HOW DO WE LEARN MATH?

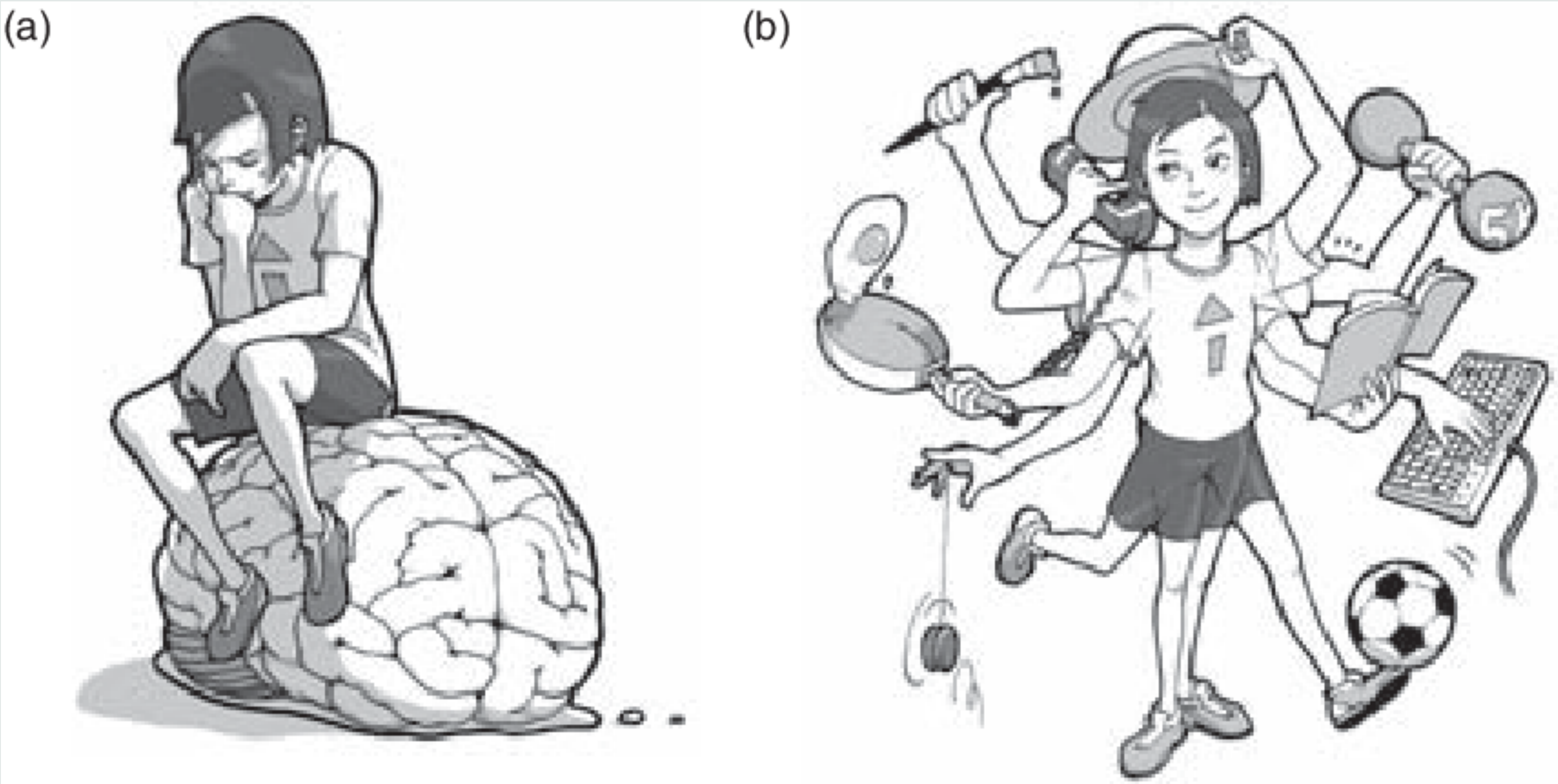
Lecture 18 – 17th May 2023

Technology in Mathematics Education

DIFFERENT FRAMEWORKS

- Embodied cognition
- Learning styles
- Multiple intelligences

EMBODIED COGNITION

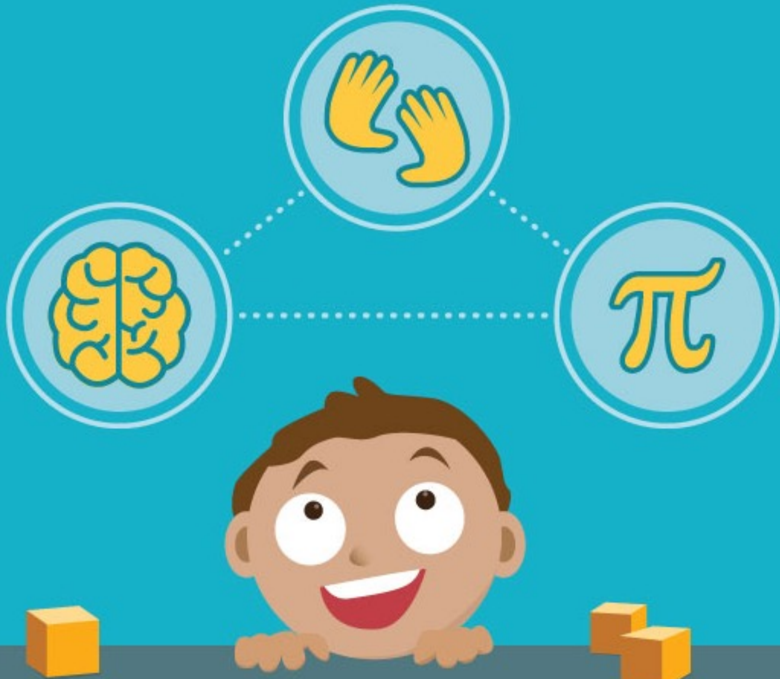


R. Pfeifer, J. Bongard (2006)

Digital Manipulatives and the

MIND-BODY-MATH

Connection in the Digital Age



We don't just learn with our brains, but with our bodies as well. Our brain and body work together to help us learn. Scientists call this embodied cognition.

Learning with our bodies helps us:

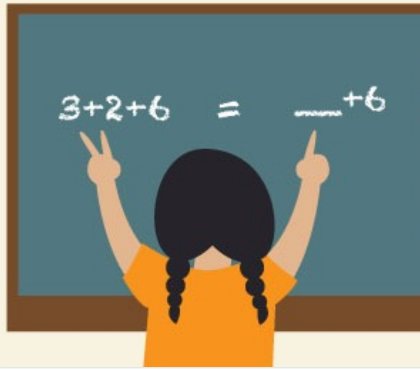
Remember what we learned

Transfer knowledge

Real-world examples

Mind-body connection in math

Using fingers for arithmetic helps students connect their real world fingers with the abstract numbers.
Manipulatives lessen the cognitive load and make learning concepts easier.



Students pointing their fingers this way as they solve mathematical-equivalence problems can help them discover the grouping strategy.

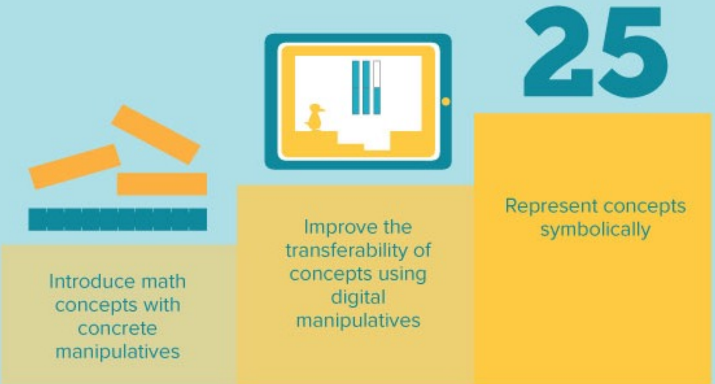
Hold! Rotate! Turn! Tap!

Why use math manipulatives?

- To develop abstract reasoning
- To interact with the math concept concretely, not just symbolically
- To allow learners to discover math concepts on their own, making it easier to later retrieve knowledge

Scaffolding with Manipulatives

How students can be guided towards mastery



From Physical to Digital

Limitations of Physical Manipulatives

- Manipulatives that are too realistic can hinder learning
- Scaling ideas like exponential growth can be difficult with physical manipulatives
- Informative feedback can be dependent upon the teacher's time, and may not be immediate

Benefits of Digital Manipulatives

- Congruent gestures (tapping, sliding and rotating) can be appropriately matched to the math concept
- Screens or virtual reality technology can provide immersive environments
- Informative feedback can be provided instantly

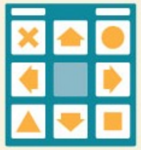
Get Moving with Technology

New ways to learn using hands and bodies

Touchscreens

Involve gestures like tapping, sliding, rotating

Digital Sensors *(like dance mats)*

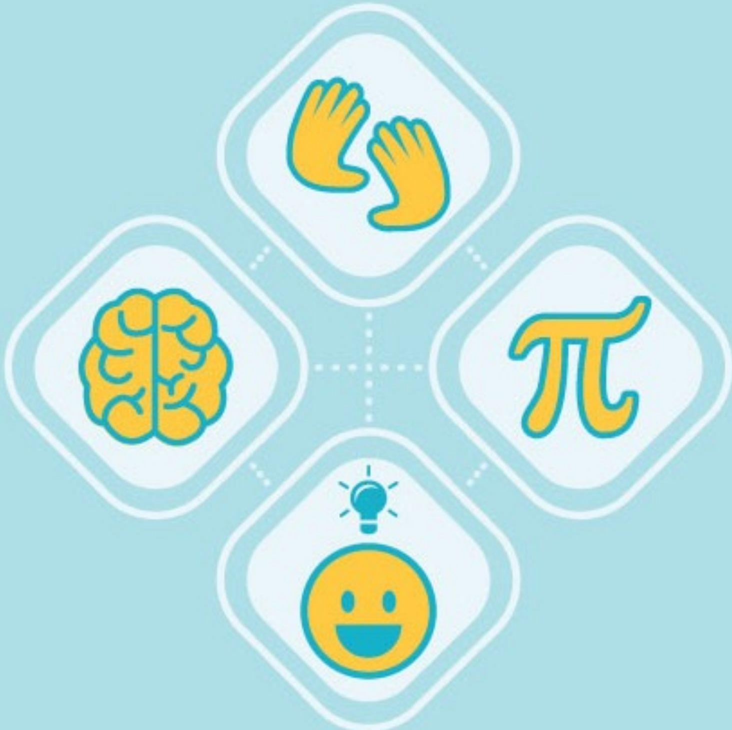


Allow full body movement

3D Printers

Produce handheld manipulatives

Putting Embodied Cognition to Work



Both physical and digital manipulatives can put embodied cognition to work in the classroom. To maximize the benefits, carefully choose manipulatives that complement the math concept!

LEARNING STYLES

The VISUAL LEARNER

Characteristics

1 Sees to learn
You learn by seeing things. You like to take in information by reading and/or through diagrams and pictures.

2 Likes images
You prefer to see rather than listen. Colour, diagrams and pictures help you stay interested.

3 Takes notes
You usually take detailed notes in lectures, tutorials and meetings.

4 Looks around
You tend to start looking around for something to watch or look at when you lose interest.

5 Struggles with ...
You can find spoken directions hard to remember and you are easily distracted by noise.

Learning Tips

Watch 1
You will take in spoken information better if it is accompanied with visual aids. Video is a great learning tool for you.

Visualise 2
Try to visualise things that you hear. This will help you remember them better.

Write it down 3
Write down key words, ideas or instructions, particularly if they are only being given orally.

Draw 4
Consider using drawings, mind maps and flow charts to help explain and remember new concepts.

Colour 5
Use colour. Colour code, highlight, circle and underline words in your notes.

Doesn't sound like you? Most people are a mixture of styles. Check our other infographics on learning types.
www.workreadytraining.com.au

Work Ready Training

The AUDITORY LEARNER

Characteristics

1 Hears to learn
You learn by actively hearing and listening. You are likely to be good at remembering conversations and the words to songs.

2 Likes listening
You prefer to listen to instructions rather than read them and you may not take notes. You like music.

3 Good talker
You are likely to be good at talking slowly and explaining things to people. You may be good at presenting.

4 Chatterbox
You tend to start chatting when you lose interest in what's being taught and may have been told off for talking at school.

5 Struggles with ...
You get very distracted by noise and may read slowly. You may find complicated diagrams difficult to interpret.

Learning Tips

Watch 1
You will take in information better if it is accompanied with audio. Video is a great learning tool for you.

Say 2
Try reading out loud the information you want to take in.

Repeat 3
To remember facts, try repeating or chanting them with your eyes shut.

Discuss 4
Talking through new concepts and ideas with a group and attending Q&A sessions will be productive learning activities for you.

Avoid noise 5
If you are trying to learn, find somewhere that is quiet and away from other people.

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www.workreadytraining.com.au

Work Ready Training

The READ WRITE LEARNER

Characteristics

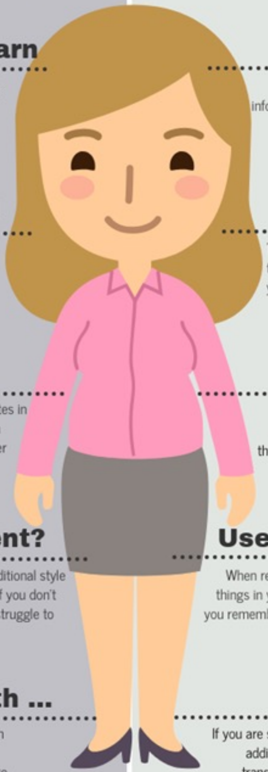
1 Studies to learn
You learn by reading and writing and fit well into the traditional style of learning by using books and writing notes.

2 Likes to read
You prefer to read or write down something to learn it. You like essay questions and books and will look words up in dictionaries.

3 Big on notes
You are likely to take loads of notes in meetings, at presentations and in class. This helps you to remember what is being said.

4 Perfect student?
You tend to stay interested in traditional style presentations or classes, except if you don't have a pen and paper! Then you struggle to take it all in and get distracted.

5 Struggles with ...
You tend not to learn well through diagrams. You may also find disorganised presentations hard to follow.



Learning Tips

Read 1
Obviously! You will take in information better if you read it yourself. Hold on to your handouts and notes.

Take notes 2
This is so important for you as the act of writing notes makes you remember. Always carry a pen and paper and write everything down.

Re-write 3
Once you've taken notes, re-write them. This repetition is the best way to get information to stay in your brain.

Use your words 4
When re-writing your notes, try to put things in your own words. This will help you remember concepts and facts better.

Translate 5
If you are struggling with a diagram, try adding notes to explain it or even translating it into your own words.

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www.workreadytraining.com.au

Work Ready Training

The TACTILE LEARNER

KINESTETIC

Characteristics

1 Moves to learn
Also known as a kinaesthetic learner, you learn by touching and doing. You favour physical movement and are probably good at sport.

2 Likes hands-on
You prefer to move, build, touch and draw, rather than listen or watch. You like to try something for yourself.

3 Does to remember
You remember things best when you have done them yourself, for example cooking a meal or fixing an engine.

4 Gets fidgity
You tend to start fidgeting when you've had to sit still for too long or when something is getting boring.

5 Struggles with ...
You may suffer from a short attention span and can find it difficult to sit still.

Learning Tips

Examples 1
Training that uses examples and case studies to explain concepts will be easier for you remember.

Discuss 2
Try discussing what you have learned with someone. This can help you remember things better.

Get active 3
You will take information in better if it is accompanied with activity. Try active learning, like role plays and problem solving.

Move 4
Move while you study. Tap a pencil (if appropriate), squeeze a ball, shake a foot. This can help to keep you focused. Typing can also help reinforce learning.

Take breaks 5
Don't attempt marathon study sessions. You work better in short, frequent bursts. Do something physical in your breaks.

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Work Ready Training

Learning Styles

VERBAL

Words are your strongpoint! You prefer to use words both in speech and in writing!

VISUAL

You prefer to use pictures, diagrams, images and spatial understanding to help you learn

MUSICAL / AUDITORY

You prefer using sounds or music or even rhythms to help you learn.

PHYSICAL / KINAESTHETIC

You use your hands, body and sense of touch to help you learn. You might 'act things out'.

WHAT'S YOUR LEARNING STYLE?

LOGICAL / MATHEMATICAL

Learning is easier for you if you use logic, reasoning, systems and sequences.

SOCIAL

You like to learn new things as a part of a group. Explaining your understanding to a group helps you to learn.

SOLITARY

You like to work alone. You use self-study and prefer your own company when learning.

COMBINATION

Your learning style is a combination of two or more of these styles.

The **verbal learner** remembers what is read or spoken. They usually do well in settings that emphasize reading.

The **visual learner** learns from what is seen, especially diagrams and pictures.

The **musical/auditory learner** listens to the rhythms of words and can memorize facts and dates with jingles or raps.

The **physical/kinesthetic learner** learns from movements, such as writing flashcards or out a historical event.

The **logical/mathematical lea rner** is good at logical puzzles and mathematical operations.

The **interpersonal, social learner** is sensitive to the feelings of others and does well in a group.

The **intrapersonal, solitary learner** is more reflective, preferring to work alone

https://www.learning-styles-online.com/inventory/

MULTIPLE INTELLIGENCE

H. Gardner (1993)

Verbal-linguistic intelligence, **"word smart"**, refers to an individual's ability to analyze information and produce work that involves oral and written language.

Logical-mathematical intelligence, **"maths smart"**, describes the ability to detect patterns, reason deductively and think logically, make calculations, and solve abstract problems.

Visual-spatial intelligence, **"picture smart"**, describes the ability manipulate and create mental images in order to solve problems and reason, to visualize concepts and space.

Musical intelligence, **"music smart"**, involves skill in the performance, composition, and appreciation of musical patterns. It encompasses the capacity to recognize and compose musical pitches, tones, and rhythms.

Naturalistic intelligence, **"nature smart"**, refers to the ability to identify and distinguish among different types of plants, animals, and weather formations found in the natural world.

Bodily-kinesthetic intelligence, **"body smart"**, entails using one's own body to create products or solve problems.

Interpersonal intelligence, **"people smart"**, reflects an ability to recognize and understand other people's moods, desires, motivations, and intentions.

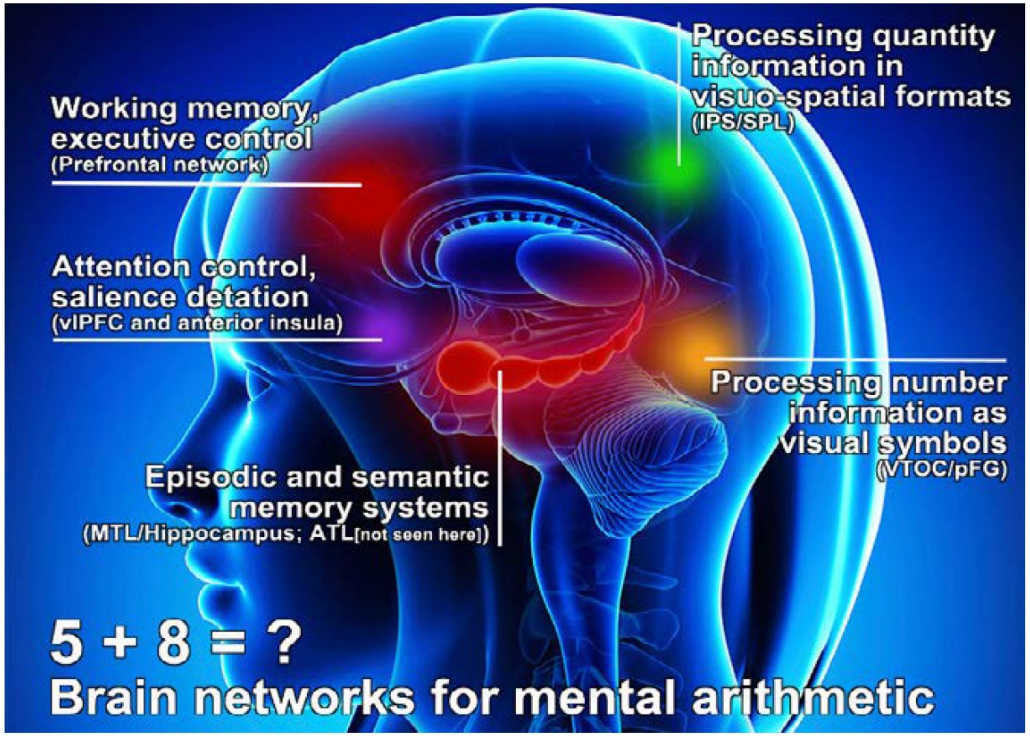
Intrapersonal intelligence, **"self smart"**, refers to people's ability to recognize and assess those same characteristics within themselves.

These intelligences, although separate, work together, in an infinite number of combinations, in each of our learning experiences.

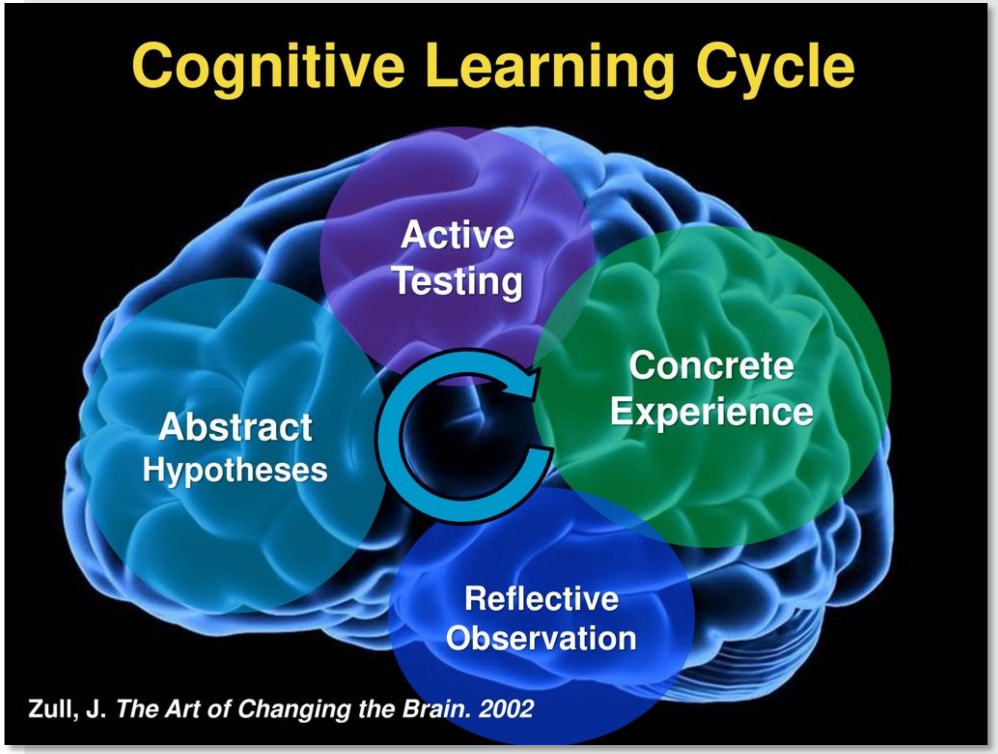
Gardner sustains that although we all possess these intelligences they do not develop in the same way and at the same pace in every individual. Some may "by nature" be stronger and more dominant than others at any given time of our evolution, but all can be strengthened.

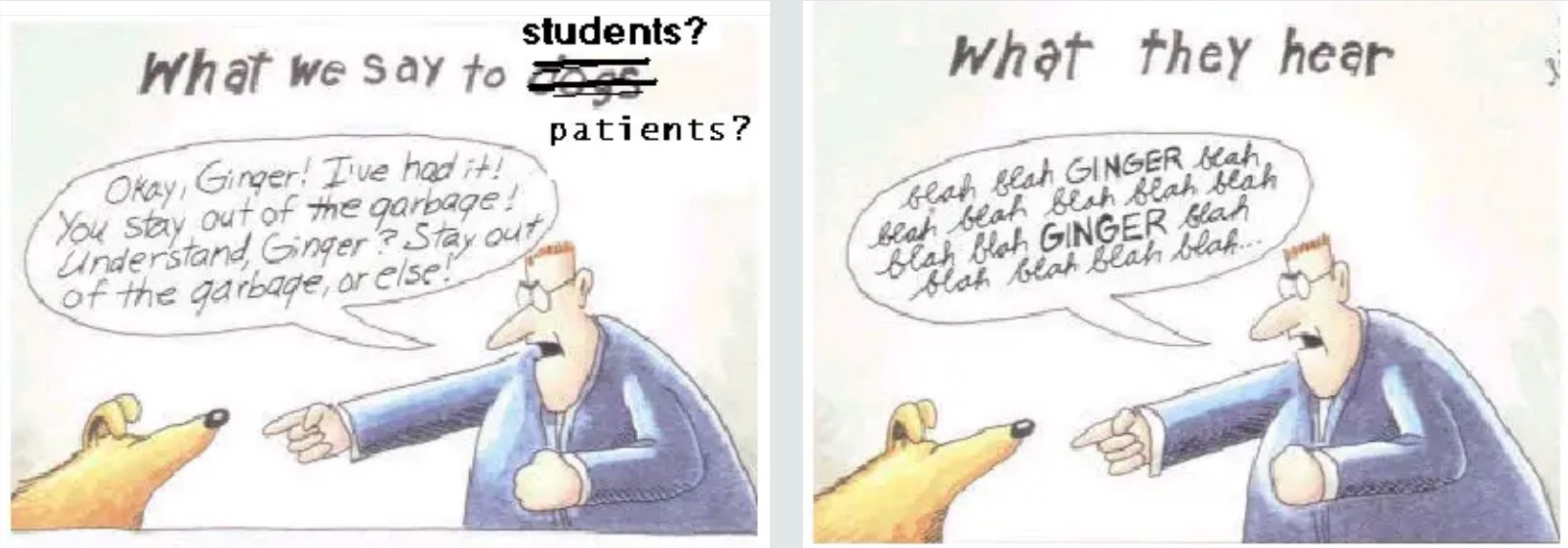
Does a DIGITAL INTELLIGENCE exist?

WE have to move towards COMPETENCES (ABILITIES AND SKILLS)



Distributed networks. (Boaler J et al., 2014)




students?
What we say to ~~dogs~~
patients?
Okay, Ginger! I've had it! You stay out of the garbage! Understand, Ginger? Stay out of the garbage, or else!
What they hear
blah blah GINGER blah blah blah blah blah blah blah blah GINGER blah blah blah blah blah blah blah...

Don't Explain

At times in the past, I was seriously disappointed in my ability to help students learn by explaining things to them. Often I noticed that their eyes glazed over shortly after I began my explanations. Still, I believed that they did need explanations and that my job was to find better ways of explaining.

But my examination of brain research has made me think seriously about giving up on explaining as a teaching tool. When I began to understand knowledge as consisting of networks of neurons, it dawned on me—powerfully—that my students' knowledge was actually physically different from my own. Particularly in my specialty, biochemistry, our networks differed. But my networks were all that I had! When I explained biochemistry, I had to use my own networks; and for my students to understand it, they had to use theirs. Maybe the two sets of networks were just too different.

So I reduced my explanations and instead turned to demonstrations, metaphors, and stories. As much as possible I tried to show rather than explain things. And when explaining seemed inescapable, I asked other students to do it, reasoning that their networks were a better match with those of their peers.

I turned away from explanations for another reason: I realized that explaining negates the emotion needed for changing the brain. Explanation transfers the power from the learner to the teacher. But neuroscience tells us that the positive emotions in learning are generated in the parts of the brain that are used most heavily when students develop their own ideas. These areas include the frontal cortex and the pleasure centers deep in the brain that are control centers for voluntary movements. Voluntary movements, of course, are "owned," or chosen. The biochemical rewards of learning are not provided by explanations but by student ownership.