


## ▾ **Nothing Works! The Art of Teaching Mathematics**

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## ▾ **The Art of Teaching**


- Find your profile!
- ▾ Example
  -  Pasted Graphic
- ▾ More examples
  - ▾ staying within math vs. making connections
    - ▾ over-prepared vs. winging it
      - ▾ routine vs. variety
        - ▾ enjoyment vs. learning
          - ▾ correct vs. incorrect answers
            - intrinsic vs. extrinsic motivation
- ▾ Lose your profile!
  - Learn to navigate along these axes





## ▾ **Nothing Works**

- ▾ Heterogeneous Classes
  - [All classes are heterogeneous](#)
- ▾ Pedagogy
  - ▾ Alliance with the strongest students
    - Support for the weakest
  - ▾ The elevator strategy
    - ▾ Stop on all floors
      - Something too difficult
      - Something too easy
      - Something "just right"
- ▾ Pacing

- Constant forward motion
    - Eternal review
- Curriculum
      - "Vertical" activities which provide both access and challenge
        - "No threshold, no ceiling"
        - Example: what perimeters are possible for a given graph paper shape?
          - Many more examples on my Web site
    - Tools
    - Manipulative and technological tools
      - Calculator: TI-89
      - Manipulatives: cubes, geoboards, Lab Gear, pattern blocks, ten-sided dice, ...
      - Software: Cabri, Fathom, ...
    - Multiple representations of concepts
      - Numeric, symbolic, graphical, geometric, applied, ...
        - To provide an entry point to more students
          - To preview or review concepts
            - To extend exposure
              - To deepen understanding
                - To increase variety
                  - To promote engagement
    - However...
      - tools are not magic
  - Group Work
    - Random groups
      - new groups every 2 weeks
    - Students mostly work independently
      - are expected to help each other
    - If a group does not function well
      - I intervene directly to get the behaviors I want

- ▾ If more than one group is stuck
    - I stop them all for a class discussion
    - guide on the side vs. sage on the stage
  - ▾ Discovery
    - ▾ Discovery vs. Direct Instruction
      - ▾ A false choice: neither works well without the other
        - ▾ **After exploration, "institutionalization"**
          - ▾ Make key concepts explicit
            - students may not get there on their own
          - ▾ Clarify what is important and worth remembering
            - and thus worth writing down
          - ▾ Make connections
            - with other representations
            - with previous knowledge
            - **"Nothing transfers"**
  - ▾ Verbalizing
    - ▾ Putting things in words is crucial to understanding
      - I encourage talking
      - I require writing
- ▾ Class Discussion
  - ▾ True Discussion vs. Interactive Lecture
    - Open-ended questions
  - ▾ Creating a safe environment
    - No putdowns
    - ▾ I praise participation and risk-taking
      - rather than correct answers
      - "Tell your neighbor..."
      - "Can you restate what X said?"
  - ▾ Handling wrong answers
    - ▾ write down many answers, then discuss
      - ▾ poker face vs. telling
        - ▾ "Choose someone to help you"

- Making 'mistakes' myself
- ▼ Feedback from all
  - ▼ votes
    - ▼ gestures
      - writing
- ▼ Variety
  - ▼ Fanfare vs. total silence
    - ▼ New problems, not same as on paper
      - Move around the room
- ▼ Homework
  - ▼ I keep it reasonable
    - most learning happens at school
  - ▼ I keep it separate from class work
    - less rushing, more cooperation
  - ▼ "Lagging"
    - ▼  Pasted Graphic
      - (constant forward motion, eternal review)
- ▼ Assessment
  - ▼ Purpose
    - ▼ To improve teaching
      - ▼ Diagnose student understanding and skills
        - Figure out next steps and generally fine-tune the course
    - ▼ To improve learning
      - ▼ Let students know where they are
        - Provide learning opportunities
    - ▼ Also...
      - ▼ Prepare students for future assessments (!)
        - ▼ Rank students / assign grades
          - Justify the grades
  - ▼ Variations on the quiz/test routine
    - ▼ Participation quiz
      - ▼ Occasional take-home assignments
        - Test corrections
  - ▼ I keep it manageable

- ▼ I give homework a quick look
    - I don't write extensive comments on tests
  - ▼ because...
    - ▼ When correcting work, I'm working for one student
      - ▼ When planning, I'm working for the whole class
        - A true passion for math and learning is not triggered by assessment or grades
  - ▼ Sequencing topics
    - ▼ Overall
      - ▼ The weight of tradition
        - quadratic formula in Algebra 1,
        - exponential functions in Algebra 2
      - ▼ Topics can and should move if they are
        - too early (with respect to student's development)
        - too late (more accessible thanks to new approaches)
    - ▼ Within a course
      - ▼ do important and/or difficult topics early
        - Example: inscribed angles near beginning of Geometry  
 Pasted Graphic
      - ▼ separate related topics
        - tangent / sine and cosine
        - exponentials / logarithms
        - sequences / series
  - ▼ Navigating a topic
    - ▼ concrete to abstract, and back
      - ▼ positive whole numbers to rational numbers
        - ▼ numbers to variables
          - ▼ discrete to continuous
            - Example: [the Pythagorean theorem on the geoboard](#)  
 Pasted Graphic 
    - ▼ concepts to vocabulary and notation, and back
      - Example: [trig ratios on the ten-centimeter circle](#)  

    - difficult to easy, and back
- ▼ Teaching for Understanding
  - ▼ Skills vs. concepts

- Another false choice!
- ▾ In part because of technology,
  - ▾ speed and accuracy are no longer legitimate priorities for math education
    - understanding is more important than ever
- ▾ A student who understands a concept can
  - explain it
  - ▾ reverse processes associated with it
    - distribute  $\leftrightarrow$  factor
  - ▾ flexibly use alternative approaches
    - e.g. to equation solving
    - successfully handle non-rote assessments
    - navigate between multiple representations
- ▾ Understanding...
  - ▾ is difficult to encapsulate in a checklist
    - ▾ cannot be easily conferred by explanations
      - ▾ is difficult to assess
        - ▾ is not always valued by students and parents
          - is the most important part of our job
- ▾ Nothing works...
  - ...for every student, every class, every teacher, every day
  - ▾ I am skeptical of claims that some particular approach is the answer
    - whether 'traditional' or 'reform'
  - ▾ I don't throw away or rule out any technique
    - ▾ I try to constantly broaden my repertoire
      - I am eclectic

## ▾ **The Art of Learning**

- ▾ Teaching / Learning
  - ▾ In the end, there is no teaching...
    - ...only learning
    - Thus the goal: self-motivated students

- ▾ Our own learning
  - ▾ about math
    - ▾ about learning
      - is what makes the job interesting in the long haul
- *There is no one way*