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What basic education and which accompaniment for which training in sciences and technologies? Learning of scientific language and experimental design: what, why, when and how?

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Abstract

Everybody needs to be educated for lifelong time, thus we have to be careful what we put in the education programs for youngsters to create a systemic acquired culture - ***ethical holistic behaviour***, ***respect for rules*** - and innovate a responsible society. Everybody needs not only to get the right information at the right time to behave societally and environmentally responsibly but first to be able to understand scientific information, to detect lies in communication, particularly in using internet sources (Bricage, 2008b) - **lack of *accountability*, lack of *transparency*** - and to develop her/his capacity of influences and factors of innovation (Bricage & al., 2006) - in the ***respect for international norms of behaviour*** and ***respect for human rights*** -!

The "*playful state of mind*", the completely open-minded state that people are in when they are innovating or learning from their experiences, allowing to construct and rearrange knowledge, is essential for children learning. The essence of innovation results from a break in perception! When it has emerged, it becomes so obvious that it is difficult to imagine that it did not exist before... However, before the break, the issue at focus is a complex problem: the relationship between cause and effect (systemics constructal law) can only be perceived in retrospect but not in advance.

A systemic approach points to a critical phase of apprenticeship: the sooner children and teachers (Bricage, 2011a) will develop *the spirit of experimental design* the better they will be ***able to use a systemic approach*** (Donnadieu & Karsky, 2002) and have ***a holistic behaviour to respect natural and ethical laws*** (Bricage, 2011b).

Key words: experimental cognition and design, innovation, mental window, mind breakage, to play.

Introduction

The economic, social and natural crisis (Bricage, 2009a) results from a dangerous one-sidedness, which lacks social responsibility's ***interdependence and holistic approach*** (Bricage, 2009b) in both values and knowledge of influential humans (Bricage, 2009c). Everybody educates for lifelong time, thus we have to be careful what we put in ***the education programs for youngsters*** (Bricage, 1981) to develop ***an ethical scientific culture*** - ethical behaviour, respect for rules (Bricage, 2008a) - and innovate a more socially responsible society. Everybody needs not only to get the right information at the right time to behave responsibly but first to be able to understand that information and to detect lies in communication - lack of accountability, lack of transparency - and develop influences over and factors of innovation - in the respect for international norms of behaviour and respect for human rights -!

Nowadays life sciences have built **a universal multidisciplinary language** (Lockard, 1981) using not only the knowledge and tools of Mathematics, Physics and Chemistry but also the tools of Informatics and Communication Technology (Bricage, 2008b) to build models and make simulations (Bricage, 2011b).

"*Knowledge comes by taking things apart. But wisdom comes by putting things together.*" (John A. Morrison)

Very young children are able to ensure their learning in letters, sciences and arts through biology centred activities (Slater, 1986) and "creative in common" responsibilities (Bricage, 1977, 1981).

What and how? : towards a multi-disciplinary and holistic behaviour.

With various objects of study - a plant, an animal, a landscape, a part of an ecosystem, an experimental device in animal, plant or human physiology, a model of a molecular structure, bacterial cultures..., all the levels of organisation and functioning of the alive are available! (Bricage, 2009d) -, practical workshops, either managed by a teacher (or a team of teachers from different disciplines) or independently (without teacher, only with pupils, alone or in groups), will allow each pupil (or student) **to observe, experiment and make writings -with drawings, data and graphs-**, at her/his own rate (Bricage, 1977, 1978). The oral and written expression through the use of mathematical and graphical languages and the application of knowledge and tools from mathematics, physics, chemistry and computing allow a better acquisition of new biological concepts **and reciprocally** (Bricage, 1981, 1993).

Role-playing games may allow the pupil/student to better find her/his working place within her/his workgroup and allow her/him to choose the best way she/he can acquire knowledge by **a motivated discovery** (Beaussart & Bricage, 2006; Bricage, 2008b).

With the use of internet data children can make some parts of the courses themselves. They can write collaborative parts of the teacher's lessons (Bricage, 2008b). They can also sign collaborative contracts, partnerships of teaching and learning (Bricage, 1998), with clear objectives of competencies acquisition (Bricage & al., 2006; Bricage, 2007) for competing for a real job (Bricage, 2011a).

"A place for each one according to her/his skills. Each one on the place she/he deserves considering her/his skills."

What pedagogy to adopt (Bricage, 1993) to optimise the pupils' success? What governance and which structures to set up to support this pedagogy? The "experimentation" showed that only a "driving" behaviour of the teachers through a very "active", "local and global", coaching of the students (Bricage & al., 2006; Bricage, 2011a), with a very strong workload of training for both and a total, but "supervised", autonomy of the students, allows to optimise the success of each one. Only the implementation of a continuous assessment and a "quality control approach", both internal - of the parts (the students, the teachers) - and external - of the whole (figure 1) -, allow to optimise the success of all the partners, with the most raised percentage of global success (Bricage, 1981, 1998). Nothing is obtained without big mutual (global) and reciprocal (local) efforts (Bricage, 1993, 1998).

"The student has the teachers whom she/he deserves and the teacher has the students whom she/he deserves, too."

Why and how? : for a local and global Societal and Environmental Responsibility.

The arrival of the today economic, social and natural crisis was anticipated 30 years ago by people who had an holistic way of thinking (Bricage, 2009a, b, c)! But nothing was done.

Because "***You can go with your horse to the watering place but you cannot oblige it to drink.***"

These days, for the first time, the World Economic Forum's Global Agenda Council was speaking about our hyper-connected world in terms of complex systems and holistic way.[1]

Man is at first a biological being, inserted into **an ecological context** (with other species which are competing between them and Man for their survivals) and **a social (human) context**. So Man has ***an Environmental and Societal Responsibility*** face to himself and for the whole earth (Bricage, 2011b). It is easier for youngsters to be interested with biology (Bricage, 1977). It is easier to have responsibility when you are educated in such a way (Slater, 1986).

But complexity is a problem..., thus only a multidisciplinary systemic approach allows to think and to act in the complexity (Bricage, 1993), it allows us to transfer concepts into applications, towards solutions of governance, in economy, ecology and sociology (Bricage & al., 2006).

"Interaction is construction and construction is interaction." (figure 1)

With the technologies of communication, we are now living in the time of immediacy, simultaneity and short term stories... (Bricage, 2008b). So to get pupils involved in Societal and Environmental responsibility we need first to have teachers trained in systemic behaviour and **at a long term story** (Bricage, 2007, 2010).

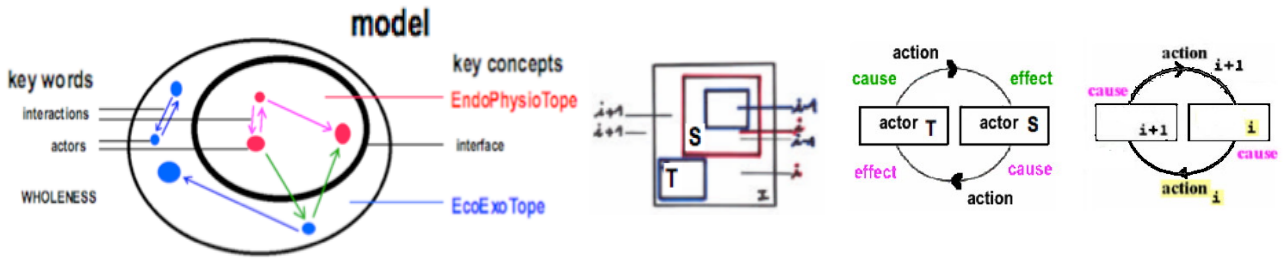

Figure 1. The systemics constructal law: ***"construction is interaction, interaction is construction."***

Each societal, economical, ecological... system is ***"a system of systems"***, made of embedded (*i-1, i, i+1* levels) and juxtaposed actors -for example: T teacher, S student-, that are sharing interactions in such a way that each cause has a direct effect which generates a new cause (or many of them) which has in turn an indirect effect (feedback) and so on.

When? : progressively but **as young as possible** for being able to read, write and design in sciences.

During 15 years, at the University of Pau & Pays de l'Adour (France), the use of the experimental approach was tested with students in the first year of the Bachelor of Life Sciences, with students in a situation of upgrading (students of various ages, entering a re-orientation process) and with students preparing the competition entrance of paramedics High Schools (Bricage, 1998). The results indicated that there is a critical period of learning (Bricage, 2008a).

If the habit of using this systemic language is not acquired early enough, the student can not avoid the risk of never be able to use it : ***"after the time, this is no more the time."*** Because, each learning is a process of exaptation.

1 **http://www3.weforum.org/docs/WEF_GAC_PerspectivesHyperconnectedWorld_ExecutiveSummary_2013.pdf**

In the brain we know that 2 ways of reading - direct and phonological - coexist. They are simultaneously activated and support themselves each other: *"the whole is more (and also less) than the sum of its parts"*.

The brain imaging shows that all people, everywhere, in all languages, to read, use the same neuronal circuit and, if this circuit is not activated, not set up, or if it is destroyed, the capacity of reading is absent or lost. It is **an emergent capacity** which is auto-organised through percolation, by re-allocation of neuronal populations (recycling) in a network of re-entries, through feedbacks (figure 1). The "reading and scientific writing and thinking" learning and the "intellectualisation" of the experimental approach is probably a similar process. It requires for its acquisition and expression, the appropriate stimulation of a neuronal territory the pre-existent properties of which make it more capable of this task, but which is not initially allocated to it. The exaptation can take place only if this territory is requested and directed to this new task of data processing. As for any physiological answer, whatever is the level of organisation, there is a minimal intensity (a threshold) for the release, a latent period for its implementation (Yeatman & al., 2012), and requests need to be repeated for the internalisation. It is only because the "operations" of networking are automated by years of learning and take place in parallel, outside our consciousness, that we could naively believe that, as for the reading, the process is immediate and global! The appropriate stimuli must be "worn" **at first at the right time**: there is a critical temporal window before which and after which nothing is possible (Bricage, 2008a).[2]

What governs our choices? The feelings! During biological evolution, the selection of the "thinking" neurones networks was made on the function and not on the structure or location of the network. The dynamic modularity, by juxtapositions and fittings (figure 1), is a usual characteristic of these networks. The psychomotor development is established by links (figure 1) which become established between neurones during the neurological, sensory, intellectual and psychological development. There is a system of neurones working as mirrors in the sight of the actions executed by other people. The same networks of neurones of the pre-driving cortex (involved in the programming of the voluntary movements) are activated as well when we make an action that when we see somebody else making the same action. Everything thus seems to take place as if the perception of the actions of others reflects ours, and vice versa. But "we do not learn to swim only by watching the others swimming, even if it can help, but by trying to swim ourselves." The role of the teacher is not only to show what can be made "virtually", but especially, **to be there, to make and to make estimate how is made what is "really" made.**

Is not the learning of the scientific approach at the time of the multimedia a prerequisite for the reasonable and reasoned expression of the citizenship? Let us expose **as soon as possible** our children to the use of the experimental approach. At the primary school games for scientific awakening (Bricage, 2088b) should be a prerequisite for the learning of reading, writing and calculation. As a hunter-gatherer Man was **at first an observer-experimenter**. Our neuronal potential is thus a priori more exaptable towards the experimental approach than towards the reading. If this exaptation does not take place, this potential is lost because it is recycled towards other purposes.

Even if a scientific training is not indispensable to the self-fulfilment of each one, it becomes necessary for every one in an advanced hyper-connected technological society because the societal governance must be able to take into account the advantages and the inconveniences of technology (for example, bio-technologies and Genetically Modified Organisms) and sciences (nuclear-energy engineering, for example). The respect of the accommodation facilities of our environment of survival implies the knowledge and the control of our capacity to be welcomed here.

What sort of governance will be able to respect our societal and environmental diversity?

What pedagogy to operate for that? Is not ***curiosity*** the first motor and ***respect*** the first skill?

Conclusion

The "*playful state of mind*" is the state of mind that people are in when they are innovating or learning from their experiences. "*Completely open-minded and able to construct and rearrange knowledge*", this state is essential for children learning. **The essence of innovation is a break in our perception.** When it has emerged, it becomes so obvious that it is difficult to imagine that it did not exist before. However, before the break, the issue at focus is a complex problem in the sense that the relationship between cause and effect can only be perceived in retrospect but not in advance. The sooner children have developed the spirit of experimental design (Bricage, 1977, 1978, 1981, 2008a) the better they will be able to experiment, compete (Bricage, 1993, 1998, 2011a) and innovate.

Education, like health, can not be satisfied by the ready-to-think, or the ready-to-heal, as well as many people are not satisfied with the ready-to-wear. But the "standard" people have not the money to pay for better individual-made solutions. Maybe ready-made solutions are necessary for a lot of people but they are neither factors of progress nor of success. Progress is always at the margins, in the **"do-it-yourself"**. Any teacher is primarily a craftsman.

2 What does not exclude that it is possible somewhere else or differently.

Nature itself creates new life forms from "the crafty embedding" of previous ones (figure 1), but respecting mandatory rules:

- there are never any rights without duties, - nothing is got without effort.

We need first a new way of formation for "systemic thinking" teachers of teachers (Bricage, 2007, 2010).

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