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Part III. PHILOSOPHY OF EDUCATION IN THE WESTERN TRADITION

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«ВАРВАРСТВО СПЕЦИАЛИЗАЦИИ» И ПЕДАГОГИКА НАУКИ: ПРЕОДОЛЕНИЕ РАЗДЕЛЕНИЯ МЕЖДУ НАУКОЙ И «ЭНЦИКЛОПЕДИЕЙ МЫСЛИ»

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Головокружительный процесс специализации наук представляет собой двойную угрозу для нашей цивилизации: с одной стороны, большинство из нас исключено из того, что можно было бы назвать "характеристическими достижениями современной эпохи" (Триллинг (Trilling)), с другой стороны, "варварство специализации" угрожает истинности науки как культуры (Ортега-И-Гассет). Как сохранить связь между наукой и "энциклопедией мысли"? Этот кардинальный вопрос приводит к другим, более радикальным вопросам: имеется ли взаимоотношение между наукой и мышлением? Каким может быть это взаимоотношение? Что есть наука в том плане, в каком она связана (если вообще связана) с мышлением?

Для того, чтобы исследовать эту проблему, данная статья обращается к важному высказыванию Хайдеггера о том, что «наука не мыслит». Сравнивая идеи Хайдеггера и Куна, автором статьи обосновывается позиция, что наука не мыслит в точности до тех пор, пока она суть исследование. Но она постоянно связана с мышлением как своим изначальным фундаментом. В этом смысле становится принципиально важным, чтобы научное образование было вдохновляемо философским подходом.

В отличие от других, автор статьи считает, что философский подход не означает, в основном, анализ концепций и логическую обоснованность. Он означает также изучение процесса формирования научных понятий из жизненного мира (Lebenswelt). Именно благодаря преодолению забвения существования научных понятий в жизненном мире, а также благодаря переоткрытию последнего как фундамента науки,

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становится возможным предотвращение исчезновения науки в простое манипулирование формулами, с одной стороны. С другой, обеспечение некоего фундамента, "общего для обычного человека, образованного технаря и среднего гражданина", о необходимости которого для преодоления разделения науки и культуры говорит физик Геральд Холтон (Gerald Holton). В заключительной части статьи обосновывается, что данное переоткрытие влечет за собой развитие педагогического измерения науки, то есть науки как части общего человеческого образования (Bildung).

Ключевые слова: *наука, культура, жизненный мир, формирование понятий, специализация наук.*

«BARBARISM OF SPECIALIZATION» VS PEDAGOGY OF SCIENCE: NARROWING THE DIVIDE BETWEEN SCIENCE AND THE «ENCYCLOPAEDIA OF THOUGHT»

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The giddy process of the specialization of sciences represents a double menace to our civilization: on the one hand, most of us are excluded from what is "the characteristic achievement of the modern age" (Trilling) because we are not able to access knowledge that is too esoteric; on the other hand, as Ortega y Gasset emphasized 80 years ago, the "barbarism of specialization" threatens the truth of science as culture.

How to preserve the link between science and the "encyclopaedia of thought" (Ortega)? This pivotal question evokes a more radical one: is there a relationship between science and thinking? What can this relationship be? What is science in so far as (and if) it is related to thinking?

In order to investigate this issue the paper examines Heidegger's momentous saying "science does not think". Comparing Heidegger and Kuhn, it is maintained that science does not think exactly to the extent that it is research, but that nevertheless it is constantly related to thinking as to its original ground.

In this sense it becomes crucial that science education is inspired by a philosophical approach. In contrast to the most widespread perspective, a philosophical approach is not meant principally as an analysis of the concepts and of the logical cogency of the theories but as an investigation into the process of the constitution of scientific notions out of the Lebenswelt. Exactly by doing away with the oblivion of the rootedness of scientific notions in the Lebenswelt, exactly by re-discovering the latter as the ground of science it is possible both to ward off the disappearance of science into the mere manipulation of formulae and to provide that ground "shared by the ordinary don, the educated technician, the average citizen" which the physicist Gerald Holton invokes in order to narrow the divide between science and culture. In the final part of the paper it is argued that this rediscovery implies dwelling in the pedagogical dimension of science, that is in science as part of human Bildung.

Key words: *a science, culture, the vital world, formation of concepts, specialization of sciences.*

1. EDUCATION OF THE MIND IN THE AGE OF SCIENCE

In his famous Jefferson Lecture (1972), devoted to *Mind in the Modern World*, Lionel Trilling highlights one of the most important cultural and educational challenges we face in our age: The far-reaching development of science has been refashioning human existence 2 in many aspects, but the radical changes effected by it are disconnected from any awareness and any ability to make sense of them at a deeper level:

> "The operative conceptions [of science] are alien to the mass of educated persons. They generate no cosmic speculation, they do not engage emotion or challenge imagination […] This exclusion of most of us from the characteristic achievement of the modern age is bound to be experienced as a wound given to our intellectual self-esteem. About humiliation we all agree to be silent, but can we doubt that it has its consequences, that it introduced into the life of mind a significant element of dubiety and alienation which must be taken into account in any estimate that is made of present fortunes of mind? [TRILLING 1972, pp. 13-4. Italics mine]".

The train of thought of Trilling, one of the last custodians of the liberal tradition, goes to the fundamentals of the question, without indulging in grievances about the dehumanization and meaninglessness caused by science. Indeed, Trilling recognizes that science is the *way of thinking of modern age*, that being unacquainted with it is a form of alienation of the life of the mind, and finally that *present fortunes of mind* are at stake.

In contrast to approaches rooted in the *romantic revolt* [BERLIN 1996, pp. 168-93] and 'carsically' running through and reappearing throughout the 20th century [ROSSI 1989; BELLONE 2005] (but also nowadays [SOKAL 1997; 2008]) we can argue, therefore, that is not science itself that is alienating; what is alienating for the mind is 'existing' outside the *way of thinking of science*, not dwelling in it and not making it a springboard to artistic creations tuned in to the spirit of the times. More generally what we must emphasize in Trilling's wake is the role science must play in an education that is integral, not 'maimed', not unrealistic (in the sense of unrelated to the most powerful factor in our reality).

But what do we speak about when we speak about 'science' in the light of Trilling's speculations? What do we mean? Do we mean 'science' as the provider of ever more refined technical devices and the transformer of the landscape of our existence from the physical point of view? Is it that science which has had a revolutionary impact as John Dewey depicted it in his memorable introduction to the second edition of *Reconstruction in Philosophy*?

> "[T]he present human scene, for good and for evil, for harm and benefit alike, is what it is, because […] of the entry into everyday and common (in the sense of ordinary and of shared) ways of living of what has its origin in *physical* inquiry. The methods and conclusions of 'science' do not remain penned in within 'science'. […] The science that has found its way deeply and widely into the actual affairs of human life is partial and incomplete science: competent in respect to physical, and now increasingly to physiological conditions […] but nonexistent

> with respect to 3 matters of supreme significance to man – those which are distinctively of, for, and by, man" [DEWEY 1920/1982, p. 269].

Both Dewey and Trilling, different though their standpoints may be, agree on considering in which sense we must construe science as something the remoteness of which from life of the mind is calamitous; which is – in other words – the dimension of science that must become part of the human *Bildung*, of the culture and education of modern men. Arguably they both consider science as a 'frame of mind', as an activity of devising new concepts and categories for our cognitive transaction with the world.

Trilling's perspective is complementary to that of another great representative of the 'liberal tradition', the Spanish philosopher Ortega y Gasset who, in his epoch-making *Larebeliyn de las masas*, stresses an important point:

> "The constitution of physics, the collective name of the experimental sciences, rendered necessary an effort towards unification. Such was the work of Newton and other men of his time. But the development of physics introduced a task opposite in character to unification. In order to progress, science demanded specialisation, not in herself, but in men of science. Science is not specialist. If it were, it would ipso facto cease to be true. Not even empirical science, taken in its integrity, can be true if separated from mathematics, from logic, from philosophy. But scientific work does, necessarily, require to be specialised. […] It would then be seen how, generation after generation, the scientist has been gradually restricted and confined into narrower fields of mental occupation. But this is not the important point that such a history would show, but rather the reverse side of the matter: how in each generation the scientist, through having to reduce the sphere of his labour, was progressively losing contact with other branches of science, with that integral interpretation of the universe which is the only thing deserving the names of science, culture, European civilisation" [ORTEGA Y GASSET, 1930/1980, pp. 140-141][1].

While Trilling draws our attention to the risk of being 'outside' the *way of thinking of science*, Ortega points to another danger *inside scientific enterprise*

[1] "Asi, la constitucion de la fisica, nombre colectivo de la ciencia experimental, obligo a un esfuerzo di unificacion. Tal fue la obra de Newton y demas hombres de su tiempo. Pero el desarollo de la fisica iniciy una faena de caracter opuesto a la unificaciyn. Para progresar, la ciencia necesitaba que los hombres de ciencia se especializasen. Los hombres de ciencia, no ella misma. La ciencia no es espacialista. *Ipso facto* dejaria de ser verdadera. Ni siquiera la ciencia empirica, tomada en su intregridad, es verdadera si se la separa de la matematica, de la logica, de la filosofia. Pero el trabajo en ella si tiene – irremisiblemente – que se ser especializado. […] generacion tras generacion, el hombre de ciencia ha ido constrinendose, recluyendose, en un campo de ocupacion intelectual cada vez mas estrecho. Pero no es esto lo importante que esa historia no ensecaria, sino mas bien lo inverso: como en cada generacion el cientifico, por tener que reducer su orbita de trabajo, iba progresivamente perdiendo contacto con las demas partes de la ciencia, con una interpretaciyn intergral del universo, que es lo unico merecedor de los nombres de ciencia, cultura, civilizacion europea". English version on http://www.scribd.com/doc/7153482/Ortega-y-Gasset-The-Revolt-of-the-Masses.

itself, the process of incessant specialization which concerns, in Ortega's view, the *organization of science* not *science itself*.

What is evident from a conjoint reading of Trilling and Ortega is an argumentative constellation whose dialectic deserves to be made explicit: on the one hand, cultivated men of our times can not be alien to science and therefore are to be educated in it, by it, and to it; on the other hand, in order to be truthful (i.e. faithful to itself) and not to selfalienate, science has *to dwell in the dimension of culture* and strive for a global interpretation of reality, beyond narrow-mindedness provoked by *barbarism of specialization* (Ortega y Gasset).

In an essay significantly convergent with Ortega's and Trilling's views, the historian Franklin Ford defines culture as

> "the most ambitious and the most exacting intellectual effort and aesthetic endeavour in every discipline. Thus defined, it also presupposes at least some exchange among the disciplines, some reciprocal curiosity and appreciation. In short, it necessarily involves a continuing tension between the centrifugal thrust of specialized exploration and a centripetal tug toward synthesis, toward the central area of shared concerns. What is worrying us now? Is it not precisely the suspicion that the centrifugal has triumphed over centripetal, that the essential tension has disappearedsand with it, culture itself? As we contemplate this possibility, chilling in its implied finality, why do we tend so readily to focus our concern on the position of science? […] Part of the answer seems to me to be that it is in discussing science that all who are concerned, scientist and non-scientist alike, see most clearly before them the threat that a synthesis of the human comprehension of the world may never again be possible, that culture as a thing shared may be lost forever to our species". [quoted by HOLTON 1965, p. xiii].

The crumbling of knowledge caused by specialization threatens both the global 'tone' of our civilization (because most people are excluded from the scientific comprehension of reality) and the future itself of the scientific enterprise as far as it is left to its dynamics of 'fragmentation' and to the proliferation of disciplinary micro-sectors.

As Ortega points out:

> "The most immediate result of this unbalanced specialisation has been that today, when there are more "scientists" than ever, there are much less "cultured" men than, for example, about 1750. And the worst is that with these turnspits of science not even the real progress of science itself is assured. For science needs from time to time, as a necessary regulator of its own advance, a labour of reconstitution, and, as I have said, this demands an effort towards unification, which grows more and more difficult, involving, as it does, ever-vaster regions of the world of knowledge. Newton was able to found his system of physics without knowing much philosophy, but Einstein needed to saturate himself with Kant and Mach before he could reach his own keen synthesis. Kant and Mach – the names are mere symbols of the enormous mass of philosophic and psychological thought which has influence Einstein – have served to liberate the mind of the latter and

leave the way open for his innovation". [ORTEGA Y GASSET, 1930/ 1980, p. 143][2].

On the other hand, as the physicist Gerald Holton has admonished,

"[…] when it comes to discerning consequences for education that follow from this point of view, one must be careful not to apply prescriptions valid for those who can contribute at the level of *scientia* indiscriminately also to the larger mass of those who will have to function at a quite different level. If it is true, as has recently been claimed, that "modern man must specialize or die," and if all he does is specialize, then most men will not know in what respect they are modern, or human, or alive. While those who make the most elevated efforts to comprehend and organize reality, by this very activity, share in one another's different thoughts, what is it that is shared by the ordinary don, the educated technician, the average citizen? What *should* it be?" [HOLTON 1965, p. xii].

Another question is tightly linked with that concerning what can be shared by the specialist in advanced and esoteric fields of research with the average citizen: how – that is, *appealing to what* – is it possible to discover this common ground?

To sum up, a mind alien to the *way of thinking of science* risks being an alienated mind, while a mind left to the specialist workings of scientific enterprise risks being a slave and unable to keep alive the inquiring tension of 'true' science.

This dialectic results in a fundamental question, which is 'propaedeutic' to that asked by Holton: is there a radical and unredeemable contradiction between science and thinking? Or is there a *contradiction inside science* between a 'thinking-dimension' and a 'specialist research dynamics'?

To answer this question it is worth investigating the theoretical proposal of the philosopher who more than any other seems to have adopted the first option: Martin Heidegger.

2. *WISSENSCHAFT DENKT NICHT (?)*

The momentous Heideggerian sentence (*science does not think*) is too often quoted out of its context, which is, instead, worth mentioning:

"….science does not think, and cannot think: indeed, that is what constitutes its chance, that which secures its own way of proceeding.

[2] "El risultado mas inmediato de este specialismo *no compensado* ha sido que hoy, cuando hay mayor numero de "hombres de ciencia" que nunca, haya muchos menos hombres "cultos", que, por ejemplo, hacia 1750. Y lo peor es que con esos pachones del asador cientifico ni siquiera esta asegurado el progreso intimo de la ciencia. Porque esta necesita de tiempo en tiempo, como organica regulacion de su propio incremento, una labor de reconstitucion, y, come he dicho, esto require un esfuerzo de unificacion, cada vez mas dificil, que cada vez complica regiones mas vastas del saber total. Newton pudo crear su sistema fisico sin saber mucha filosofia, pero Einstein ha necesitado saturarse de Kant y Mach para poder llegar a su aguda sнntesis. Kant y Mach – con estos nombres se simboliza solo la masa enorme de pensamientos filosoficos y psicologicos que han influido en Einstein – han servido para *liberar* la mente de este y dejarle la via franca hacia su innovaciyn". English version on http://www.scribd.com/doc/7153482/Ortega-y-Gasset-The-Revolt-of-the-Masses.

> Science does not think. A shocking assertion. Let it be shocking, even if we complete it with another assertion: that nonetheless *science always and in its peculiar way has to do with thinking*. This way, however, is genuine and subsequently fruitful only if the gap, which obtains between thinking and sciences and indeed obtains as unbridgeable, becomes noticeable. There are no bridges, just the jump" [HEIDEGGER 1954/1997, pp. 4-5. Italics mine][3].

Trying to think what is un-thought in Heidegger, thinking with him but beyond (and against) him, we have to point out that Heidegger speaks of *a not-completely-unrelated exteriority of science to thinking* not of an *'extraneousness'* (indeed, "science always and in its peculiar way has to do with thinking"). At the same time, Heidegger is drastic in condemning any attempt to bridge easily the gap between science and thinking. These attempts signal the inability to make *the only legitimate move, that is recognizing that science is exterior to thinking but within the framework of their relationship with each other*.

Science and thinking do not overlap and such 'exteriority' is science's "chance" because it "secures [its] own way of proceeding". Although sciences are essentially related to thinking, demanding that they constantly jump into it would jam up and hinder their development.

But what does Heidegger mean by science*s* (note that he passes to plural in his text)? To what kind of scientific activity does he refer?

To Heidegger sciences are one of the "essential phenomena of modernity"[4] [HEIDEGGER 1938/1994, p. 75] and their essence is research [*Forschung*]. Sciences-asresearch present three defining features: firstly, they are carried out within a region of reality, opening which up as a realm of definite (and so investigable) events and objects is the first task of any research. Such 'opening-up' implies the projecting of a ground plan of processes and objects which will be investigated and "sketches out how the knowing procedure has to be bound to the opened realm. This bond is the rigor of research"[5] [HEIDEGGER 1938/1994, p. 77].

Twenty-five years before Thomas Kuhn, Heidegger designates *normal science* as "science-as-*Forschung*". It is "research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice" [KUHN 1970/1996, p. 10]. What Heidegger calls the 'sketching out

[3] "Der Grund dieses Sachverhaltes liegt darin, dass die Wissenschaft ihrerseits nicht denkt und nicht denken kann und zwar zu ihrem Gluck und das heist hier zur Sicherung ihres eigenen festgelegten Ganges. Die Wissenschaft denkt nicht. Das ist ein anstoßiger Satz. Lassen wir dem Satz seinen anstoßigen Charakter auch dann, wenn wir sogleich den Nachsatz anfugen, da*ß die Wissenschaft es gleichwohl stets und auf ihre besondere Weise mit dem Denken zu tun hat*. Diese Weise ist allerdings nur dann eine echte und in der Folge eine fruchtbare, wenn die Kluft sichtbar geworden ist, die zwischen dem Denken und den Wissenschaft*en* besteht, und zwar besteht als eine unuberbruckbare. Es gibt hier keine Brucke, sondern nur den Sprung…". All translations from German are mine. Italics added.

[4] "wesentlichen Erscheinungen der Neuzeit".

[5] "zeichnet vor, in welcher Weise das erkennende Vorgehen sich an den eroffneten Bezirk zu binden hat. Diese Bindung ist die Strenge der Forschung".

of a domain of investigation' is – in Kuhnian terms – the establishing of a *paradigm*.

Secondly, sciences-as-*Forschung* deal with facts but in such a way that they make them 'objective' and can "represent what is variable in its variation, bring it to a stand and anyhow let the movement be a movement"[6] [HEIDEGGER 1938/1994, p. 80]. Now, "what is standing in the facts and the constancy of their change as such is the rule. What is constant in the variation – in the necessity of its course – is the law. Only in the horizon of rule and law facts become clear as the facts which they are"[7] [*ibidem*]. In other words, scientific activity consists in identifying and clarifying facts as facts and this activity is 'nomothetic', 'law-positing' – to use the lexicon of the German debate of the end of 19th century which Heidegger knew very well. And, according to Heidegger, this nomothetic moment of modern sciences-as-*Forschung* results in the emphasis on the experiment. In Heidegger's perspective, science is experimental because it is nomothetic, and not the other way round, as stated by the inductivist-empiricist 'vulgata': "Experiment is that operation which in its arrangement and carrying out is supported and led by the underlying law, in order to produce (as evidence) the facts which bear law out or fail the proof. The more exact has the ground plan of nature been projected, the more exact the possibility of the experiment becomes"[8] [HEIDEGGER 1938/1994, p. 81].

There can be scientific experiments *stricto sensu* only within the framework of a paradigm. More radically, facts to be investigated can 'exist' as such only within a paradigm. The canonical image of science as a ceaseless discovery of laws and gathering of new facts, as an explanation of how nature is, does not make any sense before a paradigm is established. Science as an empirical search for functional regularities ('laws' in Heideggerian terms) and as a gathering of facts demands that 'projecting of a ground plan of nature' which a paradigm is.

Thirdly, "[e]very science as research is based on the projecting of a delimited domain of objects and is therefore necessarily a specialist science"[9] [HEIDEGGER 1938/1994, p. 83]. Hence does the specialization of modern science stem: specialism "is not the result but the ground of the process of research […] Modern science is defined by a third fundamental process: the enterprise. […] But research is not enterprise because its work is carried out in institutes, but [vice versa] institutes are necessary because science in itself

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[6] "das Veranderliche in seiner Veranderung vorstellen, zum Stehen bringen und gleichwohl die Bewegung eine Bewegung sein lassen".

[7] "[d]as Stehende der Tatsachen und die Bestдndigkeit ihres Wechsels als solchen ist die Regel. Das Bestandige der Veranderung in der Notwendigkeit ihres Verlaufs ist das Gesetz. Erst im Gesichtskreis von Regel und Gestz werden Tatsachen als die Tatsachen, die sie sind, klar".

[8] "Das Experiment ist jenes Verfahren, das in seiner Anlage und Durchfuhrung vom zugrundegelegten Gesetz her getragen und geleitet wird, um die Tatsachen beizubringen, die das Gesetz bewahren oder ihm die Bewahrung versagen. Je exakter der Grundriss der Natur entworfen ist, um so exakter wird die Moglichkeit des Experiments".

[9] "[j]ede Wissenschaft ist als Forschung auf den Entwurf eines umgrenzten Gegenstandsbezirkes gegrundet und deshalb notwendig Einzelwissenschaft".

as research has the character of enterprise"[10] [HEIDEGGER 1938/1994, pp. 83-4].

Once again, it is noteworthy how far the Heideggerian approach resonates in Kuhn's: "Though science surely grows in depth, it may not grow in breadth as well. *If it does so,* that breadth is manifest mainly in the proliferation of scientific specialties, not in the scope *of any single specialty alone*. Yet despite these and other losses to the individual communities, the nature of such communities provides a virtual guarantee that both the list of problems solved by science and the precision of individual problem-solutions will grow and grow. […] scientific progress is not quite what we had taken it to be. But […] *a sort of* progress will inevitably characterize the scientific enterprise so long as such an enterprise *survives*" [KUHN 1970/1996, p. 170. Italics mine].

The way Heidegger characterizes modern sciences and the comparison with Kuhn permit us to specify in what sense *science does not think*: it does not think as an activity of normal research which articulates a paradigm, "extend[s] the knowledge of those facts that the paradigm displays as particularly revealing" [KUHN 1970/1996, p. 24] and improves "the extent of the match between those facts and the paradigm's prescriptions" [*ibidem*].

In its normal phase science is just *puzzle-solving* [KUHN 1970/1996, ch. IV] and this being just *puzzle-solving* is not a mark of inferiority or imperfection but it is the very condition of its success, it is its "chance, [what] secures its own way of proceeding", as Heidegger writes (and Kuhn could subscribe to every word).

At this level there is no thinking as inquiry, as far as inquiry, different from research, is an 'exploration of the unknown' which is always ready to re-think the frameworks of the incessant transaction with the world.

Thinking as inquiry would hamper the self-deploying explicative power of the paradigm, that is the attempt made by the community of scientists to extend it. The mechanism through which science achieves results and amasses an ever-increasing body of knowledge would jam (although – it is worthwhile insisting on it – the attained results are hyper-specialized, they do not emerge by virtue of a real investigation, of an 'interest' in the etymological sense of *inter-esse*, of being-in-the-midst-of the *Lebenswelt*).

> "Normal research which *is* cumulative, owes its success to the ability of scientists regularly to select problems that can be solved with conceptual and instrumental techniques close to those already in existence. (This is why an excessive concern with useful problems, regardless of their relation to existing knowledge and technique, can so easily inhibit scientific development)" [KUHN 1970/1996, p. 96].

As a conclusion it can be said that it is science as normal science, as *research/ Forschung*, as not-inquiry, that does not think.

In order to portray better this 'inquiring' moment of science as opposed to the normal one, we can draw on the approach of Schwab, who in the same

[10] "ist nicht die Folge, sondern der Grund des Fortschrittes aller Forschung […] die neuzeitliche Wissenschaft wird durch einen dritten Grundvorgang bestimmt: den Betrieb […] Allein die Forschung ist nicht Betrieb, weil ihre Arbeit in Institute vollzogen wird, sondern die Institute sind notwendig, weil die Wissenschaft in sich als Forschung den Charakter des Betriebes hat".

years as Kuhn's *Structure* worked out a difference akin to Kuhn's (and – significantly – he did it while reflecting on science education [SIEGEL 1988, ch. 6]).

Schwab points out that science is *inquiry* as far as "conceptions – principles – must be invented or adapted by the investigator in order to determine his subject matter and his data" [SCHWAB 1978, p. 133]. Scientific subject matters are already there, they are 'carved' from the *abundance of being* (to use Feyerabend's (2001) charming expression) by courtesy of a set of concepts which identify an object to be investigated and so establish a domain of knowledge. At the same time and through the same move, methods and the perspective with which to conduct the investigation are devised:

> "Not only the *what* but the *what-about* are determined by inquiry. When our matter is made a subject by tearing it from context and forcing on it some conception of self-supporting unity and completeness, there is also a restriction of what to investigate about it. The effect of principles which make a material investigable at all by impressing on it an appearance of unity and completeness is complemented by further effects which determine the form our knowledge will take" [SCHWAB 1978, pp. 134-135].

Recognizing this 'inquiring character' of science entails accepting its inescapable *fluidity*, although Schwab admits that in the history of science there are phases of *stable research* during which the researcher confines himself to taking for granted the domain of investigation and "to fill[ing] a particular blank in a growing body of language" [SCHWAB 1962, p. 15]. In these phases the scientist *does not think*, does not reflect upon the principles which define and "sketch out" (to use a Heideggerian lexicon) his field, but "[h]e receives them from the others and treats them as matters of fact. He uses them as means of enquiry and not as objects to be enquired into. The principles define his problem for him and guide the pattern of experiment which will solve it, but the principles are not treated as problems in themselves" [SCHWAB 1962, p. 16].

In this depiction scientists look like the figures contemptuously described by Ortega: narrow-minded men, "men astoundingly mediocre, and even less than mediocre"[11]. [ORTEGA Y GASSET, 1930/1980, p. 141], who just by virtue of the global organization of scientific enterprise are able to "discover new facts and advance the progress of the science which [they] hardly know, and incidentally the encyclopaedia of thought of which [they are] conscientiously ignorant"[12] [*Ibidem*].

Ignoring the encyclopaedia of thought (the *culture* in the above mentioned passage of Ford), reducing science to its stable, un-critical, un-inquiring dimension, is fatal to science. *Real science* to Schwab (as well as to Ortega and – perhaps – to Heidegger if read under a specific perspective but unlike Kuhn) *is* a *practice of fluid research*, which frames new principles defining a field of investigation, new *Entwьrfe der Natur*, and new tests permitting the

[11] "hombres fabulosamente mediocres, y aun menos que mediocres". English version on http://www.scribd.com/doc/7153482/Ortega-y-Gasset-The-Revolt-of-the-Masses.

[12] "descubrir nuevos hechos y hacer avanzar su ciencia, uqe el apenas conoce, y con ella la enciclopedia del pensamiento, que concienzudamente desconoce". English version on http://www.scribd.com/doc/7153482/Ortega-y-Gasset-The-Revolt-of-the-Masses.

experimental control of hypotheses. In science-as-inquiry there is no gathering of knowledge but a development of new lines of research through inventing new conceptions. Scientist is then creative, he *jumps* – to resort to the Heideggerian word – into that *original having-to-do-with-thinking* which belongs to science (in spite of any serviceable oblivion of this relation in normal phases).

These considerations have significant educational implications: science teaching is usually dominated by the *rhetoric of results* [SCHWAB 1962; SCHWAB 1978]. Students are not exposed to the process of inquiry but just given the products: theories, formulae etc. are displayed as ready-made. No questioning occurs; theories, hypotheses etc, are taken for granted and tests are at best a form of "tinkering around" [MATTHEWS 1994, p. 133] and students are not encouraged to investigate why a specific test is linked with a specific theory.

This kind of science education (which is still dominant at least in Italy) mirrors an idea of research as stable, normal, dominated by *one* paradigm, by *one* handbook, by *one dogma* [KUHN 1963] and recalcitrant to any second-level of questioning which deals with the *reasons why world is investigated in a certain way*.

Emphasizing science as *inquiry*, on the contrary, and going beyond the *rhetoric of conclusions* means that

a) "[i]f a theory is to be known as a showing-forth of some aspect of the world, we must also teach what the theory is a theory of and what about that subject is and is not incorporated in the theory […] The theory is only the terminal part of an enquiry. We need what comes before the end, the early and middle parts of enquiry, in which its guiding principles can be found, in order to discover what the theory is a theory of and what aspects of its chosen subject matter are embraced" [SCHWAB 1978, p. 134];

b) Knowledge is not cumulative, does not consist in amassing notions. The progress of *inquiry* alters terms and concepts, demands the *re-thinking* of their relationships, the abandoning of theories and the devising of new hypotheses. What takes place is a process of constructive revision of the categorial frames, not just a broadening of the body of knowledge; it is thinking-in-action, not the mechanical and uncritical use of rules; it entails conceptual change and investigation into principles. Exclusively in this way students are ushered into the epistemic structure and dynamics of science and do not assume the 'spectator attitude' which is alien to the spirit of modern science [DEWEY 1929/1984].

c) There is never *just one* set of principles in the light of which to investigate the world but it is often possible to appeal to competing sets of principles. Each of them "gives rise to a form and kind of knowledge distinct from that produced by the operation of other sets. Each such body of knowledge often turns out to have its own peculiar value and usefulness" [SCHWAB 1978, p. 136].

Science education inspired by the model of *fluid inquiry* does not build bridges between science and thinking but *jumps into the thinking dimension of science* and recognizes it as the original ground by virtue of which science is

not an enterprise of mediocre men but *the characteristic achievement of the modern age* (Trilling).

Science is *inquiry*, *ergo cogitat*, and the educational question is to recognize this 'thoughtful' calling of science and to translate it into didactic strategies, without indulging – in a concealed form – in the canonical *rhetoric of conclusions*.

Preventing the risk of the rhetoric of conclusions arising again even in the most skilled kinds of science education at the same time provides a ground "shared by the ordinary don, the educated technician, the average citizen", as Holton puts it.

But what do we mean by thinking, if thinking has to permit us to overcome the *barbarism of specialization*?

3. THE PEDAGOGICAL DIMENSION OF SCIENCE

In the perspective thus far outlined, a philosophical approach to science teaching is pivotal if learning science has to be given an educational value, a relevance to the cultivation of an open, critical, and inquiring mind, which has always been one of the chief objectives of liberal education. But the *philosophical approach to science teaching* does not entail replacing science with philosophy: philosophy is not a sort of super-discipline introducing thinking where thinking did not have citizenship. We do not have to yield to the epistemological fallacy according to which reflecting on the foundations of scientific knowledge is a compartmentalized sector, separated from science-in-action; there would be the risk of sharpening the *barbarism of specialization* instead of overcoming it. On the contrary, as has been pointed out,

> "[p]hilosophy is not far below the surface in any scientific investigation. At a most basic level any text or scientific discussion will contain terms such as 'law', 'theory', 'model', 'explanation', 'cause', 'truth', 'knowledge', 'hypothesis', 'confirmation', 'observation', 'evidence', 'idealization', 'time', 'space', 'fields', 'species'. Philosophy begins when students and teachers slow down the science lesson and ask what these terms mean and what the conditions are for their correct use. All of these terms contribute to, and in part arise from, philosophical deliberation on issues of epistemology and metaphysics: question about what things can be known and how we can know them, and about what things actually exist in the world and the relations possible between them. [MATTHEWS 1994, p. 87].

But when Matthews refers to logical-analytical questions emerging in the science lesson (questions such as *What does a particular concept mean? How do we know the truth of a proposition? Does a conclusion follow from the premises adduced?* [*ibidem*]), he evokes an aspect of the philosophical approach to science education which, although important, is far from being exhaustive.

Although Matthews takes into account the post-positivist debate, a Viennese-logical positivist echo resonates in some of his considerations. Indeed, what he principally recommends is a sort of *Begriffserklдaung* and examination of the logical cogency of statements. From this perspective philosophy is meant first of all as an activity of clarification, which is confined to checking that concepts are used in a legitimate way. A philosophical approach to science

education so construed does have (or is in danger of having) just a 'prophylactic', 'pre-emptive', and 'purging' function, not a constructive one.

In this sense the *jump into thinking* would be a *jump out of science*, in order to come back subsequently, equipped with a vocabulary not epistemologically misleading. It would not be, then, a jump which remains in the original *inter-esse*, in that in-between linking science and philosophy without bringing them to any coincidence. Such an *inter-esse* is thinking not as the activity of disembodied minds but as the activity of inquiry and exploration on the part of beings-in-the-world, who *experience* the world and are *in transaction with it*.

The main point in science, philosophy, and therefore in science education, is that both science and philosophy are secondary constructions out of the *Lebenswelt*; on the one hand, they carry out a *withdrawal from the world of appearances* [ARENDT 1978], on the other they are inescapably tied up to the world of common sense, both because it represents their backdrop and because the majority of their concepts are but sophistications/transformations/ idealizations of those doxastic notions by means of which we orientate ourselves in the world.

As Husserl pointed out in the fundamental investigations of *Die Krisis der europдischen Wissenschaft und die traszendentale Phanomenologie*, the *despised doxa* has to be recognized as the ground for science [HUSSERL 1959/2007. See also WALDENFELS 1982]. In our pre-scientific lives we already have a set of truths and of pieces of knowledge defined on the basis of the requirements of practical life, which determine their sense and guide their verification.

Empirical-experimental investigations on the folk scientific knowledge [BOZZI 1990] bear out Husserl's view. Common sense explanations are not rough, incoherent, and wrong, they are not just the legacy or the deposit of past knowledge, dominated by concepts which modern science – bursting through the fog of ignorance and imposing the methodical rigour – has been replacing. They are, instead, a repertoire of well-structured notions, often linked with each other in a system (although not fully elaborated), and they stem from the practical and lived intercourse with the world. They are themselves knowledge.

Science (but also philosophy) are constituted and constructed on this ground of prescientific knowledge. It is not possible here to investigate in-depth whether the constitution of science (and philosophy) happens as a break with this ground [WOLPERT 1992; CROMER 1993; see also ARENDT 1978 who, following the echo of the Thracian servant's laughter, explores the inevitable intestinal war between common sense and philosophical thinking; and see BACHELARD 1938, with the notion of *obstacle epistemologique*]; or in continuity with this ground; or finally as a transformation and reframing of the concepts of the *Lebenswelt*, according to a perspective which is shared, despite differences in their views, by Dewey (1929/1984; 1938/1986) and Husserl (a perspective by which the present paper is inspired).

What must be emphasized is that this pre-categorial ground should be the starting point for a philosophically-orientated science education and that the dynamics through which science constructs itself on this ground and constantly refers to it is what can represent the horizon "shared by the ordinary don, the educated technician, the average citizen", in Holton's words from which we have moved.

In a philosophical approach to *science education*, which confines itself to analysing concepts in order to identify correct use and cogent connections with each other, concepts are taken for granted, what is to learn is just their 'right' meaning. In the above quoted passage Matthews speaks of students and teachers who "slow down the science lesson" to dwell on the concepts and to try to explain what they mean. But in this way concepts are already there, available within the framework of a discursive universe (that of science), the process of constitution of which out of the worldly experience of the subjects is not investigated.

As a consequence, a kind of rhetoric of conclusions keeps on living, even if in a more articulated and refined form: in this case *conclusions* are not single theories but sciences themselves, which are presented as self-segregated disciplinary bodies to be learnt in their decoding keys and their lexicon. The science lesson runs the risk of perpetuating that oblivion of the *Lebenswelt* diagnosed by Husserl in his pages on Galileo, that concealment of the ground of the lived experience and of practical intentionality out of which science grows through operations of conceptual elaboration and idealization.

If in a class we confine ourselves to asking "what these terms [law, theory, cause, explanation, force, mass etc.] mean and what the conditions are for their correct use" (to quote Matthews once again), we stay at the surface of science. To pick up just a couple of instances: the term "law" can not be clarified if we do not start from our lived knowledge of what a regularity, a connection lived as necessary and 'inviolable', is. We can not just dispose of such an idea of 'law' because it is fallacious and with no right of citizenship in the scientific discourse. We have to investigate what transformations this notion has to undergo in order to be accepted in the scientific discourse, as well as in which ways the primordial lived knowledge of what a law is is serviceable to frame the scientific concept and remains in it as the (back)ground of its 'understandability'.

Or to mention another example: after Michotte's studies (1954), can we confine ourselves to a mere *Begriffserklarung* of the notion of 'cause' or do we not have to investigate how this notion, in its scientific version, constitutes itself on the basis of a perceptual knowledge of what a causal connection is [BOZZI 1989; BOZZI 1990]?

To complete an analytical-philosophical approach it is not sufficient to introduce the study of the history of science (important, significant though it may be); for example how Galileo re-construed the notion of cause or how the concept of 'law' is rooted in theological speculation. The study of the history of science in turn takes for granted disciplinary bodies of sciences and their sets of concepts and confines itself to awakening the awareness of a historical evolution. What keeps on going uninvestigated is the link between the *Lebenswelt*-experience of the subjects and the scientific discourse.

In a wonderful page Philipp Frank makes the following remarks:

> "It is harder to explain the uniform motion of [a] body. We say that it is caused by inertia; we all know what this means because we know from everyday experience that we are inert. Inertia means sluggishness, the lack of a desire to move. For example, there must be some external inducement to get up in the morning – some class

> that must be attended, or the expectation of a good breakfast. […] However, this method of explanation by introducing the experience of our own sluggishness is quite arbitrary […] In any case, the analogy of the everyday experience of sluggishness predicts the observable effects of motion only in a very vague way, which is useful only under very special circumstances. What really matters in physical science is the abstract scheme. […] Comparison with the phenomena of everyday life will not show any inconsistency with this scheme" [FRANK 1962, pp. 7-8].

From a completely different perspective (Frank was one of the leading figures of Logical Empiricism), what we are arguing finds an important confirmation: on the one hand scientific notions can not be identified with those of everyday experience; on the other they are constituted out of the *Lebenswelt* and they constantly refer to it.

It is on this 'space of constitution' (without any transcendentalist overtone) that a *pedagogy of science* [WAGENSCHEIN 1970; WAGENSCHEIN 1995; KUTSCHMANN 1999] has to insist, dwelling in it in order to regain that ground through which science makes sense and which can represent what is "shared by the ordinary don, the educated technician, the average citizen" (Holton) and as a consequence can ward off the danger of self-alienation for science and of "exclusion of most of us from the characteristic achievement of the modern age" (Trilling). Dwelling in it is living the *pedagogical dimension of science* [WAGENSCHEIN 1995], being-in-science as in a fundamental moment of human *Bildung* and – more radically – in that *Welt-Bildung* [HEIDEGGER 1929-30/1992; OLIVERIO 2008] which constitutes the human being.

A *pedagogy of science* so construed is what narrows the divide between science and the "encyclopedia of thought" (Ortega y Gasset) and is really the education of the *mind in the modern age* which prevents us from falling into the *dubiety* and *alienation* for which we would otherwise be destined.

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