

RESTRUCTURINGS IN GREEK EDUCATIONAL SYSTEM AND INFLUENCE IN CHEMICAL EDUCATION

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Abstract. Constructivism has undoubtedly a major theoretical influence on contemporary science and mathematics education. Recent 'reforms' in the Greek educational system are based on constructivist ideas and constructivism is presented in Greece as the only 'non traditional' method of teaching, and constitutes the main perspective taught both at undergraduate and postgraduate level in the Greek University. This article explores the constructivist philosophical base and its influence in chemical education. Recent 'reforms' in the Greek educational system, based on constructivist ideas, weaken chemistry teaching and reduce chemistry in the curriculum. The philosophical base of constructivism is related with some main philosophical dimensions of chemistry.

Keywords: constructivism, idealism, materialism, chemistry, matter-energy, atomic theory, quantity-quality

1. Introduction

Constructivism has undoubtedly a major theoretical influence on contemporary science and mathematics education. Constructivist influence has extended beyond the research and scholarly community; it has an impact on a number of national curricular documents and national education standards (Matthews, 1995). His supporters claim that constructivism can provide solutions for all educational problems, but also constructivist doctrine

has no rival theories, as a former president of the US National Association for Research in Science Teaching (NARST) has said that „A unification of thinking, research, curriculum development, and teacher education appears to now be occurring under the theme of constructivism ... there is a lack of polarised debate“ (Yeany, 1991).

Constructivism progressively expanded its dominion in the research of the whole of educational phenomena and this dominion is extended from country to country. Recent 'reforms' in the Greek educational system are based on constructivist ideas which directly or indirectly are mentioned in the curriculum documents. Besides, constructivism constitutes the main, indeed the only perspective taught both at undergraduate and postgraduate levels in Greece.

Many researchers theorize that the problem, which is presented at the evaluation process of constructivism, when determining whether it constitutes an instrument or an obstacle in the educational action, is which aspect of constructivism to evaluate: the theory of learning, theory of knowledge, theory of science, theory of education or world view. This article will make no attempt to evaluate constructivism along these perspectives, but will rather try to elevate the philosophical bases of constructivism and its consequences in the teaching of chemistry.

2. Philosophical base of constructivism

There are two major traditions of constructivism. The first is based in Piaget's work, where learning is a process of personal, individual, intellectual construction arising from the activity in the world. Ernst von Glasersfeld has made a significant contribution in the development of this tradition, giving a radical subjective dimension. Ernst von Glasersfeld enlightens us to the philosophical base of constructivism: „Our knowledge is useful, relevant, viable, or however we want to call the positive end of the scale of evaluation, if it stands up to experience and enables us to make predictions and to bring about or avoid, as the case may be, certain phenomena (i.e., appearances, events, experiences)... Logically, that gives us no clue as to how the 'objective' world might be; it merely means that we know one viable way to a goal that we have chosen under specific circumstances in our experiential world. It tells us nothing... about how many other ways there might be“ (Glasersfeld, 1987). Additionally von Glasersfeld claims „The word 'knowledge' refers to a commodity that is radically different from the

objective representation of an observer-independent world which the mainstream of the Western philosophical tradition has been looking for. Instead 'knowledge' refers to conceptual structures that epistemic agents, given the range of present experience within their tradition of thought and language, consider viable" (Glaserfeld, 1989).

According to von Glaserfeld, knowledge does not represent an independent, objective world; it is created by the individual through subjective experience. Individual conceptual structures are contextual, while they constitute knowledge when they are considered viable by individuals in relation to their experience. Constructivism is a 'form of the real', claim its supporters; while they consider that there is no preferred epistemological conceptual structure, given that conceptual structures are acceptable so long as they are viable for the person using them. There are many viable truths according to constructivism, that is, constructivism constitutes a relativistic dogma. Following in the footsteps of many idealists before him, von Glaserfeld formulates again an ontological position, „Radical constructivism, thus, is *radical* because it breaks with convention and develops a theory of knowledge in which knowledge does not reflect an 'objective' ontological reality, but exclusively an ordering and organization of a world constituted by our experience. The radical constructivist has relinquished 'metaphysical realism' once and for all" (Glaserfeld, 1987). Constructivism creates, as consistent positivist, a new philosophical system, in which the world is constituted by the experience. The founder of constructivism claims that knowledge is only the appropriate classification of a reality that is constructed through subjective experience, while according to him and many other idealist or agnosticist philosophers, the objectivity of reality constitutes a metaphysical hypothesis. We would concur with him with regard to the metaphysicality of the case for the existence of an objective reality only in the mind of idealist constructivists and back up our agreement by quoting the second thesis on *Feuerbach* of K. Marx „The question whether objective truth can be attributed to human knowledge is not a question of theory but is a practical question. Man must prove the truth – i.e. the reality and power of this sidedness of his thinking in practice. The dispute over the reality or non-reality of thinking that is isolated from practice is purely *scholastic* question" in the work *Ludwig Feuerbach*: (Engels [1886], 1995).

Antonio Bettencourt clearly elects the philosophical roots of constructivism both sincerely and without evasion, a rarity in constructivism, when he states, „... constructivism, like idealism, maintains that we are cognitively

isolated from the nature of reality. ... Our knowledge is, at best, a mapping of transformations allowed by that reality“ (Bettencourt, 1992). In the constructivist system nature is the externalization of the idea, in other words the demotion of the idea! Thought and its intellectual product, the idea, perception, are primary for constructivists, while nature is the derivative, which owes its existence solely to the idea condescending to descend to this point. And in the midst of these contradictions they attempt to deconstruct the ‘traditional’ perception of educators of the existence of objective reality. Yet nature exists independently of any ontological theorization, it constitutes the basis on which we humans developed, and existed before we condescended to formulate laws and ‘non-observable’ entities.

In following the journey of the inquiry of the positions of constructivism the views of Wheatley could be absolutely enlightening: „The theory of constructivism rests on two main principles... Principle one states that knowledge is not passively received, but is actively built up by the cognizing subject... Principle two states that the function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of ontological reality... Thus we do not find truth but construct viable explanations of our experiences“ (Wheatley, 1991). As to the active participation of the student we concur with the researcher, but not on the basis of subjective idealism on which he proceeds. Yet, how might students be active in the process of learning when we are teaching them something which does not exist or which cannot be known?

The examination of the fundamental thesis of constructivism demands detail examination. Constructivists are reported to the realities and that creates a problem since their reality collapses in the ‘experience of my individual (subjective) reality’ (solipsism). These claims do not differ from the simple but pernicious argument of the bishop G. Berkeley, the founder of idealism in his *Treatise* „As for our senses, by them we have the knowledge *only of our sensations*, ideas, or those things that are immediately perceived by sense, call them what you will: but they do not inform us that things exist without the mind, or unperceived“. Constructivists use many modes to support their subjective empiricism, and to consistently end up at Bishop Berkeley’s idealism. In the tradition of empiricism, in the form it is given by constructivists, the possibility of knowledge was weakened once it had been pointed out that the mind is active in cognition. The possibility of knowledge evaporated once it was claimed that the immediate objects of intellectual faculty were sense impressions rather than nature itself. Nature, in Kant’s terms, a thing-in-itself, became unknowable because, we only ever see it

through a distorting lens, and there is no privileged position from which to check the correspondence of thought to reality (Matthews, 2000).

The question of the relation of thinking to being, or the relation of the spirit to nature constitutes the paramount question of the whole philosophy. „The answers which the philosophers gave to this question split them into two great camps. Those who asserted the primacy of spirit to nature and, therefore, in the last instance, assumed world creation in some form or other – and among the philosophers, Hegel, for example, this creation often becomes still more intricate and impossible than in Christianity – comprised the camp of idealism. The others, who regarded nature as primary, belong to materialism“ (Engels [1888], 1995). And additionally materialist Engels claims: „While materialism conceives nature as the sole reality, nature in the Hegelian system [idealism] represents merely the ‘alienation’ of the absolute idea, so to say, a degradation of the idea. At all events, thinking and its thought-product, the idea, is here the primary, nature the derivate, which only exists at all by the condescension of idea. And in this contradiction they [idealists] floundered as well or as they could... but nature exists independently of all philosophy. It is the foundation upon which the human beings, ourselves products of nature, have grown up“. Additionally, Engels expresses the materialistic thesis about the ‘construction’ of the world: „We all agree that in every field of science, in natural as in historical science, one must proceed from the given *facts*, in natural science therefore from the various material forms and the various forms of motion of matter; that therefore in theoretical natural science too the inter-connections are not to be built into the facts but to be discovered in them, and when discovered to be verified as far as possible by experiment“ (Engels [1883], 2001). At first, the primary role of nature in knowledge is recognized, in other words we could not know the world without the world. Secondly, facts’ inter-connections are not constructed but rather discovered into the facts. So the disagreement about the ‘construction’ or ‘discovery’ of knowledge is an old conflict between idealism and materialism and the introduction of the term ‘construction’ by constructivists is not accidental.

When constructivists were accused of solipsism, they elected Durkheim’s thesis and created the second major transition the sociological one. Accord to Durkheim: „If thought is to be freed, it must become the creator of its own object; and the only way to attain this goal is to accord a reality that it has to make or construct itself. Therefore, thought has as its aims not the reproduction of a given reality, but the construction of a future reality. It follows that the value of ideas can no longer be assessed by reference to objects but must

be determined by the degree of their utility, their more or less 'advantageous' character." (Durkheim, 1971, p.251)

This idealistic tradition restored by sociologists of science in the Edinburgh School such as Barry Barnes, David Bloor, Harry Collins, Bruno Latour et al. As Matthews (1994) mention, Latour and Woolgar at one point say that: „out-there-ness is the consequence of scientific work rather than its cause“ (Latour & Woolgar, 1986, p. 182). Latour and Woolgar go on to say, that reality is the consequence rather than the cause of scientific construction. Other contributors to the Edinburgh program say such things as the planets are „cultural objects“ (Lynch et al., 1983). According to Harry Collins: „...an explicit relativism in which the natural world has a small or non-existent role in the construction of scientific knowledge“ (Collins, 1981, p.3). Woolgar embraces idealism saying that: „scientific knowledge originates in the social world rather than the natural world“ (Woolgar, 1983, p. 224). And additionally, he claims that his research program „is consistent with the position of the idealist wing of ethnomethodology that there is no reality independent of the works (text, signs, documents, and so on) used to apprehend it. In other words, reality is constituted in and through discourse“ (Woolgar, 1986, p. 312). So reality is constructed through discourse communication. But Vigotsky argues, that „true human communication presupposes a generalizing attitude, which is an advanced stage in the development of word meanings. The higher forms of human communication are possible only because man's thought reflects reality...The crisis stems from the sharp contradiction between the factual material of science and its methodological and theoretical premises, which have long been a subject of dispute between materialistic and idealistic world conceptions. The struggle is perhaps more acute in psychology [and in science education] than in any other discipline“ (Vigotsky [1934], 1993) Constructivists usually report the significance of communication but conceal the thesis of Vigotsky that generalization through communication is possible only if reflects reality.

Social constructivist thesis seems similar with Bogdanov assertions, reproduced in *Materialism and Empirio-Criticism*: „the objective character of the physical world consists in the fact that it exists not for me personally, but for everybody and has a definite meaning for everybody, the same, I am convinced, as for me“. This is a fundamentally untrue, idealist definition. The physical world exists independently of humanity and of human experience, that the physical world existed at a time when no 'sociality' and no 'organization' of human experience were possible. Religious doctrines, which undoubtedly possess a 'universal significance', are socially constructed but

it is not science. If objective truth exists (as the materialists think), if natural science, reflecting the outer world in human 'experience', is alone capable of giving us objective truth, then all fideism is absolutely refuted. But if there is no objective truth, if truth (including scientific truth) is only an organizing form of human experience, then this in itself is an admission of the fundamental premise of clericalism, the door is thrown open for it, and a place is cleared for the 'organizing forms' of religious experience.

Richard White, a proponent of constructivism, acknowledges that „although the research on alternative conceptions has sparked interest in content, it has not yielded clear advice about how to teach different topics“ (Fensham et al., 1994). At this juncture we must acknowledge the contribution made by constructivism to the discovery of student's alternative conceptions; but there is an inherent weakness in the explanation of student perceptions by constructivists. The difficulty for constructivism posed, teaching science content, is not just a practical one, it is a difficulty which betrays a fundamental *theoretical* problem within it – if nature may be unknowable, and if knowledge has to be an individual (subjective) construction, then the creation of misconceptions must be the result of learning. Every student constructs his own world individually or socially, so there are a lot of worlds! On the other hand, we wonder how children can construct complex conceptual schemes which took scientists hundreds of years to discover and practically confirm, such as the structure of atoms, or chemical bonds.

Many science educators are interested to find out how, on constructivist principles, someone can teach a body of scientific knowledge that is in large part abstract, (concepts such as speed, acceleration, power, gene), that is removed from experience (atomic models, cell processes, electromagnetic radiation) and that is alien to common sense, and several times in conflict with every day experience, expectations and concepts? Decides teaching a body of knowledge involves not just teaching the concepts but also the method, the process and something of the evolution of that methodology. How all of this is to be taught, without teachers actually conveying something to pupils, is a moot point. (Matthews, 1995)

3. Constructivist influence in chemical education 'reforms'

Recent reforms in Greece are based in constructivist ideas that are indirectly mentioned in the curriculum documents or directly in teacher's

book. The didactic methodology proposed is based upon the principles of 'constructivism...' (Georgiadou et al., 1999a, p.15). In the Teachers' book for the third year of Gymnasium (Greek junior high school, 14–15 years) clear reference to Australia's curriculum as effort of revised context. So „...hand book of Chemistry [Australia] '*Chemical Elements: Earth, Air, Water, Fire*' ... This effort aims Chemistry teaching to take distance from the principles of science..." (Georgiadou, 1999b, p. 9). Consequently, to teach as constructivist means distancing oneself from the principles of science, while the elements of Chemistry are seen as the four Aristotelian elements. And how could constructivists later explain the misconception of students that water is an element? They will reply that knowledge is subjective, a reconstruction of students' conceptual structures and other vacuities and incomprehensible theories which so often seem splendid but fail to offer practical solutions for schooling practice. And elsewhere it is said „... the more teaching is based upon the senses; the more fruitful it is to be..." (B Gymnasium, Teacher's Book, p. 16). We have already examined constructivists' doctrine of the role of the senses and if we take this together with their 'purpose' which, as they themselves assert, is the distancing of chemistry teaching from the principles of science, it is not difficult to postulate what the future of Chemistry will be in a constructivist context.

Additionally, the problem for constructivist is not created when students observe the changes of colors, since teaching occurs only at the macroscopic level, but when they move didactically from that level to the essence of the phenomenon, that is to explain at microscopic level. And, if as they claim, we must move away from science's principles then it is sufficient for them to remain only at the macroscopic level, far away from the atomic theory and allow students to observe only the smells, the colors and the bangs. When later in Lyceum (Greek Senior High School) we have to move on to explanations at the microscopic level, the authors of the teachers' books ask for reference to the corresponding Gymnasium books!

Constructivists insist on teaching in macroscopic level because of its idealistic base and hesitate to teach in microscopic level in the base of atomic theory. Atomic theory, as it constitutes a materialistic explanation of the nature, is out of the idealist constructivist curriculum. The significance of the atomic theory is stressed by Engels: „in Chemistry, thanks to atomic theory, there is order, relative certainty about what has been achieved, and systematic, almost planned, attack on the territory still unconquered, comparable to the regular siege of a fortress“ (Engels [1883], 2001). If students do not familiarize with atoms and atomic theory, then they think that „matter

is continuous, there is no space between the particles of matter“, they have „static view of the structure of matter“ (Novick & Nussbaum, 1981).

Based on science education research findings, which are related with constructivism, chemistry is considered too difficult to be taught in high school at microscopic level, which is based upon the atomic theory. In this context the atomic theory is introduced as a rhetorical conclusion (senior high school), while its contribution to the development of Chemistry is concealed. When constructivists are unable to teach chemical concepts, they claim that these are too difficult for students' level and are removed from the curriculum or are mentioned without their philosophical dimensions. On the other hand, separation of the macroscopic from the microscopic level returns chemistry to the age of alchemy, where students see changes in colors, hear bangs, smell gases, without any explanation of the phenomena. If teaching moves away from the principles of science, then Chemistry will be weaker from its dialectically materialistic dimensions.

In the same context, they prefer qualitative process of chemical phenomena, because quantitative procedures also evolve atomic theory. While constructivists teach Chemistry only in quality level, they detect students' misconceptions that „acids always burn you“ independently from quantity, or „strong acid eat material away faster than a weak acid“ (Hand & Treagust, 1988). Chemistry can be termed the science of the qualitative changes of bodies as a result of changed quantitative composition; from this opinion teaching can't separate quantitative from qualitative changes in nature. Besides, all qualitative differences in nature rest on differences of chemical composition or on different quantities or forms of motion (energy) or, as are almost always the case, on both. Hence, it is impossible to alter the quality of a body without addition or subtraction of matter or motion, i.e. without quantitative alteration of the body concerned.

It is necessary to emphasize the gap, which is expressed both in the comprehensive curricula and consequently in the textbooks, from the macroscopic to the symbolic level, bypassing the microscopic level, because there is an inability and unwillingness to explain phenomena at the microscopic level using the sinful materialistic atomic theory. This gap, i.e. the absence of the microscopic level – atomic level – from chemistry, should concern us, since chemistry without changes in molecular states becomes physics, provided that in physics, bodies are treated as chemically unalterable or indifferent. Besides, constructivists use physical models for the explanation of chemical phenomena. But mechanical physical models could not express the dynamic complexity of the microcosm and create students'

misconceptions (e.g. the model of balance in molecular chemical equilibrium). In such a context, the concepts of chemistry are expressed unclearly, vaguely, mechanically as rhetorical conclusions (Arrhenius model) that do not reflect the complexity of chemical phenomena (Kousathana et al., 2005). Since students can not construct concepts in chemistry they have to learn it as rhetorical conclusions, in other case if concepts are too difficult, it is not necessary to be learned by students. The simultaneous tendency towards the mathematicization of chemistry amputates chemistry from reality, essentially leading to the same point – to its enervation and to the concomitant distaste of students for the subject.

According to textbooks, the components of the world are matter and energy. So students think that there are particles of heat. In the processes of nature two aspects are usually still distinguished: matter and its motion. This assertion expressed by Ostwald, who claimed out that motion can be thought of without matter. Is it not 'more economical', indeed, to conceive motion without matter? For Karl Pearson „All things move—but only in conception... It is therefore, for the sphere of perception, idle to ask what moves and why it moves“ (Pearson, 1900, p. 243). The idealist would not even think of denying that the world is motion, *i.e.*, the motion of his thoughts, ideas, and sensations. The question as to *what* moves, the idealist will reject and regard as absurd: what is taking place is a change of his sensations, his ideas come and go, and nothing more. Outside him there is nothing. 'It moves'—and that is all. It is impossible to conceive a more 'economical' way of thinking. And no proofs, syllogisms, or definitions are capable of refuting the solipsist if he consistently adheres to his view.

While the idealist may regard the world as the *movement* of our sensations, individually or 'socially organized'; the materialist regards the world as the movement of an objective source, or of an objective model of our sensations. The dialectical materialist not only regards motion as an inseparable property of matter, but rejects the simplified view of motion, that matter is what moves. The fundamental distinction between the materialist and the adherent of idealist philosophy consists in the fact that the materialist regards sensation, perception, idea, and the mind of man generally, as an image of objective reality. The world is the movement of this objective reality reflected by our consciousness. To the movement of ideas, perceptions, etc., there corresponds the movement of matter outside me. The concept matter expresses nothing more than the objective reality which is given to us through sensation. Therefore, to divorce motion from matter is equivalent to divorcing thought from objective reality, or to divorcing my sensations from

the external world—in a word, it is to go over to idealism. The trick which is usually performed in denying matter, and in assuming motion without matter, consists in ignoring the relation of matter to thought. The question is presented as though this relation did not exist, but in reality it is introduced surreptitiously; at the beginning of the argument it remains unexpressed, but subsequently crops up more or less imperceptibly (Lenin [1908], 1977).

Among the German physicists, Ludwig Boltzmann systematically polemicalised against Ostwald's energetics from the standpoint of a physicist, and argued that Ostwald could neither disprove nor eliminate the formula of kinetic energy (half the mass multiplied by the square of velocity) and that he was revolving in a vicious circle by first deducing energy from mass (by accepting the formula of kinetic energy) and then defining mass as energy (Boltzmann, 1905, pp. 112, 139).

4. Anti-epilogue

Restructuring in Greek educational system reflects efforts of application constructivist ideas. These efforts were accompanied with the reduction of Chemistry in the curriculum, the abolition of Geology's lessons and the suppression of atomic theory from chemistry and evolution from Biology. Science teachers conceive that students do not acquire a completed view for the world in the constructivist context. The dominant obstacle for constructivist ideas in Greece is the spontaneous materialistic view of science teachers. So the main target for constructivists is the deconstruction of the 'traditional' aspects of educators. The dispute between materialism and idealism has a long tradition in Greece from the era of Democritus and Plato and this struggle will remain acute.

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