

# The complexity of human mind and a formulation of the incoherence principle

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## **Abstract**

A newly formulated principle, based on the observations and experiments on science teaching and learning carried out forty years along, is suggested. This principle takes into account the actual complexity of human mind and the role of incoherence when new knowledge, even in science, is constructed by individuals. In order to reach educational goals, the traditional paradigm in science teaching, which discards spontaneous thought and tries, hardly or softly, to change it, should be substituted by a novel paradigm based on the acceptance of incoherence of individuals.

## **1. Introduction**

Since 1975 Dimitrov introduced the concept of fuzziness in humanistic systems. Developments of this concept have mainly been applied to design technological apparatus and devices taking care of fuzzy realities. In a recent paper appeared on Internet (Dimitrov 2000) he states an “incoherence principle”

*According to the Incoherence Principle (Dimitrov 1983), the more certain (non-fuzzy, determine) individuals, the more uncertain (fuzzy, indeterminate) the group, and on the contrary: the more fuzzy are individuals in their ways of interpreting (understanding, executing) the meaning of an instruction, the greater is the chance for the group to negotiate a concrete (categorical, non-fuzzy) way(s) for practical execution of this instruction.*

In the same paper, Dimitrov gives some rules about the so called “fuzziology”:

*In the sense of the above explanation of inseparability of human understanding and dealing with social complexity - an inseparability which is at the very core of social fuzziology, one can visualised the subject of social fuzziology through the wings of the famous butterfly attractor of Lorenz. From the wing of understanding complexity we move towards the wing of working with it, and from there again to understanding, and then again to working, and so on, in a never-ending attempt to realize the uniqueness and infinity of our potential to think and act. In order to keep going the dynamics of the attractor so that each flap of its wings might be able to bring forth not only a "hurricane" or "tornado" (metaphors used by Lorenz when describing the butterfly effect in chaos theory) but also real fruits of human creativity, fuzziology offers three 'golden rules' - not blindly to follow but consciously to consider as practical tools for strengthening the individual awareness:*

*Not to neglect the unknown or deny it or turn away from it or try to make ourselves and others believe that it is really known and then to organize, dichotomize and impose rules on it. The unknown manifests through spontaneity of any novel expression of human creativity.*

*Not to cling to a need for certainty, definiteness and order or to ideas and practices that are familiar, commonsensical or accepted as true by an assumed majority. Remaining attached to what is certain and familiar suppresses idiosyncrasy of the human potential for self-realization.*

*Not to fight with complexity of the life dynamics, no matter where they manifest - in our inner nature or in the world around. The way to avoid being a slave or a victim of these dynamics is through understanding how they work and through applying their infinite energy for a continuous growth of the human intelligence and spirit.*

Time has come to apply similar concepts to education. In what follows I explain my personal thought about complexity of human mind and incoherence and how it can be taken in consideration when teaching.

Science teaching suffers a crisis of rejection all over the world. Students prefer to choose those disciplines where it is possible to carry out more qualitative discourses than in the rigid domain of scientific disciplines, mathematics and physics ahead. This rejection is mainly rooted in the dominating paradigm among science teachers who, hardly or softly, consider as a fundamental task to change spontaneous conceptions of their students towards coherently scientific points of view. Such a simplification of the problem of learning arises from the assumption that human mind is not as complex as it actually is.

Feyerabend (1975) criticizes the absolute value of science stating that:

*... A science that insists on possessing the only correct method and the only acceptable results is ideology and must be separated from the state, and especially from the process of education. One may teach it, but only to those who have decided to make this particular superstition their own. On the other hand, a science that has dropped such totalitarian pretensions is no longer independent and self-contained, and it can be taught in many different combinations ...*

Von Glasersfeld in his radical constructivist point of view, although rejecting the equation Science = Truth, considers spontaneous conceptions of students as acceptable if viable (Von Glasersfeld, 1993). The viability of ideas subtends coherence, i.e. absence of any contradiction. To overcome different styles of teaching, Tobin and Tippins (1993) suggest to use constructivism as a referent and not as a method. In this, no statement about coherence is advanced. Although many teachers adopt a constructivist referent in their work (Ritchie, 1998), the aim is always to introduce and control coherence in students' discourses even though their spontaneous ideas are often accepted at first. In relation to the extent of acceptance, science teachers become more or less aliens with respect to students' world (Bettencourt, 1996).

A very soft view of coherence is in the critical constructivist teaching approach (Watts and Jofili, 1998), a beautiful proposal with examples where the leading idea to open a free dialog with students in the classroom to cope with their needs is accepted and applied. Also in this description, however, the problem of coherence is not examined.

Other paradigms in teaching practices were severely questioned by Gallagher (1993) without entering the problem of coherence.

Coherent scientific ideas, when hardly put in contrast with spontaneous feelings, lose their battle and frequently people prefers to discard science as incomprehensible. This rejection is even more dramatic when teachers (not few in Italy) adopt a strictly disciplinary point of view and offer a verbal transmission (sometimes coupled with laboratory demonstrations) of scientific disciplines “as they are”, implying that no discussion on their coherence is possible. Students have only the duty to study what at school is explained in the “correct” form.

I have been working and teaching almost forty years in a Physics Department coming from studies in Chemistry and I have been frequently thinking about the causes of a substantial lack of connection of scientific world with human life and with the actual complexity of human knowledge. Recalling my curriculum as a student and also the struggles with science concepts during my research and teaching work, I was always dissatisfied with the absence of human feeling in the science world, where “mistakes” are not tolerated at all. This dissatisfaction has continued to raise during at least thirty years of research carried out on science education in contact with the school world from kindergarten to high secondary and university.

Looking around, I see that most scientists and science teachers fight against non rational attitudes of common people and openly express disguise for non scientific thought. Despite this, it is self evident that more people prefers astrology to science, even though some of them is shy in recognising such a preference. The majority of people, however, declares to be at odds with respect to science (which is considered as a myth), especially with respect to mathematics which “is not their matter”. Sometimes this situation is lived as a personal fault.

Festinger (1957), in his dissonance theory, states that whenever conflicting ideas are present in human mind, this conflict must be solved since individuals cannot stand incoherence. Most researchers in learning and most teachers think to solve conflicts in favour of scientific ideas, by demonstrating the fallacy of common thought and by fostering conceptual changes in students. As reported by Zeidler (1997), however, conceptual change is only one over six different outcomes of conflicting ideas and I seriously doubt that any real conceptual change has ever been produced in any circumstance. The other outcomes reported by Zeidler run from refusing science to accepting contrasting ideas with various degrees of acceptance or rejection. I would suggest that **education may only produce a conceptual growth by addition of new concepts and a behavioural change in arguing associated to this growth.**

Spontaneous thought, in my opinion, is the result of the addition over our life of several, more or less aware, experiences with real world. I am suggesting a model of learning where any knowledge is added to the whole, without any modification to the existing ideas. This unavoidably produces the contemporary presence of contrasting ideas and concepts in any individual’s mind without any damage to his survival. People defends himself from the lack of coherence by simply accepting it. When the use of brain is required to develop an argument or choose an action, people tries always to be locally coherent, because coherence is a spontaneous need of human beings. But, as any spontaneous thought, an idea not strictly coherent cannot be destroyed by a sense of fault generated by incoherence. In other words, a man tries spontaneously to be coherent, while in his mind incoherent ideas are still present. This substantial and natural incoherence of human beings demonstrates the importance of adopting new paradigms in the views of learning and teaching sciences, while at present the contemporary existence of conflicting ideas is not openly considered as acceptable. In this paper I try to explain my thought about the complex matter of coherence and I advance a **Principle of Incoherence** to be applied as a novel paradigm in science education and teaching.

The concept of “principle” here is advanced with the meaning of a basic statement about human behaviour.

## 2. Basis and usefulness of incoherence.

The observation of the phenomenon of incoherence in human beings should be supported by a model of human thought very different from the traditional ones. In fact, often people regard logic reasoning as the basis of any argumentation and such a point of view rules out incoherence, which is seen as a negative feature of thought. Well, let us apply logic reasoning to our spontaneous “need of coherence”. This need is built in our mind without any other origin than instinct, so it is non rational by itself. On the other hand, it is contradicted by our survival with incoherence. Both the need of coherence and the acceptance of incoherence are non rational attitudes of human beings. As a non rational attitude coming from instinct, the need of coherence gives rise to rationality and to logics: it comes out that rationality is generated by a non rational spontaneous need. This outcome is paradoxical and incoherent, but puts the basis for stating the following incoherence principle, quite different (and stated independently) from the one stated by Dimitrov:

**“Incoherence is the regular state of our mind which needs to apply a local coherence to any decision”.**

This statement is stronger than simply affirming that “absolute coherence is impossible”. In fact, it implies incoherence as a normal state of our mind and assigns no negative meaning to this fact. **No fault, no original sin, is associated to incoherence.** The complexity of human knowledge is fully reflected in this statement.

I am quite sure that such a principle will be considered as an heresy by the majority of scientists fearing that science will be destroyed if incoherence is accepted as a normal state of our mind. My intention, however, is not to destroy science and scientific reasoning, which are a very important part of our mind, but to show that rationality has no right to be considered as a superior quality of man and has to account for non rational aspects of human mind. This requires opening towards divergent (or lateral) thought and a good deal of reflective practice.

In this respect, also philosophy should be modified with the addition of non coherent thought as a valid tool for investigating the wide field of ideas. In particular, nobody should be entitled to define somebody else’s ideas as “untenable” because “contradictory”. Even in scientific research contradiction of ideas helps to grow new knowledge. No discovery is possible if “canonical thought” is always applied. Incoherence is one of the characters of intuition, the basis of fundamental steps forward in scientific discovery. Somebody will argue that, in order to produce science, intuition must be confirmed by logical deduction. All right: as I told before, we need coherence although being deeply incoherent. Science obeys to this rule and tries to describe everything according to coherence. Nothing bad in this, but neither absoluteness nor pretence of superiority, please.

## 3. The use of spontaneous conceptions in school work

Really spontaneous conceptions are deep feelings about as things work. It often happens that what is considered as a spontaneous conception comes from answers to ill structured questions and lack of shared language or meaning of words. Von Glasersfeld (1993) warns

about the intrinsic confusion introduced in discourses by the personal interpretation of words in verbal or written communication. Many problems in education arise from the use by teachers of specialised language without any negotiation (or contract) with students about the meaning of words. So, a first step in teaching science would be to develop a commonly shared language to help reciprocal understanding when exchanging ideas. In relation to instruction of disciplines, specialised language has to grow at the same time of the knowledge of the discipline, not before. The use of a commonly shared language, however, does not remove the existence of deeply rooted conceptions which are differently built in different individuals. The variety of ways of thinking is ample and complex as the variety of human beings, although there are several points of contact and superposition among them.

One of the deepest spontaneous conceptions I investigated as a physicist is the relation force/velocity. It is well known that the great Aristotle wrote the law of action as  $\mathbf{f} = K\mathbf{v}$ , i. e. force proportional to velocity and that, on contrary, after Galileo and Newton, the modern view is  $\mathbf{f} = d(\mathbf{mv})/dt$ , i.e. force proportional to momentum variation with time. Well, most people are convinced that to a moving object must be associated a force (the proportionality is not exactly put to evidence, but a faster object carries a greater force). This conception is even carried by 90% of the students of the second year of chemistry who followed a course of mechanics in the preceding semester. This was ascertained by means of a test in which forces should be indicated with arrows on drawings of the trajectory of a football and of the revolution of Earth around Sun. This last test was suggested to me by one of my colleagues: she complained about the majority of students who, after a full year of lessons on mechanics, still used to associate to the motion of Earth a force in the same direction of velocity. Well, without any shame, I intimately feel as students do. The only difference is that I accept to be incoherent and I am able to adopt a disciplinary point of view too. No conceptual change in this, simply addition of new knowledge which may be used to show that I know the discipline. In any case, Earth continues to move around Sun independent of what I or any else think about it. So, I have some advantage with respect to students who are not involved enough with physics to adapt their feelings to the examiner's requests: I am able to choose the answer "officially correct". I have **adapted my behaviour** by accepting incoherence. The main importance of this advantage is that I can go further with my knowledge because I accept either my spontaneous feelings or a coherent view of things which allows to explore natural phenomena (including my spontaneous conceptions), describe what happens and predict to some extent what will happen in well definite situations. In short, a open, critical thought, the real goal of education, which should be sought at school.

The force/velocity conceptions may have different origins in the daily experience: we perceive a force whenever we collide with a fast body, for instance a strong sea wave, or if we run fast and hurt against any obstacle. Our mind spontaneously associates such experiences to a property of moving bodies, it figures out a model of phenomena which lies in our spontaneous activity of brain. This conception rules also the very common feeling that an heavy object falls to ground faster than a lighter one (because it has more force and thus it is faster). If one carries out a simple experiment by comparing the fall of two dense objects of evidently different weights, no difference is noticed in a 1.5 meter fall. Actually, due to viscous force and density of air, the heavier of two spheres of equal diameter and different quite dense materials falls slightly faster than the lighter one. The current thought, however, is that a large difference exists independent of air, whose effects are evident only for the fall of wide area and light weight objects such as a sheet of paper. In order to develop critical thinking, a teacher should not stress as a fault the difference between what is thought to happen and what is observed, but simply concentrate on the way to investigate the phenomenon to gather new information and perceive new discoveries. Let us see how reflective practice might work. What follows is a concentrate of several experiences carried out in schools with students during last 25 years, where I (more or less successfully) applied teaching techniques in a laboratory based on individual and group discovery without recipes and using discussion of ideas as a tool for reflection.

In order to construct new knowledge, one has to look for the variables which act on the fall of objects by advancing hypotheses, no matter if contradictory to what is observed. Is the individual feeling different from the outcomes of science? Don't worry about it. It is natural. Let us take both conceptions in our knowledge and use tolerance with both! So, for instance, it is possible to study the forces associated with the velocity of bodies by looking for a method to measure such forces. It will come out that in order to carry out a measurement, bodies shall be brought to rest while exerting their force, say against a spring. Common apparatus as a cart running on an inclined table, or a freely falling body, and springs of various strength can be arranged to actuate the project. It will be seen that, with a fixed spring, the faster the cart, the larger the force (but are they proportional? Yes, they approximately are, so the model is enforced). Conversely, the same cart velocity will be arrested by different forces exerted by different springs counteracting for different elongations. The longer the counteraction, the smaller the force (but are they inversely proportional? Yes they approximately are, so we need a modification in the model to account for the spring elongation).

Continuing on this pattern (for a quite long but useful time), it may happen (but we are not sure at all) that the phenomenon is better described by a different quantity (work, energy) which remains constant even when different springs are used (De Paz, 2001). Students recognize that force is not constant. So what? If the problem is to build capacity to face complex problems, one pushes students to reflect and to devise new experiments aimed to develop a local model as simplest as possible of the observations. Briefly, the original spontaneous conception is not discarded but used to construct and add new knowledge and new behaviours. The field is open to discovery without any fear of being contradicted. Internal coherence rules the activity, while acceptance of incoherence favours the addition of newly constructed knowledge. This is the incoherence principle at work.

If, conversely, the knowledge of officially recognised laws of physics is considered as a main goal, one rejects the students' ideas and creates the conditions for inert learning and learning by heart. Laboratory work becomes dull, routinary. There is no possibility of discovery at all, except what the teacher has precisely decided before, i.e. ideal, perfect experiments with theoretically predictable results. A smart student does not even need to perform measurements to obtain correct data. He simply figures out and calculates with theory what should happen by inventing his results. But, is this science and science education?

## 4. Conclusions

The principle of incoherence stated here may prove to be a satisfactory paradigm to be applied in science education (at least).

Stating the substantial incoherence of human mind does not necessarily imply that we must adopt incoherence as a criterion to be used in our complex relations with reality. We still need internal and local coherence while analysing reality and while carrying out our reasoning. However, different and contradictory conceptions can be accepted as normal states of our mind which we use or not depending on the boundary conditions or the environment in which we are acting. In a science session, for instance, the model of Earth rotating on its axis may prevail on the idea of the Earth at rest and the Sun moving around, but it is almost granted that such a conception does not rule the mind of two individuals in love looking romantically at the sunset. Even in the science courses, misconceptions are often unwillingly enforced, for instance when the free surface of a liquid is defined as an example of "horizontal plane". Of course, such kind of misconceptions are always justified as sound "approximations", but the feeling of a flat Earth is still dominant in most people's minds, simply because things evidently look like going that way. In synthesis, the acceptance of this new principle is more consistent with a vision of teaching centered on the complexity of human thought, than on a sort of "globalised" knowledge which should be (more or less softly) "transmitted".

It is my opinion that a really innovative view of science education should include the incoherence principle and it would help to avoid a good deal of school refusal.

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