



# General Anthropology

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## Successful Teaching

### Cultivating the Teaching Moment

By Elizabeth Chin\*  
Occidental College

Teaching, for me, is fundamentally about facilitating an atmosphere in which students are able to learn, and creating opportunities for all of us to broaden our understanding of what learning is and how it can be accomplished. Because my classroom is a space in which learning is collaborative and processual as opposed to authoritarian and outcome oriented, students often have to rethink many of their assumptions about knowledge and learning, teaching and education. I want students to learn *how* to learn, to come away from their learning experiences with the ability to apply their problem-solving,

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## Tools and Brain Size

### Technology and Human Brain Evolution

By Dietrich Stout  
University College London

*Mastery over nature began with the development of the hand, with labour...the development of labour necessarily helped to bring the members of society closer together by increasing cases of mutual support and joint activity, and by making clear the advantage of joint activity to each individual. In short, men in the making arrived at the point where they had something to say to each other—first labour, after it and then with it speech—these are the two most essential stimuli under the influence of which the brain of the ape gradually changed into that of man.*

Frederick Engels

*The Part Played by Labour in the Transition from Ape to Man 1883*

Tool-use and tool-making have long been seen as “prime movers” in a uniquely human evolutionary package linking bipedalism, dexterous hands, articulate language, culture, and a large brain (Darwin 1871, Holloway 1969, Washburn 1960). The 1980s and 90s saw a major reappraisal of this orthodoxy, with influential “Machiavellian Intelligence” (Byrne and Whiten 1988) and “Social Brain” (Dunbar 1998) hypotheses explaining large brains as a response to the demands of group living rather than ecological or technological pressures. In the past decade, however, this sharp distinction has been moder-

ated by the recognition that primate ecological and technological adaptations are socially learned, and that multiple interacting causes and constraints will need to be considered in any full explanation of human brain evolution. In short, technology is social, and the early speculations of Darwin and Engels continue to look remarkably current.

The earliest direct evidence of hominid technological activity, and thus social interaction, comes from stone tools and cut-marked bones dating back as much as 2.6 million years at Gona (Ethiopia). The ensuing ~2.4 million years of the Lower Paleolithic witnessed a technological progression from simple ‘Oldowan’ stone chips to skillfully shaped ‘Acheulean’ bifacial cutting tools, accompanied by a nearly threefold increase in hominid brain size from the top end of the ape range to the bottom end of the modern human range. This coincidence of two of the most striking trends in human evolution certainly suggests a relationship, but is it one of cause, consequence, or mere corollary with other, more fundamental factors? To address such questions, we need to know exactly what it is we are trying to explain about the modern human brain.

### The brain: what needs to be explained?

Everyone knows that human brains are “big,” but what does this actually mean? Whales and elephants have absolutely larger brains and mice have relatively larger brains, yet few people want to conclude that these animals are more intelligent than us. Actually, the relationship between brain and body changes systematically with size (is “al-

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lometric”), and this fact has been used to develop measures of brain size that do put humans on top. For example, Harry Jerison’s famous Encephalization Quotient (EQ) compares observed brain size with expected brain size as predicted from an allometric (slope=0.67) regression of brain size on body size. Another method is to compare the size of different structures within the brain, based on the idea that some parts of the brain are concerned mostly with bodily regulation (e.g. brainstem) while others are more “cognitive” (e.g. neocortex). The classic example of this is Robin Dunbar’s Neocortex Ratio, which has been found

in many studies to correlate with mammalian social group size and/or complexity.

Such allometric approaches provide a neat solution to the problem of comparing brains, but there may still be a problem with simply factoring absolute size out of the equation. As Terrence Deacon (1997) has emphasized, larger animals live in a larger world. Because they tend to live longer and encounter more environmental variability, larger animals have both the motive and the opportunity to rely on flexible learned behaviors instead of hard-wired instincts. Larger brains must also be organized differently from small brains. Geometrically increasing numbers of potential connections and distances between neurons pose communication problems that require new integrative solutions—including the kind of flexible associative mechanisms commonly thought of as “intelligent.” So perhaps we shouldn’t be too surprised that gorillas seem smarter than capuchin monkeys despite having lower EQs. Within primates at least, there is growing evidence that absolute brain size is a better predictor of cognitive ability than EQ or Neocortex Ratio (Deaner et al. 2007).

But this still leaves us wondering why whales and elephants aren’t more intelligent than humans (at least according to our standards). Obviously size isn’t everything, and the answer may have something to do with the greater density of cortical neurons in humans and the relatively high conduction velocity of primate cortical fibers (Roth and Dicke 2005). Brain size alone may be useful as a rough index of cognitive ability, but it is also important to consider how and why particular brains got big. In many cases brain size increases might be a product of selection on body size, life history variables, or perhaps a generalized “information processing capacity.” From this one would expect a predictable pattern of allometric increase throughout the whole brain, most likely produced by simple

shifts in developmental timing. On the other hand, selection may sometimes have acted more directly on particular brain functions, in which case one would expect a more “mosaic” pattern of specific structural, micro-structural and even molecular adaptations. It is likely that both kinds of processes helped to shape the modern human brain.

In some respects the human brain is just what you might expect from a large bodied, long-lived, omnivorous primate. It is large in relation to other primate brains, has a relatively large neocortex, takes a long time to develop, and supports some pretty complex socio-ecological behaviors. Much the same might be said of omnivorous pigs and bears in relation to their more specialized relatives. Increased body size and the transition to a more diverse, higher quality diet probably does a lot to explain the rapid increase in hominid brain size seen over the past 2 million years. However, humans have carried these trends to extremes well beyond allometric expectations, and also display some very interesting “mosaic” types of adaptations (Rilling 2006, Sherwood, Subiaul, and Zawidzki 2008). Of particular note are: 1) disproportionate expansion of higher-order parietal, temporal, and prefrontal association cortices, 2) increased asymmetry between left and right hemispheres, 3) increased connectivity of temporal and frontal lobes, and 4) changes in the histology of occipital visual cortex and medial prefrontal cortex. In a development that would surprise Darwin and Engels not at all, these human neural specializations correspond pretty closely to distinctive human technological, linguistic, and cultural capacities.

### Technology, language and culture

By 2.6 million years ago, hominids had begun to make simple stone cutting tools that were most likely used to process animal carcasses and access meat. Although these tools were simple, they

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were skillfully made. Experiments have shown that modern apes (bonobos) can indeed fracture stone to make sharp cutting edges, but that ten years of practice in a supportive social context are still not sufficient to replicate the well-controlled flaking of the earliest hominid toolmakers (Toth, Schick, and Semaw 2006). Two critical hominid pre-adaptations probably helped pave the way for this uniquely human skill: bipedalism and an expansion of posterior parietal cortex. Critical hominid pre-adaptations probably helped pave the way for this uniquely human skill: bipedalism and an expansion of posterior parietal cortex.

Efficient stone toolmaking requires forceful precision grips that are not possible for chimpanzees, whose fingers must be stabilized for knuckle-walking. As Darwin argued, bipedalism may have “freed” the hand to adapt for manipulative purposes. Adaptations of the hand were also linked to changes in the nervous system that enhanced hand-eye coordination. Such human specializations include an increased number of direct connections between the hand and the cerebral cortex, changes in the cellular organization of the motion processing system in occipital visual cortex, and an expansion of posterior parietal areas involved in higher-order aspects of visual perception.

Fossil evidence from the interior surface of hominid skulls shows that parietal expansion had already begun in australopithecines some time between 4 and 2.5 million years ago (Holloway, Broadfield, and Yuan 2004), possibly reflecting adaptation to an increasingly manipulative lifestyle and paving the way for the subsequent development of Oldowan stone technology. In fact, functional brain imaging studies of Oldowan-style toolmaking by modern humans (Stout and Chaminade 2007) have pinpointed a region of posterior parietal cortex that is particularly important to this skill. The particular region identified is involved in representation of the central

visual field and the perception of the three-dimensional form from relative motion cues, and may be newly evolved in humans.

Although it may not have taken ten years, early toolmakers clearly would have required time, practice, and social opportunities to acquire toolmaking skills. This is especially true with respect to the increasingly refined bifacial tools that began to appear after about 1.7 million years ago. Increased social tolerance, without the distracting emotional arousal of dominance interactions, may have been critical for such learning in much the same way that docility seems to favor the development of complex social cognition in domesticated dogs and foxes (Hare and Tomasello 2005). Portions of prefrontal cortex are known to play an important role in emotional regulation and social cognition, and the more general expansion of this region in humans may have some relation to the demands of living and learning in close-knit groups. At the cellular level, it has also been suggested that changes in the frequency and spacing of distinctive “von Economo neurons” in human medial prefrontal cortex may support enhanced capacities for the fast, intuitive assessment of social situations.

Social cohesion is also promoted by talking, and human language may be a kind of “social glue” that plays a similar role to grooming in other primates or scent marking in pigs. But language is more than just verbal grooming, and plays a fundamental role in negotiating the social relationships, joint action, and shared realities that form the basis of distinctively human culture. Studies of modern humans show just how important this supportive cultural context has become to the transmission of complex technological skills as, for example, in learning to navigate on a U.S. Navy vessel (Hutchins 1995) or to produce a stone adze in highland New Guinea (Stout 2002).

Linguistic communication is itself a very complex activity that involves many different parts of the brain, but some of the core structures include Wernicke’s area of the left superior temporal lobe, Broca’s area of the left inferior frontal lobe, and the fiber bundle known as the arcuate fasciculus that connects them. Thus it should probably come as no surprise that the temporal lobe has become both larger and better connected to the frontal lobe in humans.

Language and toolmaking are clearly related to each other through the medium of social learning, but there is also increasing evidence of a more direct neuro-evolutionary link. The hand and mouth are the two most complex and flexible effectors of the human body (it is no coincidence that sign languages are manual), and are represented in neighboring sections of sensory and motor cortex that only become fully distinct during postnatal development. Adult networks for speech and object manipulation actually do overlap in Broca’s area of the left inferior prefrontal cortex, which is no longer seen as a dedicated “language center” but rather as a more generalized contributor to the understanding and execution of hierarchically structured action sequences. Thus it is quite plausible that selection acting on either toolmaking or language would have promoted neural adaptations favorable to both. Evidence from functional brain imaging strongly supports this link, and a recent study has directly shown that Acheulean handaxe making activates Broca’s area in modern humans (Stout et al. 2008). Well, almost—in a fascinating twist, it is actually the right hemisphere equivalent of Broca’s area that is activated. The left hemisphere is classically considered the “language hemisphere,” but as usual the truth is turning out to be more complicated. While the left hemisphere is indeed dominant for phonology and syntax, the right hemisphere makes critical contributions to larger scale language elements like

metaphor, figurative language, prosody, and discourse comprehension. Not so coincidentally, a very similar division of labor is evident in coordinated bimanual tasks in which the right hemisphere-left hand system typically provides a stable postural frame for the rapid and precise action of the left hemisphere-right hand system (at least in right handed people). This division is evident in everyday tasks like sweeping, threading a needle or cutting paper with scissors, and it turns out that the role of the left “support” hand is particularly critical in stone toolmaking.

The hemispheric segregation of fast and precise processing from more holistic and stable processing seems to be a general principle of the human brain, and likely represents a response to the conflicting requirements of the two modes. The increasing importance of this segregation in human evolution has produced numerous cerebral asymmetries, ranging from a macroscopic “twisting” (petalia) of the two hemispheres to microscopic differences in the spacing of neurons in Broca’s area, as well as the 90% prevalence of right-handedness in *Homo sapiens* (compared to 67% in chimpanzees). Once again toolmaking and language stand out as likely contributors to these specializations of the human brain.

### Chicken or Egg?

Ongoing research continues to support long-held intuitions regarding the tight links between technology, language, and culture in human brain evolution, while adding a great deal to our understanding of context, timing, and mechanism. However, the very tightness of these evolutionary relationships makes it difficult to distinguish cause from consequence. Fossil evidence has pretty decisively supported Engels’ supposition that bipedalism and the hand came first, but did toolmaking lead to language or vice versa? Actually this sounds a lot like a chicken or the egg type question, and it is likely that evolving technological, lin-

guistic, and cultural capacities played different roles at different times. It may not be possible, or even theoretically viable, to identify a discrete “initial kick” or single “prime mover” in human brain evolution.

Paleolithic archaeology, hominid paleontology, and perhaps genetics as well can provide evidence of relative timing, and it is certainly suggestive that stone tools predate conventional indicators of symbolic behavior (e.g. ornaments, art) by a wide margin. However, it is important to remember the real difficulty in finding direct archaeological indicators of such complex and intangible phenomena as “symbolism” or “culture.” Archaeologists and biological anthropologists would be well advised to pay attention to insights from cultural anthropology, linguistics, psychology, ethology and related disciplines in order to avoid an overly simplistic approach. New research methods like brain imaging will certainly have a contribution to make, but real progress will come from the integration of ideas and approaches in a truly interdisciplinary fashion, across the four fields of anthropology and beyond.

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**Teaching** *continued from page 1*

critical and analytical skills to any situation they might encounter. Developing translatability that is deeply connected to real-world skills makes it important to create opportunities for students to apply knowledge outside classroom.

Another element that I view as crucial is challenging students to get out of their 'comfort zone,' especially since so many of them have lived their lives within pretty definite geographic, ideological, and/or social borders. The idea, in short, is to explode the implications of their learning outward into their lives.

Attending to this variety of experiences and modes of engagement can be a tricky task, and I have lots of ways to try to get at them. My approaches range from highly structured introductory classes that require students to complete a few guided assignments to upper division courses run entirely by students. Enlisting student support and participation is key, both for getting them to 'buy into' sometimes unfamiliar approaches to learning, and to develop a cohesive and productive classroom vibe.

I take a purposefully developmental approach in cultivating students as co-learners and independent thinkers. Basically what this means (and it's not rocket science) is that assignments, tasks, activities and expectations are calibrated to the level of the course and, often, to the makeup of the group of students in any given class. Furthermore, I look for strategies that are designed to incrementally build skills for students so that as they take multiple classes with me, their capacities are stretched and enhanced. This enables them to enculturate less experienced students to my classroom environment and practices. In lower level classes, or classes in which I find myself with few students experienced in this sort of independent exploration, I try to provide assignments that are designed by me, clear-cut, designed as a series of

steps, and short. At the opposite end of this spectrum with experienced students, the course may be entirely student-run, with students facilitating all class sessions, creating the syllabus, assignments, and expectations.

### **The introductory course**

A typical introductory course assignment involves a small group of students—no more than four—facilitating an entire class meeting. I frame this as teaching rather than presentation, a distinction I feel is especially important. Teaching establishes collaborative learning/teaching as a mode of engagement and also moves students toward shaping the class session in ways they don't usually think of when doing a presentation.

For the introductory course, students are evaluated on the sophistication of concepts presented, clarity of communication, connections to class issues and concepts, and evidence of collaboration in the presenting group. Guidelines also include a requirement for them to include an active or experiential learning exercise as a way to ensure that the class session moves well beyond a standard lecture. To make sure they prepare ahead, students must submit to me a detailed lesson plan beforehand. I also ask them to think especially about addressing issues or questions that may not yet have been covered by me in the preceding few days, and I urge them to meet with me as they plan their work. While students do not always or even often feel completely comfortable with my assurances that we really are a team, I find that this approach begins the work of creating the learning process as a group effort and generally raises the level of classroom engagement across the board. Because even the largest classes at Occidental College contain only about 35 students, this is a workable format, but I think it could be adjusted to work with somewhat larger groups.