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Towards new educational paradigms

Introduction

Our western societies are undermined by numerous dysfunctions, and due to the domination of the North over the South, they have spread to the entire globe. It is no secret that pollutions know no boundaries, and the same thing can be said about epidemics and natural catastrophes, all more and more caused by human disruption. Even if we aren't, as Grinevald puts it, the only "pilot of this spaceship", our erratic choices of living threaten the fragile balance that has managed to last for millions of years.

> A Copernican counter-revolution: planet Earth is unlike any other planet! It is the only one with a biosphere. Not only it has witnessed the birth of life, [...] but the development of life has been constant, despite several catastrophes and evolutionary bifurcations. All in all, in spite of some massive catastrophic episodes, it has been a sustainable development, the one and only instance of sustainable development [...] (Grinevald 2005, p. 115).

We must bear in mind this remarkable example of sustainable development in order to recommend an education that can lead us there. The first step, which many people are beginning to take in the wake of the 21st century, is to get rid of our beliefs and false hopes in a technoscience capable of righting all wrongs. But it is not enough. The next steps, which implicate our daily lives, require deep scrutiny. As Defeyt states it,

> our societies live, willy-nilly, under the influence of interdependent tyrannies[1], which goals are to take us our essential freedom: the right to choose our life.
> – the GDP tyranny

[1] Defeyt points out 6 tyrannies, the sixth being the complexity tyranny. Yet it seems to us that this author fails to differentiate complexity and complication, this is why we will only keep the first five ones. It is also important to point out that, even though we do not argue with the relevancy of this listing, we do not give the elements used the same definitions that he does. Therefore, even if we do not dispute his definition of the time tyranny, fundamentally described by Defeyt in a perspective of "always more, always faster", we add to it the lack of long-term foreseeing, brought by the paradigm of economic growth.

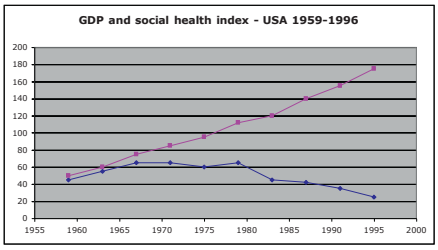
– the time tyranny
– the planned obsolescence tyranny
– the choices tyranny
– the exclusion tyranny (Defeyt 2005, p. 122).

Clearly, among these tyrannies, the GDP-one tells us more about our political and economical choices and it is not directly linked to us, individuals. Still, it shapes our way of thinking with such steadiness and pervasiveness that we cannot leave it out. We are often told "it's the economy, stupid", yet looking for alternative indicators is an excellent way of picturing the two main guidelines of this article[2], which are "changing paradigms" and "clarifying values".

Sustainable development: a change in our world perception

Beyond semantic rivalries over this conceptual term[3] as well as the education that should lead towards it[4], the emergence of sustainable development sets the question of the relation of man and nature. In the classical definition given to sustainable development, man remains the owner of this pseudo-superiority that has

[2] The "social health" indicator, for instance. The fact that the variations of GDP growth, since the 1970s, are proportionally the opposite of those of social health questions the values leading to the choices of these indicators. It seems that the purchasing power of money has always been thought more relevant than people's well being… Chart taken from de Defeyt 2005.



[3] Translating *sustainable development* into French remains quite a semantic issue. Beyond the basic problem of rendering *sustainable*, the use of the main word *development*, too much linked to economy, is questioned by many scholars as well, such as the economist S. Latouche (2004).

[4] The same way education to */ for / related to / in favor of* the environment still poses problems, education and sustainable development are caught in the same catch-22. If we stick to France, the names have gone from *education related to the environment to education* to *the environment in favor of a sustainable development* and is now being called *education to a sustainable development.* Sterling (2004) even suggests the idea of a *sustainable education*. "Founded on a more environmental and relations-based vision of the world, a sustainable education would focus on the individuals, the communities and the ecosystems. It would be ethically bearable and encourage healthy relations between all industries. It would include the education 'to a sustainable development' or 'to the environment' and even go further, since they only exist outside educational systems that remain unchallenged".

lead him to see himself at first as the *keeper* of an endangered heritage[5] and then, one century after, as the *protector* of this heritage. Still, he now enters in a new phase, that of a *negotiator*, his new goal being ***regulation***. This time, though, it is not nature that needs to be regulated, but human activities themselves, as well as their bonds with the environment and people inhabiting it.

Man and his environment from 1872 to present day

We can track back the relationship between man and his environment through a few key dates.

In 1872, the triumph of the so-called modern industry gives rise to a popular movement in reaction to it. To deal with black smokes blowing from the factory chimneys or from the mines that tarnish landscapes, many groups for the preservation of the flora and the fauna are founded. It is at the same period that the Yellowstone National Park is created in the United States.

A hundred years later, in 1972, the first international conference on the environment is held in Stockholm. The resulting document constitutes, in 26 principles, a kind of addition to the Declaration of Human Rights. The first principle proclaims especially: "Man has the right to (…) an environment of quality and he bears the responsibility to protect it for future generations". Major environmental problems lead to this action: among others DDT, the Torrey Canyon Supertanker disaster, the Minamata scandal.

These catastrophes will soon be followed by the first oil crisis (1973), which will raise awareness of resources and raw materials waste in all people, regardless of their social origins.

The concept "sustainable development" is first coined in 1987 in the "Brundtland report" of the World Commission on Environment and Development and it becomes popular in the 1992 Rio Conference. With its advent, the implication of all social actors in order to promote it becomes vital.

More important than names and dates is the way human beings see themselves in their relation with nature, and more broadly, with their environment. When the first nature reserves emerge in 1872, the main idea beneath them is ***preservation***. Both nature and heritage are preserved, their wonders are shown in cabinets of curiosities, but they are left untouched.

The 1972 Stockholm conference brings in the idea of ***protection***. We must bear in mind that between those two dates, industrialization has driven human activities to exceed the self-regulatory capacities of our planet.

And finally, in 1987, the "Brundtland Report" again alters our relation with the environment, driving us to leave this protecting facet to adopt an

[5] Since 1872, the year the Yellowstone National Park was created in the U.S.A. on a territory belonging to the Native American tribe of the Crows, this point of view was going to last for a century (see the box).

> idea of ***regulation***, since sustainable development can only last if it also happens to be a regulated development.
> This transition dramatically changes our perception of man's role at the heart of his environment and in front of his peers. It also alters the way we perceive economy, which has managed to stay unchallenged. These modifications require us to reorganize how we think, how we appreciate the world, how we picture our future, how we act… The education system as well must feel concerned by these new perspectives. A new educational paradigm has to be found, which includes a deep reflection on the school's function and on educational practices.

This transition from an idea of preservation to the one of regulation has become a key factor in understanding the radical changes that sustainable development brings in ways of thinking and appreciating the world, when personal implication, the ultimate goal of an education related to it, is in mind. Indeed, if sustainable development has to do with the management of interests relating to the three following domains: environmental, social and economical, the education *y* related to it is more about values, which are themselves linked to ways of reasoning, leading to a certain vision and appreciation of the world. This is at least what stands out from the Agenda 21, which recommends that

> both formal and non-formal education are indispensable to changing people's attitudes so that they have the capacity to assess and address their sustainable development concerns. It is also critical for achieving environmental and ethical awareness, values and attitudes, skills and behaviour consistent with sustainable development and for effective public participation in decision-making (UNCED 1993, 36.3).

On the other hand, even if the Agenda 21 expresses expectations, it doesn't mention the characteristics of these values, attitudes and skills. We therefore need to wonder about their definitions. One lead is given to us by Gro Harlem Brundtland (1993) when she declares, introducing the Agenda 21 to the general public: "the promises made in Rio will only be kept soon enough to guarantee our future if the citizens, the people ready to back tough decisions and ready to ask for changes know how to inspire their governments and how to lobby them". This means that an education reoriented towards sustainable development has to reinforce self-confidence in order to develop the will and the capacity to get dynamically involved in the setting of this project at the heart of the society. The concept of a sustainable development implies ethical principles such as ***responsibility*** and ***partnership*** in relation with one's community and nature, as well as ***fairness*** and ***solidarity*** regarding relationships with people of other cultures or other age brackets (Pellaud, 2000). Moreover, it is based on a solid economical principle "living off the interests, not off the capital, off the fruit and not off the treeix"[6].

[6] Longet, R. (2005), *La planète: sauvetage en cours*, éd. Savoirs Suisses. The use of fossil energy, ore extraction, forest overexploitation and overfishing, which beats fish capacities of procreation, are vivid examples of this "use of capital".

Sustainable development: a change of values

It is safe to say that the market has been the reference in terms of values in our western societies focused on a free-market economy. It has almost become a moral value, wiping out family, religion, faith in our country and in our flag, all points of reference during the 18th and 19th centuries. Nevertheless, with more and more frequent natural catastrophes happening and with those that may occur due to climatic changes, other values have (re)emerged. Even though the market is still significant, values such as world solidarity, respect of other cultures, tolerance are mentioned more and more often. This revival of "old" values is not always compatible with the notion of free will (Guichet, 1998; O'Connor, 1998) that the idea of freedom linked to monetary values brings. This "unconstructive" conception of freedom is based on an absence of obstacles (Rawls, 1971) that can be interpreted as "I do as I please, whenever, wherever". Our lives

> are based on the ideological foundation of the unconditional freedom of the individual. [...] Yet, in most cases, it comes down to having the freedom to buy the product that we want. The consumption tyranny oversteps other liberties and other choices, which are outside of the economical circuit. It seems solidarity has no place of its own in this kind of societyx (O'Connor 1988, p. 15).

This free will has pervert effects that are essentially translated in a lack of sense of responsibility of the individual that can be summed up as follows:

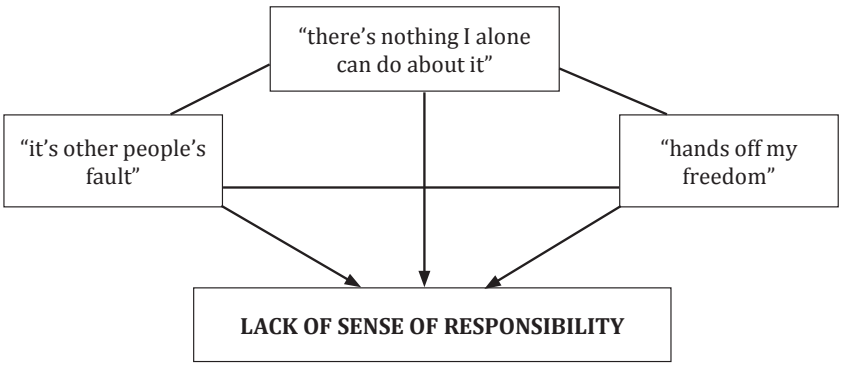


Fig. 1. The individual's lack of sence of responsibility (Pellaud, LDES, 2000)

This attitude can be explained either by unadapted ways of thinking (the difficulty to find a connection between local initiatives and global development or between the three poles of sustainable development are simple examples of it), or by a sense of helplessness (what we have called the "drop in the ocean syndrome" and expressed here in the words there's nothing I alone can do about it"), which results from a manipulation (be it economical, political, but most of all advertising). As Jollien reminds us,

> […] commercials hinder us from reaching real freedom. They point us toward an image of a packaged happiness. Mocking happiness, they pretend it relies on material conditions: financial wealth, respectable social status, other people's opinion. They put forward the need, they build up desire, but fail to give the means to satisfy it. (Jolien 2003, p. 77)

The greatest reluctance come from the fear of losing our way of life, our personal comfort, which will be caused by the assumed efforts needed to enter a process of sustainable development. Among these efforts, there is the need to think about our own actions and our choices of life and consumptions. Consequently, we find all kinds of justifications in the lack of infrastructure or information[7].

A recent study (Pellaud's 2006), which verifies an earlier one conducted in 2005 by the French Institute of Educational Researches (INRP), tells us how future teachers perceive and most of all name these values, directly associated with sustainable development. Respect – for the others, for the environment, for life or for the planet, is without a doubt the value most often pointed out. Responsibility comes second, and it requires us to be personally committed (becoming an actor instead of remaining a spectator) and at the same time to take distance from ourselves in order to better understand other people's point of view. Next follows solidarity, which involves the idea of sharing, fairness and social justice. These three fundamental values, closely intertwined, can be found in all the documents about sustainable development. They seem to appear as mainstays of an education *y* related to it. Nevertheless, to single them out and to name them is not enough. A deep, ethical, if not philosophical reflection is needed. We will come back to this in the chapter which addresses the school's new needs.

Sustainable development: changes of paradigms

In order to "assess and address the sustainable development concerns", we must take a closer look at the dramatic modifications brought by the inherent changing of paradigms. By paradigms, we understand the social strongholds of thoughts that define a human group. This definition was first given by the philosopher Thomas Kuhn in *The structure of scientific revolutions*. According to him, a paradigm is the sum of "common elements or examples, shared in practice by members of a scientific community". It allows these persons to "understand themselves painlessly, to communicate easily, as well as to achieve a consensus". As such, they are the bedrock of our way of thinking, of our way of reasoning. They are a part of our cultural background, but we are not (always) aware of it[8]. They only surface when confronted to differences (culture shocks) and their influence is great when we judge others or speak truths. Therefore, in a society where sciences and technologies are put forward as absolute truths and universal remedies, it can be

[7] These analyses and their results come from F. Pellaud's doctoral thesis held in 2000 (see bibliography).

[8] A few, simple examples of paradigms: the use of the decimal system, the division of time in sixty minutes or seconds, the seven colours of the rainbow, the twelve semitones in a musical scale, the notion of fidelity, which varies depending on the cultures and on the religion, the polluter paying principle, which comes from the free-market economy…

difficult to understand different ways of thinking, inspired by such principles as **impermanence**, **uncertainty** or **relativity**, which we will focus on later on (see fig. 2 and the box).

In addition, in societies where everything is either black or white (the world is divided between the "good" and the "bad guys", between inhabitants of the North or of the South, between the rich and the poor...), theories such as the one of the **complex systems** (Morin, 1990, 1996, 1998), the principles of **interdependence** and above all **ambivalence** are particularly hard to figure out. However, as the UNESCO rightly reminds us,

> problems related to sustainable development are characterized, inter alia, by their complexity. This complexity must be communicated and understood, even though to do so is not easy or necessarily palatable. The simplification of complex issues - so often observed today - is not only fraudulent in that it misrepresents reality, but also irresponsible on the part of those who understandthese issues (UNESCO 1997, p. 33).

To top these "total adjustments" in our ways of thinking and these extreme transformations of our vision of the world, we have to bear in mind that "to do so is not easy or necessarily palatable"... These obstacles naturally lead us to examine teaching in order to have a better understanding of its mechanisms so that, ultimately, we can recommend suitable pedagogical strategies.

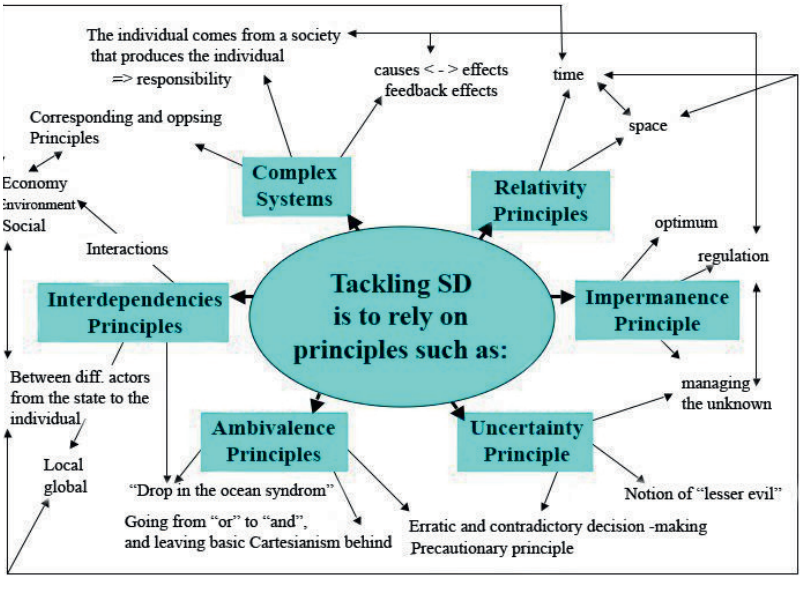


Fig. 2. The connections of the sustainable development principles (Pellaud, LDES, 2004)

Principles of sustainable development

Several principles govern the understanding and the establishment of sustainable development, both in everyday life and in the education *y* related to it.

The ***relativity principle***. This principle is based on the importance of contextualization, which defines an understanding or goals in a particular context and not in the absolute. For instance, thinking about the sustainable development, defining its priorities and ways to achieving it will be considerably different whether it is in Switzerland, Brazil or Mali.

Thanks to notions such as *time* and *space* we can get quite a good idea of this principle. The way "long term" is a remarkably enlightening example: in economy, the corresponding time span is from 3 to 10 years. As far as social development is concerned, it covers one or two generations. As for environmental issues, it can be as short as a life of a mayfly, and as extended as millions of years when talking about nuclear wastes.

Our culture, our thinking habits, our own referent, i.e. human life, didn't familiarize us, didn't prepare us to apprehend relativity in this way. As for space, pollution and other environmental problems have deeply challenged the very ideas of borders, territories, belongings and properties. There are so many paradigms that understanding sustainable development is all the more complicated.

The impermanence principle is connected to the idea of a dynamic process, meaning that the latter needs to act in terms of regulation and optimum. Unlike such notions, our culture has got us into the habit of taking decisions –the laws are a very good example of this – in order to find definite solutions. This paradigm, reflected in the popular idea that "every problem has a solution", is strengthened by the image of an ever rescuing modernity developed in western industrialized countries, its only limits being technical and financial ones. Even if this modern image is being widely questioned, school still puts forward ways of reasoning that go in this direction. In fact, all problems given to pupils hold only one solution, leading to the "right" answer. The ***ambivalence*** as well as the ***uncertainty principles*** must take into account the *paradoxal*, on the one hand, and the *uncertain* and the *random* on the other hand. This means we have to know how to manage the *unknown*, the accidental ingredient inherent in any process, but it also means that other notions appear, such as *erratic*, *contradictory* or even "lesser evil" – or "at its best" if we are being optimistic. Yet, our almost blind confidence in the development of technosciences has lead us to a paradigm that made us believe that we could or would be able to manage everything with consistency. Such notions as precautionary principle hadn't been mentioned until recently, for better decision-making in situations where the complexity and the uncertainty about the outcome won't allow considering all the consequences.

Ultimately, if quantum physics have shown us the way to a new management of the paradoxal, by showing a model where a photon can either

be a wave, a particle or both at the same time, we must realize that our most personal ways of reasoning aren't as black and white as we wished.
Therefore, if psychology tells us that behind every fear there is a desire (Salomé 1995), our own actions, our own commitment suffers from this ambivalence. As a result, many people, attentive to environmental and social issues, who are seeking, through their actions, to be respectful of certain ethics, consider that they are a mere ***"drop in the ocean"***. This attitude is basically due to a disillusionment towards economical and political systems, as Barbier (2005), among others, points it out, but also to a non-assimilation of the interdependencies principle, that has to be considered, on the one hand, between local actions and global development, and on the other hand, between the different actors of sustainable development, from the single individual to international organizations. We will be able to go past this syndrome, which reveals a way of thinking subject to a very Cartesian division, only when we understand the influence that these different parties exert over each other, and when we appreciate the effect that an action, even limited, may have on a greater whole.
Included in this interdependencies principle, the interactions are, strictly speaking, the mainstays of sustainable development, since they are at the core of the concept, bringing together ***economical, environmental and social*** developments. Just like interdependencies, interactions operate between many systems, each considered field being a system in itself.
As early as 1984, Saaty was already telling us: "Economy, for instance, depends on energy but on other commodities as well; available resources in energy depend on geography and politics; politics depend on military forces; military forces depend on technology; technology depends on ideas and commodities; ideas depend on politics in order to be approved and supported; and so on and so forth" (Saaty 1981–1984, p. 17).
It should be noted that the author remains in the decision-making spheres and neither takes into account the consumer, nor the human resources, nor the working conditions, to name only these three parameters. But this example very well shows the interdependencies and the interdisciplinarities in which dwells every issue. Interactions between these fields are not obvious, they are not "taken for granted". They don't "have" to exist, contrary to most interactions that usually govern the physics and even the social world.
The economical system, for instance, can very well run independently, as free-market economy shows us. The limits forced upon it by sustainable development are out of the system in itself, since they are environmental and social.
Furthermore, sustainable development is in line with several ***complex systems***. Yet it has been theoretically demonstrated that the latter are comprised by general characteristics that manifest themselves in particular in opposing and complementary principles, which eventually apply to sustainable development. And among these, the ***"hologrammatic"*** principle, defined by Morin (1990, 1996, 1998) which highlights the fact that

the part is present in the whole and the whole is present in the part. But beyond this insertion, it can also add up to more than this sum, since, in this particular example, this system relies on a large amount of subsets establishing subsystems, which range from big pools such as international organizations, governments and nations, to small, local communities and eventually the individual as a single body. At the same time, it can prove to be weaker than the sum of its parts, since their inherent variety loses its resources when approached globally.

The intrinsic features of each culture, of each way of addressing the development of a specific economical system, of any political system or even any person are swamped in the mass and fail to express themselves. The organization, or more precisely the setting, holds back and restrains some inherent qualities or properties to the various parts that make up the whole. This is why the notion of quality of the parts is paramount in this concept. In other words, it is thanks to the quality of all the parties that the quality of the whole will be assured.

These systems have yet another characteristic, i.e. the feedback loops, which occur at their very heart and of which our ways of thinking fail to take account.

These loops ask us to rethink the laws of cause and effects altogether. The goal is to aim at a better incorporation of the notion of cycle and what it involves, as well as to quit thinking that one cause can only have one effect. As Giordan (2002) shows, a cause can have many effects, and an effect can have many causes. It can have a feedback effect on one or more causes and therefore magnify its or their effects. Finally, an effect can magnify or modify a cause that will eventually be the source of a chain reaction.

Yet, beyond these changes of paradigms, we need to undertake a deep reflection on the underlying values beneath our actions and our decisions for the good of sustainable development.

Changing didactic models

Without going as far as the Early Greek philosophers, we can fairly say that since Locke (1693) and Condillac (1746), to name only the most famous ones, we try to explain the mechanisms at work in the way the mind operates. And yet, until today, school and the associated educational practices have mainly run in accordance with three didactic models[9].

The oldest one is the empiricist model. According to it, the child's entire knowledge can only come from sensory experience. The vision behind this idea is that of a brain similar to a *tabula rasa*, i.e. a clean slate, where new knowledge is written that the child would only have to memorize.

Of a much later inspiration, the behaviourist model suggests that learning is the result of a conditioned reflex based on positive (rewards) or negative (punishments)

[9] It is essential to distinguish the didactic models from their pedagogical applications. The only purpose of a didactic model is to clarify the mechanisms of the thought. We must bear this in mind so that we do not mix up learning and teaching!

stimuli. Established by Watson (1913), a psychologist specialized in animal behaviour, following the works of animal conditioning lead by the Russian scientist Pavlov as early as 1889, this model was to be developed by the American psychologists Holland and Skinner (1961, 1968).

The theory suggests that we cannot access people's mental states, as they are unobservable. Compared to a "black box", the person can nevertheless be influenced from without by accurately conceived situations: the subsequent propositions of the behaviourist model are set up based on a principle of training through "conditioning" and "reinforcement".

The constructivist model, as its name suggests, regards learning as the result of a construction of knowledge, one step at a time. These steps are defined mostly by biological parameters that suppose a "natural" development of the child. Research lead by the psychologist Jean Piaget (1947) and afterwards by the whole group of social constructivists, followers or not of Vygotsky (1933 and 1934), have brought this learning conception the remarkable soaring that has been witnessed.

In truth, this current of thought displays several variations. Gagné (1965, 1976, 1985) and Bruner (1986) focus on the associations that need to be made between external information and the structure of thought. According to them, any perception is a categorization. Ausubel (1968) mentions "cognitive bridges". The Piagetian school of Geneva puts forward the concepts of "assimilation" and "accommodation", borrowed from evolution biology.

None of these models is either "right" or "wrong". Each one of them is just more or less adapted to describing and explaining a given pedagogical situation. And each one of them, of course, can give rise to a specific pedagogy, whose pros and cons are directly linked to the legitimacy limits of the model it results from. As B. Fleury (2005) rightly reminds us, we can consider learning

> in a behaviourist frame (behaviourist approach, conditioning), Piagetian (changing structure or intellectual functioning register), Freudian (revision of identifications), Lewinian (changing social representations) or Bachelardian (epistemological reform). And in order to choose the education strategy, one must first determine the nature of the change aimed at: if the target is to strengthen behaviours, to polish up methods, then why not use a behaviouristic approach? But if the goal is to aim at break offs, at changing paradigms, then the other models seem more appropriate (Fleury 2005).

And these are exactly the kind of changes we aim at when sustainable development is concerned. Let us draw near a more suitable modelization by referring to Bachelard and his "epistemological obstacles". Drawing a parallel between the difficulties related to scientific revolutions as described by Kuhn (epistemological perspective) and the difficulties related to individual learning (psycho-pedagogical perspective), he puts forward a concept that will be taken up and developed by Giordan et al. Giordan, suggesting an allosteric approach to learning, assumes that the obstacles are also our thinking tools and that they cannot, for certain, be destroyed without further ado. He also stresses out the fact that these obstacles are not only cognitive: above all, they come from the various environments in which the learner evolves, among which the emotional and affective ones as well as the family play a very special role. Furthermore, in this model, learning becomes

first and foremost a matter of bonds, forging relationships, standing back, questioning values and thinking habits.

Taking conception as a unit of measurement (see the box), this model suggests that it is both the tool and the obstacle. As a tool, it must not be destroyed, as Bachelard recommended, since it represents the only referent the learner can rely on in order to approach new knowledge. As an obstacle, it must be transformed by a "deconstruction-reconstruction" process.

Appreciated through this analytical grid that makes up the explanatory system of the learner, every new piece of information is going to be interpreted, distorted, modelled, reformulated, even impoverished before it can adapt to it, since the network of conceptions works as a "reducing agent". Many examples are in line with this, showing that when there is an adjustment, it does not necessarily mean that it goes toward a better understanding of the phenomena.

Figure 3 puts forward the first modelization of learning. It shows that the new piece of information can both be filtered and distorted by conception, or can lead its transformation towards a more operative conception.

If adapting to the new piece of information is not possible to the learner submitted to it, it might end up being rejected altogether. If we want it to pass directly (without a didactical intervention), it has to strike a chord with the whole of the previous knowledge of the learner. According to Vygotsky (1933), it means that the new piece of information has to be located in the "Zone of Proximal Development", which only happens with a very small percentage of pupils. For all the other ones, appropriate didactical interventions have to be set up (in other words, an "education"), that take into account conceptions and that allow to come as close as possible to this Zone of Proximal Development[10].

Figure 3 helps us understand that the individual formation of knowledge is made of many "steps forward", as well as "backwards" and "sideways", thus requiring phases of "knowledge deconstruction". Indeed, these "sideways and backwards steps" are learning as well, but they end up as distorted, or even as bad understanding of reliable and validated scientific knowledge.

Hence the need to address the transformation of knowledge as a real-time "deconstruction-reconstruction" process of the conceptions, where the old knowledge would be altered and would only give way to the new one when it would appear as expired. Therefore, it is essential to try and find out what parameters are likely to allow this deconstruction-reconstruction inside the conceptions network. We will tackle these elements by taking a closer look at pedagogical practice.

[10] This education, if we want it to be efficient and to lead to a real learning, must be thought and built according to the learners' conceptions themselves. Since they do not easily change with just a single operation, a specific "didactical environment" is preferred. This concept is not tackled in the present article, but further details can be found in the following reference: F. Pellaud, A. Giordan, Faut-il encore enseigner les sciences ? *L'Actualité Chimique*, juillet 2002.

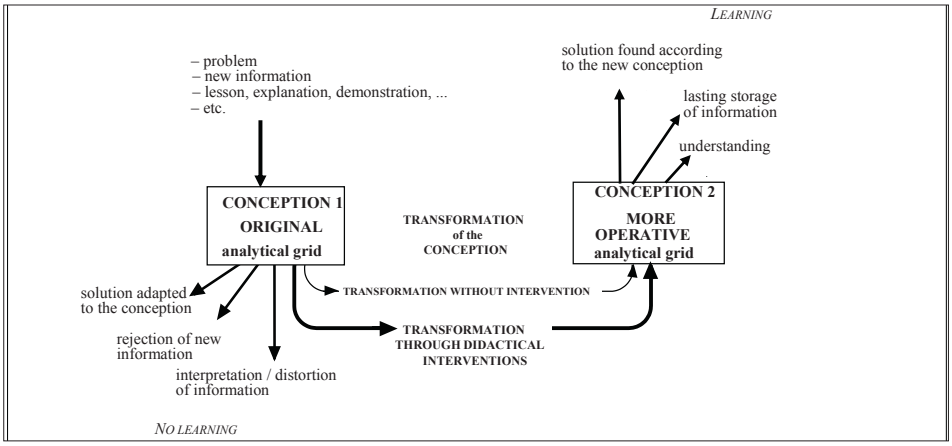


Fig. 3. The process of conceptions transformation (Giordan, Pellaud & Eastes 2002)

Conceptions: tools and obstacles to learning

Why is it so difficult to learn certain things and why is some learning reversible? How come, on the other hand, one explanation, one word is enough for a notion to stay in one's head forever? This largely depends on our "conceptions".

They are both the basic blocks of knowledge and the mainstays of the thought, i.e. the group of mechanisms that allows us to make sense in order to have a better understanding of our environment and to act on it.

More than mere representations or mental images, they relate back to ways of reasoning, networks of references and various signifiers. The whole of these elements results directly from our own experiences, influenced by the many environments in which we dwell in our everyday lives and whose affective aspects will play a major role. These conceptions are never obvious and hardly ever expressed explicitly. Such as the iceberg, spotted thanks to a minuscule portion emerging out of the water (figure 4), they are only revealed through attitudes, body language or even the expression of values, beliefs or knowledge, all things that may seem irrelevant in a discussion, through the answer to a question, or a drawing.

In our everyday lives, in our interpersonal relationships, we usually have access to this emerged part, as well as some elements telling about other people's various environments. Still, even if this knowledge is enough to manage social interactions, it is far too restricted for the mediator who is involved in the act of learning. Why is that so? Because his or her pupils' conceptions are at the heart of their way of thinking, their way of understanding and, therefore, their way of learning.

As André Giordan adds, "the conception is not a product of the thought, it is the very process of mental activity. It becomes a strategy, both behaviourist and mental, that the learner handles to have power over his or her environment" (Giordan 1996, p. 15). Hence, by turning old knowledge on, the conceptions allow situations to be recognized. It is then safe to say that they are an essential tool for any new acquirement of knowledge.

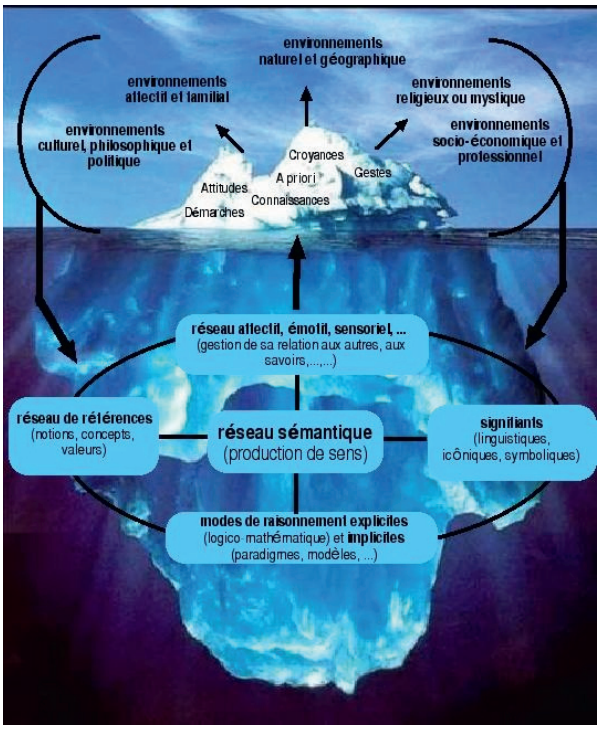


Fig. 4. The iceberg of conceptions (Giordan, Pellaud 2002)

Given such radical changes, school cannot be restricted to the basic models on which it was established. A change of pedagogical paradigms is required here as well, in order to answer these new needs that have to be met.

School's new needs

Sustainable development is not the only "education" that school has to provide. Prior to that, education to the environment, to health, to citizenship, to peace, to the intercultural and global development… was already part of the expression of a certain political and civic will, when not part of the programs as such[11]. All these themes have been more or less dealt with, and have had different natures, often thanks to enthusiast teachers' good will. Consequently, we could ask ourselves if there is a real interest in adding to this whole paraphernalia an education to sustainable development.

The answer is clear, even though "on the inside", the objectives of all these educations are much broader than their designation may let us believe[12]. To begin with,

[11] To read more about it: "Le bazar des z'éducation" in *Educateur* 9.04, report available at the Fondation Education et Développement (FED), Lausanne (Suisse)

[12] For instance, regarding education to peace, Paul Feyerabend, a sciences philosopher, tells us: "What is the main issue of our times? The issue of peace in different forms – peace with our peers, even if they do not agree with us; peace with other nations, even if this means

it is because sustainable development can be seen as a rallying concept for all of these educations, since it deals with every human action or activity. Then, as we already pointed out, it is because it requires changing of paradigms that in a way define society's new needs, ergo school's new needs, in so far as we feel that its purpose is to get us ready for tomorrow's "living together".

And finally, it is because, if we believe French official directives, the education to sustainable development does not only focus on acquiring conscientious behaviours and attitudes that would go beyond the behaviourist perspective of mere "eco-friendly gestures", but also on adopting changes that we could describe as "pedagogical paradigms".

> The Education to the Environment in favour of a Sustainable Development [EESD] must be an essential element of pupils' initial learning, as early as possible and all along their schooling, to allow them to acquire vital knowledge and methods so that they can find their place in their environments and behave conscientiously.
> The awareness of environmental, economical and sociocultural issues must help them, without doom watch but with clear-headedness, getting a better picture of the interdependencies between human societies and the whole of the planetary system as well as understanding the need for everyone to adopt behaviours propitious for its sustainable management and for the development of world solidarity[13].

These are by no means radical objectives, yet they present pioneering perspectives regarding teaching. They just happen to remind us of the importance of trans-disciplinarity, often advocated, hardly ever achieved, and they put forward the building up of knowledge all along schooling, or even life. By focusing on the perception of interdependencies, they recommend, without naming it, the systemic approach. And by daring to put forward the development of world solidarity, they clearly encourage educators to put the notion of value at the heart of their teaching, even if the latter candidly think that new knowledge and methods will only allow pupils to "act in a responsible manner"…

Addressing values is not innocent. A recent study lead by the INRP (2005) shows that teachers frequently have ambivalent opinions when it comes to tackling values. The "eco-friendly gestures" or at least attitudes socially accepted as "citizen attitude" do not raise many objections – not wasting paper, not throwing garbage on the floor, turning lights off… But as soon as the economy and above all a free- market economy as the foundation of a consumer society is to be criticized in an obvious manner, then understandable ethics leads teachers to decline to play the role of a "mister-know-it-all", of a moral professor.

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that we have to admit that we committed serious mistakes; and peace with nature, even if it means to stop considering nature as a slave and to start treating it as an element of our existence with the same rights that we have". In La science en tant qu'art, Albin Michel Sciences, 2003.

[13] Bulletin officiel no 28 du 15 juillet 2004 du Ministère de l'éducation nationale. Excerpt of the text sent to superintendents, regional schools inspectors, directors of the regional services, school directors and headteachers.

> The introduction of the 'sustainable development' aspect in the education related to the environment therefore questions its ideological content, or at least its intent. Teachers wonder about their role, and the idea of their role, on an institutional level, in the eyes of the School's missions of teaching and educating, as well as on a professional level. In other words, does School have to encourage moral and new behaviours to play a major role in the alteration of society? (Boyer, Pommier 2005, p. 18).

Then again, paradoxically enough, and as far as these practices become institutionalized, a more personal commitment implied in the presence of these values in the educating system attracts teachers and appeals to them:

> by becoming institutionalized, the EESD would allow the teacher to be „bona fide', to express himself or herself in his or her work. It would give peace of mind to the person by establishing continuity between personal and professional identity, and at the same time, it would make some practices acceptable and would reinforce the teaching identity. We can go as far as saying that it is as if, for some, the establishment of the EESD removed a proscription and brought relief by acknowledging their practices (Boyer, Pommier 2005, p. 18).

In order to answer to the teachers' worries, their fears of hurting sensibilities, of creating ideological clashes within their own classes, of seeing parents barging in to defend what they think is a stronghold of their parental education, our role is to set ourselves outside any duality that would result in asking ourselves: «is it my job to recommend certain values?" First of all, because we have to realize that every person carries his or her own values through his or her appearance. And pupils are masters in this little game called demystification. You come at work in a SUV or a bike and you are already "categorized". You wear designers' shoes or simple sandals, ditto. The newspaper you read, the tie you wear or don't wear, the look of your handbag or of your briefcase, the coffee you drink, the people you go out with, all these are part of this labelling, be it justified or not.

Therefore, our role is to allow pupils and teachers alike to **clarify their values**. Indeed, many youngsters are caught between venal values put forward by a consumer society and those, much more humanist, of equality, justice and peace which many yearn for. How can we long for the best computer money can buy as well as designers' clothes and wish to put an end to social inequalities at the same time? How can our goal be to reach a high-profile job in order to drive a Ferrari and want to cut emissions of greenhouse gases and put an end to world hunger at the same time?

In order to allow pupils to get out of this conflict between our ideal, our will and our actions, called "cognitive dissonance" by philosophers, we need to bring some hindsight to the many manipulations we are victims of and which –how ironic! – mostly appear as true liberties to the pupils. For, even if political scheming is often protested against in the most passionate way by teenagers, the most efficient and insidious one of advertising is only noticed by a handful of individuals who show their difference through the clothes they wear, their haircuts or any other aspect.

In order to reach this meta-reflection, we need to ask ourselves three essential questions:

- ***Identifying what I want*** (job, standard of living, social and intimate relationships, environment...),
- ***Why do I want it*** (what are the values and priorities that prevail in these choices/ desires),
- ***And how much am I going to put myself into it...*** (in time, energy, money, compromises...)
- ***keeping in mind I'm not alone in the world!***

Without always having to resort to philosophy[14], a deep reflection on what respect, conscientiousness and solidarity (to name only the most mentioned values, see chapter "Sustainable Development: a change of values") must be undertaken, even with very young children.

Therefore, without imposing our own values – which would amount to another form of manipulation – we can aim at a positive clarification that would give pupils or students the possibility to distinguish the many influences that condition our lives in general and hence allow them to position themselves regarding them. Realizing that a brand may promote an ideology – and therefore label us as adhering to it – and that the money given for a certain product sponsors movements that might go against our values and beliefs is not only of the utmost importance, it can also be a driving force to developing a critical eye.

This approach can also allow school to question itself on the way it "molds" individuals… Is the search for individual promotion and personal accumulation of wealth – that our free-market society keeps on encouraging and which manifests itself, at school, through a selection process based on summative assessment, consistent with the solidarity and equality principle that is behind sustainable development? What does "quality of life" mean? Is it an ever-growing access to commodities and to individual comfort or can it be understood differently, especially in the way we handle our choices of life, our social relations, etc.?

This clarification of values may also be helpful to meet "new needs". Indeed, more and more, school has to face parents' failure to cope. The "education" bit takes up an ever-growing space at the heart of the teaching. And even if some teachers consider that it goes beyond their skills and what "they get paid for", this aspect must be addressed, only because violence, racketeering and other reprehensible behaviours keep increasing, and school is an easy target for those.

[14] A philosophical approach can only be an advantage for teachers and pupils alike. Unfortunately, this subject is only taught to kids in their late teens, while we recommend it as early as nursery school. Besides, the INRP study quoted above shows that philosophy teachers have to be approached so that less "broad" and "generous" values might be talked about. "(…) What's the point in using philosophy to address these issues (the ones brought up by sustainable development), what values can we use to tackle them, what solutions can be found, how can we put things in perspective (keeping a watchful eye on information, on what is at stake behind economical manipulation…), the individual has the Freedom to act, but fails to grasp the whole Truth. Another philosophy teacher adds: "the EESD ties up with major philosophical questions. For instance: Nature (the definition of the natural and the artificial, the relationship between Man and Nature…), Culture, Law, Justice, responsibility (Jonas), conscience, Man in the Universe (Pascal) and, in relation with people from other cultures and other age brackets, the Past, Science, Anthropology, Ethics, Bioethics, Freedom, Desire…" (Boyer, Pommier 2005, p. 14).

Before we even reach "world solidarity", we must clearly go through what André Giordan calls "**learning to live together**", which starts with "**learning to live with ourselves**".

> Isn't it essential that the youngster gets to be interested in his or her person and above all, in his or her body? He or she should respect it, take care of it, and we're not only talking about looks. School has to give him or her a decent perception of himself or herself, beginning with his or her body, free from cultural or any other kind of prejudice. Who can really say that the self (the biological, psychological and cultural self I am part of) is less important than the parabola in mathematics, the carbon in chemistry or Paraguay in geography? „How can I tell what is important for me?' „How can I tell myself?' This self-awareness gives sense back or puts forward a project to many youngsters in trouble. Each and every one of them has amazing skills that need to be developed; the individual is perfectible; to realize it is extremely liberating (Giordan 2002, p. 130).

Respecting oneself and the others also means respecting one's own limits. By realizing that "my freedom stops where the other's starts", foremost principle of all respect, we work on "**our position with regard to the limits**" that André Giordan defines as yet another of these new needs that school has to meet. These limits are clearly those that we must use as references to help us live together. We will add that they also help us understand what sustainable development consists of. Indeed, if it knows no disciplinary boundaries, or at least if it transcends them, it still involves a confined space. Earth is a confined space, therefore it is restricted. Consequently, we cannot keep on ill-using it without taking this fact into account. Knowing and understanding these limits is also the beginning of ***consciousness***.

> Being true to oneself in order to honour one's commitments, refusing to escape and accepting the rules of a group prompt us to behave in a responsible way. Let us not forget committing oneself in various roles and fulfilling one's pledge for the good of the group. [...] An education towards consciousness involves that pupils learn how to draw up common landmarks and how to refer to them. [...] For it's the constraints (ergo the limits) that liberate us! (Giordan 2002, p. 133–135).

Respect is also essential to meet another need of the school, which is learning how to work in a set of connections and in synergy. With the knowledge boom that we experience nowadays, it is vital and reasonable to accept the idea that we cannot be familiar with everything, even in our own discipline. Far from any individualism and the solitary exploit (the latter hardly ever exists, even Nobel Winners own their prizes to team work!), learning how to work as a team, to share one's knowledge or "breakthroughs" with others to see them develop becomes critical. In this regard, the economic and industrial worlds can be very good examples to follow!

Learning how to work in a set of connections is also a way of meeting the need of inter / trans / and pluridisciplinary approach already mentioned. Just taking a look at all that went wrong because of overly unilateral methods and, more recently, the hard time the teachers have changing their practices to embrace this new education "philosophy", is enough to understand how essential it has become to set off such a state of mind as soon as possible!

Furthermore, by giving pupils the possibility to simultaneously apply various points of view on the same "object", we address the heterogeneity of the pupils' needs, competences and interests.

This last parameter would also allow introducing features that haven't got a place, yet, in the schools' programs. Such is the case for economy, ethics, epistemology, history of sciences, psychology, anthropology, architecture, urban planning[15], etc. All points of view which further an insight allow an authentic systemic approach and give access to other fields of exploration, interests and questioning.

Finally, nothing is possible without a certain amount of ***curiosity***. Unfortunately, school, by giving answers to questions that pupils do not ask themselves, soon kills curiosity. School has to embrace what Giordan calls a "questioning culture". The following figure sums up the four kinds of knowledge: the awareness, i.e. the behaviours, the know-how, which stands for skills and approaches, knowledge as in erudition and, last of all, knowledge on knowledge[16], in other terms, metacognition.

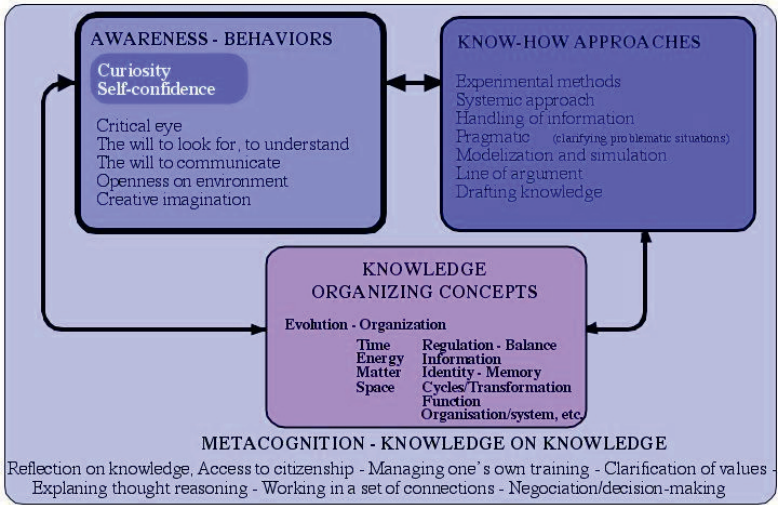

Fig. 5. The four kinds of knowledge (Giordan, Pellaud 2001)

This figure clearly demonstrates that one needs to develop a certain dose of self-confidence and have access to all sorts of knowledge, i.e. be able to handle working methods in order to access them… Everything interacts with everything else, nothing can work without the "other's" complementarity.

So that the questioning does not wear out, it must not become systematic: just as much regulation as the teacher has to set up. Moreover, curiosity doesn't have to be restricted to pupils! Teachers, too, owe it to themselves to stay curious, to have the courage to ask questions which they might not be able to answer, on topics they are not familiar with. What a joy, for the pupil, to deliver knowledge to the teacher! Far from the image of an omniscient professor, this new kind of teacher questions

[15] These suggestions come from d'André Giordan. Mentioning urban planning he reminds us that 9 children out of 10 live in the cities!

[16] We will get back to the idea of organizing concepts in the chapter dedicated to assessment.

his or her role (in this case, he or she is no longer a "knowledge medium" but a real "companion" of the learner) as well as his or her way of teaching. We will tackle both these aspects in the following chapter, and we will make some practical suggestions regarding the recommended changes.

Changing pedagogical practices

Regarding this issue, the Agenda 21 gives us very broad leads:

> To be effective, environment and development education should deal with the dynamics of both the physical/biological and socio-economic environment and human (which may include spiritual) development, should be integrated in all disciplines, and should employ formal and non-formal methods and effective means of communication (CNUED 1993, p. 229).

Our goal is to define what these methods and means are, in association with the learning theories already mentioned.

The INRP study shows that most teachers think that lectures do not fit in with the objectives of the education to sustainable development. Still, because they see themselves mainly as knowledge media and as informants, the only alternatives they can think of to lectures are group work and debates in class… try putting that into practice!

UNESCO (1997), as well as the experts council in charge of "ethical issues inherent in SD" (EEC, 1994), have tried a more practical approach, though still too broad, in which "means" and "end" meet. From this perspective, teaching methods have to be rethought in order to:

- Promote the identification and the laying down of problems,
- Support the ability to imagine other ways of life and development.
- Learn to negotiate, to justify one's choices,
- Work in a set of connections, in synergy,
- Encourage taking actions.

To achieve this, we need to:

- Open up disciplines, since the complexity of nowadays issues lies in the interactional zone of multiple disciplines, in their interface.
- Establish a *general reference frame*, which defines global objectives on the purpose of teaching, "while allowing teachers and students to make choices about the specific learning experience" (UNESCO 1997, p. 25).
- Draw up new methods of assessment, which will address learning as a process to be set.
- Consider the idea of an education aiming at self-education, so that the gaining of knowledge and reflection does not stop with the end of school.

In concrete terms, considering school in a process of sustainable development implies that all the actors of the educational world "owe it to themselves to rekindle the custom of social critic or of rebuilding teaching and sponsor, in terms of program planning and pedagogy, approaches capable of integrating social justice and environmental sustainability to a vision and a mission aiming at altering people and society" (Fien 1996).

By drawing our inspiration from these guidelines that, without mentioning it, stress the importance of the pupil's natural motivation, and by taking into account the allosteric approach of learning and the importance of conceptions in the transformation of paradigms and values, we came to develop a "didactic environment" which brings together various parameters that teachers should pay a close attention to.

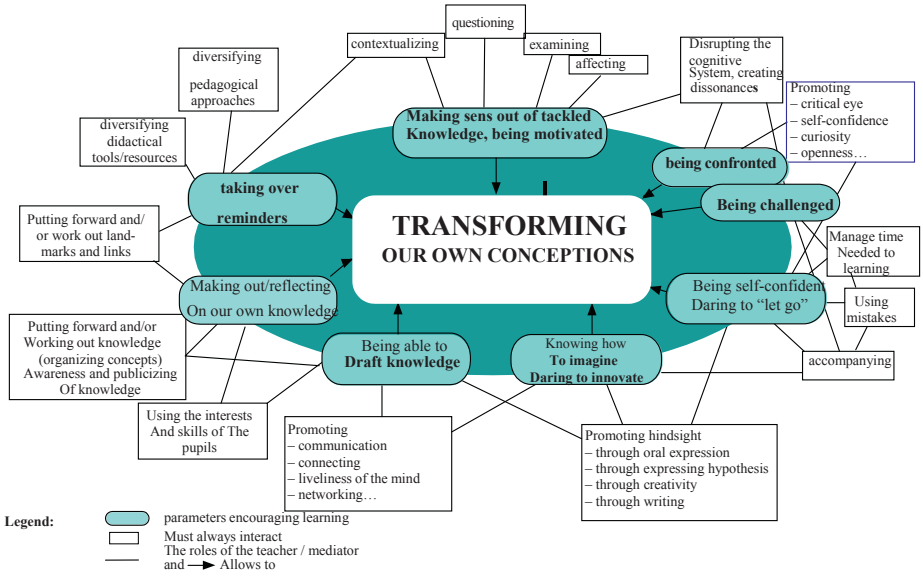

Fig. 6. Didactic environment encouraging learning (Giordan, Pellaud 2002)

Figure 6, with two distinct levels, puts forward, on the one hand, parameters promoting the transformation of conceptions (in the ovals), and on the other hand the different roles that the teacher has to play to set them in motion (in the rectangles). While the interest of this approach lies mainly in the complementarity that these different parameters bring to the learner, i.e. in their constant interaction, we will address them one by one to specify the teacher's work and the way he or she can, in practical terms, use these leads in his or her teaching[17].

The different parameters of a didactic environment

Making sense out of tackled knowledge, being motivated. This is what pupils have to perceive and feel. To achieve this result, the work of the teacher essentially consists of ***examining***, ***affecting***, and ***questioning*** by putting forward a ***context*** having meaning to the learner.

Amazingly enough, we notice that teachers acknowledge there are virtues in personally motivating the learner… yet they completely overlook this phenomenon when it comes to their own pupils. Indeed, as the INRP study shows, "setting a connection between personal and professional areas would promote a better working practice. Some teachers consequently point out that their personal commitment arouses their research for

[17] These propositions are only examples and they by no means pretend to be exhaustive or to be a magic remedy!

information, it puts them on a data watch beneficial to their pupils. Their taking part in associations deepens their questioning, allows them to build problematics that they can afterwards transfer in their own classes. Both regarding the contribution of knowledge and the coordination of debates (Boyer, Pommier 2005, p. 51)". Therefore, looking into what really appeals to pupils becomes essential if we want to make the most of this individual and personal motivation. Current affairs, watching the news on television, direct questioning on their current concerns, all these are possible ways of introduction. An experiment carried out on pupils from 10 to 12 years old has shown that, when asked about "the greatest issue in the world today", the answers go from war, racism, to water shortage, environmental catastrophes… (see. Pellaud, Muths 2006). Subjects whose roots go deeply in the heart of sustainable development and that can be tackled in inter / trans or pluridisciplinary ways thanks to history and geography, physics, biology, mathematics (by becoming familiar with curves, diagrams, percentages or statistics), philosophy, economic and social sciences, grammar, literature and foreign languages…

Being confronted, ***being challenged***. This objective is vital to "compel" pupils to seek further than their own knowledge. Indeed, we all have preconceived ideas, beliefs, convictions on such and such subject. Similarly to any other conception, we stick to them and it is sometimes difficult to make us change our mind. It is essential that the pupil be put in a situation that allows him or her to ***appreciate the limits of his or her own reasoning***[18], of his or her own way of thinking and understanding of the world. Only in these conditions will he or she see the need to trade the old conceptions for new, more operative ones. To do so, clash situations are actually quite positive. Clashes between peers through a debate, through situations where the pupil is lead to defend his or her ideas, to make a case, as well as clashes with the real world, with different cultures, philosophies, points of view that aim at "taking a fresh look" at things, and finally, clashes with knowledge, mainly thanks to media, textbooks, encounters with scientists... Role-playing game can be an effective tool to achieving one's goals[19]. Introduced to pupils with no warning, it allows, through the roles that pupils have to play, to highlight their gaps, their conceptions, their assumptions… Only then can a work be undertaken in order to fill these gaps and build a real role- playing game that would be shown, for instance, to parents or to another class. This reinvestment is directly linked to another parameter, the one related to the ***knowledge draft***.

Being self-confident, daring to "let go". This parameter calls upon the role of ***companion*** that the teacher has to play, in transforming conceptions. Indeed, self-confidence can only be acquired through the establishment of

[18] It manifests itself, in our chart, in "disrupting the cognitive system, creating dissonances".

[19] To read more about using role-playing games, see: Pellaud, F. Les enseignants doivent apprendre à éduquer à la responsabilité in *La Revue Durable no 8* décembre 2003 – janvier 2004.

a healthy relationship between teacher and learner in the heart of the class. As with disruption, the right balance has to be found. In one case or another, too much or not enough disruption or support can hinder the learning process. To allow the establishment of a health y relationship, we can still point out a few relevant elements. The first one is the pupil's ability to express himself or herself with ***no risk of being judged***. There is nothing worse for a pupil to hear other children laughing at him or her after having given an answer or an explanation to a problem, let alone the teacher's laughter! Linked to the first parameter, the second one is ***being entitled to make mistakes***. A mistake is not a failure, and understanding where it comes from is often more positive than succeeding right away... which has more to do with luck! Finally, the third parameter is ***assessment***. Instead of always relying on summative assessments, focused on memorizing notions, working on the basis of formative assessment, or even self - assessment can also be very positive. We will get back to assessment in details in the next chapter.

Knowing how to imagine, daring to innovate. Imagination, innovation, just like a productive critical eye, are necessary skills in a world where knowledge we identify as such is not definite anymore, and where the many social and environmental issues call for the creation of different landmarks and developments. Indeed, in order to be one step ahead of the issues, to plan solutions, to address the transformations inherent to the changes of paradigms and values, imagination and innovation are essential. And they are also essential to learn, as they bring to the mind certain "flexibility", propitious to transforming conceptions. From this perspective, studying practical and complex problems, setting out hypotheses and looking for alternative solutions is a rather interesting exercise.

Being able to draft one's knowledge. For knowledge to really become operational, the pupil needs to "use" it. It is the teacher's role to find situations where it could be reinvested. This reinvestment often enables the learner to ***find connections*** between knowledge and discipline and to understand the interactions at stake. Various pedagogical approaches allow putting the pupil in a reinvestment situation: preparing an exhibition for the parents to see or other classes or schools, planning a lesson, a workshop or an experience aimed at one's peers, organizing a conference, a round table where experts are invited, being able to publish a paper, even if only for a limited readership. For schools having video equipment or internet access, creating short movies or a website can also represent an exciting means of reinvesting knowledge. Mutual teaching where the pupil takes, momentarily, the place of the teacher is a very positive tool as well, as long as it doesn't always put the same people to the front. This is the error that La Salle[20] committed when, as early as the 17th century, he established

[20] La Salle (1651–1719) established a public, free and compulsory school. He is behind the primary school teachers' training within the teachers' seminar in Reims in 1680, because "ignorance, and even the moral inability was the main nature of teachers, back then".

simultaneous teaching. Gathering a group of pupils in a single room, he picked the best ones as "tutors" for "the weaker" ones[21].

The importance of such an approach lies mainly in the autonomy that the pupil gains regarding his own training. This autonomy should help him or her develop a "critical eye", capable of going beyond the models suggested not only by the teacher, but by society as a whole.

Working Out/reflecting on one's own knowledge. First, working out one's own knowledge. We saw it thanks to the allosteric approach of teaching: transforming conceptions needs a deconstruction as well as a reconstruction. This reconstruction is an integral part of the working out process. But the method is laborious and a way to turn it less off -putting is by reaching out to the possibility of standing back regarding what we think we know or what we know for sure, and regarding our own way of transforming it, i.e. of learning. This reflection on our own knowledge is consequently essential in the way "it is being aware of one's methods and one's schemes of thought that the learner can grasp all their importance and their subtleties" (Giordan 2002, p. 128).

Taking over reminders. In other words, having the possibility to be confronted with several and suitable ***tools*** and ***pedagogical practices***. The tools are all the backup material which accompanies the given teaching. Videos, textbooks, movies, articles, newspapers, internet, experiments, activities, museums, exhibitions, encounters… As for the pedagogical approaches, we already mentioned some before. Group work, debates, personal research of information (such as practical work), creation of individual or group projects, organizing a role-playing game, a show, an exhibition, a lesson for another class… Let us not forget the lecture, which is relevant, as well, such as attending a conference. It is vital to give the pupils several approaches that allow to reach ways of reasoning as different as, for instance, the systemic approach in comparison to the analytical approach, as well as "reminders", as varied as diagrams, concept charts, metaphors, trivia, some humour…

Toward a new assessment

Assessment is first of all a way of setting landmarks. In this regard, it is a relevant tool for structuring thought and personality. As long as the prevailing values will be focused on competition – at school, in family, among friends, in sports… – hence on comparison, assessment will appear to the child, to the teenager, as a need to know where he or she stands among the others. Even if this relation with the group cannot be avoided, assessment also has to put this comparison into perspective. Indeed, if the best pupils can see it as a challenge to take up, the others are usually put off by it. Assessment really needs to be thought of so that it can be seen as a tool devoted to learning. The more important in assessment is that the pupil knows where he or she stands in relation with himself or herself, the progression compared to oneself is what matters the most. Comparison with the others really

[21] To read more about it : Querrien, Stengers (préface) (2005).

has to be put into perspective. In order to do so, several kinds of assessment can be considered, since they do not necessarily fit all cases, depending on what has to be assessed and who is to be assessed.

According to school tradition, knowledge has to be assessed and, more and more, skills, too. Usually done in a summative manner, this assessment only shows what the pupil has remembered when it takes place. Since it usually happens at the end of a chapter or of a lesson, it only appeals to the learner's short term memory. What is measured is, in most cases, the ability to memorize and not what has actually been learned and above all, understood. This method does not allow any retrospect on the stored knowledge, nor does it allow connections between the different subjects studied.

Moreover, how can we give marks on subjects as varied as climatic changes, wars, access to water, and all these fields that make sustainable development the most versatile "subject"…? And what can we say about the reflection on changes of paradigms and the importance of clarifying values?

As far as we are concerned, we have gone for two radical choices.

The first one concerns values. Since the objective is their clarification and not their transmission, it would seem unfit to pass any judgment (assessment is one) on this field. The best choice is an effort of "reflection on" allowing the pupil to formalize his or her thought, but most of all aiming at a personal training.

The second one involves assessment of knowledge: in terms of quantity, as well as in terms of skills. Since any subject can be used as an "alibi" for an education toward sustainable development, it is a wishful thinking, if not useless, to consider assessment of notional or factual knowledge connected with the very theme of the study. Consequently, following organizing or integrating concepts developed in our laboratory as well as by Mauris and Hunkeler (2000), the authors of an "environmental" chart dedicated to the pupils of the first three years of the primary school of the canton of Bern (Switzerland), we have established a list of concepts that we feel describe sustainable development and how to address it. Figure 7 does not only present these concepts – four are universal (matter, energy, time, space) and they somehow constitute the "nucleus" around which other concepts "gravitate", and just like electrons around an atom, they give it their specific properties – but it shows their transversality as well, both in terms of discipline and in terms of school time.

The "organizing concept" plays the role of an "anchor" that we can track back in every theme tackled regarding sustainable development. Just like an intersection, it helps bringing together, classifying, categorizing and looking for similarities. It also helps decoding reality, by providing tools to "sort out complexity". An organizing concept leads us to pinpoint similarities in various domains that may seem, at first, quite different. Most of all, it helps focusing on the fundamental.

As the figure 7 demonstrates, organizing concepts can become the guiding thread of all teaching. They are transversal to almost every discipline and can be found at all school levels. Obviously, the main difference lies in the ***levels of wording*** that we will reach for each of them, depending on the age and the conceptions of the pupils. For instance, such a concept as energy or matter will not be addressed the same way whether it's in nursery school, primary school or secondary school. In the first

case, energy can be seen as "the capacity to do something": "what can it do?" It can then be considered according to its different forms or origin: "the wind", "the sun", "electricity", "the result of my movements"... Between this first approach and principles of thermodynamics lie all the levels of wording that will, little by little, lead the pupil to a real understanding of what energy is; its forms, its origins, its uses, its environmental and social impacts.

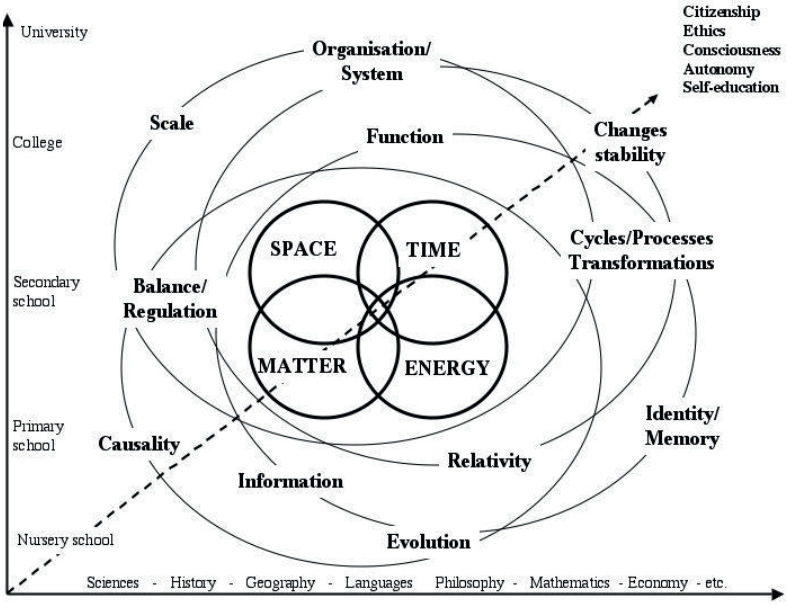

Fig. 7. Arranging concepts (Pellaud, LDES, 2006)

Thanks to them, every individual can make up his or her own "analytical grid" of the reality, a grid able of interpreting and gathering the various data he or she will find. Moreover, it is through this drafting that he or she will be able to develop it. The same thing can be said about matter. In elementary school, the level of wording can be restricted to acknowledging the existence of different materials, with their own special features. Then with children of 10 to 12 years old, we can mention atoms, raw materials and their exploitation, their transformation and the consequences of their use. Finally, in universities, we can refer to chemical compounds and their interactions with environment and health. It is still the same organizing concept "matter", inflected through other concepts, such as organization, balance, transformation, time, etc.

Conclusion

As we may gather through these both theoretical and practical leads, the concept of sustainable development, as far as we definitely put away its purely economical meaning based on an idea of growth, can be the starting point of a real revolution, both regarding our industrialized societies and teaching, all levels taken together.

If it requires genuine changes of paradigms, they will not be established through ministerial decree alone.

A will emerging from teachers themselves must surface. To paraphrase Gro Harlem Brundtland's quotation presented in the first chapter, we could say that these "pragmatic revolutions", crucial for an education aiming at a sustainable development, will only occur if teachers know how to inspire their governments and lobby them. These changes will only take place thanks to a team spirit leading to a compulsory collaboration, particularly regarding early training of the teachers. Thankfully, these practical minds, who are not even activists, exist. Outstanding experiments have been carried out[22] that will help us assess the real contributions of these new approaches and initiate a real reflection on the possibilities and the needed terms of evaluation of these "off-program" subjects.

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[22] We are mainly thinking of a class of a primary school in Paris that has created a musical on sustainable development and another one in Bienne, Switzerland that has used this theme as its subject of the year. Many other examples could be found, in Germany, for instance, which, according to de Haan (La Revue Durable n°8, 2004) would be "ahead of its time in terms of education for sustainable development".

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Towards new educational paradigms

Abstract

All revolutions, be they scientific or social ones, are the results of changes of paradigms. And the advent of the concept of «sustainable development» in our societies is no different. The radical adjustments that must be made regarding our ways of thinking and our «personal reasoning» are undeniable and they happen to have a direct influence on the educational curriculum. And it is all the more true when an education y related to it is institutionalized, as is the case in many countries. Highlighting these changes, understanding what it implies for the thought, as well as in terms of learning, opening new leads to deal with the complexity that such an education must tackle – these are the goals of this article. Inspired mainly by the results of several groundbreaking works lead by the Laboratory for Science Didactics and Epistemology of the University of Geneva, these reflections take stock of our current knowledge on the subject.

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