# *Do We Need a Philosophy of Science Education?*

*FRITZ KUBLI*
*Zürich, Switzerland*

ABSTRACT: The reflection of several decades of science teaching at secondary school level leads to the strong suggestion that a theory of science education should be based on arguments emanating from insights into the process of meaningful communication in the light of modern epistemology. These arguments show that the teacher's personality and engagement with the subject is a major source of interest and devotion of students who try to understand the presented ideas. An analysis of the conditions of this engagement leads to a vision for a future understanding of the teaching process, especially in science teaching.

KEYWORDS: philosophy of science education, epistemology, science teaching.

The title may be misleading. Of course, every teacher needs a personal philosophy of education in addition to the generally accepted guidelines, in order to give a convincing answer to questions like, "Which subjects are relevant for the students and for what reason?". How should a teacher proceed during lessons and how can he justify his own personal method in addition to the explicit or implicit official theories of education? What role has he to play in the exchange of emotions and interests with the class and within the class, according to his unique personality? Which arguments help him to defend his view of education against (a) reluctant or careless, or even hostile, students, (b) views expressed and supported by teachers with a different background and with different interests, or (c) unrealistic instructions given by the administration of the government?

Philosophies of education are the basis of every school activity. In my career as a physics teacher at secondary school level I have been confronted with all kind of ideas about what good science teaching can be and should be—that means, with different philosophies of education. The title of my presentation is, therefore, a rhetorical question, which might better be replaced by "Do we need a *new* philosophy of science teaching, a philosophy based on insights into the process of communication?". I would like to show that such a theory helps the teacher to come to a more sustainable way of teaching.

But let me sketch, first, how I experienced a hidden philosophy of science teaching during my secondary school and my university education. At secondary school level, I experienced mainly unhistorical teaching. My physics teacher considered it as sufficient to demonstrate a specific law by his experiments on the demonstration desk, to measure the relevant physical parameters, to establish the mathematical relations between them, and to show us how to use them correctly. Vignettes about the circumstances of their discovery were considered as an unnecessary ornament—nice to have, but not needed. I think that this procedure is still rather frequent and helps to deter many students from engagement with physics.

As students in Switzerland have no possibility to escape science as a subject, which might or might not correspond to their specific interests, questions about the usefulness of the taught subjects come up or are secretly hidden in their minds—questions, as for instance, Why do I have to calculate the voltage produced by the change of the magnetic flux in a coil of N loops—after all, I have not the intention to go into physics", etc. Personally, I considered this unhistorical teaching as rather boring, having no relation to the questions that deeply interested me at that time and age, even if I did not exclude a future career in science or even science teaching.

When, some years later, I, myself, became a physics teacher, I tried to avoid this method and looked for a different and more satisfying philosophical background for my teaching. During my university years, important changes in the general philosophy of science were made. Philosophically-trained historians like Alexandre Koyré or Thomas Kuhn had created a broader view of the historical development of science. For them, science was no longer an intersection of experiment and abstract logic only, but a kind of thinking embedded into a more general realm of emotions and existential feelings.

When, for instance, Koyré published his seminal book *From the Closed World to the Open Universe* (1957), it became clear, even to non-historians among physicists, that in this development of scientific ideas some deeply-rooted emotional obstacles had to be removed and cleared and that Newton was one of the key personalities in this process. Besides the calculations and experiments of natural philosophers like Copernicus, Kepler, and Galileo; rather, metaphysical ideas of thinkers like Giordano Bruno, Henry More and others—ideas that influenced Newton more than it is generally seen and mentioned in the textbooks—had to be analyzed. We know today how important these ideas were in Newton's struggle towards a coherent and satisfying general view, a view that did justice not only to experimental data, but also to the metaphysical needs of humanity.

It was a stroke of luck for me that at university level, more precisely at the Federal Institute of Technology in Zurich, I was educated by a great theoretical physicist, Markus Fierz, a former assistant of Wolfgang Pauli, who had a specific interest in Newton's thoughts. In his lectures, Fierz developed, in line with his calculations, a very colorful picture of physical thought. He did not avoid "philosophical"—that means epistemological—and ethical questions. His family had been closely attached to the Swiss psychologist Carl Jung. The recently-published correspondence of Pauli shows that Fierz was a very important partner for discussions with Pauli, discussions on a high level in various aspects. I could profit from Fierz's knowledge, as he was an excellent director of my doctoral thesis, a real "Doktorvater", as we say in German, who spent hours and hours discussing general epistemological questions with me, his faithful disciple. From him, I learned that scientific thinking is more than mathematical guessing; that it is always embedded in a general framework of ideas, interests, and emotions.

It would be beyond the scope of this paper to develop Fierz's view, in detail, here. Let me only mention that I could integrate a great number of his ideas into my paper "Science Teaching as a Dialogue – Bakhtin, Vygotsky and some Applications in the Classroom", a paper which appeared in *Science & Education* (Kubli, 2005).

Going back to the question of whether we need a new philosophy of science education, I would like to emphasize, first, that an efficient philosophy must be based on insights into the processes of successful communication. Modern theories of narratives, discussed in my paper on Bakhtin (Kubli, 2005), clearly show that the personality of the communicator is decisive also for the reception of communication. Unfortunately, a personality cannot be borrowed or artificially-constructed. It helps, however, if we integrate our arguments into a picture of the development of our science. A good knowledge of the personalities who discovered the laws of nature helps to show the enormous effort in thinking that was necessary. In addition, it helps to clarify the mode of thinking we want to explain.

There are powerful arguments in favor of such a view. One of the ideas of Jean Piaget dearest to him was the assumption that the "spontaneous" individual development of concepts in children follows, to a certain extent, the historical stream of scientific consciousness.

This means that in the development of ideas the ontogenesis repeats, in some points, the phylogenesis, in a similar way as we can observe it in the biological domain. I had the opportunity to test this idea by investigating children's representations of the universe and to compare them with the historical development of astronomy and, more specifically, with the history of representations of the cosmos. Some parallels between children's spontaneous, unguided ideas and the mythical or prehistoric representations, as they have survived in primitive cultures, could be shown (Kubli, 1984). These parallels throw a certain light on the learning process, which could be supported by using it in the curriculum, or at least by mentioning it to the students at appropriate occasions.

In my view, the parallel is a strong argument in favor of a historical approach. In the German-speaking community, a well-known educator, Martin Wagenschein, developed the so-called "genetic-historical method" as a means to integrate physical insights in the spontaneous stream of consciousness of children and students. He was the most influential follower of Ernst Mach, who created a long-lasting movement for a historically-based and experimentally-illustrated approach to physics teaching, including at the secondary school level. Wagenschein's important contribution was his emphasis on the need to relate the historical developments with the spontaneous representations of students. Unfortunately, he illustrated his method only by a few, although remarkable, "Lehrstücke", which means "pieces of learning". I recall that one of my colleagues was fond of this method, which helped him to develop a very humane atmosphere in his classroom.

Another important argument for historically-based teaching can be deduced from a careful analysis of narrative processes and their place in science teaching. Besides observations or experiments, narratives are the most important sources of our knowledge. Normally, we do not learn exclusively from direct experience. In the overwhelming majority of cases our knowledge of the outside world goes back to the experiences of others, that have been transmitted to us by narratives. In this process, the teller of the story is as important as the protagonist. Is the teller reliable? As a transmitter of the information, he is closer to the listener than the far away, or even invented, protagonist. This is also true in the classroom. Many students have difficulty in following an argument where the narrator is invisible or not reliable. They need to "feel" the person teaching them, to a certain extent. Stories give us teachers the opportunity to enter, as narrating personalities, into the learning process; better than dry arguments can do, even if the chain of conclusions is logically consistent.

The historically-based teaching of scientific ideas can attract students that would not be interested, otherwise. The remarkable textbook of Eric Rogers *Physics for the Inquiring Mind* (Rogers, 1977) serves as a good example of how physical details and general ideas can be related. He offered "a course in physics to non-physicists who wish to know physics and understand it". His Princeton lectures were a great success among students engaged in domains other than pure physics—future historians, lawyers, philosophers, and so on. This is also the mixture we have in our secondary school courses. Instead of being rather impersonal transmitters of scientific truths, we should be lively examples of investigators driven by the impetus that led gifted thinkers to their insights. If we teachers personally represent the spirit of physics, trying to show the emotions connected with the successful understanding of a certain subject, we should be able to create a climate of curiosity among our students.

In order to be a good physics teacher, it is not enough to know the subject, as we all know. The introduction of historical knowledge can be rewarding, even if it demands some energy to acquire it. In the long run, it should be possible to engage congenial teachers into a—as I hope—growing movement towards a more humane approach to physics. We need teachers committed to the idea that historically-based teaching of physical subjects is possible and even necessary. Probably the best help is, however, if these teachers can show the reason for their good results. If they make clear that their success is a consequence of their historical method, it might lead to a certain resonance outside the classroom, also. Fellow teachers might follow the given example. Let us not forget that we have to convince not only physicists or physics teachers, but also administrators and headmasters, civil servants and politicians, who are far away from the front line of physics teaching.

In summary, I would like to share the vision that historians of science *and* physics teachers should, more often, be present in the general discussions about the "right" way of teaching. I hope that a large portion of physics teachers will accept their role as storytellers in the near future—by using a teaching method based on stories, as well as on experiments, in the classroom. My general vision includes an approach to teaching that is more open to the history of science because it helps to understand the true nature of science and, at the same time, helps to illuminate an important aspect of the spirituality of man. We should not forget that the drive towards the fruit of the "tree of knowledge" is as old as humanity, and that this drive goes back as far as men have been capable of a conscious reflection on their behavior. This drive can be shown in our teaching. Let us illustrate the long lasting movement, which was started not only by the early Greek philosophers, but even before by men who discovered, for instance, the relationship between seed and plant, or the laws governing the breeding of domestic animals, the very basis of early agriculture. Let us not forget early astronomy with its insights into the calendar and the annual development of the seasons, of which Stonehenge is a powerful witness. The drive for knowledge has been vital for our living in harmony with nature.

Science, taken in this broad sense, has always been the driving force behind the development of our civilization. It has often been criticized, and antiscientific tendencies are as old as the optimism that science can solve all of our problems. But, even if we tried to do so, we could not stop this motivating force in our society. We have to live with this drive and to cultivate it. This aspect of science should not be missed in our curriculum.

There is much talk about the scientists' responsibility with regard to possible consequences of their activities, and many students, both male and female, are reluctant to follow, blindly, the popular direction of science. Science teaching should include some reflections about this concern. History of science can help to do so by showing that we live in an ever-changing world and have to adapt to these changes.

But, let me end with a personal remark. During the decades of my engagement with science teaching, I realized that my personal attitude towards these questions had a major impact on the motivation of students, even if it had not been explicitly the subject of a discussion, but was merely at the background of some of my remarks—and of some of my stories told about the development of science. Sometimes the effort of a teacher has a greater influence on students if his engagement is shown mainly by his personal attitude and the general atmosphere of the lessons, which is illustrated by the chosen stories and examples, rather than by the preaching of moral values. By telling stories, we can show and explain our personal preferences better that by dry and sober excursions into moral argumentation. Verbal digressions that give no information about us and the world in which we live and about how we deal with it, rarely have a significant effect.

It has often been required that science teaching should not only inform about facts, but that it should also transfer values to the students. Values and facts must be distinguished carefully, on the one hand, but on the other hand, values that are not connected with facts and integrated into the real world are not easily transmitted. Stories can be the link between values and facts. They may join both aspects and provide an opening to the hearts of our students.

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*Author's Address:*
Bäulistrasse 26, CH-8049
Zürich
SWITZERLAND
EMAIL: kubli.fritz@sunrise.ch