

Hands on Learning – How we learn using our bodies

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Where does thinking or cognition take place? A common answer is that thinking takes place in the head, or more specifically, in the brain. Cognition is commonly seen as a brain process. The Centre for the Neural Basis of Cognition states that “For well over a century, scientists have recognized that all the wonders of the mind are the province of the brain. Perception, attention, emotion, planning and action, learning and memory, thinking, language and all other aspects of cognition all take place in the brain.” (emphasis added; Center for the Neural Basis of Cognition, 2014).

More specifically, the central hypothesis of Cognitive Science is that thinking can best be understood in terms of representational structures in the brain and computational procedures that operate on those structures.

The claim that human brains work by representation and computation is an empirical conjecture. Some philosophical critics of cognitive science have offered such challenges as:

The world challenge: Cognitive Science disregards the significant role of physical environments in human thinking, which is embedded in and extended into the world.

The body challenge: Cognitive Science neglects the contribution of embodiment to human thought and action.

The dynamical systems challenge: The mind is a dynamical or complex system, not a linear computational system.

The social challenge: Human thought is inherently social in ways that Cognitive Science ignores.

([Thagard, 2014](#_ENREF_18))

All of these challenges to Cognitive Science are inter-related.

In this paper, we will argue against Cognitive Science that:

* we are action oriented. Our ability to understand the world comes from a pragmatic engagement with it and with other people.
* The mind consists of a complex system of brain-body-world constituents.
* The brain is not the sole cognitive resource we have available to us to solve problems. The body and the world also play their part.
* Mind is *enacted* through our bodily action in the world

That is, we will defend an enactive view of mind ([Gallagher, 2013](#_ENREF_7); [Hutto, 2013](#_ENREF_8)), that we will illustrate by reference to thinking and memory. We will examine the implications of an enactive view of cognition for education.

# The manual and the mental: the body challenge

On the enactive view, the brain is not composed of computational machinery locked away inside the head, representing the external world to provide knowledge upon which we can act. Rather, in action – whether reaching and grasping, pointing, or gesturing – the brain partners with the hands and forms a functional unit that properly engages with the agent’s environment. ([Gallagher, 2013, p. 212](#_ENREF_7))

The hands play a key role in mental activity.

Gesture appears to function as part of the actual process of thinking, rather than mere expression. As Andy Clark notes

* We gesture when we are talking on the phone; talking to ourselves; in the dark.
* Gesturing increases with: the difficulty of the task; when speakers must choose between options; when reasoning about a problem.
* Speakers blind from birth gesture when they speak and when speaking to others they know are blind.

The act of gesturing seems to shift or lighten aspects of cognitive load, thus freeing up resources for a task.

The physical act of gesturing plays an active role in thinking by providing an alternative representational format - expanding the set of representational tools available to speakers and listeners.

Physical gestures are genuine elements in the cognitive process. ([Clark, 2013, p. 256](#_ENREF_4))

Colin McGinn argues that it is not really possible to separate the hand as a functional organ from the brain that controls it. Hands and body are fully integrated. There is an extensive hand system. ([McGinn, 2015, p. 25](#_ENREF_12))

The hands are extensively employed in the manufacture and use of tools. Just as the brain co-evolved with tools so the hands coevolved with tools. Hands, tools and brains became reciprocally modified by positive feedback loops.

While minds long pre-dated hands, the kind of mind we have is influenced by the possession of hands. The hand is one of the main ways we learn about the world – it is a sensory as well as a motor organ. Our concept of things in the world incorporates the way physical objects are presented to the hand. For example a cup is an object that is to be gripped in such-and-such a way. The real is what can be gripped; the unreal is what cannot be gripped. Thus our ontological preference (what we believe is real) for medium sized dry goods. We humans interact with the world mainly through our hands, so we tend to favour their ontology.

We have ten fingers. This has a substantial impact on our understanding of arithmetic. We count on our fingers; we use base 10; fingers and numbers are both called digits. We tend to think digitally.

Our concepts of mind appear to be shaped by our concepts of the hand. We conceive of mind in manual terms. Our language is full of prehensive (grasping) terminology for the mind: apprehend; comprehend; grasp; be gripped by; pick up on; hold (in memory); catch (your meaning); grapple (with a problem); reach out (emotionally); be seized by (a passion). We “grasp” – a meaning; a theory; an implication – just as we grasp a cup or a hammer.

We seem to model mental grasping on physical grasping – as if an inner hand reaches out. We grasp ideas in quite a literal sense. We conceive of the mind doing to an idea or concept what a hand does to an object.

# The world challenge

Mental activities, such as thinking, are (or derive from) bodily actions in the world.

Vygotsky suggested that thought is internalised speech. He is right to suggest that speech is not always of a fully formed thought. Externalised speech – bodily action in the world - precedes internalised speech. Internalised speech certainly is thought, but we can also think out loud to ourselves and others – as we do long before we develop internalized speech.

Dewey makes a similar point when he claims that “Of all affairs, communication is the most wonderful.” ([Dewey, 1929, p. 214](#_ENREF_6)) Dewey believed that reflective thought comes into existence through and as a result of communication. “The world of inner experience is dependent upon an extension of language which is a social product and operation… soliloquy is the product and reflective of converse with others; social communication is not the effect of soliloquy”. ([Dewey, 1929, p. 218](#_ENREF_6)) “the import of logical and rational essences is the consequence of social interactions” ([Dewey, 1929, p. 222](#_ENREF_6)).

Developmentally, overt (external) speech precedes covert (internal) speech. Covert speech develops from overt speech through practice and eventual mastery.

The American philosopher Daniel Dennett (1996) notes that:

(a) One of the things we human beings do is talk to others.

(b) Another is that we talk to ourselves - out loud.

(c) A refinement of (b) is to talk silently to oneself, but still in the words of a natural language, often with tone of voice and timing still intact. (One can often answer such questions as this: "Are you thinking in English or French as you work on this problem?") ([Dennett, 1996 p.1](#_ENREF_5))

Some variations of (c) are to talk silently to oneself:

1. while whispering the words
2. while mouthing (but not whispering) the words
3. while moving the voice box (but not whispering or mouthing the words)
4. without moving any of the vocal organs

Similar comments apply to reading – by replacing the word ‘talk’ with the word ‘read’ in the above. There was a time where when it was rare for people to read silently. Augustine notes with amazement of Ambrose, in Book 6, chapter 3 of his Confessions:

When [Ambrose] read, his eyes scanned the page and his heart sought out the meaning, but his voice was silent and his tongue was still. Anyone could approach him freely and guests were not commonly announced, so that often, when we came to visit him, we found him reading like this in silence, for he never read aloud. ([Augustine, 2009](#_ENREF_1))

(a)-(c) are clearly bodily actions in the world. Even case (c.iv) could be said to depend causally on bodily actions. Reading out loud comes first, reading silently comes later, with practice. In general, bodily action in the world (e.g. reading out loud) precedes internalized action. We have learned to speak and read silently to ourselves through others. In Ambrose’s case he would have taught himself to do so.

It is a mistake, however, to conclude as Vygotsky does that thinking is internalized speech. Not all thinking is internalized. We can think out loud.

Also, non-linguistic animals can think, or engage in cognitive behavior. For example, Dennett (1996) discusses Kohler’s experiments with problem solving in apes. He writes:

Contrary to popular misunderstanding, Köhler's apes did not just sit and think up the solutions. They had to have many hours of exposure to the relevant props – the boxes and sticks, for instance – and they engaged in much manipulation of these items. Those apes that discovered the solutions – some never did – accomplished it with the aid of many hours of trial and error manipulating. Now were they thinking when they were fussing about in their cages? What were they manipulating? Boxes and sticks. It is all too tempting to suppose that their external, visible manipulations were accompanied by, and driven by, internal, covert manipulations – but succumbing to this temptation is losing the main chance. What they were attending to, manipulating and turning over and rearranging were boxes and sticks, not thoughts ([Dennett, 1996 p.5](#_ENREF_5))

However, Kohler’s apes may be fairly described as doing the equivalent of our “thinking out loud”. They were thinking with their hands, the boxes and the sticks. Like Kohler’s apes, humans do not just sit and think up the solutions to Rubik’s cube, for example. They had to have many hours of exposure to the relevant props – the Rubik’s cube – and they engaged in much manipulation of these items. Those humans that discovered the solutions – some never did – accomplished it with the aid of many hours of trial and error manipulating. But the humans who solved the Rubik’s cube (and those who did not) were no doubt thinking as they manipulated the colorful plastic cubes.

Developmentally, bodily action in the world precedes internalized bodily action.

Piaget suggests that thought is internalised action. While internalised action is thought, thought as we have seen, can also be overt action. As Gilbert Ryle observed, we do not reserve the title ‘thinking’ for inner processes. An architect can think out her plan while manipulating toy bricks as can a sculptor plan a statue in marble by modelling a piece of plasticine. Additional labours might be necessary to put these plans into words.([Tanney, 2015](#_ENREF_17)) In general, thinking should not be equated with using language. The mark of the mental is not its covertness or internality. It is the kind of activity engaged in - problem solving, creativity, criticism - whether overtly or covertly expressed. Thought – understood enactively as action in the world – comes first and internalised action or internalized speech follows it much later.

# Thinking and manipulation

Thinking may involve manipulation of objects themselves or representations of those objects. The action may be internal (manipulation of representations) or external (manipulation of things in the world) or both.

Wartofsy proposes a three-tiered taxonomy of mediating artifacts, with the first level involving physical tools as primary artifacts. The second level comprises secondary artifacts that are representations, for example drawings of existing physical tools. The third level involves tertiary artifacts, or artifacts that are envisioned or imagined mentally. They are distinct from real world objects, practicalities and immediate contexts of tool use. ([Oviatt, 2013, pp. 182-183](#_ENREF_13); [Wartofsky, 1979](#_ENREF_19))

From a (child) developmental perspective, these categories of mediating artifacts also build upon one another. Tertiary artifacts, and imagination about possibilities that they enable, arise from earlier manipulation of physical and representational artifacts.

“By marking with a pencil, a child learns how to use it for her own ends, gradually internalizing its functionality and properties. She may initially use the pencil as a prop to represent herself walking to school. Later she uses it to draw images of herself and her friends in their classroom. But eventually she will use it to draw her image and write a story projecting herself into the future as president.” ([Oviatt, 2013, p. 183](#_ENREF_13))

As in Piagetian theory, the use of physical objects as tools in imaginary play is viewed as central in leveraging imagination about possible worlds. The reliance on physical artifacts as an aid for imagination diminishes with age, although they continue to facilitate adult cognition. ([Oviatt, 2013, pp. 182-183](#_ENREF_13))

Wartofsky appears to overlook a fourth level of artifacts – namely concepts or metaphors. In thinking about mathematics, for example, we make use of metaphors (which are representations, or re-presentations) in an effort to make mathematics more tangible. Metaphors and concepts are human artifacts – and public representations, insofar as they are shared. They are developed and shared using other human artifacts – language in the form of speech or written language.

A fifth level of representations are gestures. The physical act of gesturing plays an active role in learning, reasoning and cognitive change by providing an alternative representational format or medium. As we mentioned earlier, gesture expands the set of representational tools available to speakers and listeners.

Thinking is not best understood in terms of representational structures in the brain but in terms of manipulation of physical objects or representations of those objects.

# The Social Challenge

In his book *The Evolved Apprentice* Kim Sterelny ([Sterelny, 2012](#_ENREF_16)) argues that the accumulation of social learning (learning in a social context) was one central causal factor in the evolution of human uniqueness. He also argues that:

“Human cognitive competence is a collective achievement and a collective legacy; at any one moment of time, we depend on each other, and over time, we stand on the shoulders not of a few giants but of myriads of ordinary agents who have passed on intact the informational resources on which human lives depend.” ([Sterelny, 2012](#_ENREF_16))

Sterelny notes human problem solving activity is often overtly social and dependent on communal resources. The division of cognitive labour is of central importance in explaining both the acquisition and the exercise of many cognitive competences. For example, many academic projects depend on collaboration and on technical and specialist support. Other agents are often important resources for our cognitive projects: cueing, demonstrating and advising.

Human cognitive competence is irreducibly social. I may work alone or with others – but whether I manipulate objects or representations, I make use of language, mathematical or musical notation or other artifacts that have been developed by previous generations.

# Memories

According to cognitive science memory involves three separate processes of encoding, storage and retrieval. Encoding involves the laying down of a memory trace. Storage is the maintenance of a memory trace over time while retrieval is the process of reactivating a stored memory for current use. According to cognitive science, memory is a representation in the brain of past events.

However, this does not seem to be the way that memory worked in pre-literate human societies. Nor is it the way that memory seems to work in non-linguistic animals.

Memory, however, involves bodily action in the world – fundamentally finding one’s way around, or orientating oneself in one’s environment. Developmentally, knowing (remembering) how to orientate oneself in the world precedes knowing/remember facts or content.

An enactive approach to memory is taken in *The Memory Code* by Lynne Kelly*.* According to Kelly:

* Memory in oral traditions such as Australian Aboriginal people, arises from interactions between the landscape (the land/country) and ritualized song lines.
* Song lines are navigational tracks - elders sing the landscape and move from location to location through it and teach each other through song.
* At each sacred site within the sung track they perform rituals - repeated songs – and thereby encode the information.
* Songs that are sung from location to location and songs that tell stories are easier to remember.
* Song lines link positions in landscape so that each location in the landscape serves as a mnemonic - a memory aid - to a particular part of the information system so that the knowledge is literally grounded in the landscape.
* The knowledge is also supported by portable devices, different forms of art, - e.g. message sticks - in combination. Information that is encoded to a range of devices reinforces itself.
* Even changes in landscape are recorded in the oral tradition.
* Humans associate memories with place. Sequences of places are grounded in order, so you cannot forget.
* Aboriginal people do not need to be walking the song line to remember. ([Kelly, 2016](#_ENREF_9))

Memory, and other cognitive processes, for Aboriginal people are constituted by a combination of country/landscape and ritual. It is difficult for literate western cultures to understand what songlines are. They cannot be reduced to mnemonic tools – though this is a part of what they are. Aboriginal people do not make a sharp dichotomy between themselves and country. Songlines are a way that Aboriginal people learn about themselves.

Aboriginal societies use physical artifacts embedded in a particular place (Wartofsky’s primary level of artifacts) to help them think about the world. Much of the thinking they are doing appears to be focused the artefacts themselves. However, these artifacts are placed in songlines, country, and dreaming stories. It is likely that this involves Wartofsky’s secondary and tertiary level artifacts.

Such approaches to memory are not confined to pre-literate societies. Luria describes the extraordinary memory of a man whom he code names S. and whom he worked with over many years. Luria writes that on his first meeting S. was

a newspaper reporter who had come to my laboratory at the suggestion of the paper's editor. Each morning the editor would meet with the staff and hand out assignments for the day—lists of places he wanted covered, information to be obtained in each. The list of addresses and instructions was usually fairly long, and the editor noted with some surprise that S. never took any notes. He was about to reproach the reporter for being inattentive when, at his urging, S. repeated the entire assignment word for word. ([Luria, 1968, pp. 7-8](#_ENREF_11))

Luria discovered that when S. read or heard a long series of words

each word would elicit a graphic image… [and] he would "distribute" them along some roadway or street he visualized in his mind… Frequently he would take a mental walk along that street and slowly make his way down, "distributing" his images at houses, gates, and store windows. ([Luria, 1968, pp. 31-32](#_ENREF_11))

To recall the words he read or heard he

would simply begin his walk, either from the beginning or from the end of the street, find the image of the object I had named, and "take a look at" whatever happened to be situated on either side of it. ([Luria, 1968, p. 33](#_ENREF_11))

S. was able to recall strings of words by dropping off and picking up graphic representations of these words in a virtual representation of a place S. knew intimately from regular walks.

Having detailed “mental maps” of places you have regularly walked is not rare. My cat, Zeno, knows her way around her territory. She will effortlessly climb up the bougainvillea, onto the pergola, the outdoor laundry roof, the roof of our house and then the adjoining house. She will usually descend by a different route. Most animals learn very quickly how to find their way around.

Like Zeno, S. learned early how to find his way around his local environment. Both have internalized this know how. Unlike Zeno, S. was able to use this know-how as a platform or framework for remembering words, in much the same way as members of pre-literate Australian Aboriginal communities were able to remember the names of thousands of animals and plants and their characteristics by taking walks literally or virtually in their country. They remembered together following their song lines.

# Learning Mathematics

Lakoff and Nunez claim that in the days of the old cognitive science of the disembodied mind, thought was taken to be the manipulation of purely abstract symbols and all concepts were seen as literal. Thought, then was taken by many to be a form of symbolic logic. ([Lakoff & Núñez, 2000, p. 5](#_ENREF_10))

Lakoff and Nunez suggest that for most part, human beings conceptualise abstract concepts in concrete terms, using ideas and modes of reasoning grounded in the sensory-motor system (the coupling of the sensory system and the motor system inside the brain). The mechanism by which the abstract is comprehended in terms of the concrete is called conceptual metaphor ([Lakoff & Núñez, 2000, p. 5](#_ENREF_10))

Lakoff and Nunez suggest that the subject matters of mathematics arise from human concerns and activities: for example, counting and measuring, architecture, gambling, motion and other change, grouping, manipulating written symbols, playing games, stretching and bending objects. In other words, mathematics is fundamentally a human enterprise arising from basic human activities ([Lakoff & Núñez, 2000, p. 351](#_ENREF_10))

In this respect, Lakoff and Nunez appear to be proposing an enactive view mathematical thinking. Mathematical thinking does not involve purely manipulation of symbols in the brain or even metaphors in the body, but arises from human activities in the world. These activities are the basis of the conceptual metaphors by which human beings conceptualise abstract concepts in concrete terms.

These conceptual metaphors are representations – or re-presentations – of mathematics – but they are public human artifacts. This is reflected in the fact that:

• the metaphors are based on *common* experiences

• mathematics is a mental creation that evolved to *study objects in the world*

• the subject matter of mathematics arise from *human concerns and activities*

• the *metaphors directly relate to these activities* e.g. conceiving numbers as point on a line; Arithmetic as object collection ; Arithmetic as object construction; Arithmetic as motion along a path

• mathematics is universal, precise, consistent, stable, generalizable and discoverable. ([Lakoff & Núñez, 2000, p. 350](#_ENREF_10))

Conceptual metaphors are representations, and mental creations, but they are not located in the brain any more than maps or diagrams.

# Educational implications

## Manual and mental

The notions of the manual and the mental do a lot ideological work in education in separating democratic societies into elites and followers.

As Woodrow Wilson put it:

We want one class of persons to have a liberal education, and we want another class of persons, a very much larger class, of necessity, in every society, to forego the privileges of a liberal education and fit themselves to perform difficult manual tasks. ([Cited in Stanley, 2016, p. 278](#_ENREF_15))

The view articulated by Wilson continues to inform education policy down to this day.

The basis of Wilson's separation of societies is the distinction, indeed a dichotomy, between the mental and the manual. On the enactive view of cognition, this dichotomy is undermined, along with its political implications.

## Teaching Mathematics

If we believe that the brain is (or analogous to) a computer or a disembodied Cartesian mind then how should we teach Mathematics, for example? To enable a computer to calculate a mathematics problem, we would need to program the computer to manipulate purely abstract symbols, through symbolic logic. Then we would need to input data. The output might be a written answer. By analogy, to teach a child mathematics you would need to in effect program their brain to follow an algorithm, and then provide input in terms of a problem to be solved. The pedagogical equivalent of programming a computer would be rote learning and drill. Such teaching would be highly teacher-centred, involving direct instruction. Understanding would matter less than learning how to manipulate abstract symbols to arrive at an answer. Students may write their answer to a problem and explain their thinking. But the solution would be arrived at in their heads and then translated onto paper to make their thinking visible.

Thus the pedagogy indicated if the brain is seen as a computer is transmissive.

Lakoff and Nunez believe that classical mathematics can best be taught with a cognitive perspective. They suggest it is important to teach mathematical ideas and to explain why mathematical truths follow from those ideas.

We agree. But Mathematics should also be taught by students manipulating physical objects, such as counters, an abacus, blocks, pieces of string, flowers, snails, bubbles, puppets, computer simulations.

A recent meta-analysis of studies compared the use of manipulatives, or hands-on practical apparatus in teaching mathematics, with teaching that relied only on abstract mathematical symbols. ([Carbonneau, Marley, & Selelg, 2013](#_ENREF_3)) The researchers found statistically significant evidence that manipulatives had a positive effect on learning with small to moderate effect sizes. This is compelling evidence in favour of using manipulatives - though the ways in which they are used is hugely important.

## Assessment

One way in which the manual/mental dichotomy is sustained is through entrenched assessment practices that prioritise standardised measurement and quantifiable metrics. The assessment of textual and numerical output is absolute, explicit, visible and static. There is a vocabulary, a number system, a systematic and universal agreed upon format through which information can be codified.

What we measure becomes what is valued – there are documented examples of the drive of standardised testing driving teachers to “teach to the test” under the pressure of accountability-driven reforms.

Our inability to consistently or reliably measure the manual means the mental is what is preferenced and elevated; hence the dichotomy is sustained.

One way to undermine this dichotomy is to change the way that we value the products of student learning. By incorporating alternative forms of assessment into a holistic system of assessment ([Barron & Darling-Hammond, 2010](#_ENREF_2)).

We need to be able to incorporate a range of assessment evidence including methods used in the creative arts and technical subject areas and appreciating the unique contributions they can make in helping us understand students’ learning abilities. The use of particular modes of assessment has benefits.

* exhibitions, projects and portfolios provide occasions for review and revision to help students examine how they learn and how they can perform better
* student presentation of their work to an audience – teachers, visitors, parents, other students can be an excellent way of learning. This approach to assessment can be used to assess students' mastery. Presentations of work, particularly public presentations, can signal to students that their work is significant enough to be a source of public learning and celebration. It can provide opportunities for others in the learning community to engage with student work.
* performances can embody representations of school goals and standards so that they remain vital and energising, and develop important capabilities.

Good performance tasks are complex intellectual, physical and social challenges stretch students’ thinking and planning abilities while also allowing student skills and interests to serve as a springboard for developing capabilities. Use of performance tasks is also important to assess the benefits of inquiry-based approaches ([Barron & Darling-Hammond, 2010](#_ENREF_2)).

## Objects to think with

Papert describes how from a young age car gears, serving as models for mathematical equations, “carried many otherwise abstract ideas into [his] head.” “I saw multiplication tables as gears, and my first brush with equations in two variables (e.g., 3x + 4y - 10) immediately evoked the differential.” Gears were able to serve this function because:

* “they were part of my natural “landscape,” embedded in the culture around me”
* “gears were part of the world of adults around me and through them I could relate to these people”
* “I could use my body to think about the gears” ([Papert, 1980](#_ENREF_14))

“The fact that so many important things (knives and forks, mothers and fathers, shoes and socks) come in pairs is a “material” for the construction of an intuitive sense of number.” ([Papert, 1980](#_ENREF_14))

Computer-generated artifacts may also be useful objects to think with. Indeed computer-generated artifacts can be tailor-made for learning. “The computer is the Proteus of machines. Its essence is its universality, its power to simulate. Because it can take on a thousand forms and can serve a thousand functions, it can appeal to a thousand tastes.”

To give children a toe hold into learning mathematics, Papert and his colleagues created Logo, a very simple computer language. In Logo, the child controls a little turtle on-screen, issuing it commands to make it move around. The turtle draws a line wherever it goes. Papert argues that programming a turtle with Logo relates to children’s knowledge and sense about one’s body. So, for example, if a child wants to make a circle she might walk in a circle herself. Moving in a circle might lead to a description such as: “When you walk in a circle you take a little step forward and you turn a little. And you keep doing it.” The Turtle circle is body syntonic in that the circle is firmly related to children’s sense and knowledge about their own bodies. Papert suggests that turtle geometry is learnable because it is syntonic. ([Papert, 1980](#_ENREF_14))

In fact, the turtle circle is implicitly a body-*world* syntonic – in that programming a turtle with Logo relates to children’s knowledge and sense about one’s body in the world – moving in a circle on a flat surface. (If a surface were heavily undulating it may be more difficult to make a circle by following the algorithm “take a little step forward, turn a little, and keep doing it”).

# Conclusion

In this paper I have argued that the brain is not composed of computational machinery locked away inside the head, representing the external world to provide knowledge upon which we can act. Rather, in action – whether reaching and grasping, pointing, or gesturing – the brain partners with the hand and forms a functional unit that properly engages with the agent’s environment.

We, like other animals, are action oriented. Our ability to understand the world comes from a pragmatic engagement with it, along with other people. The mind consists of a structural coupling of brain-body-world constituents. The brain is not the sole cognitive resource we have available to us to solve problems. The body and the world also play their part.

This all has implications for how we teach and learn. Teaching should not involve transmission of content from teacher to students like a jug filling a mug. Learning involves active engagement with the world: working with other people, manipulating physical objects or representations of them – not necessarily inside our heads.

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