BRAIN RESEARCH - MATH

- How the Brain Learns Mathematics

  By David A. Sousa

  (Corwin Press, 2008)

- Efficient Learning for the Poor – Insights from the Frontier of Cognitive Neuroscience

  By Helen Abadzi

  (World Bank, 2006)

- APPLYING BRAIN RESEARCH TO THE EVERYDAY TEACHING OF MATHEMATICS IN THE CLASSROOM

- By Kathy Stone, Ph.D.

7 PILLARS THAT SUPPORT BASIC SKILLS & EFFICIENT LEARNING FOR THE POOR

(Abadzi)

1. Supporting Children's Brain Development for Efficient Learning
2. Using Every Moment of the Available Instructional Time
3. Ensuring That All Have Textbooks to Take Home
4. Learning Fluent Reading & Calculation in Grades 1-2
5. Teaching Basic Skills to Young Students in Their Mother Tongue
6. Basing Educator Training on a Few Well-Researched Learning Principles
7. Ensuring Effective Teacher Incentives, Goals, & Oversight

EARLY CHILDHOOD FACTORS (Abadzi)

Utterances to the child per hour:

- Professional 487
- Working Class 301
- Welfare 178

Number of Words a child hears per hour:

- Professional 2,150
- Working Class 1,250
- Welfare 620

Parental Interaction Minutes per hour

- Professional 42
- Working Class 27
- Welfare 12

QUALITY OF LANGUAGE

- Richer nouns, modifiers, past-tense verbs
- More frequent imperatives, prohibitions

"Trickling Up": Investing More in the Lower Grades

- Poorer children may lack cognitive networks and prior knowledge to attach to school-related information.
- Failure to learn fluent reading & math skills in Grades 1-2 *creates inefficiencies that reverberate all through the educational system.*
- Students in Grades 1-2 are likely to perform better if they have more time on task, smaller classes, and more experienced teachers.
- Low-income entrants to grade 1 may lag behind better-off children in terms of psychomotor development, reasoning, complex grammar, and vocabulary.
- Poor parents do not talk to their children as much.
- They use simpler phrases with limited vocabulary.
- More frequent imperatives, prohibitions.

(Sousa)

NUMBER SENSE

(Sousa)

- Numbers have meaning for us.
- Born with ability to acquire it without effort at a very young age.
- Ability to acquire number concepts grows rapidly within first year of life.

TWO COMPONENTS

- 1. Ability to compare sizes of 2 collections show simultaneously.
- 2. Ability to remember numbers of objects presented successively in time.

EARLY MATHEMATICS SCREENING

(Sousa)

MEASURE	DESCRIPTION
Digit Span	Repeat Numbers forward or backwards
Magnitude Comparison	Largest of 4 numbers
Missing Number	Missing Number 0 – 20
Number Knowledge	Basic Number Sense
Numbers From Dictation	Write Numbers from oral dictation.
Number Identification	Identifies numbers 0-20 from printed numbers
Quantity Discrimination	Identifies larger of two printed numbers

LANGUAGE AND COUNTING

(Sousa)

- Say list of numbers aloud.
- Use verbal memory loop.
- Part of immediate memory can hold information for only about 2 seconds.
- Memory span limited to how many numbers words in less than 2 seconds.
- Correlation between time required to pronounce numbers in a given language and memory span of numbers.
- Hong Kong - 10 Digits
- English & Other Western Languages – 7 Digits
- Asian numerical notations more easily memorized.

DIGIT MEMORY SPAN (Sousa)

- Memorize by saying aloud with shortest words possible.
- Chunking numbers into groups – e.g. Tel. No.
- Tie parts of the number to other numbers you are familiar with.
- Western language systems for saying numbers pose more problems for children learning to count than do Asian languages.
- Western systems are harder to keep in temporary memory.
- Counting and base 10 more difficult.

MENTAL NUMBER LINE (Sousa)

- Speed comparing 2 numbers depends not just on distance but on size.
- Larger numbers more difficult to compare than smaller.
- Longer time to decide larger of 2 numbers a small distance apart.
- Internal number line only deals with positive integers and their quantitative relationship to each other.
- No intuition with other numbers such as negative integers, fractions, irrational numbers.

NUMBER SYMBOLS & WORDS

NUMBER WORDS

- Broca's area in left frontal lobe processes language vocabulary, including number words.

NUMBER SYMBOLS

- Number module located in left parietal lobe.

(Sousa)

- Human brain comprehends numerals as quantity, not as words.
- Automatically & unconsciously, numerical symbols are converted almost instantly to an internal quantity.
- Automatic orientation of small numbers to left and large numbers to the right.

NUMBER SENSE SKILLS SETS

- Recognize change in small collection when object removed.
- Elementary abilities or intuitions about numbers & arithmetic.
- Mental number line where numerical quantities can be manipulated.
- Innate capacity to process appoximate numerosities
- Make numerical magnitude comparisons
- Decompose numbers naturally
- Useful strategies for solving complex problems

(Sousa)

NUMBER SENSE SKILLS SETS (Sousa)

- Use relationships to understand base-10 number system.
- Use numbers to communicate, process, and interpret information
- Awareness of reasonableness of calculations.
- Looking for links.
- Effects of operations on numbers.
- Fluency & flexibility with number meanings
- Recognize gross numerical errors
- Numbers as tools to measure
- Inventing procedures
- Sensible talk about numerical problems

ENVIRONMENTAL IMPLICATIONS

(Sousa)

ENVIRONMENT

- Less stable family units.
- More single-parent.
- Less talk with adults who care.
- Dietary habits changing.
- No breakfast
- Home cooking a lost art.

IMPLICATION

- Need emotional needs met before academics.
- Low blood sugar.
- Need food/snack.
- Need to feel teachers really care about their success.

ENVIRONMENTAL IMPLICATIONS
(Sousa)

ENVIRONMENT

- Surrounded by media.
- Cell phones, movies, computers, video games, e-mail, Internet.
- Spend 17 hours a week with media.
- Another 14 hours a week watching television.

IMPLICATION

- Media is part of their learning experience.
- Interactive Conditioning
- Want to PARTICIPATE in learning experiences.
- Use all TECHNOLOGY that you can.
- Use all ACTIVE PARTICIPATION you can!

ENVIRONMENTAL IMPLICATIONS

(Sousa)

ENVIRONMENT

- Get so much information from many different sources besides school.
- Come to school with many preconceived notions about numbers, geometry, problem solving.

IMPLICATION

- Find out what they know.
- Identify their INTERESTS
- Use their information to motivate.
- Use problem-solving experiences that include objects related to their interests.
- Let them modify word problems to use interests.

ENVIRONMENTAL IMPLICATIONS

(Sousa)

ENVIRONMENT

- Becoming accustomed to information-rich and rapidly changing messages.
- Divides their attention.
- Try to pay attention to several things at once.
- Seldom go into any one thing in depth.

IMPLICATION

- Multitasking has NOT shortened attention span.
- Has made it more DIFFICULT to focus on ONE concept long enough to probe it in depth.
- Offer problems to solve in DIFFERENT ways.
- Forces more time analyzing the situation looking for various solutions.

ENVIRONMENTAL IMPLICATIONS

(Sousa)

ENVIRONMENT	IMPLICATION
Spend much more time indoors with technology.	Opportunities to present and solve problems outdoors.
Miss outdoor opportunities to develop gross motor skills.	Make use of large indoor areas like gymnasium.
Less socialization skills necessary to communicate and interact personally with others.	Movement & greater social interaction stimulate long-term memory and create interest in the lesson.

ENVIRONMENTAL IMPLICATIONS

ENVIRONMENT

- Young brains have responded to technology by changing functioning and organization to accommodate large amount of stimulation occurring in the environment.
- Brains respond more than ever to UNIQUE, DIFFERENT, NOVELTY!

IMPLICATION

- Doing UNEXPECTED is form of NOVELTY.
- Students have fairly accurate expectation of how teachers will present lessons.
- Violate their expectation and create NOVELTY!
- Think of many ways to introduce topics and vary unexpectedly.

TEACHING FOR MEANING

(Sousa)

USE MODELS

- Use multiple models.
- Base on CONCRETE rather than ABSTRACT.
- Select the correct model as the one to emphasize for visual memory.

USE COGNITIVE CLOSURE TO REMEMBER MEANING

- What did we learn today?
- How does what we learned today connect or add to something we already have learned?
- How can what we learned today help us in the future?

MATH CONTENT TO BE TEACHING

BIG IDEAS

- Kindergarten
  - Number Sense
- First Grade
  - Number Sense
  - Addition
- Second Grade
  - Subtraction
- Third Grade
  - Multiplication
- Fourth Grade
  - Division
- Fifth Grade
  - Fractions
- Sixth Grade
  - Fractions
  - Decimals
  - Percents
- Seventh Grade
  - Ratio & Proportion

NCTM PRINCIPALS & STANDARDS
(Sousa)

5 CONTENT

5 PROCESS

- Problem Solving
- Reasoning & Proof
- Communication
- Connections
- Representation

NUMBER SENSE

ASSESSMENT

- Number Knowledge Test for 6-, 8-, and 10-Year-Olds.
- (Source: griffin, 2002)

MULTIDIGIT NUMBER SENSE

Acquire understanding of large numbers & make judgments about reasonableness in different problem situations.

- Reading Large Numbers
- Developing Physical Examples of Large Numbers
- Appreciating Large Numbers in Money
- Appreciating Large Numbers in Distance.

ESTIMATION

- Extension of brain's ability to SUBITIZE.
- Poor Estimation inside of School.
- Early Age – Give exact answer, not estimate.
- Calculator – Right – Rarely reflect on reasonableness
- Want answer quickly.

ESTIMATION TYPES

- True Approximation
- Overestimating
- Underestimating
- Range-based estimations

ACTIVITIES

- Purpose
- Referents (benchmarks)
- Pertinent Information
- Diverse Experiences
- Range-based Techniques

MEMORIZATION TO UNDERSTANDING

INSTRUCTIONAL MODEL – GRADES 1-2

SMALL GROUP GUIDED WORK

- Solve Problem.
- Elicit
- Communicate
- Connect
- Represent Strategies

WHOLE-CLASS DISCUSSION

- Range & Analysis of Strategies
- Ways to Represent and Communicate
- Related Problem: Transfer

MULTIPLICATION with UNDERSTANDING

- Understanding Quantity
- Understanding Problem Situations Requiring Multiplication
- Understanding Equal Groups
- Understanding Units Relevant to Multiplication
- Show Multiplication in Different Ways

Traditional Method

- Three Steps:

  Multiply, Carry, Add

Lattice Multiplication

Introduced to Europe by famous mathematician, Fibonacci, in 1202.

- Novelty & Understanding

USING PRACTICE EFFECTIVELY

- Limit the amount of material to practice
- Limit the amount of time to practice.
- Determine the frequency of practice.
- Assess the accuracy of practice.
- Smallest amount with most relevancy – most can deal with 5 items in working memory at one time.
- Practice in short, intense periods of time – 5-10 minute time limit for working memory in prime time.
- Long term memory – practice over longer time intervals (distributed practice) – key to accurate retention.
- Give prompt & specific feedback. Ask students to summarize feedback in their own words for understanding.

TESTING AS FORM OF PRACTICE

- Test to evaluate students' achievement is very limited view.
- WRITTEN TESTS TELL US MUCH MORE:
- Allow students to practice what they have learned.
- Give teachers information about what each student has learned.
- Help teachers analyze their success at teaching lesson objectives.
- Can use tests for practice & record score of every third or fourth paper.

LEVELS OF LEARNING MASTERY

- LEVEL ONE

Connects new knowledge to existing knowledge & experience.

- LEVEL TWO

Searches for concrete material to construct a model manifesting concept.

- LEVEL THREE

Illustrates concept by drawing diagram to connect concrete to symbolic picture.

- LEVEL FOUR

Translates concept into math notation using number symbols, operation signs, formulas, and equations.

- LEVEL FIVE

Applies concept correctly to real-world situations, projects, and story problems.

- LEVEL SIX (Mostly Tests)

Can teach the concept successfully to others or communicate it on a test.

TECHNOLOGY

INHIBITING FACTORS

- Need for more professional development with technology.
- Time needed to prepare lessons and set up computers.
- Lack of experience, confidence, skills

- Cautions about undermining computation skills.
- Positive effects on confidence in math, motivation, time on task.
- Exploring number concepts and solving complex problems leads to greater understanding & higher achievement.
- Using technology for routine calculations does improve understanding & achievement.

REDUCING MATH ANXIETY

TEACHER ATTITUDES

Most dominating factor in molding student attitudes about mathematics.

- Present agreeable disposition.
- Math as great human invention.
- Value of math by how it contributes to society.
- Promote student confidence & curiosity.
- Appropriate, interesting, relevant tasks.
- Focus on goals, process
- Create opportunities for success.
- Build 70% Success Rate
- Resist belief males have greater innate ability.
- Display confidence rather than math anxiety.

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REDUCING MATH ANXIETY

CURRICULUM

- Much Repetition
- 53% review problems
- 23% new concepts
- Primary Grades – like most.
- 4th Grade – Math anxiety surfaces
- Shift from concrete manipulatives to abstract.
- Middle School – Abstract
- Result of innate ability.
- Belief effort matters little.
- Memorization not sufficient.
- More time to new material, discovery, application.
- Activities to apply knowledge
- Math as tool for discovery.
- Eliminate less important.
- Focus on major topics, skills
- Avoid repeating topics.

REDUCING MATH ANXIETY

INSTRUCTIONAL STRATEGIES

- Quality of teaching
- Teacher expertise link.
- Anxiety: "explain-practice-memorize" due to memorization focus
- Do not have skills to go beyond memorization.
- Go beyond basic understanding.
- Questions help learning.
- Awareness student confusion and frustration.
- LIMIT: frequent memorization, rote practice, one right answer, calculations by computer & calculator.
- Apply to students' lives.
- Incorporate projects.
- Investigate & question.
- Represent everyday situations verbally, numerically, graphically, symbolically

QUANTITATIVE STYLE LEARNERS

MATH BEHAVIORS

- Uses Recipes
- Mechanical, Routine
- Component parts rather than larger mathematical constructs
- Numerical approach over concrete models.
- Linear approach over arithmetic concept.
- Difficulty multistep tasks.

TEACHING STRATEGIES

- Meaning in Verbal terms.
- Highlight concept & goal.
- Encourage explicit description. Look for ways to link parts to the whole.
- Step-by-step approach to connect model/procedure.
- Different approaches to same concept & larger framework.
- Multiple tasks into units.

QUALITATIVE STYLE LEARNERS

MATH BEHAVIORS

- Concepts over procedure
- Overall Geometric shape
- Difficulty with precise calculations & explaining
- Variety of approaches
- Sets up problems but can't follow thru.
- Manipulatives and topics related to geometry.

TEACHING STRATEGIES

- Models first to concept.
- Components to design.
- Explicit description of each step used.
- Simulations, Word Problems
- Cooperative Groups – 1 grade setup – 1 grade exact solution
- Variety of manipulatives and models. Geometric links to new concepts.

TRADITIONAL V/S SENSE-MAKING

TRADITIONAL CLASSROOM

- Math is Procedures
- Work is Inexplicable
- Significance lost
- Student is passive
- Validated by Teacher
- Truth is as presented.
- Teacher-owned
- Teacher Language

SENSE-MAKING CLASSROOM

- Math as way of thinking
- Things make sense
- Significant Material
- Student is active
- Validated by Student
- Truth is as constructed.
- Student-Owned
- Student Language

TRADITIONAL V/S SENSE-MAKING

TRADITIONAL CLASSROOM

- Often forgotten
- Pops into existence
- Ignores readiness
- Non-experiential
- Present at Beginning
- Relies on Memory aids
- Isolated, Superficial
- Follows Procedures
- Anxious about Math
- Deadens mind & spirit

SENSE-MAKING CLASSROOM

- Remembered
- Grows into being
- Student readiness
- Experiential
- Develop at lesson end
- Minimal Memory aids
- Connected, thorough
- Develops Procedures
- Efficacy & Confidence
- Enlivens mind & spirit.

TRADITIONAL & RICH TASKS

TRADITIONAL TASKS

- Success in school
- Math Outcomes
- Relatively few skills
- Artificial, out of context
- Recollection, Practice
- Narrow range of performance
- Enrichment after task
- Few teaching strategies
- Distanced from task

RICH TASKS

- Success outside school
- Other subject areas
- Broad range of skills
- Authentic, in context
- Thinking, Reflection
- Wide range of performance
- Enrichment within task
- Wide variety strategies
- Engagement in task

LINGUISTICALLY DIVERSE STUDENTS

- Diagrams, Pictures
- Recall Number Line
- Understand Process
- Translating Difficult

- DRAW PICTURES AND SYMBOLS

Students can draw own diagrams to help translate word problem into visual.

- HELP TO SELECT THE CORRECT OPERATION

Able to solve algorithm but difficulty in deciding which operation to use.

- REINFORCE BASIC CONCEPTS

Do not assume sound number relationships.

Continually reinforce.

- USE ALL INFORMATION

Encourage use of all sources, including diagrams, to solve problems.

INTRODUCING NEW MATH CONCEPT

INDUCTIVE

- Linguistic Aspects
- General Principle
- Concrete materials to discover proof
- Many specific examples with concrete materials
- Students discuss what they discovered.
- Individual experiences into general rule.

DEDUCTIVE

- Reemphasize general principle or law.
- Demonstrate several specific examples.
- Students state principle and suggest examples.
- Students explain linguistic elements of the concept.

BRAIN-COMPATIBLE CLASSROOM THREE BASIC GOALS

- Increase student motivation by engaging students emotionally in learning.
- Master Math skills to level of proficiency that allows practical use of skill, creating meaning.
- Encourage higher-level thinking and connect new learning to prior knowledge in a complex manner.
- Improving motivation & engagement requires adding one simple thing to class – CHOICE!

STUDENT-CENTERED CLASSROOM

- Allowed some choice & decision-making through differentiated instruction.
- Higher-achieving students & test scores.
- Fewer classroom-management problems.
- More on-task behavior, fewer dropouts.
- Motivated learners actively process information, have better conceptual understanding of material, & show greater problem-solving skills.

LAYERING CURRICULUM – 3 STEPS

STEP ONE
ADD SOME CHOICE

- 2-3 Assignment Choices
- Teacher Lecture
- Small-Group Peer Work
- Hands-on Projects
- Independent Study
- Lecture Optional – Points

STEP TWO: HOLE STUDENTS ACCOUNTABLE FOR LEARNING

- Grade actual learning of objective

STEP THREE: ENCOURAGE HIGHER-LEVEL THINKING

- C Layer – (C Grade) Rote, Concrete - Entire class starts.
- B Layer – (B Grade) Problem Solving, Application, Mastery, Unique Creations
- A Layer –(A Grade) Critical Thinking, Values, Morality, Reflection, Essential Question

PLANNING THE MATH LESSON

Is the Lesson Memory-Compatible?

- CAPACITY LIMITATIONS

Keep items within limits.

Remember Less is More!

- TIME LIMITATIONS

12- to 15-minute segments

e.g. Direct Instruction, practice, research, computer

All teacher talk not effective.

Does the lesson have Cognitive Closure?

- INITIATING CLOSURE

Time to think about what was learned in the lesson.

- CLOSURE DIFFERENT FROM REVIEW

Student does the work by rehearsing, summarizing, thinking of questions.

- WHEN TO USE CLOSURE

Procedural Closure – During

Terminal Closure - End

PLANNING THE MATH LESSON

Will it take into account the PRIMACY-RECENCY Effect?

- Learning episode begins when student focuses on teacher with intent to learn.
- New information or new skill should be taught first: PRIME-TIME-1
- Most likely to be remembered.

- Students remember almost any information coming forth at this time.
- Important only CORRECT information.
- Don't start with incorrect guesses.
- Don't let prime-time get contaminated with incorrect information.
- CONSTRUCTIVIST approach not useful if no knowledge of concept.
- Cannot construct concept with ignorance.

PLANNING THE MATH LESSON

Will it take into account the PRIMACY-RECENCY Effect?

- **PRIME-TIME-1**
  - New Information
  - Minutes 0 – 15 or 20
- **DOWNTIME**
  - Practice
  - Minutes 15/20 - 30
- **PRIME-TIME-2**
  - Closure
  - Minutes 30 - 40

- New material followed by PRACTICE or REVIEW during DOWNTIME.
- PRACTICE helps organize for further processing.
- PRIME-TIME-2 – Cognitive CLOSURE takes place – determine sense and meaning.

PLANNING THE MATH LESSON

Should a Lesson Start with MATH Homework?

- Standard practice starts lesson by reviewing homework.
- Some CAUTIONS
- Because PRME-TIME-1 emphasize CORRECT solution to homework.
- Do not focus on student ERRORS.
- Do not check homework if merely to do it.
- If homework is checked, it should be SUBSTANTIVE (about its CONTENT).
- Get on with today's learning objective right away.
- Collect homework during DOWNTIME.

✓ **TEACH NEW MATERIAL FIRST during PRIME-TIME-1**

✓ Time of greatest retention.

✓ Good time to RETEACH.

PLANNING THE MATH LESSON

Should a Lesson Start with MATH Homework?

- ✓ **AVOID ASKING STUDENTS** if they know anything about a new topic. Almost any incorrect guess is likely to be remembered.
- ✓ **AVOID USING PRECIOUS PRIME-TIME-1** for classroom management tasks. Do before you get focus or at DOWNTIME.
- ✓ **USE DOWNTIME** to practice learning, discuss, etc. Retention does occur but takes more effort.
- ✓ **DO COGNITIVE CLOSURE DURING PRIME-TIME-2** Last opportunity to attach sense and meaning, and determine where it will be transferred to long-term memory.
- ✓ **LINK SUBLEARNINGS WITH CLOSURE**

PLANNING THE MATH LESSON

WHAT ABOUT PRACTICE?

- **SELECT SMALLEST AMOUNT OF MATERIAL**
  That will have maximum MEANING. Stay within limits of working memory.
  Excessive HOMEWORK
  - Erodes Motivation
  - Builds Frustration
  - Leads to Poor Attitude about studying Math.

- **MODEL APPLICATION STEP-BY-STEP** - Use concrete manipulative when possible.
  Builds visual/spatial representation.

- **INSIST PRACTICE OCCUR IN YOUR PRESENCE (Guided Practice)**
  Over short period of time while student is focused on the learning.

- **WATCH THE PRACTICE**
  Provide prompt & specific feedback.
  If guided practice is correct, assign limited independent practice.

PLANNING THE MATH LESSON

WILL WRITING BE INVOLVED?

- ✓ **WRITING** -
  As a KINESTHETIC activity, it engages more neurons and causes students to organize concept thought.
- ❑ **CLARIFY THE PURPOSE**
  Learning & Memory Tool
- ❑ **REVIEW VOCABULARY**
  Explain new Vocab words.
  Post chart with new words.
- ❑ **DISCUSS BEFORE WRITING**
  Talk about math ideas before.
- ❑ **WORK INDIVIDUALLY OR IN GROUPS**
  Discuss what they are writing.
- ❑ **ADD INTEREST - USE STUDENT'S IDEAS**
- ❑ **PROMPT WHEN NECESSARY**
  Prompts on the board: e.g "Today I learned _____. It is important to know because ____"
- ❑ **AVOID REWRITING /COPYING TEXTBOOK**
  Point is for brain to do elaborative rehearsal.
- ❑ **PROVIDE INDIVIDUAL ASSISTANCE**
  Repeat silently what they intend to write.

Overlapping MULTIPLE INTELLIGENCES & NCTM Process Standards (Sousa)

- LINGUISTIC
- LOGICAL/ MATHEMATICAL
- SPATIAL
- BODILY/ KINESTHETIC
- MUSICAL
- INTEPERSONAL
- INTRAPERSONAL

- Stories, Write, Define
- Numerical Data, Calculate, Categories
- Drawings, charts
- Use Parts of Body, Drama, Charades, People Action
- Songs, Rhythms
- Cooperative Groups
- Feelings, Think Aloud

DIFFERENTIATION (Sousa)

- CONTENT
- PROCESS
- PRODUCT

- READINESS
- INTEREST
- LEARNING PROFILE

- Implement gradually.
- Variety of materials & opportunities – Workstations
- Student options to choose.
- Bloom's Taxonomy – Various levels of difficulty/complexity
- Vary lesson delivery style
- Consider grouping students according to ability or interest.
- Several Assessment options.

FLOW of INSTRUCTIONAL CONSIDERATIONS

(Sousa)

PreK-1

- Build on Intuitions
- Number Sense
- Subitizing
- Counting
- Puzzles
- Activities that play into natural curiosity

Grades 2-4

- Gradually shift to intro symbolic representations
- Arithmetic symbols shortcuts for written arithmetic manipulation
- Continuously link symbolic knowledge to quantitative intuitions

FLOW of INSTRUCTIONAL CONSIDERATIONS

(Sousa)

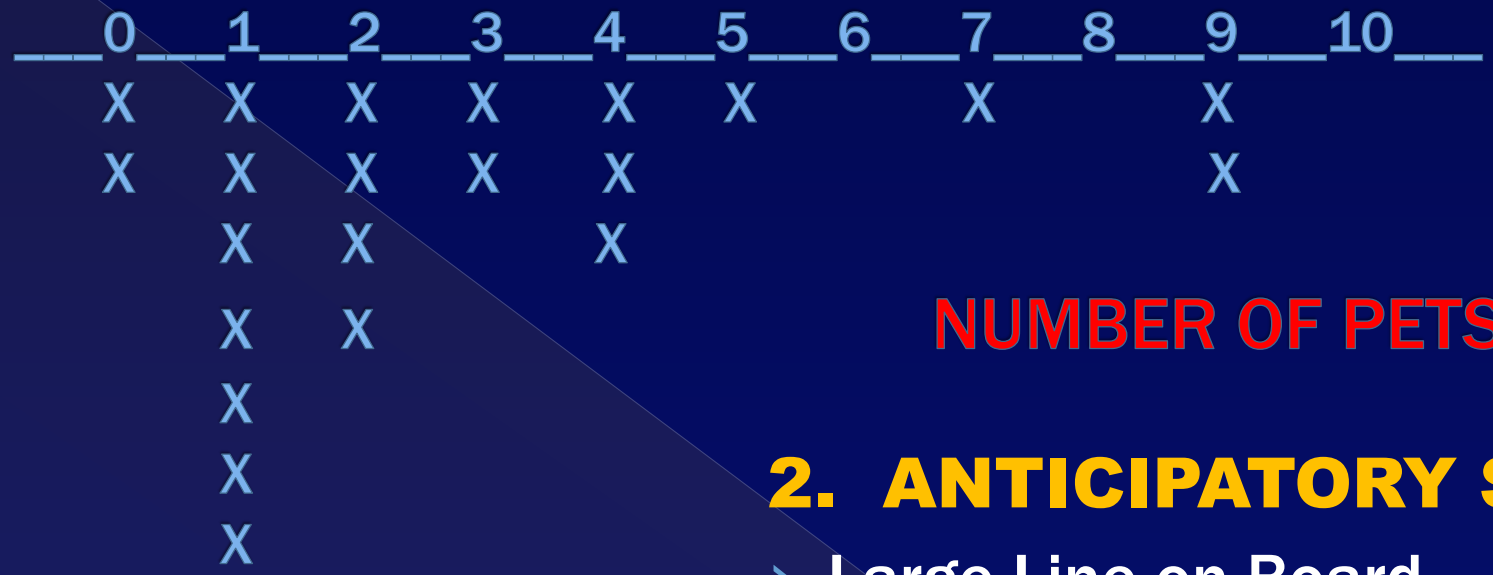
Pre-Adolescents

- Introduce & Explain arithmetic axioms
- Use concrete manipulatives
- Approaching critical time when students are turned off by abstract nature of symbolic math.

Adolescents

- Introduce & explain geometric & other mathematical axioms and theorems
- Show practical applications as much as possible.

SAMPLE LESSON: TERRIFIC T'S



1. OBJECTIVE

Students will display data on glyphs and learn to identify the mode.

2. ANTICIPATORY SET

- Large Line on Board
- Number 1 to 10
- Space as far as possible
- "How many pets do you have at your house?"
- Volunteers find number on board and STAND in front of it.
- Draw Line plot on Overhead

SAMPLE LESSON: TERRIFIC T'S

3. PURPOSE

- To learn more about each other by collecting DATA.
- Will be answering questions about themselves.
- Then organizing the DATA on PLOTS and GRAPHS.

4. INPUT

- Note Line on board.
- MODE is number that occurs most in set.

5. MODELING

- How many aunts do you have?
- Find number on board and stand in front of it.
- Draw new line plot.
- What is new MODE?
- Ask other questions.
- For each question, plot line on board.
- Identify MODE each time.

SAMPLE LESSON: TERRIFIC T'S

6. CHECKING FOR UNDERSTANDING

- Explain definition of MODE.
- Draw new line plot on overhead.
- Name MODE each time.
- Continue to MODEL more line plots as needed.

7. GUIDED PRACTICE

- TERRIFIC T'S GLYPH reproducible (Page 134)
- Transparency of page on overhead.
- Read each direction.
- Allow time to draw buttons, stripes, etc.
- Go up to board to graph results.
- Line plot on overhead.
- Identify MODE each time.

SAMPLE LESSON: TERRIFIC T'S

8. CLOSURE

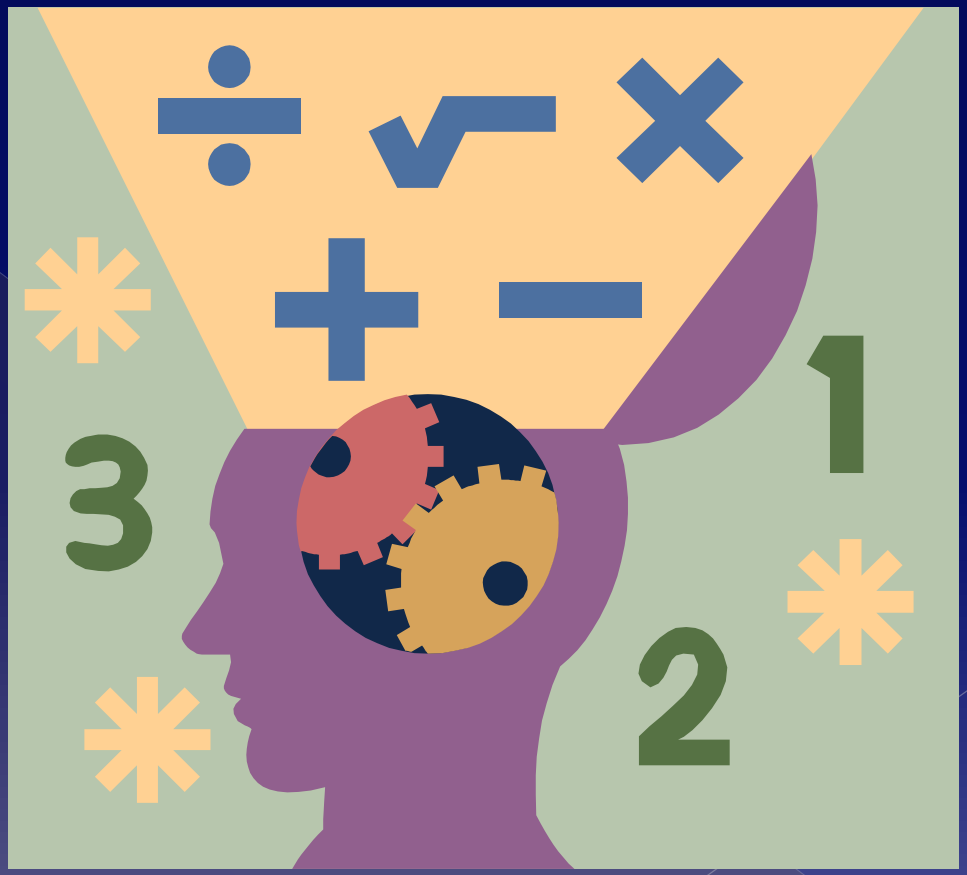
- Invite students to share their glyphs with the class.
- Write in their math journals what they learned about line plots and glyphs.
- Display glyphs on bulletin board.
- Discuss results.

9. INDEPENDENT PRACTICE

- **Take simple survey and collect data.**
- **Ask at least 5 people**
- **Family members, neighbors, friends.**
- **State number of brothers, sisters, pets.**
- **Draw line plot**
- **Determine mode.**

TRIED AND TRUE

STRATEGIES DEVELOPED AND PRACTICED IN GRADE 5 ACCELERATED MATH CLASS



ENGAGING MOMENTS

- DIRECTIONS AND PLAN FOR CLASS ALREADY ON BOARD.
- Walk around the classroom and connect personally with students as they enter.
- Train students to immediately put out pencil, highlighter, journal, homework.
- **SIGNAL TO BEGIN PRIME-TIME-1**

  (Clever gesture, gadget, rhyme, phrase, etc.)

TC = TEACHER - CLASS
I = INDEP. PRACTICE
G = PARTNER
TRIADS
GROUPS
TC-2 = CLOSURE

BOARDS NOT BOREDOM

CLASS WHITEBOARDS

- Color Dry Erase Markers
- Pairs of Students display showing of work as answer keys
- Model Presentation
- Teams Take Turns

HAND HELD WHITEBOARDS

- Quick individual response
- SHOW WORK Practice
- Value of Presentation
- Pair/Team Responses
- Encourage Questions

ENGAGEMENT APPLICATIONS

OVERHEAD PROJECTOR

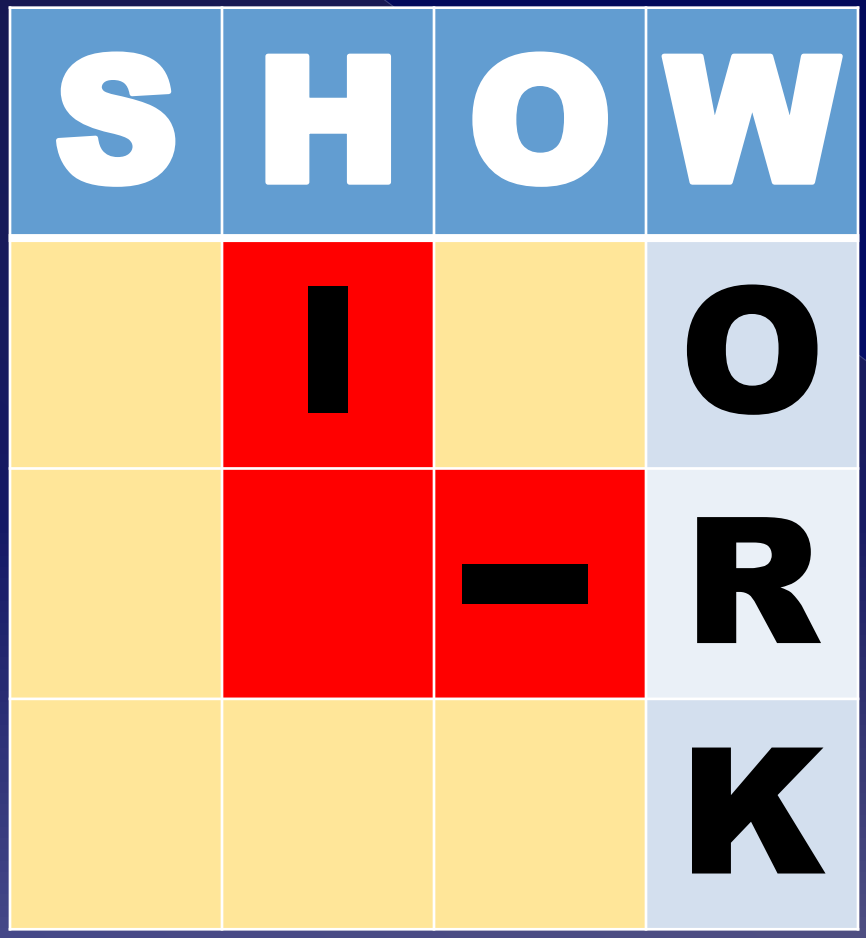
- Use of Varied Color in Overhead Markers
- Clever amusing images
- Step By Step Writing increases curiosity for what comes next.
- PRE-MADE with Graphics and copies for Students
- Engagement code check symbol

SPONTANEOUS ENGAGEMENT CHECK

- "Gauge Check" with student THUMB signal
- UP – Engaged
- DOWN – Disengaged
- SIDE – Neutral

- Hold Up Amusing object to indicate pause/check

SHOW WORK



- CLEVER SIGNS TO REMIND FREQUENTLY

RHYTHMIC/REPETITION

SPELL WORD With GESTURES That Relate TO LESSON

- **“A-C-U-T-E”**
  Sharp Quick Clap
- **“O-B-T-U-S-E”**
  Vocal Drawl
  Wide Arm Spread

“PEMDAS”

- Parentheses
- Exponents
- Multiply
- Divide
- Add
- Subtract

CLEVER QUESTION

- **Put a clever question on individual whiteboard to draw attention.**

GEOMETRY

"How did the word BASEMENT gets its name?"

"How would you measure the VOLUME of an Easter Egg?"