy*. Retrieved November 25, 2004, from Learning Skills Program. Website: <http://www.coun.uvic.ca/learn/program/hndouts/bloom.html>