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Centre for Real-World Learning at the University of Winchester

Intelligence in the flesh

How new scientific understanding can help practical education regain the respect it deserves.

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‘The hand is the cutting edge of the mind’

Jacob Bronowski

Centre for Real-World Learning[1]
University of Winchester

There appears to be a widespread resurgence of interest in practical learning. In the USA, the 'Maker Movement' is pressurising manufacturers to make their machines more mendable. There are Summer Schools in Tinkering[2] for young people, in which they learn practical skills, and are often scraped and bruised in the process. Stanford University now gets its student designers and architects to build model airplanes and take bicycles to bits, while MIT runs a course called 'How to Make (Almost) Anything' that is one of the most popular on campus. In the UK *The Dangerous Book for Boys*[3] was the runaway best-seller of 2006 and has spawned a number of lookalike books promoting challenging, practical activities for boy and girls.

In times of recession, interestingly, sales of art materials to the general public go up markedly, signalling a renewal of interest in cheaper and possibly deeper forms of manual accomplishment. And books such as Richard Sennett's *The Craftsman* argue that the current public rhetoric of 'skills' woefully fails to do justice to the sustained love-affair of the jeweller, gardener, animator or architect with their materials and capabilities. 'Being a cook' is not just a matter of skill, Sennett reminds us; it involves passion, identity, sensitivity, creativity and community as well[4]. Anyone who saw the recent television documentary where celebrity chef Jamie Oliver trained fifteen novice chefs to operate in a commercial restaurant would have seen this assertion translated into a compelling narrative[5].

In short there is rebellion in the air from various quarters against the reduction of children's bodies to the 'Listen/Read - Talk/Write' processes of classroom-based schooling, and the 'Eye-Brain-Finger' configuration demanded by the world of the computer screen (and only marginally improved by Virtual Reality applications such as Wii). Such straws in the wind suggest a revival of interest, both personal and social, in the challenges and satisfactions of practical activity – learning that involves bodily activity, physical skill and tangible material - as a balance to the kinds of learning that mainly manifests itself as mouse-clicks and key-strokes. From windsurfing to gardening, cooking to dancing, 'making and doing' it seems remain powerful sources of human learning and fulfilment at both work and play.

At the same time there are the stirrings of interest from educationalists across the world in the wider and often more practical skills young people are supposed to need if they are to survive and thrive in a fast-changing and increasingly sedentary world. We have recently reviewed such skills for NESTA[6] (The National Endowment for Science, Technology and the Arts) and the independent foundation Edge[7] has led the way in championing the value of practical learning in schools in the UK.

Education's curious undervaluing of practical subjects

Yet, as we know only too well, societies place some strange judgements of value on such practical accomplishments. Cellists, surgeons and architects are esteemed, while electric guitarists and occupational therapists get less recognition. The occasional celebrity chef, gardener, vocalist or footballer serve only to emphasise the more lowly esteem in which cooking, gardening, singing and sports are held – especially within education. 'Abstract' is seen as more intelligent, more complex, and better than 'concrete'.

In 2009, for example, it remains an easy task to rank-order school subjects from the most rarefied and disembodied at the top of the hierarchy of esteem to the most physical and material at the bottom. Mathematics carries most prestige, having apparently nothing of the body about it at all, and representing a Platonic world of pure geometrical forms, algebraic symbols and abstract computations. English is not far behind. There may be 'creative writing' now, but there are also abstract categories such as 'conjunctions' and 'participles' to be mastered, and the timeless treasury of Shakespeare to be understood. The sciences are esteemed in order of their proximity to maths – physics, then chemistry, and lastly biology. Then come History and Geography, Art and Music, and traditionally, at the bottom of the heap, those subjects from which the body most obviously cannot be excluded: Dance, drama and PE, and what used to be called Woodwork and 'Domestic Science'. Why is it, when people can get so much satisfaction, and make good livings, from learning

1. Drafted by Guy Claxton, developed by Bill Lucas, and substantially improved by Rob Webster, Jennifer Elmer and David Harbourne. **www.winchester.ac.uk/realworldlearning**
2. See **www.gevertulley.com** where Gever Tulley, the founder of Tinkering School, has a lecture on the called '5 dangerous things you should let your child do'
3. Conn Iggulden and Hal Iggulden (2006), *The Dangerous Book for Boys*, HarperCollins, London.
4. Richard Sennett (2008), *The Craftsman*, Allen Lane, London.
5. See **www.fifteen.net** for more about this example and how it has spread to Cornwall, Amsterdam and Melbourne.
6. Bill Lucas and Guy Claxton (2009), *Wider skills for learning; what are they, how can they be cultivated, how could they be measured and why are they important for innovation?*, NESTA, London.
7. See **www.edge.co.uk** for more about the range of current activities.

to do subtle things with their hands, feet and taste-buds, that schools and colleges persist – despite many determined efforts – in treating practical learning as second rate? In this paper, we argue that this hierarchy of esteem reflects some deep but outmoded misconceptions about the nature of bodies, and their relation to minds and 'intelligence'.

So where did we get the idea that ''Mind'' is separate from ''Body''?

Descartes' error

The human brain is not much to look at. Slice the top off someone's head like a boiled egg and what you see is no yolk, but a three pound wrinkly blob of grey-brown spongy meat. If you put your ear to it, you hear no sounds. If you cut it open, you find no movie show going on inside. It is eternally dark and silent; and it looks rather unimpressive.

To anyone looking at a brain, before about a hundred years ago, it would have been literally unthinkable that this dull organ could be intelligent, in any real sense. Descartes was no fool: in the 16th century it would have been just plain obvious that consciousness, reason and imagination could not arise from the machinations of any kind of meat, let alone this particularly uninteresting looking lump. Mind stuff was clearly different from body stuff. Minds were clever, conscious and sophisticated, capable of reason and decision-making. Mere flesh was mechanical,menial and, by contrast with minds, simple. The 'house-keeping' processes with which bodies concerned themselves – breathing, digesting, contracting muscles and so on – did not warrant being called 'intelligent'.

Minds were also capable of 'knowing God'; they had the capacity for purity and sanctity, while bodies were corruptible and unreliable. So minds were not only much more complex and intelligent than bodies, they were also 'higher', while bodies were lustful, wayward and therefore 'lower'. (If bodies could be said to have 'knowledge' it was merely, and reprehensibly, of the carnal variety.) The schism was cognitive, moral – and unbridgeable. Descartes declared, for example: 'There is nothing included in the concept of the body that belongs to the mind; and nothing in that of the mind that belongs to the body'[8].

This powerful attitude towards minds and bodies – 'Descartes' error', as neuroscientist Antonio Damasio has dubbed it - was born in classical Greece, strongly endorsed by the early Christians, and turned into irrefutable 'common sense' by the learned philosophers of the Enlightenment, that period in our history when rationality was the highest manifestation of our humanity[9]. 'Mind over matter', and especially over the physical matter of which we are composed, became the watchword.

This disparity of esteem between the physiological and the intellectual became enshrined in the core social institutions of the Western world. Christian religion revolves around a struggle between our baser bodily impulses and our 'higher nature'. God gave us reason and 'free will' so we could overcome the deadly sins of the body, and be bettered by the struggle. The law's attitude to crime hinges on whether the accused is judged to have 'been in his right mind' – and therefore had the capacity (bit not the inclination) to override his anti-social impulse - at the critical moment. And so on.

Because Descartes had no way of understanding the cleverness of bodies and brains, thousands of young people who are good with their hands and feet, but not so good with equations and prepositions, have been led to think that their alents and interests are second-rate, demanding, perhaps, of hard work and practice, but not requiring genuine intelligence.

Before the advent of modern neuroscience, such a view might have been understandable. More recent research on the 'intelligence of bodies', however, shows that it is simply untrue and untenable: Mind and Body are intricate and equal partners. Findings from this research need to become more widely known, because they fundamentally challenge long-standing – but wrong – beliefs and values: beliefs and values which have had negative effects on the self-respect of millions of individuals, as well as the prosperity of their societies.

8. Quoted in F. Sommers (1978), Dualism in Descartes, in M. Hooker (ed), *Descartes*, Johns Hopkins Press, Baltimore.

9. Antonio Damasio (1995), Descartes' Error, Quill, New York. For the history, see E.R. Dodds (1951), *The Greeks and the Irrational*, University of California Press, Berkeley; Guy Claxton (2007), *The Wayward Mind*, Little Brown, London.

Embodiment: the science of physical intelligence

The name of this exciting new field of research is ''embodied cognition'', sometimes shortened to ''embodiment''. Through this research, we are beginning to understand some of the things which have sat uncomfortably in our old body/mind split; why, for example, young learners do better in maths when they use their hands, or why actors pace and posture to help them learn their lines.

The science of embodied cognition demonstrates and illuminates the intimate relationship which exists between mind and body. It seeks to explain how the way we think depends on what we are doing with our bodies and how we are interacting with the physical environment.

Our body is not just our mind's container; it is an extension of our mind. What do you do when you are struggling with a complicated problem? Do you sit quietly and close your eyes, doodle absent-mindedly, or go for a run? How we answer this question moves us into the territory of the embodied mind. For it is increasingly clear that the quality of our thinking differs according to what our body is doing at the time (and the relationship is different for different people). As the eminent roboticist Rodney Brooks[11] puts it: ''The physical manifestation of the body is primary. The stuff of intelligence has evolved in conjunction with that body and is a modulator of its behaviour rather than a primary and central control system.''

As we learn more about embodiment it seems that, far from language and mathematics occupying domains divorced from the physical, they actually have their origins and foundations in the way our bodies have evolved[12].

To go into the full details of this area of research would take a whole book. But a mention of some recent developments and findings might serve to indicate the way that the science is moving.

1. Doing comes before seeing and thinking

The brain is designed to put 'doing' before 'seeing' or 'thinking'. We have evolved to be fundamentally active, not contemplative, creatures. The idea that human cognition proceeds in a linear sequence from Perceiving through Interpreting to Thinking, Deciding and then Acting is out of date. Before we open our eyes in the morning, our sensory systems are primed by what we want to do and what we are able to do, and the interaction between Wanting, Doing, Perceiving and Thinking is intricate, near-instantaneous (within hundredths of a second) and continual.

The brain sees objects differently depending on whether they are near our hands or not (even when our hands are hidden from view) – because the proximity of our hands makes us look for clues about how graspable or manipulable the object might be[13]. The brain has a whole visual system for grasping that is not fooled by visual size illusions. Things can be made to look bigger than they are, but when we reach out to grab them, our hands adjust to the real, not the illusory, size[14]. Thinking is an occasional adjunct to this integrated, whole-brain process, not the Grand Conductor, standing outside the neural orchestra and telling it what and how to play.

'Never trust any thought you have while sitting down.'
Friedrich Nietzsche[10]

10. Quoted in Karl Albrecht (2007), *Practical Intelligence; the art and science of common sense*, Jossey-Bass, San Francisco.

11. MIT Robotics Lab Director Rodney Brooks' Foreword to Rolf Pfeifer and Josh Bongard (2007), *How the Body Shapes the Way We Think: A New View of Intelligence*, Bradford / MIT Press, Cambridge, p. xv.

12. See note 25.

13. R. Abrams, C. Davoli, F. Du, W. Knappii and D. Paull (2008), Altered vision near the hands, *Cognition*, 107(3), 1035-47.

14. In the Titchener Circles illusion, for example, a circle surrounded by smaller circles looks bigger than the same circle surrounded by larger circles. David Milner and Mel Goodale (2006), *The Visual Brain in Action*, Oxford University Press, Oxford.

The perceptual underpinnings of intelligence seems only to develop in the context of purposeful action and movement. A kitten that receives rich and varied visual experience, but gets it by being carried around, not by using its own legs and acting on its own curiosity, fails to develop a functioning perceptual system.[15] What a young animal sees only has meaning and significance in terms of its motivated interactions with the world – what it is currently 'up to'. A baby that could not smile, cry and squirm would have nothing to tell it which changes in its sensory world mattered, and which did not. In learning to touch, squeeze, nibble and throw objects, it is learning how to see them – and what meaning and potential they have.

Contrary to the emphasis in education on attending, recognising and understanding as ends in themselves, biologically these are always secondary to getting important things done. (It is worth remembering that the word 'mind', used as a verb, means 'to care about', and that being 'thoughtful' means being both reflective and considerate.)

What counts as the body is not just 'what's inside the skin'; the brain creates a variety of different body maps and images to help it do smart things, and these maps are surprisingly malleable and sophisticated. Body maps extend to include spectacles, pens, walking sticks, squash racquets and prostheses of all kinds. 'The backbone of the story of human evolution has been the story of perfecting our knack for incorporating an increasingly sophisticated assortment of physical tools into our increasingly flexible body schemas'.[16] A simple science-based party trick, the 'Pinocchio illusion'[17], can give you the compelling feeling (with your eyes shut) that the tip of your nose is half a metre out in front of your face. Another makes you 'feel' a pinprick in a plastic arm lying on the table in front of you. The human body turns out to be psychological construct, not a physical one.

2. Body and mind are closely interlinked

Emotion and reason are not controlled by different, antagonistic circuitry in the brain. There are many structures in the brain, such as the anterior cingulate and the insula[18], where cognition, feeling and goals are deliberately brought together and integrated. The brain does not have to control or suppress emotion in order to be intelligent. The basic idea of an antagonistic relationship between reason and emotion does not square with the biological facts. Our emotional systems have evolved to help us out in tricky situations, and they are fundamentally intelligent guides as to how to act. However, these systems get tuned and modified by experience, sometimes leaving us with reactions that were appropriate once, but misleading now.[19]

Students used to be taught about the body's three control systems – the endocrine or hormone system, the immune system, and the central nervous system – as if they were separate. They aren't. They are connected in much more immediate and complicated ways than we used to think. The brain responds instantaneously to changes in the concentration of peptide molecules in the immune system, for example – so much so that immunologist Francisco Varela[20] has described the immune system as 'the body's second brain', and peptide molecules as 'bits of brain floating round the body'.

Conversely, changes in what you are thinking have immediate effects on endocrine chemicals such as adrenaline and oxytocin (and thus affect sweating, digestion or the composition and flow of breast milk). In medicine, 'psychosomatic' no longer means 'made up' or 'malingering'; it is a science-based recognition of the fact that thoughts and feelings, on the one hand, and pain and disease, on the other, are two manifestations of the workings of the same integrated system.[21]

15. Held, R., & Hein, A. (1963). Movement-produced stimulation in the development of visually guided behaviour. Journal of Comparative & Physiological Psychology, 56, 872-876.

16. For a good summary of this research, see Sandra and Matthew Blakeslee (2007), *The Body Has a Mind of Its Own*, Random House, New York. The quotation is taken from page 147

17. See **www.viswiki.com/en/Pinocchio_illusion**

18. The anterior cingulate is the front part of the cingulate cortex and sits like a collar around the bundle of nerves called the corpus callosum. Insula (an abbreviation for insular cortex) is a part of the brain implicated in various emotional responses.

19. Jaak Panksepp (1998), *Affective Neuroscience: The Foundations of Human and Animal Emotions*, Oxford University Press, Oxford; Edmund Rolls (1999), *The Brain and Emotion*, Oxford University Press, Oxford. Many approaches to psychtherapy involve the retraining of these emotional habits.

20. Francisco Varela and Antonio Coutinho (1990), Immune networks: getting on to the real thing. *Research in Immunology*, 140, 837-846.

21. Candace Pert (1997), *Molecules of Emotion*, Prentice-Hall, New York, 1997; Francisco Varela at al, Cognitive networks: immune, neural and otherwise, in A. Perelson (ed) (1988), *Theoretical Immunology*, Addison-Wesley, New Jersey.

One area in which body and mind are obviously linked together is imagination. Using our imagination to solve problems, imagine futures, rehearse presentations or see other people's point of view is clearly a valuable and highly intelligent asset – one which is now quite well understood in terms of what is going on in the brain. When we look at a situation 'though other people's eyes' we know which bits of the brain become active; and people who have damage to those bits of the brain are unable to show empathy. When we mentally rehearse a skill, brain networks specific to that skill become active, and are modified as a result; imagination is a proven amplifier of learning, and scientists can show what is happening in the brain when we learn though imagination, and why. The potential of mental rehearsal in the context of practical learning has hardly begun to be tapped, yet it is clearly significant.[22]

3. Our bodies are cleverer than we thought

The way we carry out complicated actions depends as much on the physical properties of the body as it does on central control from either mind or brain. We are intelligent because of, and in the context of, the way our fingertips deform under pressure, and the elasticity of our bones and muscles. Programming a robot to run on a level but uneven surface is very difficult, if you start from scratch with metal legs and try to load all the control into a central 'brain'. But you can build quite a simple toy that will totter down a slope if you design the joints right. Starting with that, and then modifying it to work on the flat, turns out to require a whole lot less 'central computing power' and is much more lifelike and successful. Artificial intelligence researchers used to think all the intelligence lay in the central computer, and it didn't matter much what you housed it in. They don't think so any more – they know the 'mind' is not at all independent of the 'body'. [23]

The exploration of neural networks – simplified computer simulations of how brains might work – have shown that lots of individually very simple neuron-like elements, wired together in particular ways, can learn to do very intelligent things, despite having no Articulate Supervisor anywhere in the system. They can recognise human faces under varying conditions of light, distance, orientation and dress; they can read emotions from people's faces, again under a wide range of conditions; they can learn to play chess pretty well; they can make up children's jokes quite well; and they can determine your credit-worthiness better than your (human) bank manager can. When such brain-like systems are housed in the right kinds of bodies, and placed in the right kinds of physical worlds, they can behave in ways that make an observer swear that there must be some kind of 'central intelligence' controlling the system – but there isn't. There is a growing suspicion amongst researchers that we human beings, despite having a strong sense that 'we' are in control, are actually built in this embodied, self-organising way. [24]

4. Physical movement helps thinking

Physical gesturing and gesticulating turn out to be important components of thinking and talking: not mere ornamental accessories, but significantly embroiled in the thinking process itself. Children who are made to sit on their hands have been shown to think less intelligently about a maths problem than those who are free to gesture. And their gestures give evidence of more sophisticated understanding of mathematical concepts than they are yet capable ofarticulating verbally. It has been suggested that we are able to 'think more freely' with our hands than with our mouths, and thus that gesturing is integral to creativity. [25]

If you ask people 'when they get their best thoughts', they often say 'in the shower', 'walking the dog', 'doing my lengths in the pool', 'driving to work' and so on. There seems to be something about repetitive activity that puts the brain into a conducive state for creative thinking. Philosophers are known to jump up and pace about in the middle of a vigorous discussion. Actors learn their lines in terms of where they are standing and how they are moving (and can be thrown when a scene gets re-blocked late in rehearsals).

22. Jean Decety and Jennifer Stevens (2009), Action representation and its role in social interaction, in Keith Markman et al (eds), *Handbook of Imagination and Mental Simulation*, Psychology Press, New York.

23. See Pfeifer and Bongard, op. cit. p 363; Steve Collins et al (2005), Efficient bipedal robots based on passive-dynamic walkers, *Science*, 307, 1082-1085.

24. See Manfred Spitzer (1999), *The Mind within the Net*, Bradford / MIT Press, Cambridge MA.

25. Susan Goldin-Meadow and Susan Wagner (2005), How our hands help us learn, *Trends in Cognitive Science*, 9(5), 234-41.; Andy Clark (2008), *Supersizing the Mind*, Oxford University Press.

John Allpress, Head of Youth Player Development at the Football Association, says that many footballers 'can only think when they are moving'. The same is true of dancers[26]. People who are allowed to doodle whilst listening to a long telephone answering machine message show 30% better attention and retention than those who are not. (To be able to think without moving may be a very recent trick acquired by the brain, requiring a sophisticated deployment of inhibitory activation to block movements that would otherwise have taken place.)[27]

Neuroscientists have suggested, on the basis of the anatomy of the brain, that language itself began as a kind of sign language and has never quite outgrown its gestural origins; and that mathematics, too, grows out of brain regions that are associated with counting on the fingers.[28] Indeed, one recent study has shown how much neuroscientists themselves rely on gesture when they are trying to explain complicated neuroimage so each other![29] More generally, cognition often seems to work better when it is accompanied by physical movement.

5. Much thinking is not conscious

The brain does very clever things without the aid of consciousness. Brains can detect and make use of faint patterns of information that are too subtle for minds to be able to grasp. In one study, people had to spot which quadrant of a screen of numbers contained a specified digit. Every so often, the location of the target was a complicated function of where it had been on a few of the previous trials. Nobody spotted this pattern consciously – yet they all got faster on the critical trials, showing that their brains had picked up the information unconsciously. People are clearly making use of such information to become more skilful, but they can't explain how they are doing it or what they have (unconsciously) noticed. Our bodies are continuously transmuting subtle information into intelligent control – without telling us – the conscious 'us' – what they are up to.[30]

Even the old idea that 'sleeping on it' can help you be more creative turns out to be confirmed by neuroscience. A period of sleep seems to help the brain to find links between unlikely ideas that can lead to the creative breakthrough. And sleep can also help you get out a rational rut that is stopping your brain going where it needs to.[31]

Indeed, conscious thinking often gets in the way of intelligent choosing and acting. When trying to master a computer game that behaves in a counter-intuitive way, people encouraged to try to figure out consciously what is going on learn more slowly than people who are encouraged to play the game more 'thought-lessly'. People facing a difficult decision, having been given lots of different considerations to weigh up, do better if they have a 10 minutes wait before deciding in which they are prevented from thinking about the problem. As in many areas of life, people's golf game falls apart if they start to think too much about what they are doing. So that much-vaunted conscious reasoning process turns out to be irrelevant to some kinds of intelligent action, and actively disruptive of others.[32]

Adherence to conscious clarity and explanation turns out to hold learning back in a deeper sense. Berkeley philosopher Hubert Dreyfus has analysed the development of expertise, in many different situations, into five stages through which a person passes on their way from being a novice to becoming a virtuoso. In the first three phases, novice, advanced beginner and competence, the learner moves from following general rules of thumb through more context-sensitive rules and maxims to possessing a more highly developed framework of knowledge and understanding to guide action.

'If you can explain it, you don't really understand it.'
Hubert Dreyfus

26. John Allpress, personal communication; Gillian Lynne, choreographer of Cats, as told to Ken Robinson in *The Element: How Finding Your Passion Changes Everything*, Allen Lane, London, 2009.

27. Jackie Andrade (2009), What does doodling do? *Applied Cognitive Psychology*, online doi.10.1002/acp.1561.

28. D. Armstrong, W. Stokoe and S. Wilcox (eds) (1995), *Gesture and the Nature of Language*, Cambridge University Press; Sandra and Matthew Blakeslee, op. cit., pp 148-9.

29. Morana Alac and Edwin Hutchins (2004), I see what you are saying: action as cognition in fMRI brain mapping practice, *Journal of Cognition and Culture*, 4(3), 629-661.

30. Pawel Lewicki et al (1992), Nonconscious acquisition of information, American Psychologist, 47, 796-801; Guy Claxton (1997), *Hare Brain, Tortoise Mind: Why Intelligence Increases When You Think Less*, Fourth Estate, London.

31. Ullrich Wagner, Steffan Gais, Hilde Haider, Rolf Verleger and Jan Born (2004), Sleep inspires insight, Nature, 427, 352-355. Mark Holmes, Art director at Pixar Animation Studios, summed it up (in a science article in the New York Times, 12/10/08): 'You can get tunnel vision when you're hammering away at a problem. You keep going down this same path, again and again, just tweaking, making incremental changes at best. Sleep erases that. It resets you. You wake up and realise – wait a minute! – there is another way to do this'.

32. Chen-Bo Zhong, Ap Dijksterhuis and Adam Galinsky (2008), The merits of unconscious thought in creativity, *Psychological Science*, 19(9), 912-918; Kristin Flegal and Michael Anderson (2008), Over-thinking skilled motor performance: or why those who teach can't do, *Psychonomic Bulletin and Review*, 15(5), 927-932.

33. Hubert and Stuart Dreyfus, *Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*, Free Press, New York, 1986.

34. George Soros (2006), quoted in Malcolm Gladwell, *Blink: The Power of Thinking without Thinking*, Penguin, London.

35. Antonio Damasio (1999), *The Feeling of What Happens*, William Heinemann, London. The small region referred to as the 'right frontal insula' is especially implicated.

These phases are relatively dispassionate and technical. However, as the learner moves into the phase of proficiency, and beyond into true expertise, their modus operandi becomes more emotional and intuitive. They develop hunches, feelings and sensitivities about their craft that defy explication. Their experiential mastery becomes more subtle than can be accurately captured in words. Conscious deliberation now occurs only at occasional moments of indecision, or in the context of high-level strategy-selection. At these advanced stages, therefore, to continue to cling to conscious comprehension is to hold yourself back from developing full expertise. And a teacher or an education system that insists on testing explicit understanding therefore arrests their learners' development at an intermediate stage of mere competence or mediocrity. As Dreyfus said at a recent symposium in Birmingham, 'If you can explain it, you don't really understand it'.[33]

Scientists now largely agree that consciousness, though mysterious, is a product of the activity of bodies with complex nervous systems going about their business in the world. When certain bodily events occur – sleep, a blow to the head, a stroke – consciousness is lost or changed. But the intact Brain-Body-Context System generates conscious experiences of knowing (or believing or seeing or feeling) of many different kinds. Some are verbal, logical and reasonable. Some are what we call 'perceptions' or 'images' or 'hallucinations' or 'memories'. Some are what we call 'emotions' or 'feelings' or 'moods', and these are associated with experiences that we think of as belonging to the body as well as the mind. We also experience forms of 'knowing' called intuitions, hunches, inklings, and being 'touched' or 'moved', and these too have physical properties as well as perceptual or cognitive ones. Then there are what we call 'promptings' and 'impulses' and 'attractions', that are associated with the physical readiness to act in certain ways. The financier George Soros, sums up this aspect of 'embodied knowing' like this[34]:

> 'Realising that logic alone cannot be the basis of successful speculation led me to study bodily knowing in my post-doctoral research. There's a whole side to our embodied, experiential knowledge that computers don't have and that the 'rational economic man' in models most economists construct doesn't have either. Our bodies 'know' the situations we meet in life and how they can unfold. I found that physical experience has much more organised knowledge about the world that the usual understanding of the body admits.'

We have known for some time that certain injuries to the frontal lobes of the brain leave rational intelligence intact, but disconnect it from physical sensations of emotion and intuition. When this happens, people are able to articulate choices and decisions, but not to carrythem through into action. To put it crudely, they talk clever but act stupid. Apparently these bodily sensations, what Damasio calls 'somatic markers', are essential to glue comprehension and competence together. Abstract intelligence, decoupled from its essential partner, the body, turns out to be clever at reasoning but bad at living[35].

36. Jonathan Schooler, Stellan Ohlsson and Kevin Brooks (1993), Thought beyond words: when language overshadows insight, *Journal of Experimental Psychology: General*, 122, 166–183.

37. George Lakoff and Raphael Nunez (2000), *Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being*, Basic Books, New York.

38. Chris Frith (2007), *Making Up the Mind*, Blackwell, Oxford: Guy Claxton (1994), *Noises from the Darkroom*, HarperCollins, London; Francis Crick (1995), *The Astonishing Hypothesis*, Scribner, New York.

Practical and academic learning are much more alike than we thought

This very brief review of research from a wide range of current paradigms makes it clear that brains, bodies and minds are much more closely tied together than the traditional model would have had us believe. Conscious mental experience accompanies some intelligent cognitive operations, and not others. Explicit rational thinking sometimes supports intelligent behaviour and sometimes gets in the way. Abstract reasoning seems to interfere with the operations of human intelligence, as often as it supports them[36]. Even mathematics turns out to have it roots in the physical fabric of the body (and not to have been borne down from heaven on the wings of angels)[37]. Intellect is one aspect of our intelligence, but by no means the only one, nor always the best one to make use of. Emotion and imagination are grounded in the intricate processes of the physical body, yet are vital elements of real-world intelligence. If there ever was a rationale for universally valuing rational debate, mathematical computation and essay-writing above intuition and imagination, it has been comprehensively swept away in this flood of fascinating new neuroscientific research.

So cognitive science and neuroscience are turning those old Cartesian assumptions – that mind and body are separate, and one is clever and the other isn't - upside down. It turns out, on closer inspection, that the meat of which we are made is very clever indeed. It is no longer unthinkable that the brain, and the body of which it is an organ, could underwrite cognitive complexity, the use of language, mathematical computation and propositional reasoning.

We still haven't a clue why embodied brains should generate conscious experience. Indeed, knowing that brains are capable of all kinds of intelligent operations without conscious control or observation, it is the function of conscious reasoning itself that is looking increasingly problematic. The strong likelihood now is that the fundamental organ of human intelligence is not the brightly-lit front office of the conscious mind, but the dark, silent physiological factory that lies behind. Conscious trains of thought are not the workings of intelligence; they are intermittent – and often rather unreliable – indications of what is going on behind the scenes.[38] And if the body turns out to be the seat of all human intelligence, it seems perverse to value one set of its products – the verbal, let's say – above any of the other subtle actions and promptings through which the body makes its intelligence known.

Misconceptions about practical learning

Once this information gets out, it will spur an inevitable reconceptualisation of the relationship between body and mind, and that must lead to the long-overdue rebalancing of our esteem for the practical and the intellectual. This will, in turn, require shifts in the way many of our social institutions and professions operate. If true expertise depends on embodied knowledge that is in principle not capable of full description and explanation, then its assessment must be practical and not intellectual, for example. Practices of assessment in medical schools will change if this information is taken on board. So will the understanding and place of 'clinical intuition'. Issues of accountability will have to be re-thought, if the construction of a plausible rationale, to be used as a defence against litigation, means that a surgeon feels obliged to 'pull back' from making full use of her intuition and expertise. Many such changes, too many and intricate to be spelt out here, can be expected to occur.

But it is with the implications for 'practical and vocational education' (PVE) that this paper is principally concerned. So let us review some of the attitudes that seem to underlie PVE – the attitudes and assumptions that have emasculated previous well-intentioned attempts to raise its status – and see where they might now be in need of revision. It turns out that Descartes' error is at the core of a number of these familiar beliefs. They include the following, each one of which is indicated in *italics.*

8 beliefs which are largely false

Belief 1
Practical learning is cognitively simple.
'PVE basically involves watching demonstrations, understanding instructions and practising until you can 'do it'. So physics and economics require thinking that is intricate and difficult, but horticulture and plumbing just require the memorisation of facts and formulae, and mastery of procedures.'

This belief is looking increasingly suspect. Developing expertise requires concentration, practice, imagination, critical thinking and self-evaluation, as well as knowledge and understanding. These all have to be woven together in practice in increasingly intricate ways. As people get better at germinating seedlings or styling hair, they can also be developing more sophisticated and fluid forms of dynamic cognition. It is not at all obvious that the cognition of a master craftsman is in any meaningful sense simpler that that of a university lecturer, and it may well be more complex.

Belief 2
Clever people 'grow out of' practical learning
'Practical learning is typical of the child; cerebral learning is typical of adults. Growing up means moving from practical to cerebral ways of learning and thinking. Learning by watching and trial-and-error is what people do when they don't have more powerful learning tools at their disposal. The job of education is to get young people to move from physical to cerebral ways of learning as quickly as they can. When you have begun to master a more powerful way of learning, you can rely less and less on the more primitive ones.'

The gestures of an academic, the physical sensibility of a potter, and the acute perception of a poet are no mere hangovers from childhood; they are integral to their real-life intelligence and performance. The idea that 'sensorimotor learning' is a simple form of learning to be outgrown is false, and a hangover from the days before embodied cognition. As children grow, so they add more 'instruments' to their cognitive ensemble – principally imagination, rational argument and self-awareness – but these supplment the earlier ones, they do not supersede them. Each can continue to grown in sophistication, and each has to find its proper place in the dynamic workings of the larger ensemble.

Belief 3
You have to understand something before you can (learn how to) do it.
'Being able to talk (or preferably write) about what you are doing or explain the basis of a skill is a necessary precursor to being able to do it – or if not necessary, then at least very helpful. Comprehension is prior to competence. Sometimes people even assume that comprehension is sufficient for competence – if you can explain and describe it, then somehow you ought to be able to do it. If you can't talk or write about it, you haven't learned it 'properly'.

This is false, as much of recent experimental work on 'implicit learning' and skill acquisition makes abundantly clear. Many skilled activities suffer from 'thinking too much', both during learning and during performance. The continued acceptance of this assumption as a rationalisation for much of the present examination system is untenable and unacceptable. Ask a top-ranking snooker player and he (or she) may not be able to describe what is going on in mind or body as he builds a century break, imagining the table two shots ahead, totting up the score, calculating angle and spin, while, perhaps, also trying to put out of his mind the bad mistake of a few moments ago.

Belief 4
Clever people don't get their hands dirty

'Bettering yourself' means not being as physically tired and grubby at the end of the day as your parents were. Self-improvement used to mean, first, not coming home covered in coal dust, smelling of fish, or with blisters and a sore back, and then (maybe) not coming home with eye-strain and inky fingers. The best kind of jobs are those where physical strength or dexterity don't matter at all, but where you do lots of talking, arguing and decision-making (and where other, less intelligent or well-educated, people get to carry out what you have decided).'

This assumption is questionable. Many highly successful professional people derive as much joy from the manual and bodily activities they practise at weekends and on holidays as they do from their Monday to Friday 'brain work'. There are university vice-chancellors who get as much satisfaction from their wind-surfing as their faculty restructuring, senior civil servants who lavish as much care on their rose gardens as their policies, and highly-paid actuaries who get as much fulfilment from their golf as from evaluating life expectancy in specific parts of the population. Conversely (if less socially 'influential') a male carpenter may well be part of a 'dads and lads' book group or a nurse may choose to spend time as a parent governor. The 'either-or' assumption is both false and harmful.

Belief 5
Clever people don't 'need' to work with their hands.

'They don't especially enjoy physical work, or find fulfilment in the processes of making and doing. Basically there are two kinds of people: those who feel proud when they have done The Times crossword, or written a persuasive position paper for a board meeting, and those who feel proud when they have done a complicated wheelie for the first time, or managed to propagate a magnolia cutting. Life is reduced either to living in the ivory tower or working on the factory floor.'

This is again highly questionable. Many kinds of people need to be intelligent both with their hands and with their thoughts. Try imagining how an engineer on site, an earth scientist or a talented sculptor would react to this proposition. It has even been suggested that practical learning is a better 'breeding ground' for the development of generic attitudes and dispositions towards lifelong learning than is academic learning.[39]

Belief 6
Practical education is only for the less 'able'.

'If you are 'bright enough', you go to university and 'read' (notice the deep prioritisation of literacy) history or classics. If – sadly – you aren't, you go and train to become an electrician or a gardener. If you got a place at Oxford and turned it down because you really wanted to become a great hairdresser or a rock guitarist, you would be seen as 'throwing away your talent'.

This is perhaps the core error that we have to expose and eradicate. There are many forms of intelligence, and many intricately interwoven elements to intelligence. Some of these are abstract and logical, other are embodied, intuitive, social and physical.[40] Different phases and domains of intelligent activity require different mixes of these elements at different times. Students differ in their shifting and situated profiles of intelligence. One might be highly resilient and have great sensibility for material; another might be able to sustain concentration on difficult text, but not on their practical work. The idea that 'ability' is a single continuum along which all students can be graded is false and dysfunctional.[41]

39. For example, nursing now acknowledges the importance of expert 'float nurses' who are especially good at very quickly 'getting their head around' a wide variety novel situations. See Patricia Benner et al, *Expertise in Nursing Practice*, Springer, Berlin, 1996; Sennett, The Craftsman, op. cit., see note 50.

40. See Bill Lucas and Guy Claxton (2010, forthcoming), *New Kinds of Smart: How the Science of Learnable Intelligence is Transforming Education*, Open University Press, Buckingham.

41. Howard Gardner's theory of 'multiple intelligences' suggests that there are eight or nine key domains of human activity each of which requires a different kind of cognitive strength or orientation. The argument here is slightly different: that there is a kind of core intel-ligence, but that it comprises a host of elements and aspects each of which, to a significant extent, is learnable and improvable. See Howard Gardner (1999), *Intelligence Reframed: Multiple Intelligences for the 21st Century*, Basic Books, New York; and Lucas and Claxton op. cit.

42. See, for example, Angeline Lillard (2007), *Montessori: The Science behind the Genius*, Oxford University Press, New York, for more about this tradition of work and its scientific validity.

Belief 7
Practical learning involves only lower order thinking

'More specifically, practical learning is a matter of 'acquiring skills', while academic learning involves imagination, cogitation and a much more sophisticated attitude towards knowledge and understanding. Skills are technical, relatively clear-cut, trainable, and, once acquired, available whenever they are appropriate. Once you have been 'trained' in a 'skill' (or a 'trade'), you go out and practise it (with occasional short refreshers and updatings), whilst an educated mind thirsts for ever-deepening understanding.'

Minds are more embodied and more complex than schools and colleges typically allow. And so is the world. Very few occupations are either purely cerebral, or purely physical. Scientists need rational thinking to design a good experiment, but they also need a 'feel' for their apparatus, and the good sense to balance hard thinking with intuition, imagination and incubation. Sports coaches need to think and plan as much as they need to exercise and demonstrate. Bakers need to know about the chemical and physical properties of flour – for example, that flour from newly-harvested wheat is different from flour harvested some months ago, and that if they do not adjust the moisture content, fermentation and baking times of different batches of bread, they will end up with loaves that are either burnt or under-cooked.

Playing with a restricted deck of intelligences, people can be dull teachers and inflexible solicitors, just as well as they can be limited plumbers or unimaginative beauticians. A dance teacher without grace and empathy is as restricted as an accountant without numeracy. Occupation is no predictor of intelligence. For some professions and trades, embodied intelligence matters a lot, and debating skill counts for less; for others, vice versa.

Belief 8
Practical teaching is a second-rate activity

'Given the 'lack of complexity' involved in practical learning it follows that teaching practical learning is less sophisticated and demanding activity than teaching Shakespeare or thermodynamics. Therefore it is right that those who teach in Further Education Colleges (where much practical teaching occurs) should have less non-contact time (because their preparation ought to be easier) and be paid less than University Lecturers.'

This is both false and unjust. In many cases PVE teachers and lecturers are in the business of cultivating a broader portfolio of intelligent skills and attitudes than those who teach more academic subjects. It is also the case that they may have to work harder (and smarter) to rectify dysfunctional learning habits, beliefs, attitudes and self-perceptions that have been laid down over years of schooling. Undoing these errors, and helping practically and vocationally-inclined young people to develop their learning potential, and, in manycases, regain their self-respect, is a highly skilled and significant activity, and one which should be valued and remunerated accordingly.

In sum, it is our belief that misrepresenting the nature and underestimating the complexity of practical (and therefore of much vocational) learning contributes substantially to the perpetuation of many of the other misconceptions. For the sake of brevity, we have painted these misconceived attitudes towards PVE in primary colours, but we are sure that they, or only marginally more sophisticated versions of them, are pervasive and widely recognisable, certainly in British society, and in much of the world. Spelled out, some of them are self-evidently untrue and/or dysfunctional.

Of course, inspired by, for example, Maria Montessori, educators have long known of the intricate connections which exist between mind and body and the important role of physical activity in absorbing abstract concepts and learning practical skills. Many in the Montessori movement[42] have seen the benefits of this at first hand. Now, however, we have hard science to back up this experience, and to encourage educators to see that, what is obvious appropriate to a four-year-old may well be of much greater relevance to a 17-year-old than we had thought.

43. *The Craftsman*, p9.

Conclusion

Research on embodied cognition lays the ground for a radical reappraisal of practical learning, and thus of practical and vocational education. If philosophers need to walk to argue, and neuro-scientists need to gesture to explain, then equally, carpenters must make full use of their reasoning and sports coaches of their imagination.

Practical (and much vocational) learning is not 'simple' at all; it involves a delicate synthesis of watching and noticing, tinkering and practising, imagining and rehearsing, reasoning and appraising. The 'somato-cognitive' (i.e. body-mind) mix will be different for a radiologist and a plumber, or a novelist and a hairdresser, say, but the same elements of feeling and thinking, moving and imagining, tinkering and appraising, will be present, and woven together in ways that make it impossible to judge the work and the learning of one as less complex or demanding than the other.

Hands, eyes, brains, tools and consciousness are connected together in intricate and highly intelligent ways. They form a system, in which no one element – certainly not Reasoning – can be picked out and held to be the Boss – instigating, supervising and controlling what the more junior or 'menial' partners have to do. Learning to do skilful things with hands and feet and lungs and physical balance turns out to be no less taxing and creative than learning to do skilful things with speech and writing. Unpacked, and looked at properly, practical and vocational learning is every bit as worthy of our full esteem as the academic learning with which it so often, and so falsely, contrasted. As Richard Sennett says, 'Every good craftsman conducts a dialogue between concrete practices and thinking; this dialogue evolves into sustained habits, and these habits establish a rhythm between problem solving and problem finding'.[43] That process is intelligent and protracted.

In the film Good Will Hunting, when the Professor of Mathematics questions the gifted young Will as to why he wants to spend his life working as a builder instead of realising his potential as a maths student, Will is deeply offended. He cannot fathom why the professor does not understand his desire to do a trade in which there is 'honour' (building a home for a family).

'So the foundations on which the old disparity of esteem between 'practical' and 'academic' has been built have crumbled.'

Vocational education – helping people become learning-hotel-managers or learning-vehicle-mechanics – is commensurately intricate, demanding and worthy of respect. Neither a traditional 'Sitting by Nellie' model of passive observation and absorption, nor a pseudo-intellectual diet of diluted sociology or biochemistry, does justice to the learning required. Young people need to build habits of concentration and attention, smart practice and intelligent playfulness, controlled imagination and critical thinking, and helping them develop this mix is a demanding job.

Practical and vocational learning does not stop when a learner gets a BTec or a Diploma; and practical and vocational education is not merely the communication of knowledge and skill. To be a good teacher for practical learning, you have to be a role model, an explainer, a critical friend, and a coach of the 'wider skills' that every learner needs. You have to teach that being an electrician or a beautician is an honourable and difficult lifelong journey, not something you do because you weren't 'bright enough' to do something more academic. Learning to be an electrician can take a lifetime – if you have been set off right, full of curiosity and determination, resourceful and keen to learn more and more – just as learning to 'be a doctor' or 'a linguist' can. Imparting such a learning orientation is the job of every teacher – no matter whether their specialism is netball, animal husbandry, astro-physics or classical history.

So the foundations on which the old disparity of esteem between 'practical' and 'academic' has been built have crumbled. The assumption that 'those who can, think, while those who can't think, do' has no basis in science, and no place in an informed and egalitarian society. It is a deeper understanding of the true nature of learning, and the delicate ways in which body and mind inter-weave on the learning journey, that can rectify that disparity of esteem – not yet another round of tinkering with curricula, qualifications or funding.

For more information about how the science of learning is changing education please contact:

Centre for Real-World Learning
The Masters' Lodge
Romsey Road
University of Winchester
SO22 5HT

Web
www.winchester.ac.uk/realworldlearning

For more information or to discuss the 6 Steps to Change manifesto please contact:

Edge
10 Golden Square
London
W1F 9JA

Telephone
020 7734 6414

Fax
020 7734 8328

Email
centre@edge.co.uk