

# The Learning Game: A New Approach to eLearning and Knowledge Computing\* (On Microlearning)

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*"I never let school interfere with my education"*

Mark Twain

**Abstract:** Interactive computer games are beginning to enter the educational and instructional fields under the flag of a more 'playful' approach to learning. But on a much deeper level, games herald a new computer age that is based on simulation and generative, dynamic data instead of the current approach of representation and static data. The paper traces the current computing approach to a platonic understanding of objects and proposes a new relationist approach that replaces data altogether and opens a true 'post-Gutenberg' era based on simulation. The computer, currently a static learning 'assistant' at most, could become a co-learner and dialog partner.

## 1. What is 'Learning'?

Learning is not just what we do in school or in institutionalized 'learning environments'. Learning is something we do all the time, in fact, we cannot but learn. Learning is the description of an observer who describes an internal process whereby our body seems to 'adjust' ('adapt') to its environment by internally constructing concepts of this environment (and of the body itself). These concepts basically enable to make distinctions between 'us' and 'them', between the learning system and its environment, as well as

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\* The contribution of Peter Krieg is referring to the pre-conference workshop day of the European Academy of Microlearning.

between other 'systems' and 'objects' within this environment. Fundamentally, this is what living systems do all the time in interaction with their environment.<sup>1</sup>

Learning has nothing to do with 'representing' the environment inside the body (the brain) like a camera or a tape recorder is supposed to do. The nervous system is not a storage device of data about the environment. The theories of representation (concepts people developed over a long period of time about themselves), where a 'correct' or 'true' representation can be checked against 'reality' suffer from the problem of who is supposed to do the checking and based on what? Since the brain only has access to states of relations and correlations between brain cells and encoded electric signals, it has no way to interpret any representation as, i.e. an 'image'. So it would require a second brain and then a third and so on ...<sup>2</sup>

So learning can be explained as a completely internal trial and error process where successful (viable) interaction with the environment is the only criterion of 'truth'. Among humans, there is yet another and very unique aspect to learning: Language. With the help of language (as an activity) we can induce states in our own minds that simulate whatever the 'reality' that we talk about. We can develop descriptions as linguistic concepts of the world which serve as abstractions not so much of what the world is like, but what our body has constructed to be the world. We now can interact with these abstractions, because they induce the same or similar states as the described interaction would.

In this way, we build a reality in language that we can talk about. Since we are part of this reality, we can now even speak about ourselves. This is called self-consciousness. So learning for human beings has two aspects: building behavioural concepts of the world (we usually refer to this kind of learning as *training* in a physical sense, e.g. in sports, and the teachers helping us to achieve it are referred to as 'trainers' or 'coaches') and building linguistic concepts of the world (which is mostly taught in educational institutions by 'teachers', 'tutors' and 'professors').

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1 For a more detailed discussion of learning see Maturana H. R. and Varela F. J. , The Tree of Knowledge: The Biological Roots of Human Understanding, Boston: Shambhala, 1987.

2 For a discussion of the „second brain problem“ see v. Foerster, H., On Constructing a Reality, in Observing Systems, Intersystems Publications 1984.

But in essence (in terms of nervous activity), the two are identical: both are based on interaction with the environment. Speaking, listening or reading are activities like any other, the only difference is that we are using a tool (language) as a medium to simulate other activities. They could be called 'second order activities' ...

## 2. Objects and Relations

Considering the 'outside world' as an abstraction of internal states and relations of the nervous system, (=a 'construction') does not necessarily require to deny the very existence of such a world. In fact, doing so requires the assumption of its existence, because otherwise no such abstraction could be made or communicated. It does, however, deny any direct access of the living system to that world. The look and feel of this world is the look and feels that the specific organs of our body are able to construct. We have only access to our own body, so the world is structure dependent on our bodies. What we perceive as 'objects' in the world are in fact relations and correlations within our nervous system that suggest to distinct one entity from others.

In the view of the philosophical school of Plato, objects are static givens and are represented in our minds as such. The primary purpose of learning and of science is to categorize and order these objects in 'ontologies' and describe their relationships.

In the Heraclitean view, which is widely shared by Eastern philosophies (e.g. Buddhism), the world is in flux, i.e. it is our minds who create 'objects', objects do not exist independently. The world according to Buddhism consequently is an 'illusion' of the mind ...

The 'relationist' approach basically describes the world as relations and generates objects in a ontogenetic way. In terms of logic, ontologies represent axioms (roots, theories, prior assumptions, reference systems etc.) from which logic deductions can be made. Ontogeny is a non-logical (or polylogic) process where axioms, ontologies, theories and assumptions are reached 'bottom up' by means of inductive, intuitive or associative reasoning. Logic and Ontology are static order systems based on hierarchy. Ontogeny and polylogic are dynamic order systems based on heterarchy. They are not a-logic or against logic: in fact, logic as a system of deductive reasoning and inference is of major importance here also. The main problem of static logic is that it only allows

to relate whatever belongs to a defined logic domain ('a logic'), excluding everything else. Polylogic is able to connect within AND outside a logic domain, thus providing a 'holistic' or synaptic structure where everything is interconnected while still allowing hierarchical orders.<sup>3</sup> Mathematically, this is usually achieved by complex networks.

### 3. Complexity and Interaction

Dynamic orders are complex, static (hierarchical) orders are complicated. The difference between complex and complicated is important: a complex order can only be described by two or more reference systems (logics) simultaneously. Complicated systems can be described with just one reference system, i.e. within one single logic domain. All machines (including computers) are constructed as complicated systems (mechanisms), where a defined state defines other states in a sequential linear order. Mechanisms follow strict classical logic (including variations like fuzzy or multi-valued logic). Their 'interaction' with the environment (if so constructed) enables only defined actions (output) based on defined external inputs. They thus can also be described as input-output systems that process a given input into an internally defined output.

Complex systems are not input-output systems. They interact with the environment without inputs by rearranging their internal structure in order to maintain an internally defined homeostasis (balance). Their observable 'behaviour' cannot really be called 'output' because it is not determined by input, but rather by internal structural and organizational requirements. Complex systems react to external 'perturbations' and by doing so in higher degrees of complexity can even develop expectations and anticipations of future states, which we then may call 'learning'. These anticipations are history and structure dependent, i.e. the system assumes that events in the past may happen again (in similar situations) and learns to adjust its internal states to whatever proved successful in the past. Interaction is the key to this process.

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3 The concept of Polylogic is extensively discussed in the works of Gotthard Guenther. See <http://www.vordenker.de>

4 A short summary of Piaget's concept of adaptation and assimilation is available from Ernst von Glaserfeld: <http://www.oikos.org/Piagethom.htm>

## 4. Assimilation

The process of ‚incorporating‘ the world as a construction through interaction has been described by Jean Piaget as ‚assimilation‘<sup>4</sup>. Learning according to this theory is a triadic process of assimilation (integration of differences), accommodation (integration of new differences in earlier concepts or ‚schemas‘) and equilibration (balancing earlier and new concepts in order to gain new operational options).

Assimilation thus is not ‚input‘ of information, data or content in the sense of representations, but rather the registration of differences. Learning has nothing to do with the popular notion of “transmission” of information or knowledge. Quite the opposite: Knowledge and information principally cannot be transmitted, but emerge ontogenetically in the ‚learner‘ by incorporating differences into his existing concepts. The newly developing relational structure must be stabilized through ‚training‘ until it can be generated at will together with the related behaviour (including effective and linguistic operations). This describes the learning process.

Training is always interactive: in play, exercise, repetitive speech etc. It becomes stabilized and located in the existing relational schemas by associative connections. Memory therefore is not a repository of information or representations, but rather the capability to generate certain relational patterns through associations with others. The idea of the brain as a container or ‚hard disk drive‘ for orderly storage of data is an illegitimate projection of complicated technical system onto a complex biological one. Such projections are understandable on one side, because we can only understand what we can technically implement, but misleading on the other, because our technical expertise is (still) restricted to complicated mechanical systems. We still cannot technically model complex biological systems.<sup>5</sup>

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5 On the problems of modeling biological and other complex systems see the work of Robert Rosen: <http://www.rosen-enterprises.com/>

## 5. The Gutenberg era and beyond

Most if not all current technical systems for the storage, reproduction and management of text, images and other descriptive forms (including sound recordings) are based on ontological and representational principles. They implement a platonic world view: they order representations in hierarchic order systems (like books, shelves, libraries, folders, files etc.)

The new computer based electronic order and management systems also follow these principles. It is therefore premature to speak about a post-Gutenberg era. Even the internet is nothing more today than a poorly interconnected collection of 'books' (=Websites) with hierarchically ordered contents. Even the non-hierarchical order of the books placement (the URLs) has already been introduced in libraries since the 18<sup>th</sup> century. New are only the digital representation, recording and networking technologies and the hereby achieved global access over communication networks.

The real break with the hierarchical Gutenberg principle begins with interactive simulation, such as already realized in a narrowly restricted area of computer- and videogames. Here, at least in the domain of animated computer images, no data are stored any more. Data are interactively generated from relations. Computer games display a kind of movie as user data. But unlike classical film (as DVD or analog medium) no frames as static and unchangeable images are stored and retrieved, but are dynamically generated. The individual image is not fixed, but is determined by the interaction of the player.

The difference to the traditional approach is qualitative, for here no data in the classical sense are processed any more, but data are interactively constructed and dynamically generated. The space of interactivity thus not a data space any more, but a relation space. A data space would just not be able to record and retrieve the huge amount of possible images. A generative method thus is the very precondition for interactive games.

Extending this principle to all data and data types would allow all possible applications to be interactive and eventually adaptive. Only such an adaptive and interactive computer can replace (and at the same time integrate) the Gutenberg era.<sup>6</sup>

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6 For a detailed discussion of a purely relationist approach to data and computing see Krieg, P., *Die paranoide Maschine*, Heise Verlag 2005 and [www.pilesys.com](http://www.pilesys.com)

## 6. The Game Approach

Computer games represent a much deeper innovation than even the gamer community and game industry possibly recognize:

- games provide a new interactive man-machine interface with promises for high degrees of individual personalization, flexibility and adaptivity;
- games are based on fluid and dynamic simulation and navigation, not on static and hierarchic data structures. This puts them in a new machine category much closer to the human users;
- game image data are “virtual data”, i.e. data are dynamically *generated from code*, not physically stored and retrieved as static data frames. This represents an entirely new data paradigm;
- The computing space of game engines primarily is a relation space, not a data space (although traditional data are still employed also). This points towards a new *relationist* paradigm;
- In contrast to the traditional closed Turing machine concept of computing, the game concept is interactive and open to input during operation. This is just a step away from a revolutionary extension of the Turing machine concept.

Taken together, these changes anticipate a very different computer technology and computer usage in the future. There has been just one missing link: Virtualization of data so far has been largely restricted to pre-constructed image models and animations (as well as similarly constructed audio models). Arbitrary ad-hoc inputs (like text, live video and sound etc.) still have to be represented in containerized bit-sequences. This has resulted in two classes of ‘citizenship’ in traditional computing: code (‘bits that *do* something’) and data (‘bits that *mean* something’). Only code can be seen as active and dynamic first class citizens, while data lead a static and containerized second class existence in current computing, causing such unresolved problems like data flood and complexity explosion. Like any class society this one also highly restricts its own growth and further evolution: Freeing data from their passive existence in data silos therefore has become a major target in computer science.<sup>7</sup>

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<sup>7</sup> See Ralf Westphal, Freeing Data From the Silos:  
<http://www.pilesys.com/new/Documents/Freeingdatafromthesilos-Pileexplained.pdf>

Due to a new technology now becoming available<sup>8</sup> which allows to turn arbitrary input into 'pure relations', the entire range of computer applications is at the verge of becoming part of the game world. The reason is quite simple: in analogy to the brain, this new approach is not representing data in containers and silos any longer, but *assimilates* changes into a fully integrated relation space. A relation space is a connection space which only contains connections (think of a "connection machine" made of software). Anything that the machine has assimilated into such a space, it can faithfully reproduce, without having to hold it as data. A relation space also needs no index, because its connections are unique and can be reused for any recurrent piece of information. And the relation space itself is virtual, i.e. it is a logic space generated in run-time (like a computer game) and thus not restricted by physical data.

To illustrate this effect, let us imagine playing "Doom" by using "PowerPoint": instead of generating the images of the game, any possible image would have to be stored as a slide (or frame) like in a digital movie. The number of images that can be generated in a computer game is practically unlimited, however. To store each and every one of them would require a considerable chunk of our universe as storage device (while first rendering all of them would probably require the rest as computation device...). And that just for *one* game! So it is evident that only a generative approach makes gaming as we know it today possible at all.

The consequences of applying this approach to computing in general are dramatic:

- Computers would become simulation machines for just about everything: not only games, but also data driven simulations of our bodies, of complex systems in society and nature etc. Although we already can build simple models of such systems and use giant supercomputers to simulate them, these 'simulated simulations' suffer from the fact that they cannot interactively change their models and output as new data came flowing in. Unlike a game computer, where the inputs of the gamer instantly change the animated output, these simulations are not really data-driven.
- Being able to change an internal model based on external input is the basic requirement for a learning system: computers that can do such will, for the first time, become true learning machines (not like AI which is using closed internal models only)

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8 See <http://www.pilesys.com>

- Learning is also adapting: These new interactive machines will be able to adapt to their environment including their individual user and are no longer restricted to one 'standard user'.

For the game industry this means the opening of a new field much larger than gaming. The field of data simulation is even much bigger than computing today, because it enables new applications that are still inaccessible to computers due to exploding complexity and data!

With today's games, we can take a first but tiny glimpse into the future universe of simulation computing, but we have not even begun to explore the possibilities beyond gaming. Emerging "Serious Games" or simulation based teaching and educational tools are still restricted by the "dead data paradigm", but their potential is already visible.

What also should be obvious is the fact that gamers represent a new generation of computer users whose interactions with games shape their expectations for human-machine interaction in general. This generation will not be content with static tables, hierarchic data systems or non-adaptive interfaces with their metaphors of bureaucracy. They expect fluid navigation, instant interaction, flexible structures and adaptive automation – and soon...

## 7. The Future of Computer Learning

Learning can be, as was done here, described as a process of adaptively constructing an environment by interactive simulation. To reproduce this process in computers, we were until now largely restricted to mathematical models, integrating few and selected data (environmental signals). During simulation, the computer had to be closed off from the environment, so new signals could not influence or even change the model. This constitutes a mechanical process, unable for adaptation or learning.

Of course such a machine still can be helpful to a learner. But it would be much more helpful, if the computer could learn also. This would allow learning in dialog, where the communicated arguments lead to learning effects on both sides. Learning computers must be able to adapt to unknown environments (e.g. a complex individual user). For this, they must be highly interactive and able to break the logic closure of their respec-

tive programs. This requires to overcome the current concept of data as redundant representations and instead to operate in a globally connected relation space. Such a computer learns in the interaction a user's preferences, needs, weaknesses and personal idiosyncrasies and can use this knowledge by properly adapted behavior.

In reverse, a human user can operate his machine in an increasingly intuitive manner, can conduct increasingly effective dialogs and get more and more fitting answers. Learning for him will not any longer be a one-sided process of exercising against a static system, but an interactive dialog with a dynamic and challenging learning partner ...<sup>9</sup>

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9 This short paper was accompanied by a powerpoint presentation, available directly from the author.  
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