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Multiplying Intelligences: Hypermedia and Social Semiotics

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In his influential work, *Frames of Mind*, Howard Gardner (1983, 1993) has offered us the useful view of human sense-making capacities as multiple distinct intelligences. Already in that early work Gardner recognized that, however distinct they might be biologically, and however useful it might be to separate them analytically, multiple intelligences are intimately integrated with one another in practice (*FM*, 313-316). What is the significance of this integration? How can we conceptualize what happens when, say, verbal inference, abstract visualization, and mathematical symbolic representation are combined in scientific reasoning? What are the implications for education of attending to the explicit teaching of skills and strategies for co-deploying our multiple intelligences? And for doing so in socially collaborative media?

In this chapter I want to present a social semiotic approach to these questions. Social semiotics suggests that each intelligence is mediated by an analytically distinct semiotic resource system: language, visual depiction, mathematical symbolics, etc., and that when we combine these resources their meaning-making potentials quite literally multiply one another, making possible distinct kinds of meaning that cannot be made in each one separately. The advent of computer-based multimedia and hypermedia offer us new opportunities to fashion multimedia genres and new associated forms of individual and collaborative reasoning.

Building on prior research on multimedia semiotics in science classrooms and scientific print publications and new work on multimedia websites and the semantics of hypertext, I will analyze the semiotics of hypermedia as both requiring and facilitating a multiplication of verbal, visual, mathematical, motor and social intelligences in new ways. From this analysis I will draw out a number of important implications for educational research and practice in teaching students how to multiply their intelligences.

From Lumping and Splitting to Multiplying and Dividing

Gardner explicitly situates his arguments for multiple intelligences within the historical debate between the 'lumpers' – those following Spearman's g-factor model of a single general intelligence realized in different ways in different settings – and the 'splitters', who, like Thurstone and Gardner himself, emphasize the differences among verbal, mathematical, or spatial abilities. For a long time this debate was a technical one, turning on the issue of how to mathematically model the larger or smaller correlations among various quantitative measures of each different 'intelligence' or aspect of the one single 'intelligence'. Gardner brought two major additional lines of argument to this debate, one biologial and the other semiotic. He pointed out that various kinds of biological evidence, such as aphasias resulting from brain damage that impaired one kind of intelligence but not another, pointed toward separate biological bases for distinct intelligences. He also followed the lead of his mentor, Nelson Goodman (1976), and saw that different intelligences specialized in different kinds of meaning-making or meaningful action (speaking words, composing music, calculating quantities, imagining spatial relationships) had evolved correspondingly distinct notational or symbolic systems (writing, musical notation, mathematical symbolism, architectural drawings).

Beneath these arguments lie deeper questions. Is intelligence, whether single or multiple, an inherent property of each human organism, or is it an aspect of human situated behavior, dependent not just on the organism, but on the setting and tools available (cf. Lave 1988)? Is intelligence definable in purely biological terms (e.g. as speed or energy-efficiency of neuron functioning), or do we call behavior intelligent depending mainly on how closely it conforms to what is valued in our culture? Finally, is intelligence in fact solely a 'cognitive' phenomenon, a matter of individual psychology alone, or does it represent the individual's use of semiotic tools and resources, such as language, systems of pictorial conventions, mathematics, musical genres, etc., that cannot be found within individuals but only between them? I will not attempt answers to these questions here, but they underlie many of the issues I do wish to discuss.

In one sense the core issue between lumpers and splitters that motivates Gardner's work is this: What is more important, the similarities or the differences in the ways we speak well, paint or sculpt brilliantly, dance with inspiration, juggle logical abstractions insightfully, lead nations effectively, or know ourselves deeply? The answer to such a question must depend on the uses to which we will put our model of intelligent behavior.

By narrowing the range of behaviors considered to those that define upper-middle class cultural capital (Bourdieu 1984, 1990) in a technological society (e.g. verbal skill, logic, mathematics, spatial reasoning), the lumpers demonstrate that up to a point all of these are of a piece. Facility in this kind of behavior is highly useful for making money and developing profitable technologies, as it is for designing modern weapons and planning modern battles. It has been argued (e.g. Walkerdine 1988) that it is moreover largely a masculinized kind of behavior, encouraged in males and dismissed as unfeminine or inappropriately employed by females. The unitary notion of intelligence justifies meritocratic rule and embodies the values of the 20th century's dominant subculture: instrumental rationality, quantitative evidentiality, technological growth, economic and military dominance. With a single measurable 'intelligence' as a fixed property of each individual that predicts 'success' by these values, society becomes naturally and biologically ordered in a strict hierarchy. It is a short political step to advocating the right or the necessity of having the most intelligent make decisions for all.

By expanding the range of behaviors considered intelligent to also include musical composition and performance, dancing and athletics, painting, sculpting, and architectural design, as well as social insight and leadership, self-understanding, and insight into nature, Gardner reduces the possibility of establishing quantitative correlations among measures of these abilities. Without correlations there is no one-dimensional hierarchy anymore. Instead we find ourselves in a multi-dimensional space of human abilities; those who excel in some respects may be mediocre or disastrous in others. Politically, it is not now so easy to say who should rule; but how much change has there been in the underlying value assumptions about what forms of behavior matter most? Gardner's 'naturalist' intelligence gives some political support to the values of environmentalists. 'Social' or interpersonal intelligence recognizes communitarian values, and perhaps is an area in which males do not excel, as our society is presently gendered. The value of the arts are an easy sell to upper middle class people who count 'high culture' among their valued cultural capital. It would be interesting to know if there are quantitative measures of 'bodily-kinesthetic' intelligence on which working class athletes and upper-middle class ballerinas fare equally well, of musical intelligence in which rock and classical composers do so, or measures which treat on equal terms the social intelligence of gossip mavens and corporate ladder-climbers. We can fashion discursive technologies to treat differently valued practices as 'the same', but we cannot escape from the role that values play in determining what shall count as intelligent behavior.

The original logic that gave birth to the modern concept of intelligence was that there was a common factor across highly correlated quantitative measures of how well people did somewhat different things: remember words, images, and numbers; solve verbal, visual, and mathematical puzzles. Gardner's proposal that there is not one common factor among a few kinds of behavior that should be called intelligence, but rather several factors, each common to a different behavioral domain and 'intelligence' and each mostly uncorrelated with the others, relies on the same common-factor logic, but multiplied. And yet, *how* are we to reduce the vast diversity of human behavior to a small number of domains and factors (six to eight in various versions of Gardner's model)? Again Gardner's strategy was to combine biological criteria and semiotic criteria: Was there a dominant sensory mode or motor repertory? Was there a distinctive form of representation which mediated the behavior? For the record, and candor's sake, let me say that I agree that the analysis of human behavior is mainly the project of figuring out how our biological and ecological behavioral possibilities (what our bodies can do in interaction with object- and agent-filled settings) get enhanced and restricted by using semiotic resources (language, depiction, mathematics, music, dance, cuisine, dress -- routine systems of culturally meaningful procedures of many kinds). But I do doubt that we can usefully reduce the domains of intelligent human behavior to a small number, and I mainly fear that every attempt to do so which claims the universal validity of objective science may in time become part of political projects to unjustly advance the values and interests of some social and cultural groups in the world at the expense of others.

Suppose, however, that we acknowledge that everything we say on this subject reflects our particular cultural and historical position, and our social and political viewpoints and interests. What are the uses of splitting, as opposing to lumping, our view of intelligence? One advantage, clearly, is that we can better resist efforts to evaluate individual human beings along a single scale; instead we place them somewhere in a large space of multiple dimensions. We become less likely to assume that someone who does one thing well will also do other things well. We begin to suspect that to the extent that many people who do some valued things well also do many other valued things well, that the correlation may lie primarily among the *values*; that all these things may be valued by some particular social group because such values accord with their interests. This, to me, is useful intellectual progress.

Suppose we also acknowledge that what seems to some to be the same task, in an abstract way, when it is presented in different settings, or for different examples, or with different available tools, partners, and contextual cues is *not* the same task functionally for the same individual (Lave 1988; Cole 1996: chaps 5 and 8), much less across different individuals with different interests, desires, and experiences (quite apart from any differences in brain function or sensorimotor physiology). This means that how intelligently we behave, as judged by the criteria of some observer, may depend on whether we happen to enjoy the particular example chosen for the task, whether it has positive cultural associations with our sense of personal identity, or whether it is presented in a setting in which our preferred tools are available or where the other persons present are to our liking (Walkerdine 1988, 1997). With this view, we are less likely to assume that just because someone cannot perform what seems to us the same task in one case or one setting, that they could not perform it quite exceptionally well under other circumstances. We begin to see success and failure not in terms of inherent and constant 'abilities', but in terms of 'matches and mismatches' among persons, tasks, contents, and settings. We begin to doubt that it is so easy to separate 'cognitive' from 'affective' from 'sensorimotor' processes in practice and outside laboratories specifically built to try to do so (Latour 1987, 1993). We may even begin to think of reasoning and rationality as one particular affective mode, always mixed with others, and to see affect, desire and identity as more central to behavior than ability. How can we even *define* 'the level of ability' to do something if the quality of performance varies tremendously across different instantiations of 'the task'? What makes these occasions instances of 'the same task' except our own desire to see them as such and to ignore their differences?

What then is left of the notion of 'an intelligence'? Perhaps a consistency in peak performance, under optimal conditions for the individual, across a range of behaviors that are valued in some community, widely regarded in the community as similar or of the same kind, and for which the community recognizes substantial individual variation in consistent levels of peak performance of a kind that matters. Without inquiring here as to why these variations exist, from occasion to occasion for one individual, or across occasions from one individual to the next, we can still ask what it might be about a community that could lead it to name and pay attention to a small number of distinct kinds of intelligence? For one thing, clearly, its values. And for another, its systems of semiotic resources. Both are primarily characteristics of the community, but as we say, they are 'internalized' in individuals as well. This metaphor may be an unfortunate one. We are speaking here of aspects of interactional processes; they are not replicated inside individuals. Rather individuals learn to play their parts in these social processes, and by virtue of being able to do so, and by the miracle of (perhaps) re-entrant connectivity in our brains (Edelman 1992), we can enact both sides of a social interaction in imagination, and integrate imagined action with real action. We learn to talk with others, to talk to ourselves, and to talk our way through tasks even when alone. We learn to interact (and so act) consistently with the social values of those with whom we interact most, and with whom we care most about our interactions. We learn to use language, make gestures, draw pictures, play music and games in the same way. We learn, in effect, to make situated sense to and of others, and so to act meaningfully and make meanings for ourselves as well.

I am trying here to build a bridge of words from the culturally-aware, but still basically psychological perspective of Gardner's book to my own way of seeing these matters. What matters for Gardner are different mental 'intelligences' -- biologically rooted, semiotically mediated, and functionally integrated in specific culturally meaningful activities. What matters for me are situated social practices, deploying various semiotic resources, in ways that are permitted but not required by the interaction of organism and object- and agent- filled settings. In my own social semiotic perspective what lends commonality to these practices are the lifeways of particular sub-communities, including their beliefs, values, habitual styles of action, and distinct 'dialects' of language and other semiotic resources. If we consider aggregate larger-scale communities, then across their internal diversity there is less and less in the way of shared beliefs, values, and actional styles, but there is still quite a bit in common among their semiotic resources. One reason for this is that the primary function of semiotic resources is communicating meaning. Or perhaps it is better to simply say that all meaning is at least implicitly communicative: 'addressed' (cf. Bakhtin 1953/1986 on dialogism in language, or Halliday 1978, 1994 on its pervasive interactional meanings) and 'positioned' (Bakhtin's 1935/81 heteroglossia or my generalization of Halliday's 'attitudinal' function to 'orientational' meaning, e.g. Lemke 1989, 1995) within a diverse community. Semiotic resources function to link communities together across their differences, as well as to create and maintain distinctive practices within each community. Thus it happens that the semiotic resource systems, the 'meaning potentials' (Halliday 1978) of different communities which are regularly in contact, and particularly of different sub-communities of the same larger community, can provide a common denominator at the wider social scale.

The multiplicity which Gardner discerns among 'intelligences' corresponds very largely, from the social semiotic viewpoint, to the multiplicity of the semiotic resource systems themselves: to the different kinds of meanings people can make, and to the different ways in which these meanings can be made. From the social semiotic viewpoint, there is no question that semiotic systems for making meaning are multiple, but there is a mystery as to why. Would not a single unitary semiotic resource be ideal for communication, articulation across diversity, and the production of intelligible meaning within communities? If there were such a single semiotic, those who mastered it, or who were physiologically pre-adapted to use it more effectively, might indeed be counted 'most intelligent' across a wide range of tasks and settings. But it is not so. There is no single semiotic common denominator across all meaningful human behavior. Why not? What is there about the uses to which semiotic resources are put that has led biological-cum-cultural evolution to a different strategy? That strategy, I will argue, is 'divide and multiply'. Understanding it perhaps gives some insights into not only why there are a multiplicity of broad modes of intelligent behavior, but why real social practices always necessarily combine distinct semiotic modalities together.

'Divide and Multiply': Semiotic Differentiation and Functional Integration

A semiotic strategy of 'divide and multiply' means that:

(1) phylogenetically and ontogenetically there were fewer, perhaps just one, semiotic modality, and that with evolutionary and developmental time an initial semiotic becomes progressively differentiated into diverse practices, which, under the functional pressures of use, become separately organized into distinct semiotic systems ('divide'), and
(2) historically in each culture, and biographically as each individual learns to participate in cultural practices, the newly separate and distinct semiotic systems come to be co-deployed simultaneously in integrated ways that permit more complex and precise meanings to be

made through their combinations than could be made with any one separately, or with the proto-semiotics from which they descend ('multiply').

In less formal parlance, when you combine two semiotic modalities, such as writing and drawing, the set of possible combinations is multiplicatively greater because each possible text (N) can in principle combine with each possible drawing (NxM), and so in any actual case, the meaning value of the combination is greater, and the meaning made potentially more precise, because it is one combination out of (NxM) and not simply one text out of N possible ones plus one drawing out of M possible ones (N+M). To get the multiplicative advantage (100+100=200; 100x100=10,000!) two conditions are necessary. First, the two modalities cannot be redundant with one another; that is, they cannot simply present the same meaning in two different forms. Second, some system of conventions must exist (multimodal genres) whereby it makes sense to 'combine' text and drawing, i.e. the meaning of the text must potentially change when accompanied by a different drawing, and the meaning of the drawing be potentially different when accompanied by a different text.

The first condition is met if you accept, as I do, the principle of the incommensurability of different semiotic presentations. There is no possible one-to-one correspondence between the meanings of texts and those of pictures, in general. Even if we artificially create a correspondence between their forms (i.e. reckon their formal information content, not their cultural meanings, as say a computer would do, reducing both to strings of numbers), this does not create a correspondence between their meanings because their meanings depend on how we interpret that particular medium. We read a text in relation to many other texts in very different ways than we read a picture in relation to other pictures. A picture always has 'pictorial meaning' that is qualitatively different from 'textual meaning'. No number of words can ever have the same meaning as a picture, and no picture or pictures can ever have the same meaning as some text.

But the more we see the incommensurability of meanings made verbally and pictorially, the more mysterious it becomes how they could in fact 'combine' with one another. How do we make pictorial-textual meanings? These must themselves be incommensurable, as meanings, with either the pictorial or the textual meanings of their components taken alone. What is the nature of all that 'extra meaning' that we get, beyond the sum of the parts (N+M), up to a maximum of the multiplicative product (NxM)?

Our theories of meaning are still quite primitive. We can reasonably say something about how a single sentence of a few clauses means what it does for people, at least in terms of the semiotics of language (lexis, grammar, and semantics; e.g. Halliday 1978), but much less about how that sentence contributes to the meaning of a whole novel, or how its meaning for us is changed by the preceding and following sentences, paragraphs, sections, or chapters. The task of saying how its meaning becomes different when accompanied by a picture, or when said in the context of some particular social activity, is one that has just begun to be undertaken. Likewise we can say something reasonable and informative about how we read pictures (e.g. Arnheim 1956, Kress & van Leeuwen 1996, O'Toole 1990) in isolation, one at a time, and even how we integrate one part of a picture with another. It is much more difficult to explain how we intepret pictures in relation to other pictures, or to architectural settings or social activities in which the pictures play some role.

Nevertheless, it has been possible to find common denominators in our accounts of how at least texts and pictures (including diagrams) mean, and these common principles seem extensible to sculpture and architecture (O'Toole 1994), music and bodily action (van Leeuwen 1991, Martinec in press), and mathematics (Lemke 1998a, O'Halloran in press). We can take these shared principles among different semiotic systems as evidence of their common ancestry (differentiation from proto-semiotics), and/or as helping to explain how it is possible for us to make combined or joint hybridized meanings with them despite their semiotic incommensurability.

In generalizing Michael Halliday's original insights into the semantic functions of language, and of every text as a unit of meaning (as an 'utterance' rather than as a formal unit such as a sentence), I have proposed that across all semiotic systems, every meaningful unit means simultaneously in three parallel ways (generalizing Halliday's 'metafunctions' for language): Presentational (creating or describing a world, a state of affairs, a content, however abstract), Orientational (taking a stance toward the Presentational meaning and its audiences; 'addressed' dialogically and 'positioned' heteroglossically), and Organizational (linking parts into wholes, and the whole to its exterior contexts; Lemke, 1989, 1995). For instance, representational imagery in painting presents the world, but figure perspective orients the viewer to it, and the composition of masses and vectors of edges and lines organize its parts into a coherent whole. In text, we present with propositional content ('John is coming'), orient with mood (command vs. question; 'Is John coming?') and modality (may vs. must; 'John may be coming'), and organize with genre structure (introduction, body, conclusion) and cohesion ('John is coming. He wants to'; *he* links to *John*), among other resources.

Thus the possibility arises that the overall Presentational meaning of a combination of text and picture can be produced because both are contributing functionally to this aspect of meaning, and likewise for combining their Orientational and Organizational meanings. Of course it not so simple. Within a single semiotic modality, the three functional aspects of meaning interact with another. A smile on a pictured face both presents a smile and orients to the viewer by engaging us; similarly as the eyes are shown looking directly at the viewer or not. In a text, a consistent orientational stance of skepticism toward what is being said also helps contribute to the cohesion of the text, and a change in that stance can contribute to marking the boundary between two textual units of organizational structure. Similarly, the three functional aspects of meaning can also interact across semiotic modalities: the presentational content of verbal labels in two diagrams or two parts of one diagram can create organizational ties between the visual elements to which they are attached. To the extent that the three generalized semiotic functions (Presentational, Orientational, Organizational) are applicable to all semiotics, they provide a basis for analyzing and explicating how joint meanings are made in multimodal combinations of elements from different semiotic resource systems (Lemke 1998a).

It is not so surprising that there is an underlying commonality among the meaning functions in different semiotics if we imagine that they have all descended from a common ancestor. On the principle that each new developing organism must recapitulate the steps by which historically, and perhaps phylogenetically, the process of differentiation occurred, we might imagine that meaningful motor activity, especially social inter-activity, was itself the original proto-semiotic. Co-ordinated gross motor activity precedes the co-ordinated fine motor activity of speech, and initially vocalizations are not necessarily differentiated as signs from the rest of the stream of communicative (or at least functionally interactive) motor communication. Speech develops, and likely evolved, as part of interactional synchrony: the bodily and material integration of individual organisms with one another and the rest of their ecosocial environments. The intonational patterns of speech and the musical patterns of song descend from common ancestral modes of behavior. The rhythms of synchronization are the likely precursors of drumming and dancing. The synchrony, not just in individuals but across dyads and groups, of verbal action with other body movements and rhythms signals the participation of gesture and movement in the unitary communication system from which we abstract the semiotic systems we call language and gesture (cf. Kendon 1990, Scheflen 1975). Our perception as well as our production of semiotic interaction makes use of visual and kinesthetic information and responsiveness as much as it does of the auditory channel.

Ontogeny also shows that writing and drawing also share common ancestry; that each generation must be taught anew to make the separation between them. Writing is not merely the annotation of speech, as drawing is not simply the inking of images. Drawing begins as the extension to paper of gesture, as the product of lasting visual traces of our gestures in acts which are indiscriminately gesturings and drawings (cf. Arnheim 1956, cited in Kress & van Leeuwen 1990: 25). And these are accompanied you can be sure by vocalizations which are not as distinct from other motor gestures as the abstractions of linguistics and the ideology of intellectual verbalism dispose us to believe. It is not surprising that children do as one act what adults have been taught to separate into two: drawing and writing (cf. Dyson 1991; Hicks & Kanevsky 1992). Like our first drawing, our first writing is not a *representation* of speech, but an *extension* of it that produces a lasting visual trace.

If we compare this semiotic phylogeny with Gardner's multiple intelligences we find striking parallels and some key differences. In following modern linguistics in separating the semantics of verbal language from the motor vocalizations of speech, there is a danger that 'linguistic intelligence' may be defined in a way that does not take account of the ways in which rhetorical brilliance and poetic achievement depends on the sound-effect of language, on a kind of 'singing' and even breathing and swaying that entrains an audience in an almost magical communion of speech. The African-American preacher, the Jamaican story-teller, the enacted and performed Shakespeare, and not the fluent writer of winning legal briefs or the successful print novelist may represent the heights of linguistic intelligence. Perhaps it is even the case, contrary to our logocentric ideology, that not verbal semantics but the sound-spell of speech is what gives it its greatest social power. That is what the Hindu linguists believed when they wrote the first treatises on language; it is what Afrocentrists affirm when they ground Ebonics in the music and affect of African-American speech, recalling that of Africa, and not in the standard linguistic features by which European linguists define it as merely another dialect of English.

Gardner also associates language with music physiologically, but as aural forms, not as oral ones. He does not appear to be thinking of the motor dimensions of speech and song, but only of the auditory sensory modality. For too many people today, music is something heard, not something made. How does a drummer's supreme effort differ from the kinesthetic-bodily intelligence of a dancer or an athlete? Should we take tone to be more fundamental to music-making than rhythm? Were the motor areas of the deaf Beethoven's brain less active than the auditory ones when he was in a fit of composition? Do we imagine Mozart just sat still and listened to inner music as he composed, or that he danced about and pounded his instrument? How long in phylogenetic terms can it have been since 'pure music' was culturally distinguished from singing-and-dancing and singing-and-drumming? Long enough for a separate biological basis to arise? Or is ‘pure music’ in the modern European sense a hybrid intelligence, with a mathematical-logical parent as well as a kinesthetic-bodily one? Motor-logic, with auditory feedback?

The area of mathematical-logical intelligence also raises interesting questions from a semiotic point of view. Both mathematics and logic quite clearly descend, at least on one side of their parentage, from language. That side is their algebraic-symbolic side. Mathematics, one can argue (e.g. Lemke 1998a, in press), functions historically as the bridge between conceptual, categorial language and other semiotics with which we cope with matters of continuous quantitative variation. The latter are mainly spatial-motor and visual. You can describe an irregular shape with a gesture or a drawing, but not very well in words. You can calculate a nonsimple ratio with numbers, or visualize it in a triangle, or experience it moving on a slope, but the linguistic name for it is intuitively meaningless (‘nine twenty-thirds’). Our scientific theories are built from relations among concepts, which are language’s forte, but they can be applied to phenomena that depend on continuous quantitative covariation only through translation into numbers, graphs, and motor actions. It is the job of mathematics to achieve this translation, to provide a common semiotic between language, which gives rise to algebra, and visual-spatial-motor semiotics, which give rise to geometry. It may be only a conceit of modern European mathematics that logic is its heart, and that it concerns itself with relations of pure form. For most of its history, and in most cultures, mathematics has been about quantity and ratio, and its operations were often performed as much manually and bodily-kinesthetically (the abacus; Oksapmin body mathematics, Saxe 1982) or visually (geometric diagrams and modern graphs), as symbolically and logically.

Gardner distinguishes a ‘spatial intelligence’ from the bodily kinesthetic one, presumably on the grounds that it is entirely a matter of visualization. But this again, as in the case of music, seems to too radically separate the sensory from the motor elements of how we know the brain works. Pure spatial visualization, as in the three-dimensional rotation tasks beloved of laboratory psychologists, does not seem to me a good candidate for an evolutionary intelligence apart from its integration with motor-coordination in three-dimensions (e.g. arborial monkeys and our brachiating primate cousins). Perhaps the brain does three-dimensional processing differently than it does two- and one- dimensional spatial-visual tasks, but I would not think 3D visualization would evolve apart from 3D motor proficiency. Certainly there is some fundamental semiotic differentiation between the spatial-motor-visual cluster and the language-logic mode. Musical intelligence perhaps specializes the rhythmic aspects of the former and hybridizes with the intonational qualities of speech. Mathematics functions in much more recent cultural history to bridge across the divide of the two main clusters. But semiotically is it hard for me to see all these intelligences as independent and equal peers, each with its own separate phylogenetic roots.

Finally, Gardner proposes separate status for the ‘personal intelligences’, i.e.interpersonal or social intelligence and intrapersonal or introspective-reflexive intelligence. I would certainly agree that these two are linked to each other, and that they touch on something fundamental. If we assume that meaning begins in sensorimotor interaction of the organism with objects and other persons, then the meaningfulness of relationship to others, even mediated by things, tools, and signs, is fundamental indeed. But I am a little warier of the eighth, ‘naturalist’ intelligence, not because I doubt that interaction with Nature is as fundamental as interaction with other humans, but because the very Nature/Society dichotomy is so obviously cultural and historically recent (Latour 1993). It seems to me that we relate to nonhumans in exactly the same ways we relate to humans, except where this is taboo in our culture, and our individual proclivities lead us to develop our intuitions about people, other animals, plants, and the rest of the arbitrarily distinguished 'natural' and 'artifactual' settings to vastly different degrees. Intrapersonal intelligence is interpersonal intelligence turned inward, and naturalist intelligence is interpersonal intelligence turned outward, and developed less species-centrically. Of course it is difficult in all these cases to identify in what modes of behavior and perception these intelligences consist apart from their mediation by language. Introspective intelligence has the least to go on other than language; we rarely see ourselves, and we hardly know what to make of how we feel, physiologically and emotionally, apart from the names and discourses we can put to these feelings, or at best how these inner sensations correlate with our assessments of outer circumstances, or our outward imaginings. Perhaps it is no accident that Freud proposed a 'talking cure' for our inner disturbances. Nonetheless, even if the intrapersonal is a latecomer, reflecting interpersonal intelligence back on itself with the help of language, there is still very likely some early core semiotic, which we might call interpersonal-ecological or perhaps 'ecosocial' intelligence, which may be the progenitor of a third main cluster, and itself have arisen from sthe one original proto-semiotic of sensorimotor inter-action.

But are these all there are? In terms of social semiotics, there are of course many more organized resource systems for making meaning, derived from various kinds of social activity which have become ritualized and systematically differentiated in meaning and value, one form of action from another, by kind or by degree. Some of these are clearly hybids, as for example writing with its visual typography combines language and depiction (with late parallels in musical notation and dance notation). Some are further specializations, such as the use of typical cultural narratives to make meaning by allusion and expectation. But what of Acting? Or Cooking? Or Fashion? Or if we are looking back as far as possible along the family tree, what about 'sexual intelligence'? Is it an early hybrid of bodily-kinesthetic and interpersonal intelligences? Or is that just our modern sex-shy analysis trying to deny it a more fundamental role? Certainly if we define it as broadly as Freud did, it could well be a forerunner of interpersonal intelligence, or kindred to it and coeval with it. Since our definitions of intelligence are clearly bound up with what we value culturally, it is not surprising there might be strong ambivalences about 'sexual intelligence'. This case in turn suggests we ought to at least consider whether some forms of human behavior which are negatively valued by us, but have been positively valued elsewhere, might also be candidates, for either primary intelligences or important semiotics.

What about 'warrior intelligence' 'killer instinct' or 'torturer's intelligence'? What about religious or spiritual intelligence? Or the ability to totally suspend rationality or ego-dominance in states of trance, possession, or 'berserk'? What of 'shamanistic intelligence' or 'mystic's intelligence'? What about the ability to become totally incorporated into herd-behavior, 'mass hysteria', or mob-riot? What about 'submissive intelligence'? or the ability to deceive with total sincerity and effectiveness? Such examples, I think, again point to the need for a very careful analysis of the role of local cultural and subcultural values in defining any number of intelligences.

From the perspective of a theory of multiple intelligences it becomes very important to decide what are the few substantially distinct core intelligences because the claim of the theory is twofold: first, that there is more than one such mode of intelligence, and secondly that each of the core intelligences is rooted in physiology and phylogeny. Social semiotics, on the other hand, can be perfectly content with multiplying the number of recognized semiotic resource systems indefinitely. Every specialized mode of human interactivity in the ecosocial setting for which a community construes systematic relations of meaningful differences of kind or degree in the participating actions, events, objects, and persons can define a distinct semiotic resource system. It is a useful task within the theory to examine the kinds of relationships among these semiotics, whether by classifying them (e.g. by their typological and/or topological strategies; see below), adducing probable genealogical relations (differentiation from precursors), or formulating the principles underlying their potential integration or co-deployment with one another.

From the viewpoint of social semiotics what matters most is not how we decide to divide up the systematic semiotic resources of the human behavioral repertoire, but how well we can explicate how those resources are co-deployed to create complex multimodal meanings. For in this model, *all* actually produced meaning is multi-semiotic in nature. We cannot mean with just one analytically separable semiotic system. There are no pure instances of linguistic meaning, no material signifiers that mean in terms of the linguistic (or depictional, or gestural, or mathematical, or any specialized actional) semiotic system alone. At least not past any imaginary point early in human development, preceding differentiation of distinguishable semiotic systems. (By the way, you distinguish such systems by their different systems of relationships among signs, even for the same signifiers.) Every spoken utterance means not just linguistically, but also vocally; we interpret it as a sign of the speaker's social status, geographical origins, state of health and state of mind; we appreciate its musicality and timbre, its intonational colorings, and the 'grain of the voice' (Barthes 1977) along with the verbal semantic meaning of the words. Every written sentence means not just linguistically, but also by its choice of typeface and font, or its calligraphy and orthographic features by which some experts and many amateurs read all kinds of meaning about personality, etc.(whether usefully or not). Speech in person cannot fail to be accompanied by body movements and gestures, the grounds of interactional synchrony, facial cues, eye blinks, breath rhythms, etc. all of which are physiologically coordinated in a single (two- or many-person) dance, with many meanings other than the verbal ones exchanged. Language, moreover, often conjures for us or inspires in us visual images and kinesthetic tensions and many inner sensations which have their own kinds of meaning for us. And once we have caught the language disease, are we ever again entirely free, except for fleeting moments, of the filtering grids of linguistic semantics when we examine a painting or choose our wardrobe?

How could it be otherwise? Every act of meaning-making is a material process, and by its very materiality it cannot be totally comprehended by any single system of representation. So also every material signifier. You cannot speak a pure phoneme; every actual sound has acoustic properties in excess of the minimal distinctive features, we can only speak 'phones'. All interpretation is experiential, and as phenomenology has long maintained, experience always overflows in meaning and specificity and uniqueness any formal categorization that can speak only of generals and not of particulars. Semioticians at an event are like the blind men feeling the elephant; each knows only those aspects which matter semiotically in some one system, none know the whole elephant. Even collectively, they do not comprehend the whole elephant, real, unique and present, though they can perhaps say as much as can be said of elephants.

In some ways this argument underestimates semiotics because it usually assumes that all semiotic systems are fundamentally like language in being based on distinctions of kind or type among signs. But this ‘typological’ semiotics is not the only way in which meanings are made. We also make meaningful distinctions between signs by degree as well as by type. In speech there are an infinite number of sounds between ‘take’ and ‘took’ but there are no intermediate linguistic-semantic meanings corresponding to those sounds. The sound must be interpreted as one word or the other, the verb as in one tense or another, categorially, to be linguistically meaningful. Not so for the visual and spatial-motor semiotics, where degrees of color and shading, degrees of rate of movement, degrees of difference in shape or position can be meaningful at any level of detail that can be perceived or implied. These semiotics of degree, of continuous quantitative variation, which (after the topology of the continuum or the real numbers) I have sometimes called ‘topological semiotics’, are often functionally complementary to the typological or categorial semiotics. As I suggested before, much of mathematics historically has been an effort to create a hybrid semiotics that allows us to bridge between conceptual-categorial language and these topological semiotics (see also Lemke 1999, in press). If we include both the topological and the typological resources of semiosis, there is much less of the unique experience of a particular elephant that escapes the semiotic sieve, though still something.

The rest of this chapter will describe several examples of how we actually do multiply our meaning resources by combining different semiotics, thus multiplying our ‘intelligences’. I want to concentrate on the human activities I have studied most: the use of language, gesture, visual representation, and social interaction in professional scientific communication and in science education. I will try to argue that we do not do enough to teach students how to combine and integrate their different intelligences, or to integrate their individual intelligences in different domains with one another in collaborative work. I will draw my examples briefly from my previous research on the multimedia semiotic demands of the science classroom and studies of multimodal integration of different semiotics in scientific print publications, and more extensively from work-in-progress on professional and educational multimedia in science as presented in websites on the internet.

Multiplying Intelligences for Learning and Communication

Academic perspectives analytically exaggerate the autonomy of the different semiotic resource systems and the intelligences we can recognize in how well people make use of them. One can find academic treatises in which there is only text and typography and page layout contribute only minimally to relevant meanings. But any newspaper or glossy magazine will show the complex integration of text, typography, layout, visual imagery, and use of color effects that we take for granted in everyday life. Japanese newspapers make very heavy use of quantitative graphs (Tufte 1983, p. 83), reflecting cultural preferences and the education of readers. Hobbyist magazines about cars, computers, stereos, boats, and even golf are filled with specialized diagrams of many kinds. The business pages of daily papers everywhere contain extensive numerical tables and some amoutn of accompanying explanatory or commenting text. Japanese popular reading consists less of the inexpensively printed text-only paperback novels of the West and far more of the image-centric *manga*, often mistaken for their nearest Western relative, the comic book (a closer comparison would be to the postmodern graphic novel). From illuminated manuscripts to ‘profusely illustrated’ classics, the Western tradition also favored the combination of image and text in the humanities until economics and logocentrism ruled images dispensable, if not intellectually suspect. Gardner would remind us that few great writers were also great artists (one think of Blake); social semiotics suspects the impoverishment of European humanistic culture since it abandoned the multiplication of meanings that the text-image combination affords. If it is true that we do not often find the peaks of achievement in these two media in the same individual, there is still no reason not to favor collaborative production, other than a fetishism of the individual author.

Film, television, and video are also multimodal media, at least since the advent of the 'talkies'. Take away the sound, and how much of the total meaning remains? Take away the image, and how much do we miss? Construe both together, and how much more, qualitatively, does the experience engender? The great Sergei Eisenstein, a founder of the film genre, wrote brilliantly (Eisenstein 1943) about the art of co-ordinating image composition, cinematic action, shot montage, music, dialogue and narration. The music-and-light shows of the psychedelic sixties prepared the way for the creative fusion of music, singing, and dynamic images in the modern music video genre. Dance as art today fuses musical and visual-motor semiotics in new ways. The tradition of grand opera was always that of the *Gesamtkunstwerk,* varying only in the mode and degree of integration among music, dance, singing, lighting, costume, stage setting, and action. Popular musical theatre and many films and television productions continue this tradition for large audiences.

Life itself is a multimodal experience, not just in terms of multi-sensory input, but perhaps more significantly in terms of action and activity. We talk, gesture, mime, act, write, sketch, calculate, and perform meaningful social actions of infinite variety every day; there are systematic actional semiotics of driving, cooking, cleaning, shopping, and certainly of teaching or officework. Classroom activity is a particularly well-documented domain of action in which the meanings and typical actional patterns (activity genres) have been thoroughly studied, not just with regard to language and discourse, but for the use of gesture, mime, writing, diagrams, maps, charts, video, computer media, and science demonstration apparatus. Science classrooms are perhaps particularly rich multi-semiotic sites because of both the scientific tradition of combining language, mathematics, and visual representations with experimental activity that I argued above is necessary if we are to study natural and experimental phenomena of continuous co-variation and complex quantitative ratios.

Multiplying intelligences in the classroom

In a recent analysis of videotape data following one student through a day of advanced chemistry and physics classes (Lemke 2000, see also Cumming & Wyatt-Smith 1997), I observed that in his chemistry lesson this student had to interpret a stream of rapid verbal English from his teacher; the writing and layout information on an overhead transparency; writing, layout, diagrams, chemical symbols and mathematical formulas in the open textbook in front of him; the display on his handheld calculator; more writing, layout, diagrams, symbolic notations, and mathematics in his personal notebook; observations of gestures and blackboard diagrams and writing by the teacher; observations of the actions and speech of other students, including their manipulation of demonstration apparatus, and the running by-play commentary of his next-seat neighbor. In fact he had quite often to integrate and co-ordinate most of these either simultaneously or within a span of a few minutes. There is no way he could have kept up with the content development and conceptual flow of these lessons without integrating at least a few of these different literacy modes almost constantly.

In one episode in the student's physics lesson that same day, there was no role for the notebook, and not even a diagram, but a pure interaction of language and gestural pantomime, including whole-body motion. The teacher is standing just in front of the first (empty) row of student desktables, at the opposite end of the room from where the student is sitting. The student sees his teacher's hands cupped together to form a sphere, then the hands move a foot to the left and cup together to make another sphere. Then back to the first, and one hand and the teacher's gaze make a sweeping gesture from one to the other; then he begins to walk to the left, repeating these gestures and walking down toward the student's end of the room. Fortunately, the teacher now is also talking; by integrating the teacher's precise and conventionalized mime with his accompanying technical speech, this student can interpret that the cupped hands are atoms, the sweeping hand a photon, emitted by the first, traveling to the second, absorbed there, re-emitted after a while, passing on down through a ruby crystal, producing a "snowball effect" of more and more photons of exactly the same energy. In other words, the crystal is a laser, and we are experiencing a multi-semiotic performance explaining how it works.

The teacher says he's going to add more complexity to 'the picture' now. An atom "might shoot out a photon in this direction" -- gesture away from the axis of the room-sized imaginary ruby crystal toward the students -- "or in this one" -- gesture back toward the blackboard -- "or ..." -- oblique gesture. How do we get a laser beam then? He walks back and forth between the ends of his now lasing, imaginary ruby crystal, describing the mirrors he gestures into being at each end, but saying they differ in reflectivity and transmissivity, to build up and maintain the avalanche of photons, while letting some out in the form of the laser beam. The student has seen mimes like this before; he has seen diagrams of atoms and crystals, of photons being absorbed and emitted by atoms. By making connections to these other visual-verba-actional 'texts', he can use his visual intelligence and experience of these past diagrams, together with his bodily-kinesthetic intelligence in pantomime, and his linguistic intelligence in interpreting the discourse of atomic physics to make sense of how a laser works. But he cannot deploy these intelligences separately; they must be complexly and effectively integrated with one another. The meanings he makes must be multi-semiotic meanings in which far more is meant by the combinations of word, image, gesture, and mime than each can mean or does mean separately or even in simple addition (e.g. if experienced separately and without interconnection).

In his classroom learning activity our student must constantly translate information from one semiotic modality to another: numerical to algebraic, algebraic to graphical, graphical to verbal, verbal to motor, pantomime to diagrammatic, diagrammatic to discursive. But simple translation is not enough; he must be able to integrate these multiple semiotics simultaneously to re-interpret and re-contextualize information in one medium in relation to that in the other media, all in order to infer the correct or canonical meaning on which he will be tested. In most cases, the complete meaning is not expressed in any one channel, but only in two or more, or even only in all of them taken together (see detailed examples in Lemke 2000, Roth & Bowen 2000, Wells 2000).

Multiplying intelligences in technical writing

In another recent study (Lemke 1998a), I examined the semiotic forms found in the standard genres of research articles and advanced treatises of professional scientific publication. In a diverse corpus, across disciplines, venues, and formats of publication, the clear finding was that there is typically at least one and often more than one graphical display *and* one mathematical expression per page of running text in typical scientific print genres. There can easily be 3-4 each of graphics displays and mathematical expressions separated from verbal text *per page.*

In one prestigious journal of the physical sciences, each typical 3-page article integrated *four* graphical displays and *eight* set-off mathematical expressions. Some had as many as three graphical displays per page of double-column text, or as many as seven equations per page. In another journal, in the biological sciences, each typical page had two non-tabular visual-graphical representations integrated with the verbal text, and each short (average length 2.4 pages) article typically had six graphics, including at least one table and one quantitative graph.

To appreciate the absolutely central role of these non-verbal textual elements in the genres being characterized, it may help to ponder a few extreme (but hardly unique) cases:

- In one advanced textbook chapter, a diagram was included in a footnote printed at the bottom of the page.
- In one 7-page research report, 90% of a page (all but 5 lines of main text at the top) was taken up by a complex diagram and its extensive figure caption.
- The main experimental results of a 2.5-page report were presented in a set of graphs occupying one-half page and a table occupying three-fourths of another. The main verbal text did not repeat this information but only referred to it and commented on it.
- In most of the theoretical physics articles, the running verbal text would make no sense without the integrated mathematical equations, which could not in most cases be effectively paraphrased in natural language, even though they can be, and are normally meant to be read out as if part of the verbal text (in terms of semantics, cohesion, and frequently grammar).

A more detailed analysis in this study showed how absolutely normal and necessary it is to interpret the verbal text in relation to these other semiotic formations, and vice versa. It is not the case that they are redundant, each presenting the complete relevant information in a different medium; rather the nature of the genre presupposes close and constant integration and cross-contextualization among semiotic modalities. (For a confirming study of the frequency of nonverbal elements in professional scientific writing and in school science textbooks in one field, see Roth et al., 1999).

Multiplying Intelligences in the New Hypermedia

Finally, I want to take an example that look towards the future. The future of communication, and of education, fairly clearly lies in the use of the new genres of the global internet. Of these the most prominent today, and the likely forerunner for many future developments, are the webpage and website. The moment of revelation for me, after several years of using the internet for email and file transfers, came when I first launched Mosaic, the original graphical web browser, on a Sun workstation and after several lines of text appeared on the screen, a small full-color photograph of

Vice-President (and internet booster) Albert Gore, downloaded into view in the middle of the first homepage (at the government-sponsored supercomputing center in Illinois). Multi-semiotic expression had arrived on the internet, where formerly even font and page-layout were not usually transmitted faithfully, and where images could be sent as files, but not in a way that permitted them to be integrated into text documents. This webpage had far more meaning than just an page of text and a picture file of Gore would have had separately. The implications were staggering because for science multisemiotic media are necessary, not a luxury. (There were, before the web, large complex postscript file formats that could be downloaded and printed; the result was not too different from using a fax machine.) And for many other social activities, what humans can do with communication that engages multiple intelligences simultaneously, whether in advertising or education, is far greater than what can be done with words alone or isolated picture images.

What has been done so far is well known. Every domain of human activity is represented today on the WorldWideWeb, from science to sex, commerce to cookery. Limited only by speed of transmission, text and images are now joined by elaborate page layout, animation, audio, video, and manipulable virtual three-dimensional objects and navigable virtual 3D spaces, unique to the computer medium. Also unique to the computer medium, though not unprecedented in other genres, is the principle of hypertext: segments of text can operate as links to other segments of text, with no intermediate reading or searching. And on the web, this becomes hypermedia: images can link to other images, but also to text, and indeed all combinations can link to all combinations, elements of one webpage to another complete webpage. I will not discuss here the enormous implications for education of this new medium (see Lemke 1998b), which is not simply a medium for access to multi-semiotic information, but also a new medium of communication and collaboration between individuals and among groups, and perhaps most importantly a new medium of creative and intellectual expression, with implications for modes of thinking and ways of learning.

In a research project in progress, I am examing two sets of webpages within the large meta-site of the National Aeronautics and Space Administration's government domain, nasa.gov. NASA's more than 435,000 webpages are distributed among hundreds of servers in the many laboratories and project sites of this large government agency. From among them I am currently examining just two small subsets: parallel presentations of sattelite data about the earth intended for, in one case, the educated public, and in the other, professional scientists and researchers. I have described my initial analysis of these websites elsewhere (Lemke, in press). Here I mainly want to comment on some of the multi-semiotic features of these sites and the ways that they engage our multiple intelligences and encourage us to multiply meanings made with each. I also want to consider some of the implications of the collaborative, as opposed to the individual, multiplication of intelligences.

At the NASA Earth Observatory (http://earthobservatory.nasa.gov) website, data on conditions of the atmosphere, oceans, land, and biosphere of the earth as observed from space are presented for science teachers, students, and interested members of the educated public.

[Figure 1. NASA Earth Observatory Observation Deck Webpage (January 2000, http://earthobservatory.nasa.gov/Observatory/) ABOUT HERE]

The level of multi-semiotic proficiency required at the Earth Observatory (EO) site is hardly minimal. Users of these webpages confront the complexities not just of simplified scientific text, but of an interactive glossary function, links to background information in documents accessed from a Library page, links to closely related websites documenting research projects on related scientific topics (the Study), and most notably the option of linking to an interactive system for scientific visualization of relevant sattelite data (the Observation Deck, Figure 1a). By selecting a 'parameter' (i.e. type of data derived from sattelite sensors, e.g. Vegetation) and a time range (see Figure 1b), users can display, in the form of color-coded maps (Figure 1c), an animated display that shows changes in the values of this parameter worldwide over the chosen time range, and even display side by side for comparison maps coded for two different parameters. Users have the choice of three display modes: mercator-like projection maps in an animated strip (Figure 1c, rather like cartoon frames that can be flashed by quickly to show a single dynamically changing image), a grid or matrix table of maps each for a different fixed time within the range, and a globe which shows only a single time frame, but can be rotated to show the color-coded values of the paramter(s) at all points on the earth, or as seen from any direction in space above the earth.

> [Figure 2. NASA Earth Observatory: Life on Earth, Vegetation Dataset Webpage (January 2000, http://earthobservatory.nasa.gov/Observatory/Datasets/ndvi.avhrr.html) ABOUT HERE]

Moreover, the color-coding in the maps and globes quantitatively based, providing a good example of a topological semiotic (see above), and a key is provided that shows a continuously variable color-spectrum and the corresponding numerical values (Figures 1b, 1c). Along with this is an explanatory paragraph discussing what the color-coded image maps show that is of scientific importance, and in some cases what the technical nature of the parameter is and from what sattelite instrument it is derived (e.g. Figure 1b, truncated at bottom).

> [Figure 3. Display of Vegetation NDVI Data in Animated World Map with Key (January 2000, http://earthobservatory.nasa.gov/Observatory/showqt.php3) ABOUT HERE]

In making use of the Observation Deck's scientific visualization facility, visitors must integrate scientific language, specialized visual display genres, quantitative values, and time-dependent animation. The latter is also interactive; the user employs a motor routine to control the animations by dragging the mouse over the images while a counter changes to show the month and year of each frame. What are the intelligences at stake in proficient use of these pages? In learning by interacting with this new multi-semiotic medium?

Surfing the web, or just linking among the webpages within a particular integrated website such as the Earth Observatory, is an interactive experience with a much more prominent component of bodily-kinesthetic or motor intelligence than reading print or viewing a video. It involves also some transposition of the resources of spatial intelligence, since the primary metaphor of website design and use is 'navigation' as if in a virtual space where we must remember, if not three-dimensional spatial relationships, then at least pathways and sites of intersection, rather as in learning a maze (or in the aboriginal Australian view of territory spatialized by sacred paths joining landmark sites).

The semantics of hypertext introduce a new element to the organization of textual or hypermedia meaning: trajectories across scales in these virtual topological spaces (Lemke 1998c). Meanings are made by users of the web as they create a trajectory or pathway from page to page; some kinds of meanings are typically made in related consecutively traversed pages, others are made on the longer pathscale of pages across different subsites, different sites, and different content domains. A whole session of surfing brings new contexts to any visit to the nasa.gov domain, and within that domain, at the scale of the Earth Observatory site, there are meaning relations to be made among pages in its different divisions (the Library, the Study, etc.), and then at a finer scale there are the meaning relations within its Observation Deck subsite.

In this example, shown statically in Figure 1, passing the cursor over each menu item on the right (Atmosphere, Oceans, etc.) causes a different frame to appear to the immediate left. Shown in Figure 1 is only the frame for Life on Earth, and within it an image of the earth globe colored according to the patterns of a (land and sea) measurement of vegetation, and a link menu to the page for scientific visualization of datasets relevant to each topic in the menu. Just within this one page, linguistic, visual, and motor intelligence are at work making meaning. At the next hypertextual scale, the pages actually linked to (e.g. Figure 2) have particular complex meaning relationships to the Observation Deck page, and to each other. To identify for example the basis of the color-coding of the Life on Earth globe on the Observation Deck page, one has to use visual memory and discrimination at a fairly fine order to make the identification with the globe shown on the Biosphere page, rather than say that on the Vegetation or the Chlorophyll page. On such a page, as in Figure 2, we must use page layout savvy and linguistic intelligence to see how the color code key towards the bottom of the page corresponds to the coloration of the strip map and globe at the top of the page. We need to combine visual with mathematical intelligence, and an understanding of a standardized technical genre (in the key), to relate color values to numerical values of the NDVI vegetation index, which then, with further use of visual intelligence, can help us interpret quantitative variation in the strip map.

At another fine scale of hypertext linking, each Dataset View page, such as Figure 2, links to a set of possible new pages which are dynamically generated by our interacting with the View page. In the View page we use motor and visual and linguistic and numerical intelligence to interpret and operate the dropdown boxes in which we select the range of dates and possible comparison datasets for generating our animation. Clicking the ‘Build Animation’ button, and a short wait, leads to a page such as in Figure 3, which has linguistic-cum-visual-cum-quantitative meaning relations to the page of Figure 2. We now see the strip map enlarged and keyed to our range of dates, with the color code and numerical value key below. Visual-motor intelligence is needed now to operate the animation, by dragging the mouse and observing the changing date counter as well as the changing colorations of the map. At this coarse timescale, there is not true continuous variation (the animation actually jumps from month to month), but our visual intelligence interpolates the continuous intermediate changes. In a more complex view, we would have a second map at the right, color-coded for a different kind of data and for the same or a different time range; we would now motor and visually coordinate animated changes in time for both of these, while reading the date counters with a combination of visual-linguistic-and-numerical intelligence, all the while interpreting the color changes in terms of two different keys (one below each map, if we have chosen datasets for different parameters), and again both visually and numerically. This is a high order of amateur multi-semiotic meaning-making!

I have also compared other NASA webpages which begin in multi-semiotic complexity where these leave off (Lemke, in press), and are meant for science professionals. No one should wonder after a visit to this NASA site for the educated public at the emphasis in the new U.S. science education standards on achieving higher levels of visual scientific literacy. But it is not the isolated visual literacy that matters in practice; it is the integrated use of language, visual representations, mathematical-quantitative reasoning, and motor and spatial intelligence. If the level of motor intelligence seems quite modest in these examples, that is not true in the various 3D immersive data worlds that are today mainly accessible only with more powerful computers, but are coming to a screen near you very soon, as presaged by the extreme popularity of 3D computer games, where the levels of bodily-kinesthetic intelligence required for success often exceed my own limits. They are also very clearly tightly integrated with high levels of visual and spatial intelligence. Once the linguistic and mathematical-quantitative semiotics are added to this mix, the multiplied power of semiotic possibilities will certainly challenge even the multiplied intelligences any one of us can bring to bear.

But what of our collective multi-semiotic intelligence? Neither 3D videogames, nor the NASA webpages in the Earth Observatory or other similar sites, are produced by single individuals. On the EO Masthead page, we find a team leader, system administrator and webmaster, an art and design specialist, and a programmer, as well as an editorial staff of 11 more people, including an observation deck editor and a science writer. Finally there is a scientific advisory board of twelve specialists and acknowledgements of the contributions of seven other individuals. Many of the webpages in the Study and Library also originated with outside contributors, as did the basic data and scientific visualization methods in the Observation Deck (for the origin of one, see Lemke in press). The combined talents ultimately of thousands of people went into creating what we see (many thousands if we count those who helped build and launch and monitor the sattelites). But even at the most immediate level, this multi-semiotic site is the product of multiplying the specialized intelligences of a writer (linguistic), an art designer (visual), a programmer (logical), and a team leader (social). The semiotic resource systems of language, page design and color graphics, computer programming (another offshoot of language, but back-hybridized with finitary mathematics), scientific visualization (the topological semiotic relevant here), and website design (based in a specialized hypertextual-spatial intelligence) at least are involved in production.

This fact, too, has important implications for education, and not just for education in science. One of the goals of collaborative learning ought to be not just learning to work with others in the sense of developing interpersonal or social intelligence, but specifically learning how to integrate the semiotic forms of meaning-making that I prefer and excel at with those that you can contribute to our joint project. We can teach students effectively how to integrate their own work with that of others, as well as how to integrate their own multiple intelligences and semiotic skills, only if we better understand just how, in our own community and others, in this period of history and in the human past, people have found ways to multiply our resources for making meaning by multiplying one intelligence by another in multi-semiotic projects. It may even be, if we look to find it, that the interaction and integration of different semiotic skills and intelligences will help students to leverage their strengths in some domains to build up better skills others. Multiplication, in all these senses, may yet be education's best strategy for the future.

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