Chapter 8 – Assistive Technology for Mathematics

Assistive Technology for Mathematics

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Overview

Building mathematical skill has life long implications for students but can be easily overlooked. Basic life tasks such as paying bills, balancing a checkbook, creating budgets, arriving at work on time, and measuring can be the make or break point(s) for a student to move out of the house and live independently. More advanced skill(s) may determine the type and pay of a student's employment. Skills such as measuring in the building trades, estimating the amount needed in inventories, budgeting business expenses and reading stock charts and graphs for investing or insurance purchases also use mathematical skills.

The performance level of math for the average American student is not spectacular. The National Center for Education Statistics 2003 found only 32% of fourth graders and 29% of eighth graders scored at or above the proficient level in math. Lynn Steen (n.d.) in her article *How Mathematics Counts* noted two studies: "1 in 3 students who enter college must remediate major parts of mathematics as prerequisite to taking such courses as college Algebra or Statistics" and "College students in the natural and social sciences had trouble conveying the meaning of data they were looking at" This data comes from the regular education research.

The special education picture is grimmer. Very few special education students advance into upper level mathematics.

> Statistics suggest that many special needs students who struggle with the early computational focus of elementary math elect not to take upper level classes where they may actually excel in the theoretical applications of math that these classes explore. This choice affects their college or technical school preparedness and needs to be considered as students prepare their transition plans. A small percentage of these students find their way back to the math curriculum at the tech or college level, but a greater number of them do not. (Stefanich 2007)

Educators need to help students look forward and to help them prepare marketable skills for an increasingly technical workforce. Students are often surprised to find that many college and technical college course of studies require math and algebra as prerequisites. They end up paying expensive fees to take classes they could have completed for free in high school had they only known they needed them. Even students who choose not to continue their education may need to look at charts and graphs to interpret meaning. They may need to measure with precision. They will need to manage their budgets, understand the impact of various mortgage choices and manage their retirement portfolios. They will need more than math facts, they will need to interpret math data and may even need to present gathered information in acceptable mathematical formats to others. This means that at least a percentage of special education students currently absent from upper level math classes may need to reconsider.

The challenge providing assistive technology to accommodate and modify math experiences is much more than decreasing a problem set. The bigger picture is how to assist students in gaining an understanding of the language of numbers and apply what they know to the problems they are encountering. Diane Bryant (2004) calls this new focus "the shift from mechanics to meaning." Teaching mathematics can no longer focus just on teaching procedures, students need to know why they are doing what they are doing. They need to understand the **process** of math. Assistive technology can then assist the students in gaining or demonstrating this understanding.

This chapter will utilize the ASNAT process to look at assistive technology tools to support students with disabilities in the area of mathematics. Included will be an overview of some of the issues in the current system of mathematic instruction that challenge students with disabilities to succeed. A continuum of tools and strategies and resources will be provided to support further inquiry into the subject.

Using the SETT process and Decision Making Guide

It is intended that you use this as a guide. The Decision Making Guide follows the SETT (Student, Environment, Task, and Tool) format with a subcategory of Sensory Considerations included with Student and Environment. Additional categories include:

- Narrowing the Focus to help identify a specific task in order to select appropriate assistive technologies
- Implementation Plan to assign trials, dates, responsibilities and data collection
- Follow-Up Plan to set a date for the team to reconvene and review the student's progress

Again, this is intended as a guide; during the actual assessment process, each topic should be written in large print where everyone can see (i.e., on a flip chart or board). Information should then be transferred to paper for distribution, filing, and future reference. For more information about using the SETT process, please refer to Chapter 1 of this manual.

The questions posed in the guide are not intended to be all inclusive but rather to prompt the team to consider as many factors as possible in order to identify and ultimately try appropriate assistive technology tools and strategies for their students.

WATI Assistive Technology Decision Making Guide

Area of Concern: Math

PROBLEM IDENTIFICATION

Student's Abilities/Difficulties	Environmental Considerations	Tasks
What are the student's abilities and difficulties related to the area of concern? • Learning Strengths • Understands math concepts and mathematical notation • Does not understand steps to solving a problem • Difficulty reading • Does not know how to recognize a problem • Ability to handle multiple steps • Physical difficulties, fatigue • Visual processing • Other concerns	What environmental considerations impact the area of concern? • Curriculum approach is different than previous approach • Are materials accessible? • Manipulatives and e-text versions available • Teacher or aide available to adapt curriculum • Support for staff development in math	What task(s) do you want the student to do that relate(s) to the area of concern? • Gain fluency in reading math • Demonstrate ability to perform math computations • Align a problem and apply steps • Write or draw a mathematical notation • Apply math skill in context (purchasing, filling online form, check writing and balancing accounts)
Sensory Considerations		**Narrowing the Focus**
What sensory challenges does the student have that impacts learning? (i.e. visual, auditory, tactile)		i.e. Specific task identified for solution generation
Solution Generation Tools & Strategies	**Solution Selection Tools & Strategies**	**Implementation Plan**
Brainstorming only No Decision Review Continuum	Use a feature match process to discuss and select ideas(s) from Solution Generation	AT Trials/Services Needed: • Objectives to determine effectiveness of trial • Training needed • Date • Length • Person(s) Responsible
		Follow-Up Plan
		Who & When Set specific date now.

Important: It is intended that you use this as a guide. Each topic should be written in large print where everyone can see them, i.e. on a flip chart or board. Information should then be transferred to paper for distribution, file, and future reference.

Student's Abilities and Difficulties

- Struggles to read math problems and notation.
- Doesn't understand the language or vocabulary of math.
- Difficulty identifying and organizing the steps to a problem.
- Notation errors such as aligning numbers and forming shapes.
- Math instruction does not tap into visual strengths.
- Understands math facts and can use a calculator but is not allowed to move on.

What do we see in the classroom?

- Struggling with vocabulary
- Confusion with word problems and what to do next.
- Poor recall of math facts.
- Mismatches between problem and notation.
- Missed steps.
- Poorly aligned work.

Common myths related to math performance:

Teacher

- We have to work on math facts until they get them.
- Special education students can't handle upper level math.
- If they can't do math facts quickly they can't do higher level math.
- If they don't get the times table they don't get moved on.
- With limited time during the school day, it is more important to work on reading than math.

Student

- Math is hard.
- I am never going to use math in real life.
- I am never going to get this.
- I don't "see" it.

In reality the student may have difficulty with the math curriculum for a variety of reasons. Poor visual processing can affect how they align numbers or work with geometrical shapes, interact with manipulatives and add data points to a graph. Difficulties with language may impact their understanding of math, draw out the key points of a word problem or interpret meaning from a chart or graph. Slow or inaccurate computational speed may convince the student or others that they are not ready for higher level math concepts; writing struggles may impact their ability to write symbols and fractions in small answer spaces. These are just a few of the challenges they might face. It is important to figure out what is the underlying cause of a student's difficulties, before choosing the tools or techniques for intervention.

Visual Processing, Visual Spatial or Visual-motor Integration Challenges: This grouping looks at how a student's brain perceives, manipulates or navigates visual information related to math. Coordinating these challenges with motor actions needed to draw or represent math notations can also be impacted.

The student with difficulty in this area may have problems counting a group of items. They may visually lose their "place" as they count or labor to differentiate numbers like 6 and 9, 2 and 5 or 7 and 1. The student may stumble on operational symbols like < or >, miss the placement of a decimal point, struggle to visualize 3 dimensional shapes on a 2 dimensional medium or correctly perceive a color/shape pattern. They may have a difficult time reading or completing charts or graphs correctly, work from left to right or "see" the axis points of a parabola. Add the spatial component and they may struggle to work right to left (which is opposite of reading), up to down, correctly align the numbers in a vertical math problem, work a number line or correctly find coordinates on a grid or graph. Add in the motor components and they may struggle to copy problems from the chalkboard or textbook or draw an intricate geometric design. They may also be challenged when they need to fit a number into a small space on the worksheet.

Physical Access
Students with physical issues may struggle to engage with the tools used in the math curriculum. Even mild forms of decreased trunk control, shoulder and arm strength and fine motor/ hand skills may affect performance. The child may have difficulty writing numbers or equations legibly and in the spaces on the worksheet. They may find that their writing legibility decreases as support muscles fatigue. They may lack the finger strength, control or dexterity to work with manipulatives, pull the tape measure, align the ruler or generate the graphics needed to depict a math problem. Students with visual impairments may struggle with the color coding of manipulatives and gaining understanding of visual representations of math concepts such as how shapes look in 2, 3 or multiple dimensions.

Math Facts
A significant amount of research suggests that students are having difficulty remembering math facts or using them at speeds necessary for functional computation. While a calculator can help a student generate the answer needed to work a problem through routine procedures, the literature suggests that understanding the process behind those math facts is critically important to further math progress. This may be a challenge to determine in the individual student but is important to note that there is a growing body of literature [Hasselbring(n.d.), Campbell and Stuart(n.d.), Suydam and Brosnan (n.d.)] that does not support holding a student back if they **understand** the facts process but haven't mastered the memorization math facts demand. If they get the concept of multiplication, division but get mixed up writing the steps, get out the calculator and move on!

Math literacy: Math offers a new set of language skills for students to acquire. Math terms, numbers and symbols are, in a sense, the alphabet. Some teachers actually go so far as to call math a language of numbers and like other literacies must be navigated in similar challenge steps such as **reading** math notation, **organizing** the steps needed to solve the problem, **writing** math notation and **sharing** the completed project which in a math context may be some type of geometric structure, graph, or equation set. This may contribute to the challenge of word problems for many students. Hyde found "to help develop a deeper understanding of

mathematics concepts, use reading and thinking strategies adapted to math". He felt this helps students gain process understanding so that they would know what procedures to apply. Marilyn Burns found that real life connections, building comfort with math vocabulary and tracking thinking through math writing help struggling students catch up.

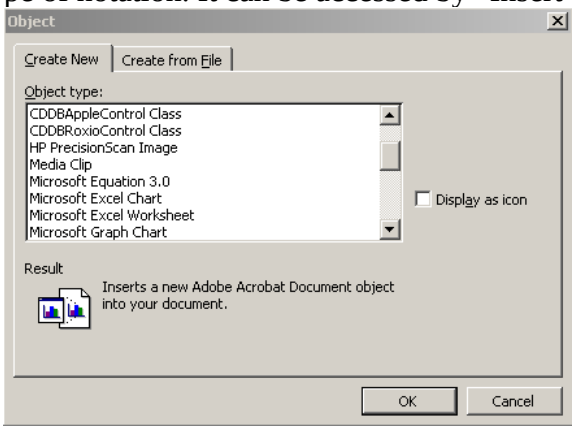
Multiple Steps/ Operations

Students can struggle with calculation, attending to the operational sign, applying multiple operations, following the steps in the correct order or sequencing the appropriate steps to complete a math problem, missing the carried number in an addition problem, or the regrouping of numbers during subtractions. These challenges often emerge in the elementary grades where computation is heavily stressed. When working a word problem, students may need to apply more than one operation. Using a math graphic organizer may help them plan out the sequences they will need to solve a problem. There are several good websites that carry printable and digital organizers. *Inspiration/ Kidspiration*, a software commonly found in the school environment, offers several examples of math graphic organizers at their website.

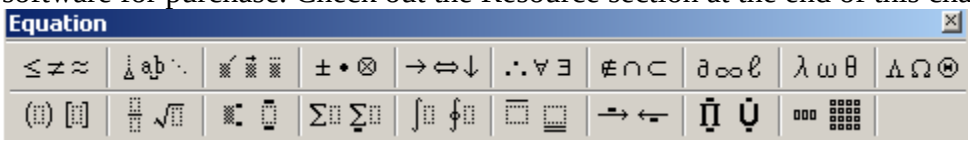
Reading and Writing Math language

Mathematical and scientific notation offer an entirely different vocabulary set to learn. Number, Symbol- and image-based, it may be helpful to add a vocabulary instruction component to the math lessons. There is a wonderful interactive math dictionary at http://www.teachers.ash.org.au/jeather/maths/dictionary.html that offers definitions and graphics to help explain various math terms.

Finding and typing the math symbols and sentences on the computer is not intuitive on the keyboard. *Microsoft Word* does have a toolbar called Equation Editor that can be used to do this type of notation. It can be accessed by "Insert Object".



If you have trouble finding it use the help menu. There are higher end versions of this type of software for purchase. Check out the Resource section at the end of this chapter.



Environmental Considerations

1. **The recent shift in the way math instruction is handled means older students missed the new way and younger students are coming into a support system designed for the old.** The math curriculum has experienced significant changes in its delivery at this writing. The focus has shifted from multiple problems of a similar nature to a more inquiry-based approach. It is important to note that many of the older students' (middle and high school) early training differs greatly from the experiences of younger students. The focus has shifted to making math feel more life applicable. The impact of the change in instructional focus hasn't worked completely through the K-12 system so the impact/outcome for upper level instruction is not known. The dramatic change means that regular and special education instructors may need to revisit some of the earlier concepts and maintain communication with elementary and middle school regular education on the need for a different set of accommodations and modifications.

2. **Access to materials**
   Since the change in instruction is so dramatic, staff should be aware of the need for accessible tools for manipulation and construction. These tools may be hands on or digital. Staff may need time to explore and learn how to use these new tools. An explosion of computer programs and online support activities are available but students need to be able to access them easily. This may be difficult in a busy classroom with only 1 or 2 computers. Students who need mathematical text read with a text reader face an interesting challenge. Current text readers were not designed to convert print math notation through their optical character recognition (OCR) to digital text or to recognize the symbols and math notations used to write equations. The error rate can be high making the conversion process slow and there is usually a greater amount of time needed for staff to do editing. Mathml is an emerging tool that may simplify this process of print to digital conversion. Companies are aware of the problem, so watch for newer version text readers that can handle the task better. Some of the current text reader programs can handle reading math text that is already in digital format, such as math found in online sources with minor hurdles in reading notations like fractions and math symbols. It is good to try this out before working with the student. To reiterate, adapting math materials so that a text reader can read them is currently very time consuming. Choosing online sources may save time and improve accuracy of current readers. A final challenge is having enough student work stations available if more than one or two students need access the digital text. Most regular classrooms are not set up for multiple users.

3. **Teachers need time** to integrate new concepts in math instruction, to create or find materials that work, to teach support staff the new system, to develop alternative manipulatives and measuring tools, and to scan math text when needed. If a teacher's or paraprofessional's expertise in math is limited, there is an increased need to have time to work with the math instructors. It may be difficult to make the necessary adaptations with limited expertise or comfort level with the material.

4. **Administrative Support**
   The intense focus on literacy for state testing may lead some to a feeling that math is not as

critical. Studies suggest the intense administrative focus on literacy shortchanges the time needed for math. One study found students were pulled from math and science to gain extra work time for literacy activities. This presents a challenge for students whose strength may be in this area or the functional math student who will need time to solidify the math skills needed for various work opportunities. Another study found that while schools offered a plethora of development options in literacy there was a lack of professional development opportunities for math and strategies for accommodation and modification.

5. **Common Environmental Barriers**
   - Students are not enrolled in classes they need.
   - Struggle with concepts because they are taught procedure instead of process.
   - Minimal or no support for poor math fact recall.
   - Instructional content not related to real world.

6. **Common Environmental Myths**
   - Students should memorize math facts before moving on to upper level math skills.
   - Over-reliance on calculators.
   - Upper level math is hard to support.

Tasks

As a team, discuss and write on chart paper the reading tasks that the student needs to do.

One of the most important questions when assessing a student's need for assistive technology is: What are the tasks the student needs to do? In this instance what does the student need to read and then what does the student need to do with the information read? These are some questions to consider:

What Tasks do you want the student to do?
- Gain fluency in "reading" math
- Understand math processes
- Gain mastery of math facts
- Organize steps to solve the problem
- Align and apply steps
- Draw or write mathematical notation

Sensory considerations
- Visual Processing
- Visual Perception
- Ability to work in 3-D
- Ability to sequence

Task considerations

Visual Processing

If a student has visual perceptual, visual spatial or visual motor difficulties, he/she may struggle with:

- Aligning elements on the page, vertical numbers, working left to right versus up to down, drifting margins and writing on the lines when paper is unlined.
- Drawing from perspective or conceptualizing 3D object from 2D images on paper.
- Locating graph coordinates.
- Completing paper and pencil tasks after creating a model using manipulatives.
- Fitting numbers into answer spaces.
- Copying from the book or board.
- Accurately reproducing a model.
- Difficulty creating patterns, fractions, etc.
- Visual impairments may also make it difficult for the student to read the textbook.

Physical Issues

- Writing legibility.
- Fatigue while writing.
- Fitting writing into small answer spaces.
- Accurately drawing shapes or models.
- Managing manipulatives (blocks, pop beads, etc.).
- Managing measurement tools.

Lack of arm and hand strength, fine motor skill and dexterity may affect the student's ability to successfully complete math assignments. Math concepts are often taught by using manipulatives, such as blocks, especially in the early grades. If is student is unable to physically engage in these activities, they miss out on the hands-on learning aspects of the instruction and may lose out on the concept that is being taught. Poor hand skills can affect measuring with a ruler or scale, manipulate a protractor or a compass, pressing buttons on a calculator or using various tools to draw geometric structures. Marking map coordinates or writing in small answer spaces may provide additional challenges. Finally, a student's writing speed may be too slow when writing longer, multi-step equations.

Visual Issues

There are several visual components to math to consider. The color of manipulatives as placeholders or used as a pattern marker has little meaning when a student can't see it. Understanding what shapes and structures look like can take on new meaning for a student with a visual impairment.

Math facts

Traditionally math facts were handled with a fair amount of drill and practice. While the strategy works for some students, teachers need to be aware of alternatives. A student may struggle to memorize or not be able to recall basic math facts even though they have drilled and practiced repeatedly. Sometimes attention issues lead a child to make mistakes, missing steps or working too quickly. Common supports such as a calculator or smart charts may help the student keep up with their peers, but it is important to ascertain whether they **understand** the underlying

concepts of math facts (**process**) and struggle with **procedural** steps or not. It is the understanding piece that is important for higher level math skills. (Hyde, 2008) The same challenges may arise when a student is measuring or telling time.

Laskerzewski and Susi (2008) used fractions to delineate this challenge of student understanding of math process and procedure. Students were given a fraction pretest. Questions focused on process math, i.e., given a circle prompt and asked to represent fractions such as ½ or ¼. Teachers were surprised that students did poorly on the pretest because they had already covered fractions and the students "knew" them. Upon review, the researchers found that a math procedure was taught for fractions. The teachers typically provided the lines dividing the circle in half or fourths, then asked the students to fill in the sections to represent the fraction. In the pretest, no lines were given. The students needed to understand the process of fractions. Take a whole, divide into parts and then select enough parts. To help students the researchers found the Chicago Reformed Approach (CRA) model worked well for most of their students. CRA-based instruction starts in concrete manipulatives and activities, then moves to drawings and finally on to the more abstract numbers and symbols. Some students have difficulty switching between these formats or applying different functions in the same problem, whereas other students may take longer than their peers to acquire understanding of abstract ideas. Different strategies are necessary to help students understand more abstract ideas when they are still at the concrete level; *Every Day Math* and *Math Experience* are examples of the reformed approach.

Multiple steps

Math "language" follows the steps we see in the literacy continuum when we look at problem solving. The student reads the problem and then organizes the strategy (equations) needed to solve the problem. Several authors suggested students highlight key words in a story problem and then associate those words with their math equivalent.
Below is an example using the underlining technique with a math graphic organizer.

> Story Problem: Millie must fly from New York to Minneapolis. The distance is <u>1227 miles</u> and takes her <u>2 hours and 37 minutes</u>. <u>How fast</u> was she flying?
>
> Graphic Organizer:
> **What do we need to know? -** Speed
>
> **How do we notate <u>speed</u>?** - Miles per hour
>
> **Do we have <u>miles and time</u> information**? – Yes but time is in minutes and hours
>
> **How can we make time all one type**? 60 minutes =1 hour so 2 hours and 37 minutes is **60 + 60+37= 157 minutes**
>
> **How can we make a math sentence for this? -** Speed equals miles per hour (one hour equals 60 minutes per hour)
>
> **Can you write this using math notation?** Speed = 1227miles/157 minutes x 60 minutes/1 hour

Decoding the meaning from story problems is often a first step. When a solution requires multiple steps the student may struggle to break the problem into the smaller solvable units, a little like highlighting key points when reading a text. Graphic Organizers may help support students through the step making process.

Narrowing the Focus

As a team, identify by circling or other means those few tasks the student needs to do for reading that will have the most impact.

After the team has generated a list of tasks that the student needs to do, you may want to refine the list to limit the tasks that the team (including the student) will focus on. Too many tasks can overwhelm the team. Introduction of too many factors and tools may reduce your ability to determine effectiveness. Maintain your original list of tasks and review it later. Some tasks may already be effectively addressed with the new tools/strategies that you are using. The tasks that remain can become your new focus at a later date.

Solution Generation: Tools/Strategies

As a team, brainstorm and write on chart paper any assistive technologies &/or strategies you think will assist the student in successfully completing those tasks you identified.

The team brainstorms strategies and assistive technology tools that may be of benefit for the student to complete the identified tasks in the given environments. Do not critique or otherwise evaluate the suggestions at this time. List all suggested tools and strategies including those currently in use on chart paper for all to see. The tools and strategies discussed below follow the general continuum for reading. The continuum is generally organized from low to high Assistive Technology. It is not intended to be used as a step-by-step protocol for using AT tools with a student, but rather an organizational continuum of types of Assistive Technology.

A CONTINUUM OF CONSIDERATIONS FOR ASSISTIVE TECHNOLOGY

Math

Low Tech Tools for Reading/Writing

↓

Math Manipulatives

↓

Low Tech Physical Access

(Rulers, stamps, adapted manipulatives)

↓

Abacus/Math Line

↓

Adapted Math Paper

(Enlarged worksheets, graph paper, guideline paper)

↓

Adapted Math Tools

(Calculators, adapted measuring devices, adapted time tools)

↓

Math "Smart Chart", Math scripts

↓

Digital Access to Math

↓

Math Tool Bars

(Equation editor)

↓

On-screen calculator

↓

Alternative Keyboards/Portable Math Processors

(e.g., CalcuScribe, IntelliKeys®)

↓

Virtual Manipulatives

↓

Math Software and Web Simulations

(physical access, computation, visualization, scripting)

↓

Voice Recognition Math Software

Low Tech Tools for Reading/Writing

Math manipulatives - Math manipulatives act as physical representations of math concepts such as numbers, shapes or place holders. They can include base ten blocks, coins, clock-faces with moveable hands, colored or textured shapes of varying sizes, pattern blocks, tangrams, spinners, rulers, fraction bars, *Cuisenaire, Algebra Tiles, Geoboards*, moveable number lines, geometric plane and solid figures. Blocks or small plastic toys may be used to teach 1-to-1 correspondence, counting, addition and subtraction. Colored blocks that snap together or number rods can correspond to place holders for units of tens or hundreds. Shape blocks or tangram pieces may be used to explain or explore early geometry concepts of shape or symmetry, while pie pieces correlate part-to-whole concepts of fractions.
Students with fine-motor or visual-motor issues may be a struggle to even interact with the manipulatives. The struggle to control the manipulatives may come down to the size and type of manipulative used. Kathie Snow (2008) identified with this idea when working to adapt math for her son. Her son couldn't pick up the traditional little beads and buttons. So Snow used a *Thomas the Tank Engine* set her son enjoyed as a large motivating manipulative. The type, size and relevance of manipulatives can make the difference for a child learning math or being labeled a "failure." There are a lot of choices of small plastic or foam toys that could be used. Increasing the size of the counting toy may make it easier to grab. To 'add' toy pieces together for concepts such as addition and subtraction, consider adapting blocks with Velcro so they stick together or adding handles so they can be easily be manipulated. Texture codes may be added to symbolize colors for students with low or no vision. They might also be used for a student that learns better kinesthetically can work a pattern activity similar to the colored versions of their

peers. Enlarging or shrinking these tools as needed is another common access strategy. For some students the management of little parts and pieces is distracting. Moving to online or contained units can help. Check out mathlines and virtual manipulatives in the resource section.

Low Tech Physical Access – Selecting manipulatives with an easy grip is important for access. If a student needs more assistance, foam or wood pegs can be added to aid pick up. An array of low-tech number, thermometer, fraction and clock stamps, easy grip rulers, and other low-tech math tools can be found at *Onion Mountain Technology* as part of their *LOTTIE Math Kit* or are available individually. Stencils can be used to create basic or more intricate shapes. Students can explore number relationships at a pre-algebra level with an algebra balance.

Abacus/Math Line/Master ruler/Master fractions – An abacus or Math Line products offer a physically contained counting system for calculating/counting early math problems. They come in different sizes with up to 100 rings for counting. Each time you move a set of rings, the number they represent is exposed on the math line. They are color-coded to assist counting by fives and tens. There is even one in Braille and one with tabs for easy manipulating using a head pointer or a mouth stick. The master ruler breaks measuring down into layers. Items can be measured first in inches, then viewed in smaller units by turning the "pages" to smaller unit measurements that define the measurement more accurately. Math Line also offers a similar product to help break down time and fractions from part to whole in layers. The Master Fraction is a three-part set for teaching fractions. The white plastic base of each shows four different shapes. Each clear layer divides these shapes into progressively smaller fractions (halves, thirds, fifths).

Math Line Products

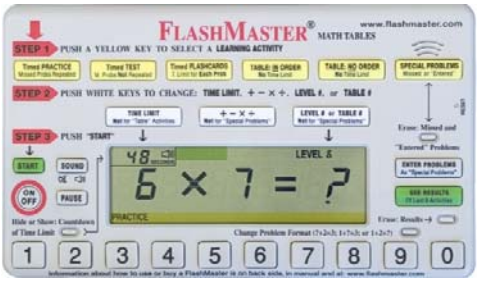
Adapted Math Paper - Math work sheets, graph paper, or assignments can be enlarged on a copier. Font, grid size, and/or colors can be manipulated before printing an assignment. A range of printable or digital graph paper and dot paper (used for Geoboard, area and perimeter concepts) can be found on the web. The choice of styles allows the adapting and printing to meet student needs. Regular notebook paper can be turned sideways for aligning vertical math problems. Add color coding on the math columns, such as green for ones and red for tens. Glue or *Wikki Stixs* can be added to paper to help define textural boundaries for writing or to outline shapes on the paper.

Adapted Math Tools

Adapted Calculator - Calculators come in an abundance of forms: large displays; large keys; small keys; lighted or talking displays; graphing and audio graphing functions; scientific; speech

output; and tactile input. The number of functions can range from a basic addition/ multiplication version all the way to graphing and college level calculators. There are special calculators for figuring out percentages and money. Some calculators offer a print out, useful for tracking steps used or as a tape that can be glued into a worksheet space. Calculators can also be found that convert a variety of items such as metric-to-US measurements for weight, length, area, liquid volume, cubic volume and temperature *(Radio Shack English/Metric Conversion Calculator).* The *Coin-U-Lator* is a calculator with keys shaped and sized exactly like coins and a dollar bill. It adds or subtracts money amounts and has voice output. The *MoneyCalc* is a standard calculator and money calculator in one device. It also features one touch figuring of tax and tips as well as help with unit pricing. Both of these calculators are available from *Onion Mountain Technology*. The *Math Keyboard* and *Fact Master* are portable low-tech push the button to get the answer type gadgets for students practicing or needing quick answers for math facts.

Math Keyboard



Flashmaster

Adapted Measuring Devices - Talking measuring tapes, thermometers, scales and other devices help children who have trouble seeing or reading the numbers or amounts. The *Master Ruler* from *Onion Mountain Technology* helps to teach length, measurement and their divisions. The ruler has transparent overlays that can go over a white one-inch incrementing ruler showing ½", ¼", 1/8" and 1/32" increments. Because these different layers are transparent, the student can see the other layers and understand the relationships between different units of measurement.

Adapted Time Tools – There are a number of watches that can give verbal feedback. Some like the *Watchminder* can have messages programmed in while others will say the time with the push of a button. There are watches that show digital and analog readouts on their face piece, decreasing the confusion of telling time from just a clock face. *Onion Mountain Technology* offers a special set of clock stamps to add a time element to schedules that allow you to add the minute and hour hands. A *Timetimer* (right) uses a visual face of disappearing red to convey the passage of time for a student who is not ready for numbers on their clock faces. The *Timetimer* comes in watch and stand alone models.

Math Smart Charts/ Scripts – Math smart charts/scripts work as reference guides. They contain math facts, conversions or process steps for solving tasks challenging a student. They can encompass multiplication tables, geometric functions, conversion tables such as inches-to-metric and Fahrenheit-to-Celsius, fraction and decimal procedures, percentages etc. These charts can easily be created on your own, found and printed from online sources such as www.wati.org or at several of the teacher sites, or purchased from manufacturers like *Really Good Stuff.*

Another great set of tools for organizing are math graphic organizers. There are several online sites that offer samples that can be printed out or used online to solve an array of math questions. *Inspiration/ Kidspiration*, a popular software program commonly used to organize literacy projects, can be used to build a math graphic organizer as well.

Digital Access

Math Toolbars - There are a couple of great digital math dictionaries that explain various math-related vocabulary items and include interactive models that explain various math concepts. There is a nice listing of math-based <ALT> key commands that can insert math notation on the fly. See the Resources section for these. If a student needs to write equations or solve math problems on the computer, use the built in *Equation Editor* in *Microsoft Office* (if you have it). *Math Type*, an advanced, easier-to-use version of *Equation Editor* is available for purchase. *Scientific Notebook* offers math notation as one of it's built in features and may already be available in high school computer labs. These toolbar-based programs offer the typist the symbols they need to use to write equations. *Mathpad* and *Mathpad Plus* (by *IntellTtools*), makes math assignments easier to do on the computer, especially when computing multiple digits. These types of problems are typically solved moving right to left, starting with the ones column. Most word processors work the other way when you type. Mathpad holds the correct format for solving these types of problems. Programs such as Excel and Geometer Sketchpad offer a way to digitally create graphs and geometric objects by adding coordinates or parameters. These programs are also common in regular education. The Department of Educational Statistics has created an online tool for generating a of variety graphs. Their website is http://nces.ed.gov/nceskids/createagraph/default.aspx. There are several online drawing and graphing sites if students need a digital format to create graphs. For those that need a math text reader, *Read and Write Gold*, *Math Player* and *GH player* are able to read mathematical Markup language (MathML). OCR conversion of printed materials involves a lot of labor.
Students who need assistance with working through the steps of the problem may want to check out online supports like http://www.webmath.com/

Onscreen calculators - There are onscreen versions of calculators available. One is built into the Microsoft operating system, several are web-based/online calculators, and there are some available for purchase. An onscreen calculator is useful if the student is already using a computer to write..

Alternative Keyboards/ portable math processors - Alternative keyboards provide access to the computer and provide computational experience with mathematical concepts. The *IntelliKeys* keyboard can be tailored by key size, pressure needed to activate a key, and the amount of key choices. The keyboards look/layout can be modified to ease access and/or the number of keys can be reduced. Activation areas can be big enough for a student to press. *On-screen Keyboard Magic* is an MS utility that creates an onscreen keyboard that can be accessed through a touch window or pointer. *Calcuscribe* works like a portable word processor that can handle math notation and then connect to a computer for download into a variety of text documents.

Virtual Manipulatives - The digital version of manipulatives adds movement and interactivity to math concepts. They also increase the potential for adaptation and access. Online manipulatives offer a greater array of problems and the full spectrum of complexity, which is hard to mimic with real manipulatives, especially at the middle and high school levels. There are digital forms of *Cuisenaire, Geoboards*, counters, tangrams and algebra tiles. There are more complicated versions including an abacus, fractals and vectors. *The National Archive of Virtual Manipulatives* houses an amazing number of interactive manipulative to meet the K-12 grade level content needs. Use a *Google* search to find interactives for the desired math concepts. Key words like simulation, model, interactive or tutorial should generate the visuals or manipulatives that you need. Educator-friendly search engines like *Thinkfinity*, *Nettrekker or Awesome Library* can find leveled, interactive activities that have been "kid" checked by teachers.

SMART Notebook software offers a nice choice of math interactive tools that can be built into lessons and activities. They have a number of pre-made activities. One of these includes a rolling dice. A simple addition activity can be created where students roll the dice a couple times and the amounts are added or multiplied. Promethean boards also offer some of these interactive tools.

Palm/ PDA technology provides students with a portable math notation tool. Being mobile means accessible computing power can go out into the world and help students explore math in a whole new way. Various probes can provide data for research projects or the student can gather data from experiments in the field that help ground abstract math concepts into real life experiences. They can also add drawings to their work on these devices.

Math Software and Web simulations:
Math graphic organizers can help a student systematically organize their solutions to math problems. Macinni and Gagnon (n.d.) in their article *Math Graphic Organizers for Students with Disabilities* found that three types of organizers worked well with math: hierarchical diagrams, sequence charts, and compare and contrast charts.

Hierarchical diagrams can be created in word processing or graphic organizing software such as *Inspiradata* or *Inspiration*. They are used to document entities and their relationships, with the constraints that bind them. The relationships can be linear or branching. In other words, if we were looking at an algebra problem we might want to know how polynomials work. We can break polynomials into multiple categories; indicate the relating notation and any equations that challenge that level of thinking. The process of hierarchical structuring is used heavily in computer software generation and in creating visuals of various business models. Advanced versions can be used to create visualization diagrams. Students with strong visual skills may be able to understand concepts better in these visual formats that hierarchical formats create. Sequence charts use visuals that should flow in one direction. They tend to follow the more typical procedure type instruction plans seen in math classrooms today. Venn diagrams, a type of compare/contrast chart, can help students visually categorize by offering spaces to sort out similarities and differences in a problem.

An emerging opportunity is the new tidal wave of math- and science-based digital labs/ simulations. Like virtual manipulatives, these programs can put math concepts into real life perspectives. There are simulations to run businesses, track the stock market or play out

probability and statistics in a virtual lab. Other online sites track student progress, provide tutorials on subjects not understood, generate the geometrical shapes or patterns a student may be studying in geometry, or show the fluid movements of calculus. Again, digital search engines can help locate what you need by topic and level.

Voice Recognition Software
For students who use voice recognition (VR) for their writing assignments, entering equations and science notations can prove challenging. *Math Type* is a software program designed to add this capability to the popular *Dragon Naturally Speaking* line of VR software.

Solution Selection Tools and Strategies

Use a Feature Match process to discuss and select those ideas, tools, and strategies that were generated during the solution brainstorming. Select those that best match the student, the environment and the reading tasks that need to be accomplished. Limit your selections to a reasonable number and prioritize them according to those that can be accomplished immediately, in a reasonable time period and those that will be considered at a later time or require additional or significant staff training.

Implementation Plan

After tools have been selected and prioritized, identify any trials or services that are needed including procurement of trial materials, team member(s) responsibilities, start date and length of trial, training needed and any other student/staff specific issues. Be certain to identify reading objectives and criteria of performance to determine the effectiveness of the trials.

Resources

Math Manipulatives:
General manipulative
www.lakeshorelearning.com
www.beacon-ridge.com

Adaptations for Algebra and Geometry for VI students
http://www.tsbvi.edu/math/tools-blind.htm

Unifix cubes and Cuisenaire rods: snap together manipulative
http://www.onlinetoyworld.com/search

Directions for making various math manipulatives
http://mason.gmu.edu/~mmankus/Handson/manipulatives.htm
http://www.mathcats.com/mathtoolbox/

40 Easy to Make Math Manipulatives , a book of how to make by Carole Resnik (see references for full citation)

Low Tech Physical Access
Math Lottie Kit: contains an array of low tech access tools to try with students
Finger grip ruler
www.onionmountaintech.com
Balance Scales, Stencils
http://catalog.beacon-ridge.com

Number stamps: Stationary stories, several outlets online

Abacus, math line:
Math line http://www.howbrite.com/
Master ruler/Math Fraction http://www.themasterruler.com/ 908-859-1788

Adapted math paper:
Free online printable graph paper
www.printfreegraphpaper.com

Incompetech: variety of math paper
http://incompetech.com/graphpaper/

Math bits: look under student resources for graph paper, high school math
www.mathbits.com

Science graphing paper
http://geolab.seweb.uci.edu/graphing.phtml

Math Smart Chart, Math Scripts:
Touch math: Multisensory program for teaching and working with numbers
www.touchmath.com
Math folder, smart chart
www.reallygoodstuff.com
Percentage and upper level math charts
www.helpingwithmath.com

Graphic Organizer
Inspiration/ Kidspiration/ Inspiradata
www.inspiration.com
http://www.inspiration.com/Examples/Inspiration#Math

Elementary Middle school math graphic organizers
http://www.teachervision.fen.com/graphic-organizers/printable/6293.html

Higher level math organizers
http://math2.org/

simple equations to calculus
http://www.sw-georgia.resa.k12.ga.us/Math.html

Adapted Measuring Tools:
Talking calculators, large print calculators, talking or large print watches, clocks and measuring tools
LS& S:
http://www.lssproducts.com/
Attainment:
www.attainmentcompany.com
American Printing House for the Blind:
www.aph.org

Calculators:
Large Screen
www.independentliving.com

Talking:
www.independentliving.com

Talking Graphing: Grid comparing talking graphing calculators:
http://www.tsbvi.edu/math/talk-sci-calc.htm

Online calculators:
Large number, talking desktop calculators:
www.independentliving.com

Giant onscreen calculator
http://mrjennings.co.uk/teacher/maths/calc.html

Graphing
http://www.webgraphing.com/
http://www.coolmath.com/home.htm
www.calculator.com
http://www.math.com/students/calculators/calculators.html
www.middleschool.net
www.independentliving.com

Scientific: The Sci-Plus 300 large display scientific calculator with speech output
www.tfeinc.com

Audiographing calculator
www.tfeinc.com

Audio Graphing Calculator
www.tfeinc.com

Online calculators and converters
http://www.gamequarium.com/onlinemathtools.html

Calculator Practice site:
http://everydaymath.uchicago.edu/educators/samplegames.shtml

Time:
Time Timer: color display for time passage
www.timetimer.com

Talking time pieces:
LS& S:
http://www.lssproducts.com/
American Printing House for the Blind:
www.aph.org

Watchminder: messages can be added to the watch
www.watchminder.com

Digital Access Options:
Math Dictionary
http://www.teachers.ash.org.au/jeather/maths/dictionary.html
http://www.coolmath.com/reference/online-math-dictionary.html

Alt codes list for math
http://www.usefulshortcuts.com/alt-codes/maths-alt-codes.php

Equation Editor: tool within MS Office for typing math symbols

Math type: Win/Mac equation writer with advanced math symbols
www.dessci.com

Online Unit Conversion
www.onlineconversion.com

Virtual Ruler
http://www.desktopruler.com/products-dr.htm
http://www.svet-soft.com/ruler.shtml
http://www.spadixbd.com/freetools/
http://www.downloadjunction.com/product/store/15482/index.html

MathML Readers:
Kurzweil
http://www.kurzweiledu.com/
Read and Write Gold
www.texthelp.com/
Mathplayer
http://www.dessci.com/en/products/mathplayer/tech/accessibility.htm
GH Player
www.**gh**-accessibility.com

Graph creators:
MS Excel has the capability of graphing coordinates

Kid Zone Create a Graph
http://nces.ed.gov/nceskids/createagraph/default.aspx

GraphSight Junior 1.0 highly rated freeware for drawing 2 D graphs
http://www.freedownloadscenter.com/Utilities/Automation_Utilities/GraphSight_Junior.html

Geometer Sketchpad: Drawing tool for geometry figures
www.dynamicgeometry.com

Scientific Notebook Tool bar for writing scientific notation
www.mackichan.com

Online higher level math/ graphing tools
http://people.hofstra.edu/Stefan_Waner/realworld/utilsindex.html

Alternative Keyboards and Portable Math Processors
Calcuscribe portable keyboard
www.calcuscribe.com

Math keyboard-They keep multiplying: Math fact portable tool
http://www.wonderbrains.com/math-keyboards-they-keep-multiplying.html

IntelliTools: Math Pad and Math Pad Plus
www.intellitools.com

Onscreen keyboard magic: Onscreen keyboard with enhanced features
http://oskm.ifastnet.com/

Virtual Pencil digital pencil for writing math
www.hentermath.com

PDA Probes
www.pasco.com

Moneycalc
Coin Abacus
www.tfeinc.com

Flashmaster portable digital math facts generating tool
www.flashmaster.com

Virtual Manipulatives:

Web search Engines:
www.nettrekker.com
www.thinkfinity.com
www.awesomelibrary.com

National Library of Math Manipulatives
http://nlvm.usu.edu/en/nav/vLibrary.html

Smart Notebook software has a large number of interactive tools to "visualize" math concepts including money, several premade activities as well. http://www2.smarttech.com/

Promethean Boards also have math related interactive tools
www.promethenworld.com

Shodors www.shodor.org/interactivate/activities/

Illuminations: Interactive online/ manipulatives/ lesson plans. Excellent set of fraction activities
http://illuminations.nctm.org

Computing Technology for Math Excellence
http://www.ct4me.net/math_manipulatives.htm#Calculators

Math Playground (Elementary concepts)
www.mathplayground.com

Virtual Cuisenaire Rods: http://www.arcytech.org/ (Select educational java programs

Algebra Tiles: http://my.hrw.com/math06_07/nsmedia/tools/Algebra_Tiles/Algebra_Tiles.html

Geogebra: Virtual tools for algebra, geometry and calculus
http://www.geogebra.org/cms/

Virtual Fractions:
www.virtualfractions.com

Visual Fractions:
www.visualfractions.com

Real Money
www.attainmentcompany.com

Math Educational Java Programs simple money, time manipulatives
http://arcytech.org/java/

Math Software and Web Simulations:
Gizmos
www.explorelearning.com

Operations/Tutorials
Clear Math (Edutron Corp.) - algebra I & II and pre-algebra topics; self-paced
www.clearmath.com

Hey Math! E math lessons based on Singapore Math
http://www.heymath.com/main/howitworksschool.jsp

IntelliMathics - (IntelliTools, Inc.) - interactive math manipulative program with a variety of manipulatives, e.g., base ten blocks, Venn diagrams, attribute blocks; for middle school concepts not learned.
www.intellitools.com

Simulations:
Real World Math
www.realworldmath.org

Math for the Real World, Davidson, grades 5-6 Real world experiences with time and money
http://www.knowledgeadventure.com/school/catalog/mrw.aspx

Math Workshop Deluxe, grades 3-6
http://www.smartkidssoftware.com/ndbro40.htm

The Math Work shop
www.themathworkshop.com

Math Problem Solver, Curriculum Associate, grades 1 - 8 & Adult Ed, teaching/reinforcing key concepts
www.mathway.com

Math simulation games
http://www.techtrekers.com/sim.htm

Microsoft Math is a purchasable add on program that creates graphs and provides a nice adv. feature online calculator
http://microsoft-math.en.softonic.com/

Voice recognition Math software
Math Talk Works with dragon products to write math
http://www.mathtalk.com/

General Web Resources

FDLRS/TECH, frequently updated web options in many areas
http://www.paec.org/fdlrstech/math.html

Select Math Program with Boston Public Schools
http://boston.k12.ma.us/teach/technology/select/index.html

The Math Forum at Drexel, Ask Dr. Math
www.mathforum.org/te/index.html
http://mathforum.org/mathtools/

Online tutor or help sites for various math concepts:
www.math.com
http://www.aaamath.com/
www.shodor.org
http://mathforum.org/math_help_landing.html
http://illuminations.nctm.org/

Online utilities for writing upper level math notation
http://people.hofstra.edu/Stefan_Waner/realworld/utilsindex.html

References

Ainsworth, L., & Christianson, J. (2000). *Five Easy Steps to a Balanced Math Program* . Denver, CO: Advanced Learning Press.

Alejandre, S. (n.d.). *Middle School Mathematics Curriculum*. Retrieved October 8, 1931, from http://mathforum.org/alejandre/

Askalon. (n.d.). Retrieved November 8, 2008, from http://www.dps.uibk.ac.at/projects/askalon/visualization/index.html

ATP Staff, (2007) *Math for the Building Trades*, USA: American Trade Publications

Bryant, Diane (2004), *Using Strategies to Teach Mathematics Skills to Struggling Students* Retrieved Nov. 8, 2008, from http://www.texasreading.org/downloads/special_ed/cec_2004_math.pdf

Burns, M. (2007). *About Teaching Mathematics: A K-8 Resource 3rd Edition*. null: Math Solutions Publications.

Checkly, K. (2006). *The Essentials of mathematics K-6*. Alexandria , VA: ASCD.

Gibilisco, S (2006) *Technical Math DeMystified*, NY, NY McGraw-Hill.

Guranus, S. (2007). *Math Instruction for Students with Learning Disabilities*. Boston , MA: Pearson.

Hasselbring, T., Lott, A., & Janet, Z. (n.d.). *Technology supported math instruction for Students with Disabilities: Two Decades of Research and Development"* . Retrieved August 8, 2004, from www.ldonline.org/article/6291.

Hyde, A. (n.d.). *Mathematics and Cognition*. Retrieved May 22, 2008, from www.ascd.org/publications/educational_leadership/nov07/vol65/num03/toc.aspx

Johnson, L. (n.d.). *Math Manipulatives*. Retrieved August 8, 2008, from http://www.iched.org/cms/scripts/page.php?site_id=iched&item_id=math_manipulatives

Lambert, M. (n.d.). *Textbooks, Materials and Manipulatives*. Retrieved August 8, 2008, from www.cldinternational.org/PDF/Initiatives/MathSeries/lambert.pdf.

Laskarzewski, J. & Sussi, L (2008, October 16). Combining Technology and Reseaarch: A balanced Equation for Math. *Closing the Gap*, Closing the Gap, Radisson, Minneapolis.

Learner Accommodation and Instructional modifications in the mathematics Classroom for Students with Learning Disabilities. (n.d.). Retrieved October 8, 2008, from http://www.k8accesscenter.org/.

Maccini, P., & Ruhl, K. (2000). Effects of a graduated instructional sequence on the algebraic subtraction of integers by secondary students with learning disabilities. *Education and Treatment of Children, 23,* 465-489.

Maccini, P., & Gagnon, J (n.d.). *Math Graphic Organizers for Students with Disabilities*. Retrieved October 8, 2008, from www.k8accesscenter.org/training_resources/mathgraphicorganizers.asp.

"Overall Guidelines for Planning Adaptations for Students with Special Needs". (n.d.). Retrieved August 8, 2008, from math.pghboe.net/econnectedmath/usage.htm.

Pedrotty, D. (n.d.). *Using Strategies to Teach Mathematics Skills to Struggling Students*. Retrieved August 8, 2008, from www.texasreading.org/downloads/special_ed/cec_2004_math.pdf.

Pedrotty, D. (n.d.). *Emerging Model: Three Tier Mathematics Assessment & Intervention Model*. Retrieved October 31, 2008, from http://www.texasreading.org/downloads/special_ed/SchoolDistrict-06.pdf.

Reesnik, C. (2003). *40 Easy-to-make Math Manipulatives*. New York, NY: Teaching Resources.

Scharff, R (1989), *Workshop Math,* New York, NY Sterling Publishing Inc.

Snow, K. (n.d.). *I Hate Math.* Retrieved August 8, 2008, from ftp.disabilityisnatural.com/articles/documents/CM104Math.pdf .

Steen, L. (n.d.). *How Mathematics Counts*. Retrieved August 8, 2008, from www.ascd.org/publications/educational_leadership/nov07/vol65/num03/Making_Math_Count.aspx - 56k .

Stefanich, G (2007) *Inclusive Science Strategies,* USA: National Science Foundation.

Stefanich, G. (2007, September 4). Science For All. *Ed Tech Training*, CESA9, Tomahawk, WI.

Tools for Life | Welcome!. (n.d.). Retrieved December 22, 2008, from http://www.gatfl.org.

"Using Manipulatives". (n.d.). Retrieved August 8, 2008, from mathforum.org/.

Thornton, C and Lowe-Parrio, G. (1998) *Hands-On Teaching (HOT) Strategies for Using Math Manipulatives*: *Grades K-6*. ETA Cuisenaire: Vernon Hills, IL.

Thornton,C and Gutman,D (1998) *Hands-On Teaching (HOT) Strategies for Using Math Manipulatives: Grades 6-9.* ETA Cuisenaire: Vernon Hills, IL.