# Avoiding Math Taboos: Effective Math Strategies for Visual-Spatial Learners

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## Abstract

Mathematics concepts are most often taught using auditory, sequential instructional methods. Not only are these methods ineffective when used with visual-spatial learners, they may be detrimental to both academic and emotional progress. Ways in which visual-spatial learners process information are explained. One child's story is presented, illustrating both negative academic and emotional impact on a visual-spatial learner who possessed exceptional math ability but performed increasingly poorly in math class. An extensive list of effective strategies and resources for teachers is provided.

## Keywords

Visual-spatial learners, giftedness, math strategies

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## Math Taboos in the Car

A friend and colleague told me a story that occurred during a family road trip. One of their children was in the back seat doing her math homework. Lucky for her, she was sitting behind two great math minds. My friend is a college professor of math education in a teacher preparation program. Her husband is a college professor of mathematics. The exchange went something like this:

Rachel asked, “23 x 6? I forgot how to do it.”

What’s 3 x 6?” prompted her father.

“18.”

“Okay, then,” said Dad, “just put down the 8 and carry the one. Now....”

“Wait!!” interrupted my friend, “She’ll never understand what she’s really doing if she just follows the steps!”

While Rachel may have been perfectly happy to complete her homework quickly by following her father’s simple instructions and memorizing the steps, my friend was right. Lower level, auditory processing of the steps may not result in a true understanding of the foundational concepts, including the overall concept that the multiplication of a times b means *a* groups of *b*. If not riding in the car, it is likely that Rachel’s father would have taken the time to draw or otherwise illustrate the underlying concepts of the problem at hand. In a situation that did not lend itself to creating visuals or using manipulatives, he resorted to a quick, traditional, and solely auditory method of teaching math skills. Teaching memorization of sequential steps in order to solve a math problem does a disservice to all math learners. However, it is particularly detrimental to visual spatial learners.

## Auditory Sequential Learners v. Visual-Spatial Learners

Auditory-sequential learners tend to do well in school where the curriculum, materials, and teaching methods are predominantly sequential and provided in auditory format (Haas, 2003). Relating back to the story about doing math in the car, auditory-sequential learners would readily be able to recall their math facts, memorize the steps to complete the multiplication equations, answer the homework problems correctly, and earn straight A’s in math without ever truly understanding the underlying mathematical concepts.

While these characteristics provide certain advantages in learning mathematical concepts (e.g. finding patterns easily and thinking pictorially), over-reliance on auditory-sequential math teaching methods pose stumbling blocks for visual-spatial learners both academically and emotionally in this subject area (Silverman, 2002). Relating this to the story in the car, visual-spatial learners would share the disadvantage of missing the underlying mathematical concepts. Also, they may not be able to recall math facts, nor readily be able to memorize the steps to complete the multiplication equations. Thus, visual-spatial learners are not likely to get correct answers to the homework problems (academic stumbling block), subsequently leaving them with a lowered self-esteem and a perceived deficit in mathematical ability (emotional stumbling block).

## Math Processing and Impact on Visual-Spatial Learners.

Auditory Sequential Learners

- Are left-hemispheric learners;
- Think primarily in words;
- Have a good sense of time;
- Are step by step learners;
- Follow oral directions well;
- Are well-organized;
- Memorize linear instructions and arrive at one correct answer;
- Progress readily from easy to difficult material.

(Silverman, 2002).

Visual Spatial Learners

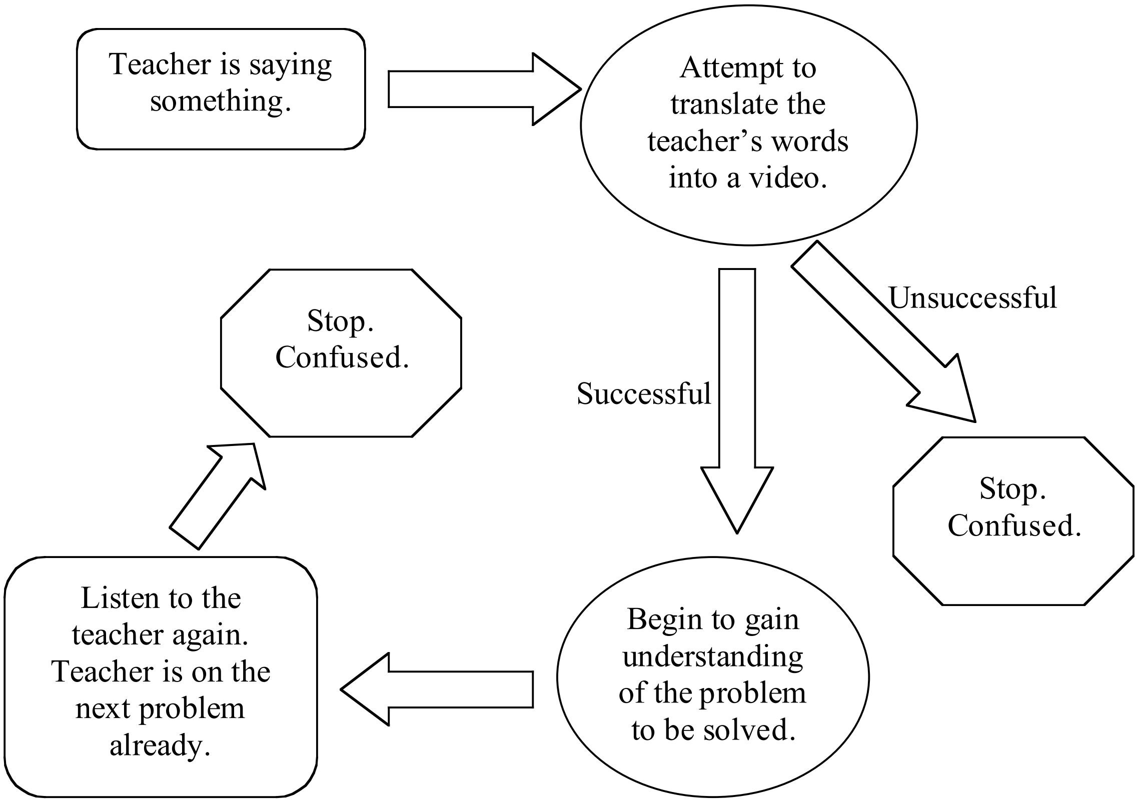
- Are right-hemispheric learners;
- Think primarily in pictures;
- Relate well to space but not to time;
- Are whole concept learners;
- Read maps well;
- Have unique methods of organization;
- Learn best by seeing relationships or patterns;
- Learn complex concepts easier than simple ones.

(Silverman, 2002).

Mathematics, by simplest description, consists of symbols and what the symbols represent. Auditory-sequential instruction of math often separates the symbol (number) from what it represents. If one is competent in auditory-sequential processing, in other words a predominately left-hemispheric or left-brained learner, he can manage to succeed in math in ways that success is most often defined in school - homework and test questions answered correctly with all work shown. The process will ensue as follows:

1. Listen to the teacher explain the steps.
2. Copy the sample problem(s) from the board in the order as completed by the teacher.
3. Memorize the steps used to complete the sample problem(s).
4. For any new problems, plug in the new numerals and follow the memorized steps.
5. Show all work by writing out the steps completed in a linear display.

*Table 1: Flowchart of visual-spatial learner's processing.*



However, for a learner who is competent in visual-spatial processing, a predominately right-hemispheric or right-brained learner, the experience will resemble something like the diagram above.

Within this flowchart of the visual-spatial learner's processing, several things are occurring:

1. Translation to visual imaging and increased processing time. The visual learner needs to see the information rather than hear it in order to make sense of it. This is not the same as an auditory processing disorder. The visual spatial learner can decipher auditory input, but needs to translate it to visual images if any true learning and application is to occur. Anytime a teacher is presenting information auditorally, the visual-spatial learner is listening to the words, then actively creating a video, photograph, icon, or other image in her brain – often while doodling, twirling her hair, or fiddling with an object at her desk which helps her with this translation process (Freed, Kloth, & Billett, 2006; Haas, 2003; Silverman,

**"Over-reliance on auditory-sequential math teacher methods may pose stumbling blocks for visual-spatial learners both academically and emotionally."**

2002). This takes additional processing time, which leaves the visual-spatial learner behind. In addition, she may be accused of daydreaming rather than paying attention to the lesson, when in fact, she is as actively involved in learning the lesson as the rest of the class.

2. <u>Whole concept learning and 'showing your work'.</u> Visual-spatial learners grasp concepts holistically rather than in parts (Haas, 2003; Silverman, 2002). What may seem to the auditory-sequential learner like a logical progression of steps to solving a math problem, seems jumbled and disjointed to the visual-spatial learner. If the task at hand is presented in a meaningful way so that the visual-spatial learner sees a real-world application for finding a solution to the problem, he will arrive at a solution by constructing and synthesizing a larger conceptual framework that incorporates the concepts to be learned. It may be very difficult for the visual-spatial learner to 'show his work' after this process. There is not a finite set of steps followed in a specific order. It is an overall understanding of a problem and multiple ways of arriving at the solution. A visual-spatial learner in second grade compared having to show his work in math to having to explain how he knows that C is the letter c, "I can't tell you how I know it. I just know it." This poses problems for the learner when placed in a class where the teacher insists that the answer is correct (implying that learning has occurred) only when the work is shown, step-by-step.

> **"She may be accused of daydreaming rather than paying attention to the lesson, when in fact, she is as actively involved**

3. <u>Simple versus complex tasks</u>. Visual-spatial learners often understand complex problems much more readily than simple ones. The explanation for this involves the roles of the two hemispheres of the brain, which deal with information processing in very different ways. The left hemisphere better handles recall, memorization tasks, verbal fluency, syntax and grammar, time, and sequence. This is the visual-spatial learner's weaker hemisphere. The right hemisphere of the brain better handles visualization, synthesis, spatial orientation, and broader concept formation. This is the visual-spatial learner's stronger hemisphere. A simple task involving knowledge recall engages only the left hemisphere of the brain, so the visual-spatial learner is operating at a disadvantage. When the task becomes more complex, requiring application, synthesis or evaluation of information, both hemispheres of the brain are engaged together. Now the visual-

spatial learner is using his preferred and stronger hemisphere, so the complex task is easier to accomplish (Silverman, 2002).

4. Writing. Many visual-spatial learners have difficulty with writing, whether it is copying from the board or showing the steps to their work. An associative (second-nature) task for auditory-sequential learners, writing is a cognitive task for visual-spatial learner , due in part to motor difficulties that accompany right-brain dominance. Freed, Kloth, & Billett (2006), explain this by saying, “the very act of writing requires tremendous concentration, which takes away from the ability to focus on the task at hand. When children write, it’s more difficult for them to visualize because they are looking down at the page” (p. 6).

There are areas of math that tend to be strong for visual-spatial learners because they lend themselves well to visual processing and spatial reasoning. Some examples of these are geometry, money, roman numerals (still a symbol system but based on a pattern and positioning of the figures), fluids, and maps. However, mastery of computational math skills is often used as a gatekeeper to these higher concepts. As Haas (2003) states, “this teaching strategy often works against visual-spatial learners. Typically, they are not very attentive to detail. They are prone to computational errors or missing a negative sign” (p. 31). The academic impact of this is misunderstanding of math concepts and declining grades. The emotional and psychological impact may be much greater.

## Tyler’s Journey

The following examples illustrate the experiences of one visual spatial learner from pre-school through fifth grade. The examples are drawn from collected documents as well as conversations with his teachers and parents. An extremely bright boy, Tyler reached all infant and toddler developmental milestones on the early side - talking at nine months, walking at ten months, dressing independently and toilet training by two and a half years.

At an early age, Tyler began demonstrating strengths in understanding math concepts. At two, this young mathematician climbed the staircase in his home, counting out each time his *left* foot stepped down, “1-2-3-4-5-6!” When he reached the top, he proudly exclaimed, “There are 12 steps!” Even though he had only counted every other step, he immediately doubled the number, understanding that there were two groups of 6, or 12.

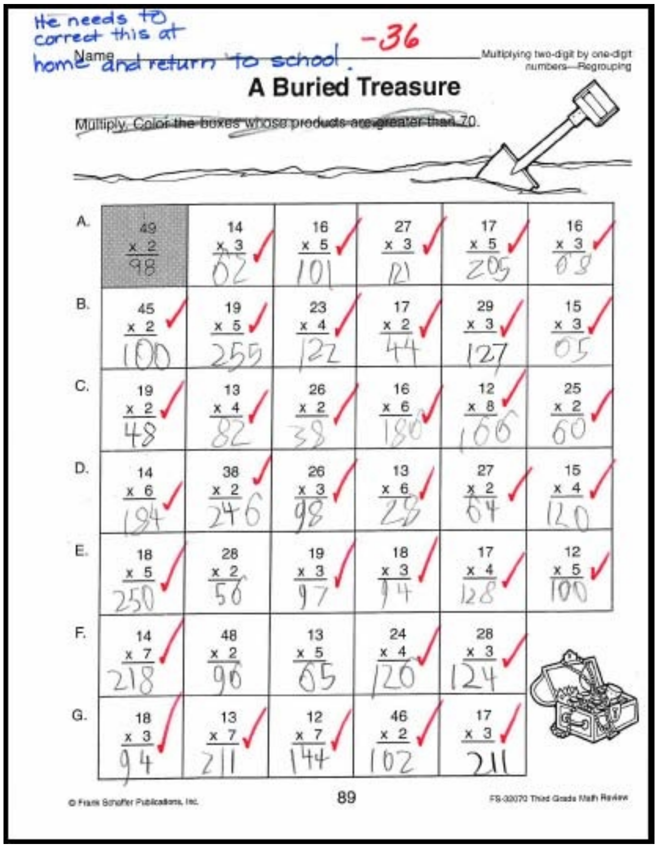
At four, Tyler brought himself out of a brief reverie at the dinner table to ask, “Does counting ever stop? I don’t think counting can ever stop.” Promptly being informed that indeed counting does not stop and this is the concept of ‘infinity,’ a new word was indelibly added to Tyler’s already impressive vocabulary.

In October of his kindergarten year, Tyler was assigned a color-by-number page with six pumpkins, arranged in two columns of three each. He colored the three pumpkins on the upper left correctly and the three in the lower right incorrectly, according to the numbers on the page. When asked why, he replied, “because when I folded it diagonally, I wanted it to be symmetrical.” Later that school year, Tyler was invited to leave the classroom twice a week to join first and second graders for extended study in geometry.

He thrived and added words like pentagonal trapezohedron to his everyday vocabulary.

What's the problem, one might ask? Well, at some point, usually first grade, math in school takes on much less of a discovery approach and transitions over to numerals on papers, equations with precise symbols, worksheets, and even journals where Tyler was expected to record in writing how he reached his correct answers. Most of the pages in Tyler's journal read, "I jst nu it" [I just knew it]. Even an understanding first-grade teacher who was willing to brainstorm additional recording strategies was not enough to counteract a district-wide curriculum that required evidence of math achievement in a format that was a far distant match for Tyler's strengths.

Through second grade, Tyler's dislike for 'math' as he now thought of it grew, until he consistently reported it to be his weakest and most abhorred subject in school. During third grade his perception of math came to equate the marks on his papers, of which this is a representative sample:



He needs to correct this at home and return to school.

Name -36

Multiplying two-digit by one-digit numbers—Regrouping

A Buried Treasure

Multiply. ~~Color the boxes whose products are greater than 70.~~

| | | | | | | |
|---|---|---|---|---|---|---|
| A. | 49<br>x 2<br>98 | 14<br>x 3 ✓<br>62 | 16<br>x 5 ✓<br>101 | 27<br>x 3 ✓<br>121 | 17<br>x 5 ✓<br>205 | 16<br>x 3 ✓<br>08 |
| B. | 45<br>x 2 ✓<br>100 | 19<br>x 5 ✓<br>255 | 23<br>x 4 ✓<br>122 | 17<br>x 2 ✓<br>44 | 29<br>x 3 ✓<br>127 | 15<br>x 3 ✓<br>05 |
| C. | 19<br>x 2 ✓<br>48 | 13<br>x 4 ✓<br>82 | 26<br>x 2 ✓<br>38 | 16<br>x 6 ✓<br>180 | 12<br>x 8 ✓<br>166 | 25<br>x 2 ✓<br>60 |
| D. | 14<br>x 6 ✓<br>194 | 38<br>x 2 ✓<br>246 | 26<br>x 3 ✓<br>98 | 13<br>x 6 ✓<br>28 | 27<br>x 2 ✓<br>64 | 15<br>x 4 ✓<br>120 |
| E. | 18<br>x 5 ✓<br>250 | 28<br>x 2<br>56 | 19<br>x 3 ✓<br>97 | 18<br>x 3 ✓<br>94 | 17<br>x 4 ✓<br>128 | 12<br>x 5 ✓<br>100 |
| F. | 14<br>x 7 ✓<br>218 | 48<br>x 2<br>96 | 13<br>x 5<br>65 | 24<br>x 4 ✓<br>120 | 28<br>x 3 ✓<br>124 | |
| G. | 18<br>x 3 ✓<br>94 | 13<br>x 7 ✓<br>211 | 12<br>x 7 ✓<br>144 | 46<br>x 2 ✓<br>102 | 17<br>x 3 ✓<br>211 | |

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It wasn't long until the mere thought of 'doing math' (no longer a discovery learning process involving the space and patterns around him, rather finite exercises that emphasized sequence, memorization, writing, and timed tasks) made Tyler anxious and withdrawn. By fifth grade, Tyler was classified as Other Health Impaired with an Individualized Education Program for difficulties with executive functioning, anxiety, and sensory integration. The Wechsler Individual Achievement Test-II (Wechsler, 2001) was administered to Tyler as part of his comprehensive evaluation for a disability. Tyler scored in the 90th percentile on the Math Reasoning subtest but 27th percentile on the Numerical Operations subtest. The diagnostician's summative comments on the Individualized Education Program (IEP) included:

> Math is [Tyler's] most challenging subject in school. He is aware of this and is reluctant to take risks. He prefers to do math mentally, and is frustrated when asked to show his work or write about his thinking. His mathematical reasoning skills are superior, but his computation skills are weak.

Further, Tyler reported himself to be "dumb, especially at math." This distorted self-perception of his abilities in general and particularly in math led to damaged relationships with his teachers. When they commented on how smart he truly was in math, Tyler felt as though they were teasing him and formed a mistrust of the encouragement they intended. What came next was a slow and arduous journey, filled with activities geared toward visual-spatial learners, to get Tyler back on the road to confidence in himself and his math abilities.

## Math Strategies and Resources for Visual-Spatial Learners

First and foremost to remember when planning math activities for any learner is that, "math is not about memorization or drill or speed. It's about patterns: seeing interesting relationships about numbers" (Silverman, 2002, p. 302). Visual-spatial learners are particularly adept at these skills, so providing them with opportunities to demonstrate them in ways other than drill worksheets will bring them out.

### Provide as many different manipulatives as possible

Visual-spatial learners will visualize different problems in different ways, so one type of manipulative will not be optimal for all learners or all tasks. Here are some to start with: unifix cubes, legos, drinking straws, paper clips, buttons, geoboards and rubber bands, peg boards, beads and strings, checkers, and coins. Keep collecting!

### Incorporate physical movement

Not all visual-spatial learners are bodily-kinesthetic learners, but physical movement will add to the visual images that are necessary for conceptual understanding. Have learners shape themselves like the numerals they are learning. Have them group themselves into sets for addition or multiplication. Rather than counting or measuring drawings on paper, have them move around the classroom or entire school counting and measuring real objects.

### Play or create math games

Board games and card games are inherently visual. In fact, most can be played without any auditory input at all. There are games already on the market that utilize math skills, including Candyland, Monopoly, Othello, Spirograph, Uno, Battleship, Rubik's Cube, Chess, and Checkers. Others can be found in resources such as *25 Super Cool Math Board Games*, by Lorraine Hopping Egan. Best yet, have learners create their own math board games using existing boards and pieces, or ones of their own design. Silverman (2002) shares an example of students who modified the pieces of a Stratego game so that each contained a multiplication math fact. In an attack, the higher product won the square.

### Offer opportunities to do math on the computer

There are several math software programs available as well as math websites. Try these for starters:

- Interactive Math Games at www.gamequarium.com/math.htm
- Building Big: Shapes Lab at www.pbs.org/wgbh/buildingbig/lab/shapes.html
- Math Cats at www.mathcats.com
- Cool Math 4 Kids at www.coolmath4kids.com

### Incorporate art with math

Every classroom has a plethora of art materials – crayons, markers, paper, paints, easels, glue, glitter (if the teacher is brave!), scrap fabric, recyclables. However, too many times, the art supplies come out for art time and are then put away for academic time. Part of planning for visual-spatial learners is to understand that academic time needs to be art time simultaneously. Keep those art supplies out and available! The following books will get you on your way:

- *MathART Projects and Activities: Dozens of Creative Projects to Explore Math Concepts and Build Essential Skills*, by Carolyn Ford Brunetto;
- *Mathterpieces,* by Greg Tang;
- *Cartooning with Math*, by Bill Costello
- *Comic-Strip Math:40 Reproducible Cartoons with Dozens of Funny Story Problems that Build Essential Skills*, by Dan Greenberg.

### Allow output that does that not involve writing

Other ways for visual-spatial learners to demonstrate what they know include drawing, making audio-recordings of their explanations, dictating to a scribe, computer representations such as Power Point, and hands-on projects.

### Allow for extra processing time

The most important strategy you can use along with any of these others is to allow more time to complete tasks. It goes without saying that creating art projects, designing and playing board games will take longer than completing a pencil-and-paper task. However, even thinking through an explanation will take longer for a visual-spatial learner, because he will need to make that translation from your words to his visual images.

### Give math problems a real world application

Many students who are gifted and/or visual-spatial learners have a raised awareness of and sensitivity to global issues. By teaching math concepts in the context of social justice, more than one need is being met. *Rethinking Mathematics: Teaching Social Justice by the Numbers*, edited by Eric Gutstein and Bob Peterson, provides a multitude of examples for teaching math across the curriculum, infusing social justice into math class, and incorporating the learners' backgrounds into math. Here is just one example that builds on the math concept of percentages:

Here are Illinois data based on police reports from 1987 - 1997

- In an area of about one million motorists, approximately 28,000 were Latinos.
- Over this period, state police made 14,750 discretionary traffic stops.
- Of these stops, 31,000 were of Latino drivers.

Have students set up their own simulations of this situation using cubes (in this example, one could use three different colored cubes our of 100. or one out of 28, to approximate the ratio or Latinos). Have them pick and replace a cube 100 times, record the data, and calculate the results of simulating 100 “discretionary” stops.

- What percentage of the motorists in part 3 were Latinos?
- What percentage of the discretionary traffic stops involved Latinos?
- How did you set up the simulation? Why did you choose those numbers?
- In your simulation, how many Latinos were picked out of 100 picks and what percentage was that?
- Do the results of your experiment support the claim of racial profiling? Why or why not?
  (Gutstein, 2005, p.17).

## Conclusion

In summary, do not teach math like you are in the car. If you must teach auditorally, use visualization strategies, allowing the learner to create a picture or movie in her head. An effective way to do this is to start with the equation and turn it into a story problem. Allow the visual-spatial learner time to translate this into visual images and help fill in the details. Then present the learner with the end goal. Avoid coaxing through the steps *you* would use. Give her room to work through the problem her way, which is apt to be holistic and spatial – and as equally effective!

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