Spatial Reasoning

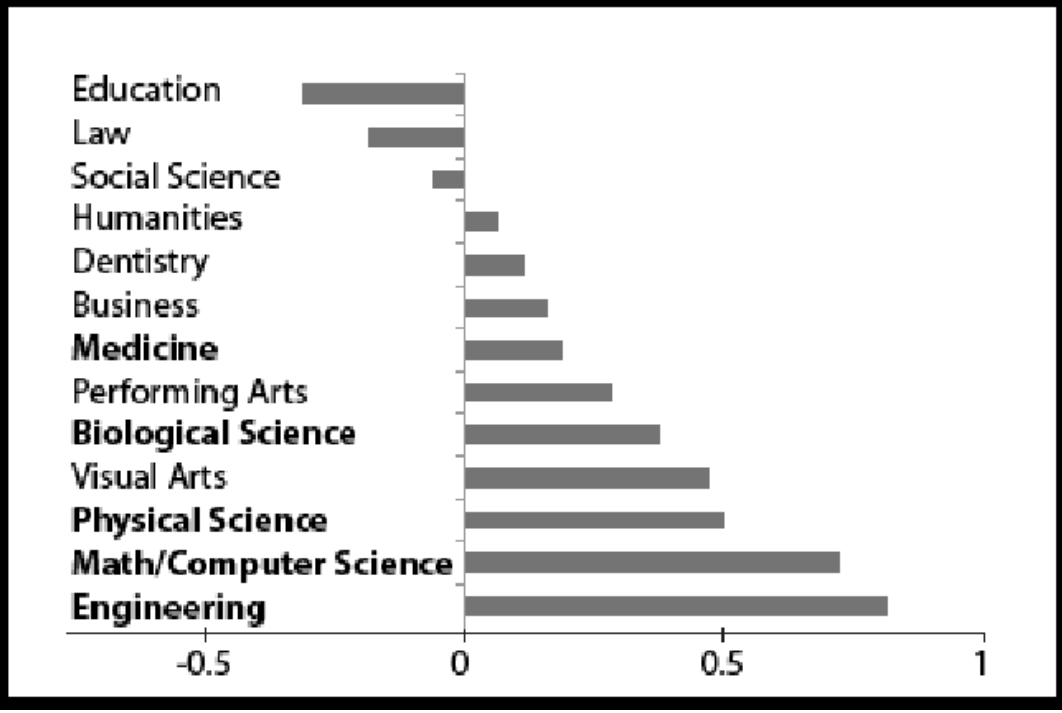
- The ability to think in terms of spatial information, such as shape and orientation
- Includes
  - Regressing from image to 3D model
  - Representing a concept as a spatial model
  - Manipulating spatial models in the mind

On a scale from 1 to 10,
where 1 is non-spatial fields like singing
and 10 is highly spatial fields like sculpture,
how spatial is computing?

8 7 3 10 10 10 9

Spatial Reasoning in CS

- Correlation between HS spatial ability and career choice



Spatial Reasoning Matters

- Correlates with ability in many fields, including computing
- Correlation appears causative (increasing spatial reasoning skills has been shown to increase performance in related fields, including computing courses)

Why Does it Matter?

- Definitive answer not known
- Some ideas:
  - We teach concepts visually
    - Variables = boxes, addresses = arrows, …
  - Computing terminology is visual
    - Stacks, trees, threads, flow, branching, nesting, lining up, moving, addresses, …

Why, continued

- Challenge: find a computing concept that is not visual in terminology and that you can explain without a spatial analogy

Binary

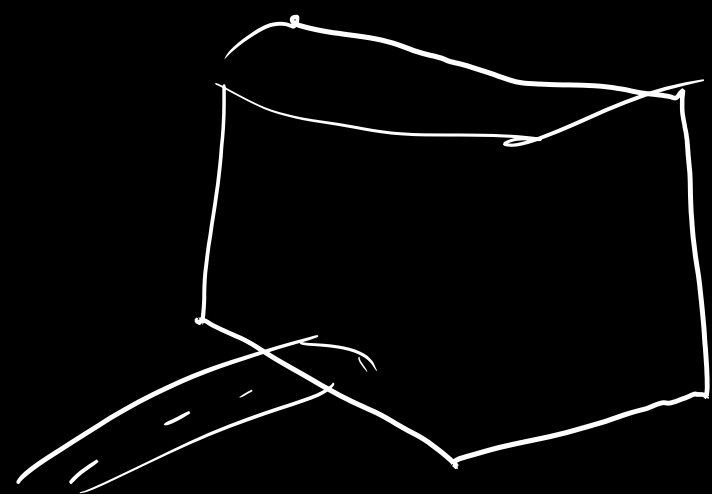
abstraction

Alonzo Church / Alan Turing

λ-calculus

TM

$\lambda x.x$

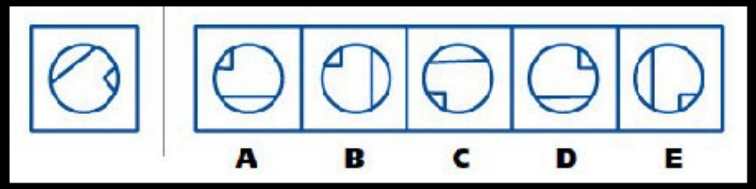


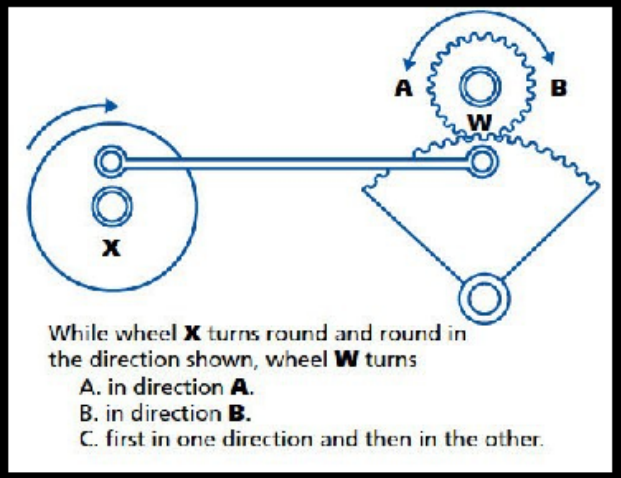
Boys Have the Advantage

- Taken as a group, boys have more skill at spatial reasoning than girls
  - Better are rotation and mechanical reasoning
  - Not better at folding, pattern matching, cross sectioning
  - Training can narrow gap

Boys Have Some Advantage

Advantage

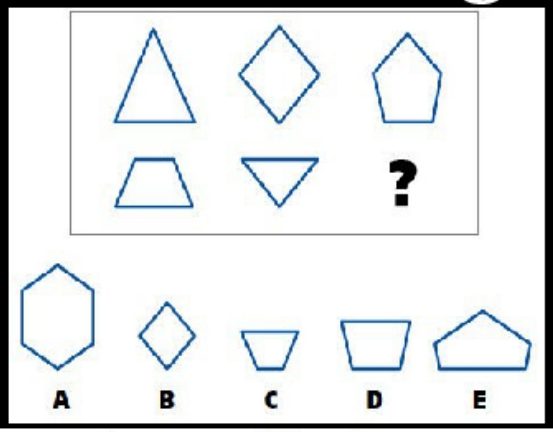


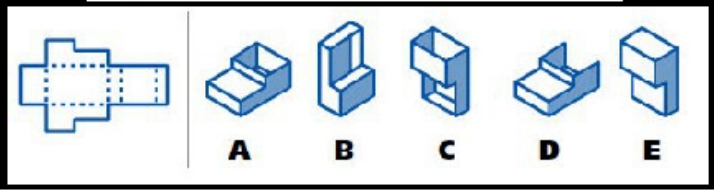


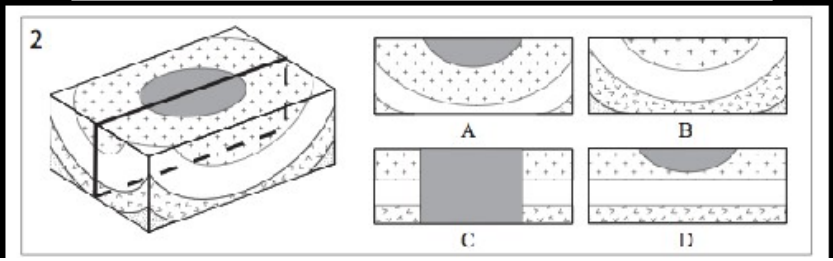
While wheel **X** turns round and round in the direction shown, wheel **W** turns

A. in direction **A**.
B. in direction **B**.
C. first in one direction and then in the other.

No advantage







Differences

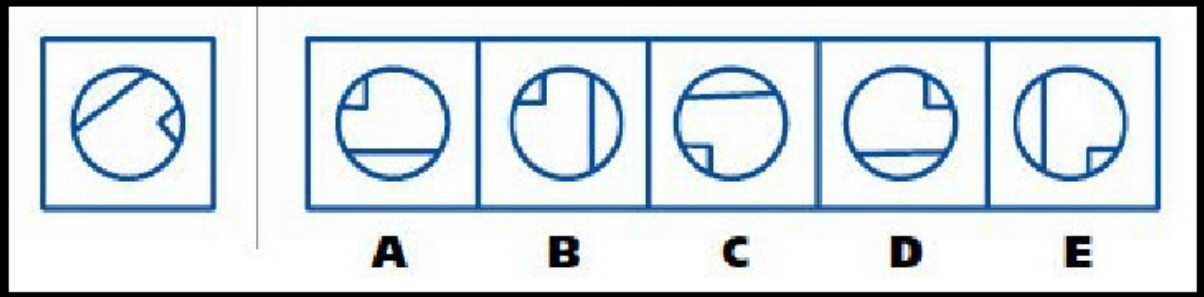
- Boys better at spatial reasoning at early age
- Higher economic class, more different genders are
- Experience definitely important

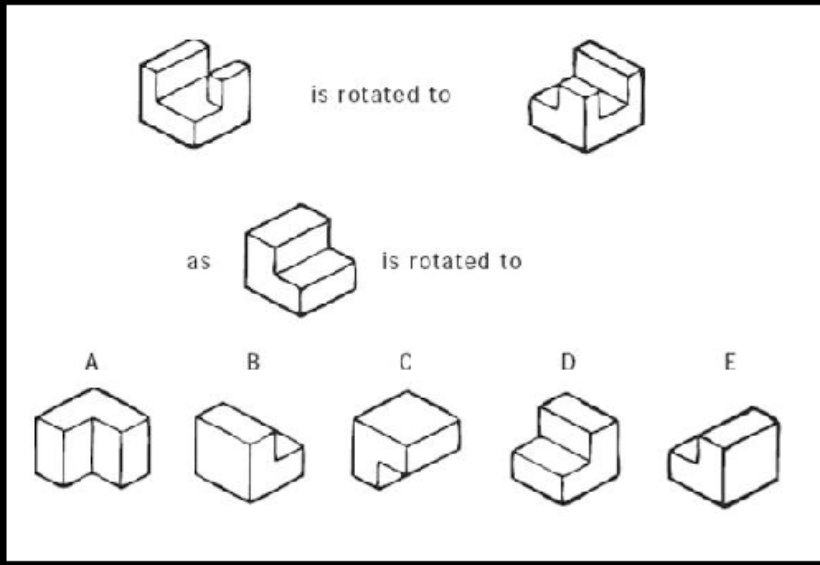
Spatial Experience

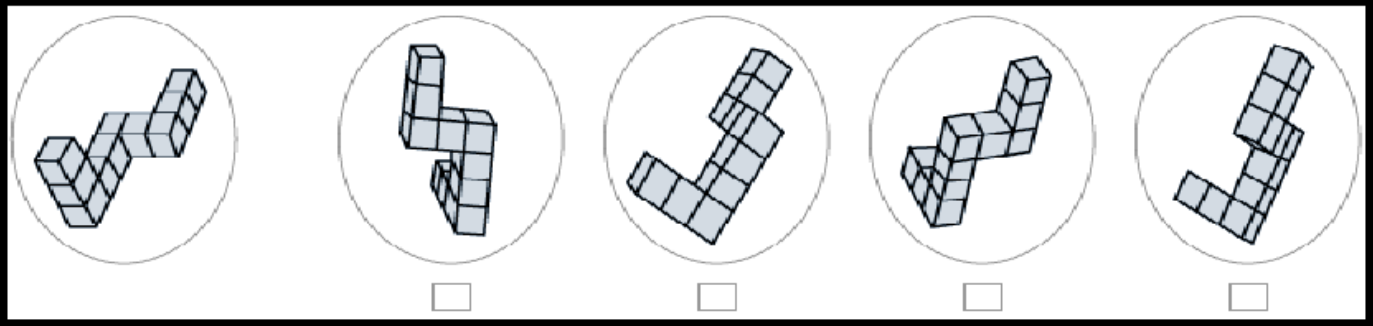
- Construction toys
- Shop, drafting, mechanics classes
- Some computer games
  - Especially 3D first-person shooters
  - Also geometric ones like Tetris
- Sketching
- Some ball sports, mathematics classes

Measuring Spatial Skill

Rotating

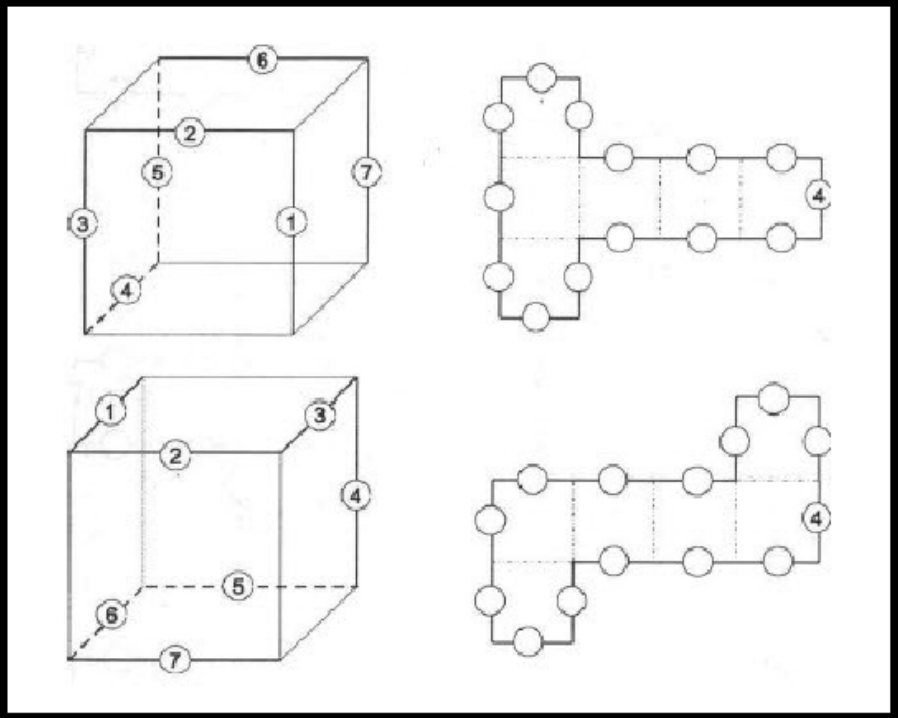


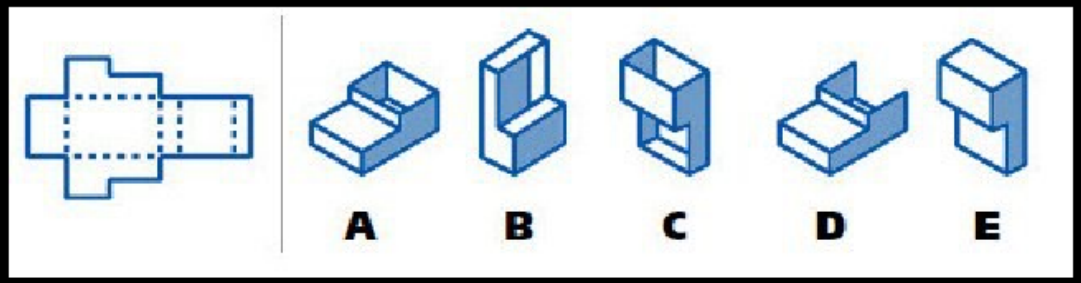




Measuring Spatial Skill

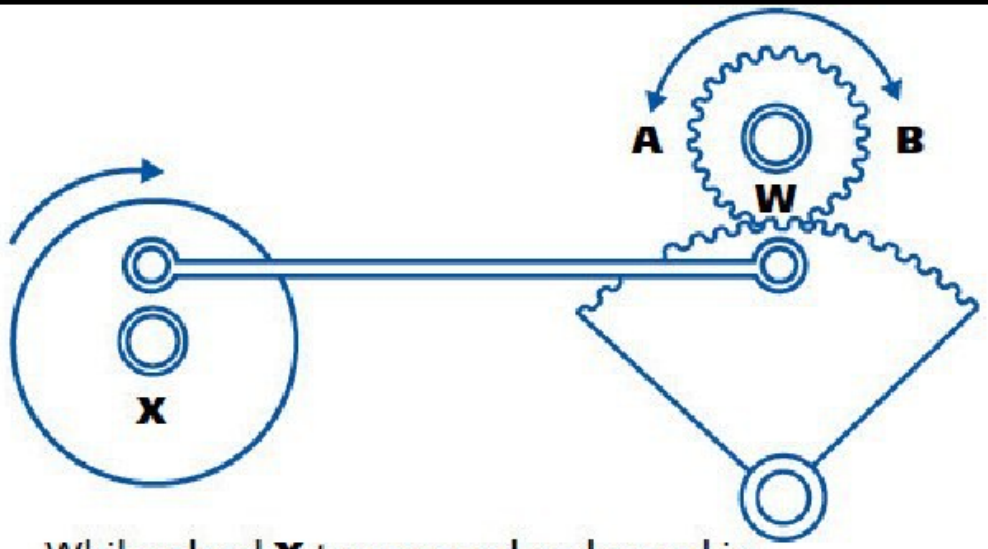
Folding





Measuring Spatial Skill

Mechanisms



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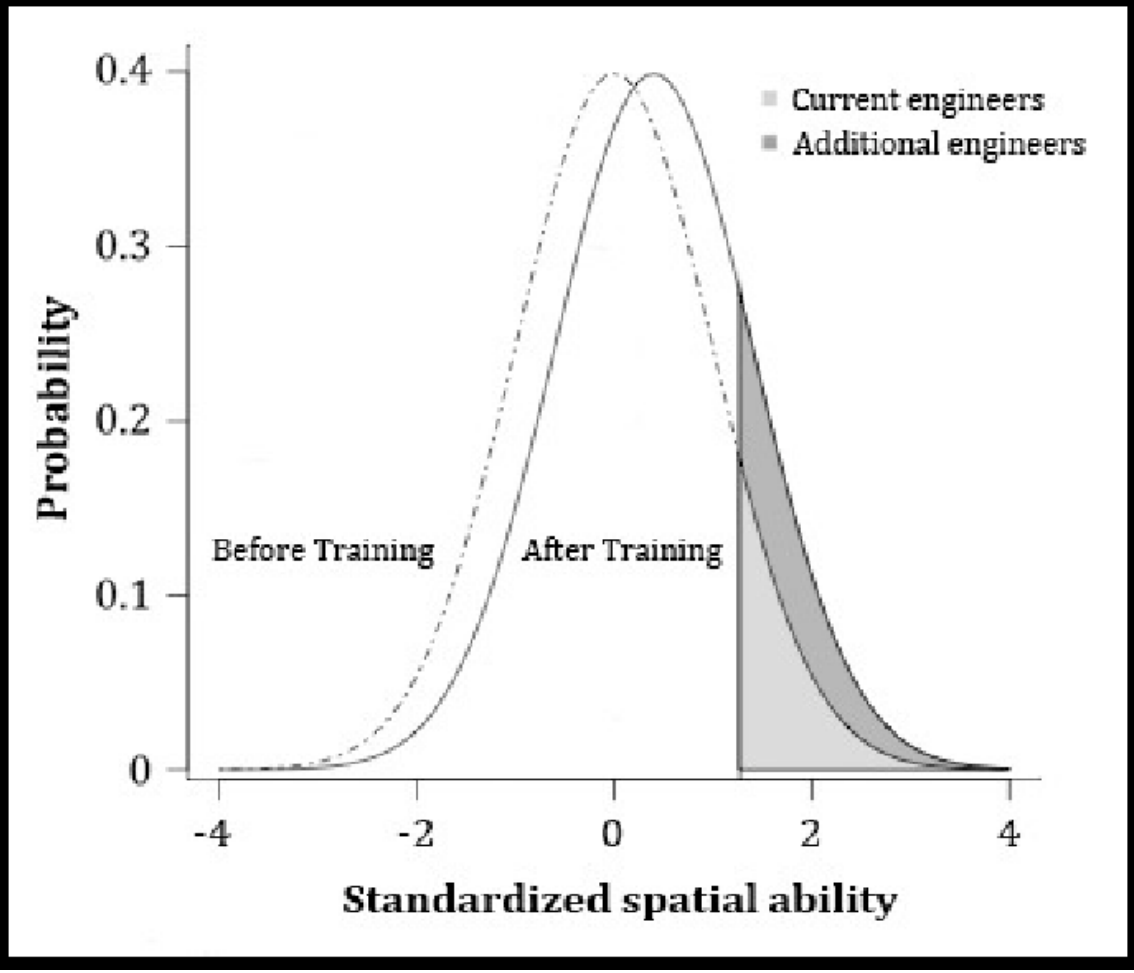
Small Change = Big Impact



How do you increase it?

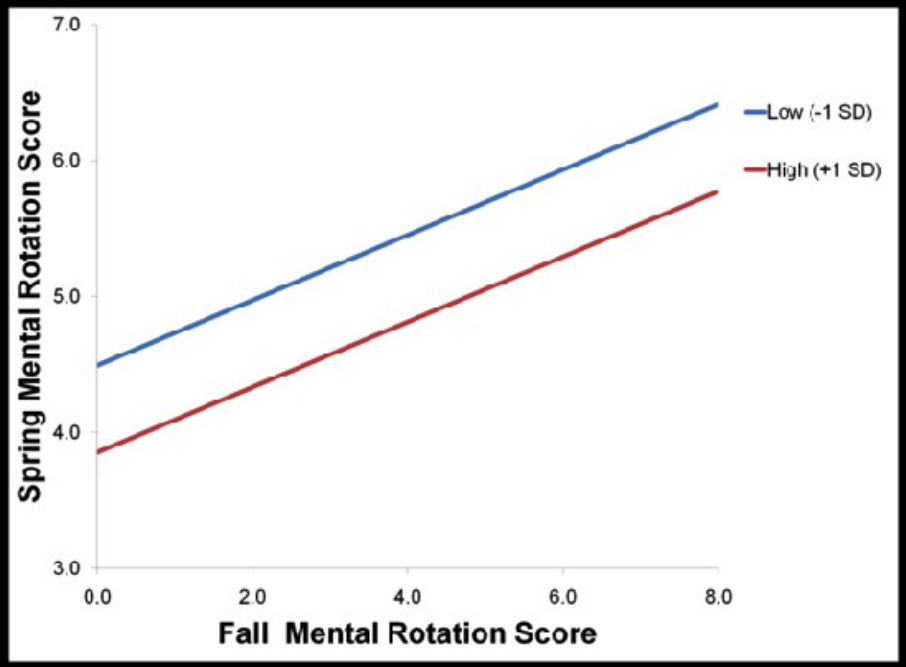
- Provide exposure
  - Logic group activities
  - Draw when teaching and have them draw
- Manipulatives
  - Physical objects in lesson
  - E.g., if variables are boxes, bring in boxes
  - Also good to, e.g., cut the cutting tasks, rotate the rotating tasks, etc.

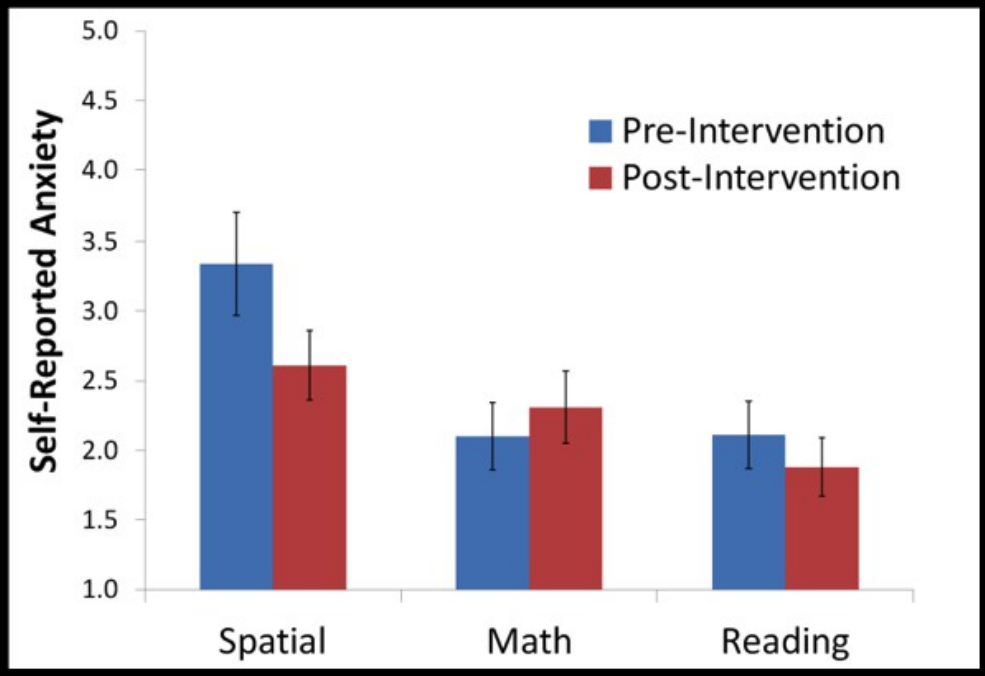
How do you Increase it?

- Teach process (use-modify-create)
  - Discuss the process of solving a spatial task
  - Work through a few examples
  - Provide a set of decreasingly similar tasks
- Interventions
  - Colleges have had success with 1-credit remedial spatial skills courses

Teacher ability matters too

- Teacher spatial anxiety correlated to end-of-year student spatial ability





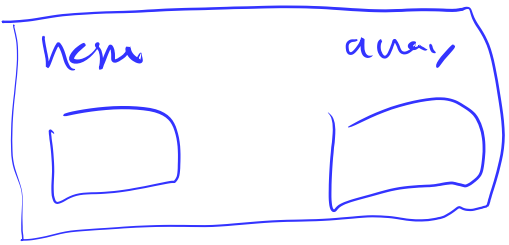
Activities

4 Eqlar Δ edge 1 Tourniquet

$$f(x) = \begin{cases} 1 & x \leq 1 \\ f(x-1) + f(x-2) & \text{otherwise} \end{cases}$$

Variable
→ box

Scoreboard



$f(3) + f(2) + f(2) + f(1)$

~~$f(4) + f(3)$~~

~~$f(5)$~~

Prerequisites

listed

assumed

Geometry
Pre calc

hidden
1
Spatial

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