



Rivista italiana
di tecnologia
cultura e formazione

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Bari - via Melo CIN: C - ABI 03067
CAB 04010 - c/c 000000010042
specificando come causale
del versamento:
Quota Associativa Socio CKBG.
Registrazione del Tribunale di Bari
n. 29 del 18/7/2005
© 2007 by Progedit
ISSN 1828-7344
www.progedit.com
Stampato da Global Print srl
per conto di Progedit
Progetti editoriali snc

Affordances in the construction of meaning: heuristics of thematic graphics for CSCL

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Introduction

In the Da Vinci Code, Jacques Sauniere is found dead in the Louvre. The Harvard symbolist, Robert Langdon, is summoned to make sense of the body. It is a puzzle. You see, Mr. Sauniere is strewn on the floor in the shape of a Vitruvian Man – a pentacle, a five pointed star, a pentagram saturated deep in meaning from the past. Da Vinci himself drew the original sketch of the Vitruvian Man a long time ago; the Vitruvian man has meaning.

Seduced by his knowledge of signs, and of course, the inviting eyes of the demure Sophie Neveu, Langdon begins an odyssey of meaning making – a summoning of knowledge of mind. And, yet, what is this knowledge of mind? What is this five-pointed star; this pentagram? What does it mean? Langdon's knowledge is swiftly searched.

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Meaning in this case has two agendas. What is the meaning of the star? And, what is the meaning of the star carved across Jacques Saunier's chest?

The pentagram, Langdon knows, has come to represent dark or black magic in the eyes of many Christians – the head of Baphomet, a symbol of Satan. And, yet, he also knows that the origin of the pentagram was not always so dark. It was actually a talisman, or sacred geometrical sign, which could be traced back to ancient Greece, and before that, to ancient Mesopotamia around 3000 BC, where it simply meant “heavenly body” or “star”. For Egyptians, Langdon knows, the pentagram within the circle also represented the duat – or underworld, if you will – of Egyptian mythical symbology. In the tradition of Christianity, the pentagram was used to represent the five wounds of Christ. But, for the Pythagoreans, Langdon was also aware, the five points of the star stood for the five classical elements of divinity – fire, earth, air, water, and idea – perfection for the Pythagoreans. Perfection because, within its lines, the pentagram also hid the GOLDEN RATIO; 1.618. The ratio between cheekbones, mouth, lips, nose, eyes, and jaw line of the most beautiful face, the proportion of waist to hips in the most attractive female to the gaze of a gentleman's eyes, the pitch of the spiral of DNA, the Fibonacci sequence, the angle of growth from one leaf stem to the next on a tree, ... the list goes on.... Perfection is divine. In short, the pentagram also meant perfection.

This is a lot of knowledge and Langdon holds all of this knowledge in mind.

But, even with layer upon layer of knowing, Langdon still does not know what this pentagram means carved in the flesh of Jacques Saunier's chest. Sophie Neveu neither knows. But, she is the granddaughter of Saunier, and she has knowledge of him.

And, so begins the transaction of minds – two minds constructing knowledge together: knowledge of context, history, symbols and signs. This is what this paper is about: how we make meaning together, and how visualizations guide, restrain, permit and constrict this process.

The epistemology of knowledge building

There is a strong epistemology in the study of meaning making among minds – a theoretical perspective that tends to dominate all others. The theory is social constructivism – a philosophical orientation deeply rooted in the writings of Baldwin, Vygotsky, Bakhtin, Piaget, Karl Buhler, and Pierce. From their position, human cognition is dual, always oriented both towards the speaker and the listener, each of which adopt simultaneous roles of active participation. They exchange, and they fuse, jointly generating all dialogical and interactional contributions. They share social realities dyadically because the human mind, as Markova (2005) contends, is dialogically constituted. That is, each participant reciprocally adjusts their perspective by focusing their attention to the other via the process of social attunement. In short, reality is constructed, rather than given, within the context of another. It is housed, not within a mind, but in the process of negotiating affordances of objects between minds. The affordances are borne from the artifacts left from mind and facilitate the propagation of knowledge between minds.

The example is often given of the blind man with the cane. Is that which he taps given meaning in his hand? In the juncture of his hand at the stick? Along the stick? Or at the point where the stick meets the world? This is the conundrum of the meaning making process... It exist all at once in all of these and none of any one these at the same time.

On the other hand, what, if anything, is actually in the mind of Mr. Langdon and Ms. Neveu? And, is it reasonable to ask this question?

For Plato, as for Descartes, the question is steeped in the issue of mimesis – the world of forms. For them, the world is real and objective. It can be known. It is unchanging, universal, incorporeal, and perceptible. When the world is perceived, the perceiver makes meaning by what the world's forms reveal. The revelation enters mind and represents the forms. Hence, the mind constructs a representation. Even for Aristotle, knowing could not be derived or dispensed without representation. That is, the mind knows by way of what it represents from the material world.

However, is this really true? Does the mind know by way of what it represents of the material world? For Mr. Langdon, as for Ms. Neveu, the ma-

terial world is a dead corpse with an engraved, if you will, pentagram on it lying on the floor of the Louvre. Is it objective? And, is it necessary for Langdon and Neveu each to construct a representation of it in mind? Is it necessary for you to construct a representation of this scene to make meaning from it? To discuss, debate, understand, know it? Ivana Markova (2005) points out that «in all the modern studies of cognition, from Descartes through to Chomsky and on until today, a mental representation has become an essential concept of all cognitive theories of the mind.» (p. 8).

And yet, there is a tense schism between the cognitivists and the social constructivists. For the social constructivists, the issue of representation is irrelevant – moot. For, cognitivists, it is essential.

So, here we are considering mimesis – the representation of form... the imitation of aspects of the sensible world; the actions of another – in biology as mimicry, in art as the aesthetics of movement in dance, composition, color, and subject in sketch; in chemistry, as 3D visualizations of molecules the naked eye cannot see. A cognitive image is a representation. A thought or idea is a representation. In short, representations are borne from form, and it is up to the mind, or the negotiation between minds, to make meaning from these representations. I contend that representations are important.

However, I am also a cognitivist. And, as a cognitivist, I propose that internal representations of mind are essential for the meaning making process, because it is my contention that learners spend much of their time in dialogue negotiating meaning by translating and illustrating their representations.

When representations are illustrations, they are artifacts of mind – visualizations of what a person knows. When individuals are put together in a problem solving activity, as Langdon and Neveu, or learners in a computer-supported collaborative learning environment, what is known can be shown. When it is, representations are visualizable, and visualizations have a dramatic influence on the way learners think, reason, and problem solve; in a word, learn.

Co-construction of knowledge, collaborative knowledge construction, and reciprocal sense making are all examples of phrases commonly used in research to describe the processes learners employ to learn in cooperative learning venues. However, it is my contention, that within

these transactions, visualizations become tools of mind that guide, restrict, permit, or constrain the learning process.

The role of visualization

So, what do we know about these visualizations? Visualizations can take the form of diagrams, maps, photographs, or art. They can be seen in sculpture, paintings, flowcharts, or scribbles. They can be semantic maps, Internet navigational guides, charts, tables, and figures. The point is that visualizations are, at a glance, perceivable and knowable – and it is up to the mind to make meaning from them, by oneself, or more importantly for our interest here in CSCL environments, in transaction with another. When learners have visualizations available to them, learning is produced, influenced, and changed. Learners use visualizations to think; they also use visualization to explain.

The point about visualizations is that we rely heavily on them to build the computer environments with which we teach – in hypermedia environments and in virtual environments; using either static or animated visual displays. In either case, the visual system is a strong modality with which to construct representations within a learner's mind. Computer technology is also a powerful medium with which to capture and propagate – from mind to mind – the individual construction and adaptation of these representations. That is, representations from mind are left as artifacts of mind in the form of visualizations – either as the written text learners leave behind in the form of words, phrases and sentences in synchronous or asynchronous chats as in WebCT, instant messaging, or communities of knowledge, or as personal graphics in the form of icons, diagrams, scribbles, and modifications of the spatial displays of others. In either case, visualizations can be literary or graphic, abstract or concrete, literal or metaphorical, but they are always constructed and transformed within learners' minds – and they always carry meaning.

There are a number of theoretical notions of the way visualizations work. Most of this work has been done in the context of learning with graphics and text. Raymond Kulhavy (Verdi & Kulhavy, 2002) and Wolfgang Schnotz (cf. Schnotz, Bannert and Seufert, 2002) have produced much work on the subject. For Kulhavy visualizations in the form of

maps, diagrams and charts are encoded as a single chunk of information in mind that acts as an organizer for the semantic and spatial relations it represents. According to Kulhavy (Verdi & Kulhavy, 2002), visualizations reliably facilitate long term retention of information by freeing up working memory for processing. This processing – thinking – leads to deeper comprehension; deeper comprehension leads to deeper understanding. However, graphics also have a down side. They function to restrict the latitude with which a person can think. Visualizations are strong images that chain thoughts to their features. The fact that humans, by and large, are principally visual in nature constrains their ability to think outside of that which they see.

Schnotz and his colleagues (Schnotz et al., 2002), on the other hand, maintain that because graphics and language-based material (text, for example – the kind of text that may comprise asynchronous logs) are based on different sign systems and use different principles of representation, they are encoded separately and stored differently. That is, the mental models constructed from the descriptive (language-based) and depictive (graphic-based) information are created through two separate systems. Descriptive information contained in the surface structure of utterances is initially processed verbally, and then broken down into its propositional parts. On the other hand, depictive information is initially perceived visually, and then represented internally as a visual image. The two are transformed into separate mental models containing both descriptive and depictive information that are shared and integrated during the comprehension process. Thus, the information contained in each influences, and is influenced by, the other in order for the interpretation and comprehension of both. However, the net effect is a heavier, rather than lighter, load on the memory system; Thus, learners are strained in making sense of what they see and what they read or hear. The meaning-making process is labored, and understanding is slow.

These models are steeped in the cognitive tradition. After all, they are speaking about processing, about mechanisms, about images, about encoding – not mind, nor transactions of mind, but processes of a *system*. And, yet, there are constructivists that have labored to understand the same thing. Jonassen, Beissner & Yacci (1993), for example, found that conceptual knowledge in both science education and preservice

teacher education was benefited by the use of concept mapping visualization tools. Plotzner and his colleagues (Plotzner, Fehse, Kneser, & Spada, 1999) found that cooperative learning was fostered with concept mapping tools. Still others, Dan Suthers, (2000), for example, demonstrated that learners working collaboratively on a challenging science lesson with the help of a content-specific mapping tool externalized a higher number of evidence relations than learners who were only provided with a text tool and no map. Finally, Fischer and his colleagues (Fischer, Bruhn, Grasel, & Mandl, 2002) revealed that students having the benefit of content-specific visualization tools were more inclined to integrate abstract theoretical concepts into the solution of a problem.

So, even with more cognitive load, and a belabored cognitive system, learners worked together to make sense of the maps they produced, revealing that collaboration in the meaning making process forges strong alliances between learners in their quest to understand, and tools fostering visualization are major players in this process.

Is it any wonder Robert Langdon was summoned to help crack the Da Vinci code? The pentagram, the talisman, the image of the holy grail as a chalice, both helped and hindered his efforts – efforts that make for great fiction, but efforts, nonetheless, that are real functions of the mind.

Still, are the empirical effects of visualization tools and the explanations of these effects, pure fiction? Erica DeVries (personal communication) would suggest that they are not. She contends that visualizations of concepts must be provided to students for learning to occur because they operate much more elaborately than most text-graphics models suggest. For DeVries, visualizations give way to abduction – abduction in a semiotic sense vis-à-vis the work of Peirce (1991). Abduction is a reasoning process where a learner thinks about what a visualization *could* mean – very different than the logic of deduction or induction in which a learner reasons top down or bottom up, either from the prior knowledge of what a visualization is known to convey, or the definitive rules for articulating meaning from its parts, respectively (Moriarty, 1996). Thus, abduction functions to *challenge* learners to consider what the visualization of an object *might* reveal. This process is, in essence, the meaning-making event itself, and the sine qua non of what visualizations induce in the event itself. In short, it is through abduction that meaning making is pos-

sible, because it literally propagates the possibilities of meaning both within and between minds throughout the entire CSCL environment. The real challenge, however, according to DeVries (2006) is finding the right visualization tool – if there is one, and examining the transactions between learners, tools, and artifacts as to the way meaning is revealed.

Relationship between cognitivism and social constructivism

And what of the tension between cognitivists and social constructivists? Is this issue real? Dillenbourg (2006) thinks yes. In his introduction to a 2006 issue of *Computers in Human Behavior* he writes: «Psychology has for long been compartmentalized between cognitive studies of individual cognition and socio-cultural studies of group processes» (p. 155). He wrote that the Berlin wall between these two streams fell down in the late eighties with the emergence of the distributed cognition theories of people like Hutchins, (1995), Pea (1993) and Salomon, (1993) – distributed cognition theories viewing groups as a cognitive system describing group mechanisms with concepts borrowed from individual cognition. However, Dillenbourg states «even though the wall fell, one can still clearly perceive the two sides of the former border.» (p. 155).

Finally, what about representations? Is the issue of representations really moot? Jorna and Van Heusden (2003) in a recent issue of *Semiotica*, said it best when they wrote:

Discussions about ‘representation’, and especially, the so-called ‘crisis of representation’ are subject to fads and fashions. In our view, there can never be a crisis of ‘representation’, just as there can be no crisis of weather or crisis of the atom. We believe that there is a philosophical debate on the notion of ‘representation’, but we also believe that ‘representations’ have a steady empirical-constructivist side that will continue to exist as long as knowledge and human cognition exist (p. 113).

As for our hero and heroine of the meaning-making process – Langdon and Neveu? Their odyssey was released during the spring of 2006 in a full-length motion picture – a very long visualization, if you will. I will think deeply about the fact that it was not as good as the novel.

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