Pedagogical Exercises in a Russian Classroom

1. The presentations already made at this conference suggest that we face an array of new political and socio-cultural problems and tasks. An important one among them is to keep theoretical thinking going in society, while under aggressive attack by the information culture, wherein information pushes knowledge aside. The information culture's offensive is more and more strongly evident in the schools, with each passing year. It has been our experience working in education, that with each year it is becoming not only more difficult, but downright impossible to instill an ability to engage in theoretical thinking, in a society where everything is subordinated to the opposite sort of goal, and where the cultural basis for theoretical knowledge is being destroyed. Classical models and forms of education are being replaced by mass-media culture, with all its post-modernist techniques for influencing the mind. Because of this, unfortunately, we not only need special professional training, but we must also make decisions on how to define ourselves in a field of endeavor where passions are running high. Each of us has to make a tough choice of worldview: either to fight for vital, personal knowledge in society, or to begin to live by the laws of the information and Internet culture; either we shape and cultivate theoretical thinking in ourselves and in society, or we acquiesce to a society without it.

2. As you know, the question of how to transmit to the younger generations the culture of theoretical thinking of the highest quality, along with models of it, has always been a major concern of the


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Schiller Institute since its founding. Many Schiller Institute publications have carried articles on the rediscovery of great scientific discoveries, the identification of new "junctions" or "forks in the road" in the history of science. This makes it possible for us to re-examine truths that were taken for granted. It inspires us to be interested in them, jolting us to think about questions that were supposedly "closed" and "solved" once and for all. I would like to note the political importance of these writings, as well as their tremendous scientific and socio-cultural significance: These publications show that theoretical thinking and theoretical knowledge are possible today, that there is demand for them, despite all the brutal social destruction that has occurred.

But what I would like to emphasize, is the importance of these writings for education. Their authors identify immortal examples, in the history of world culture, of the work of the mind. If we turn to these models, and study them, we can create a culture of theoretical thinking at the highest level, in ourselves and our children.

Our Pedagogical Work in Russia

3. There are few people today, who consciously adopt such a great task, but there are some. I myself represent a part of the education community in Moscow, which is working just as actively as the Schiller Institute on the problem of preserving a culture of theoretical thinking in modern society. The scientific team I belong to—the Regional Policy Center for Education, under the Russian Academy of Education—has developed and tested during the past 15 years, an approach to working with knowledge, on the basis of developing theoretical principles of thinking in children of various ages. We have created special, non-traditional subjects—metasubjects, which make it possible to work simultaneously on two levels: on the subject level (i.e., the level of the material for study) and the supra-subject level (i.e., the level of thinking itself—various concepts, schemes, models, as well as various thought techniques and capabilities).

One such non-traditional subject is the metasubject called Knowledge, which is built on the material of several subjects at once—biology, physics, literature, mathematics, history, etc. The main task of this metasubject is to teach the pupils the principles, according to which knowledge itself is organized and lives: knowledge as such, independent of the various subject forms in which it may be manifested. Knowledge is captured thinking, a captured thought.

If we wish to teach living knowledge, we need to show how and under what circumstances it was developed; what models of thinking it is based on, and so forth. This cannot be done, using textbook material alone, without reflecting the basis on which it was put together. We have to deliberately teach children the principles, techniques, and methods of theoretical thinking itself (and, not only theoretical), which we encounter as "cast" or "imprinted" in the form of specific knowledge, but which are not identical to those "imprints." We identify various techniques, such as a technique for working with conceptual distinctions, a schematization technique, a modelling technique, a technique for concept-formation, a technique for constructing theoretical concepts, etc. In the classes at our experimental school, we

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try to teach the pupils these techniques, thus shaping the relevant thinking and anthropological capabilities.

The Principle of Paradox

4. One of the most important thought principles which we use in our pedagogical work with schoolchildren, is the principle of paradox. Working with paradoxes is extraordinarily productive from the standpoint of drawing the student into the process of the genesis of theoretical knowledge. Let me remind you, that members of the Schiller Institute constantly employ this principle in their scientific and theoretical studies. Often this is precisely how they make real discoveries.

What is the secret? A paradox, as a rule, is built upon the interaction of two, mutually exclusive principles: *A* and *not-A.* The paradoxicality is rooted in this collision: The same question can be viewed both from the standpoint of *A,* and from the standpoint of *not-A.* As long as you are within the framework of one of these logics, either *A* or *not-A,* no paradox arises. The paradox arises only when you put them together, and see that, although each of them appears to be internally true and consistent, when they are taken together at the same time, they destroy each other, losing their absolute truth. There can be only one way out of this heart-rending tension: the discovery of some third link, a level at which the two logics—*A,* and *not-A* that negates it—can be reconciled. This third level, *B,* can be viewed in our epistemological context as a new thought-foundation, to which fundamentally new knowledge will be hitched.

Zeno identified the epistemological creativity of paradox. Plato, in his dialogues on diverse questions, demonstrated the universal force of paradox: its methodological power and, at the same time, its formative force, which makes any interlocutor think; it is capable of setting any form of thinking and any mind, even the most inert, into motion.

In our pedagogical experiments, we employ paradox as a didactic, as well as a methodological, principle of work. We incorporate paradox into the content of the lessons, while simultaneously using it as a way of interacting with the children, regarding the content being conveyed to them. As a result, we arm our pupils with paradox, as a basic methodological work tool, and enable them independently to reread history and rediscover fundamental discoveries.

5. Now I would like to give three examples from our educational program, to show how we use the principle of paradox in our work.

The Theory of Electromagnetism

5.1. For the first example, I would like briefly to show how the principle of paradox may be used to introduce students to the genesis of the theory of electromagnetism.

> **Each of us has to make a tough choice of world-view: either to fight for vital, personal knowledge in society, or to begin to live by the laws of the information and Internet culture.**

As a rule, Russian schoolchildren learn about electromagnetism by studying and memorizing information from textbooks on the experiments and theoretical approaches of Coulomb, Oersted, Ampère, Faraday, and Maxwell. They usually don't get into the question of why one theoretical approach was replaced by the next. The majority of pupils remain in the dark about why Coulomb thought that electricity and magnetism were different phenomena, while Ampère concluded that both of them were current, and that the nature of magnetism was identical to the nature of electricity. How did Ampère get the idea of his famous experiment with the two conductors, which can attract and repel each other? How did he come up with a fundamental notion like "magnetic atom," and why did physicists have to reject it, later on? Why did thinking through Faraday's experiments, alongside the notion of "magnetic atom," lead to proposal of the notion of "electromagnetic field," which transformed the previous idea? On what is the idea of the field based? What is its meaning? Couldn't we return to Ampère's original notions—"molecular current" and "magnetic atom"—and throw out the notion "electromagnetic field" as unnecessary?

Jonathan Tennenbaum has a very interesting discussion of the emergence of the theory of electromagnetism in his article, "Fresnels und Ampères wissenschaftliche Revolution," where he reconstructs the ideas in which the conceptual opposition of Coulomb and Ampère was grounded. We, in turn, introduce our students to this opposition (the way Dr. Tennenbaum himself did it, only without the help of a teacher), and make them take sides between Coulomb and Ampère, by formulating the following paradox: Does the nature of magnetism differ from that of electricity (as Coulomb believed), or are they identical (as Ampère thought)? Wrestling with this paradox, taking the side now of Coulomb, and now of Ampère, our students try to design experiments themselves, in order to validate each side. They themselves get into the generation of fundamental notions. They imitate, they reproduce each scientist's way of thinking, then reflect on the limitations of each. The result is that they master several important techniques and ways of theoretical thinking, namely, the technique of constructing notions, the technique of modelling, etc., which they can then apply not only in their physics class, but in other classes, because these techniques are universal. Another outcome is that the children themselves become interested in learning what will ultimately enable them to solve the paradox. In this process of discovery, they make very interesting attempts and propose interesting answers, which show us that the pathway of scientific development from milestone to milestone, as it is presented in the textbooks, has not been cut in stone, but might well have been taken in some other direction.

Conceptions of Space and Time

5.2. The second example is our experience in working with seventh-graders on Lewis Carroll's *Alice in Wonderland.* Using a number of episodes from this book, we introduce students to the conceptualization of such fundamental notions as space and time, which, of course, underlie the entire body of knowledge in the natural sciences. In high school, students are taught Euclidean geometry, which makes them begin to see the world through Euclidean space. (It is noteworthy that the regular seventh-grade geometry course does not include conceptualization of the notion of space, although the introduction to geometry takes place through and on the basis of that notion.)

Remember the basic characteristics of Euclidean space:

"It is infinite;
it is limitless;
it is homogeneous;
it is isotropic;
it is connected;
it is well-defined;
it is three-dimensional;
it has a constant curvature, equal to zero."[1]

One of our tasks was to show that the space of Euclidean geometry is not the only possible geometrical space. And, moreover, that an entirely different notion of space might be the basis for other theoretical realities (such as physical reality, for example). Carroll's "Wonderland" came in handy, because it is constructed in non-Euclidean space.

(I described this part of our course work for the Knowledge metasubject in my article "Lessons in Knowledge with *Alice in Wonderland*," for the forthcoming issue of *Ibykus.* Therefore I shall just touch on one aspect of it here.)

We selected the famous episode from *Alice in Wonderland,* about the polarized mushroom. The caterpillar offers Alice a bite of the mushroom, telling her that if she bites from one side, she'll become very big, but by biting on the other side, she'll shrink.

We propose the following thought experiment to our students. We ask them: "What if you put one of the cakes from another part of Wonderland on top of the mushroom? Will it grow? Shrink? Neither?" (It's hard to find a simple answer in the book, since cakes in various parts of Wonderland behave differently. In the preceding chapter, when Alice ate a cake in the Rabbit's house, she shrank, but when she went down the hole at the beginning of the story, she grew.) "What will happen to a bottle of liquid, if we put it on top of the mushroom? Will it grow, or shrink?" (Again, there are various answers in the story: At the beginning of her journey, Alice shrank when she drank from a bottle, but when she drank from the same bottle in the Rabbit's house, she grew.) "What will happen to the mushroom, if we put it on a glass table in the Rabbit's burrow? Will it still expand things with one of its sides and shrink them with the other, or will it only expand things? Or, only shrink them? How will the mushroom behave in the White Rabbit's house?" And so forth.

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In order to answer these questions, the students are forced to experiment. They mentally move the cake or the bottle over the mushroom, or alongside the mushroom; they move the cake and the bottle from left to right and right to left, then they begin to move the mushroom itself around Wonderland, trying to discern a lawful pattern in the appearance of its enlarging or shrinking capabilities.

Our purpose in launching this group game was to get the students to move from the organization of the mushroom, the bottle filled with liquid, and the cake, to a discussion of the organization of the space itself, in which polarized mushrooms, bottles, or cakes are possible.

In the course of this thought experimentation, we planned to uncover the various visions of the spatial organization of the world, existing in the class, and to have them collide with each other. For the students, it was to be a situation of conceptual self-definition, with respect to the various offered principles and models of the world's spatial organization. The final result should be the birth of a notion, or notions, of space.

Two positions emerged in the class: those who thought that space was homogeneous and isotropic (nothing happened to the bottle or the cake when it came alongside the mushroom), and those who thought the opposite. A battle of worldviews began between the two groups in the class. The majority, which was the first group, was really determined by its own Euclidean concept of space. In combat with that group, the second, smaller section of the class was able, through its consistently opposing thought, to reveal to all of us another principle of the organization of space, which is not presented in geometry textbooks, but on which many scientific discoveries were based, and which continues to make scientific discoveries possible—the principle of the heterogeneity and anisotropy of space.

Gravitation

5.3. Lastly, I would like to show you a third piece of our work. It is an attempt to introduce students to the field of questions having to do with gravitation, and to help them see that Newton's approach to this question was by no means the only one.

The terrain of the thought battle here could be defined as follows: Gravitation is a property of bodies (Newton) vs. gravitation is a property of curved space (Einstein, LaRouche).

My textbook for the metasubject Knowledge includes a translation of a chapter from LaRouche's book, *In Defense of Common Sense,* titled "How Newton Parodied Kepler's Discovery." In this chapter, LaRouche smashes the Newtonian approach to gravitation. After studying this critique, as well as Hegel's critique of Newton in the *Science of Logic,* the students were supposed to decide what gravitation means for them. Does it exist? And who is right, Newton, or LaRouche?

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1. Pavel Florensky, "The Absolute Nature of Space," *Collected Works* (Moscow, 2000), p. 200.

The children, brought up on Newton's formulas, at first took his side, and tried for two months to refute Mr. LaRouche. But the more they tried to refute it, the more and more comprehensible and interesting the critique became. In the course of things, they had to solve a number of problems, to convince themselves that Newton's approach really was close to the truth and could be applied. But they didn't yet manage to solve several problems, which would refute Newton's approach.

The traces of this battle are presented in a letter, which our students wrote to Mr. LaRouche. Please allow me to read it to you:

"Dear Mr. LaRouche,

"We are students at Moscow school No. 1314. In the Knowledge metasubject, taught at our school, we learn how to deal with open, "undiscovered" problems, i.e., problems that have not been solved by mankind. A problem means a question that has no means for its solution and arises in a multipositional environment. One of the problems we have dealt with in the Knowledge metasubject is the question of gravitation, which is also an open question, because there are different positions (points of view) on this problem: your position, that of Newton, Kepler, Hegel, etc., and nobody knows for sure, which of the positions is true. It is very difficult to take a position that casts doubt on the truth of Newton's position, although such positions definitely exist, such as your position or Einstein's. That is why it is a matter of great importance for us to understand your position on gravitation, because of the prevalent delusion on this question (that Newton's position is the only one that exists and is, therefore, true); therefore, it is very difficult, and very important, to obtain real knowledge, rather than just information, about this question.

"During our work we often came to the conclusion that we share this common delusion.

"At the outset, we discovered that any position of our own on this question has been replaced by Newton's, and that we don't understand the phenomena of gravitation, but merely believe Newton's explanation. At this stage, our delusion was eliminated, when we were asked to explain the phenomenon of weightlessness (in a spaceship or in a falling elevator), using the knowledge about universal gravitation obtained by Newton. We could not do this, so we had to conclude that this knowledge does not belong to us because we cannot use it. Next, while trying to reconstruct the position of Newton himself (not just what is presented as that in various encyclopedias), using your critique of him (given in the chapter 'How Newton Parodied Kepler' in our Knowledge metasubject textbook), we could not understand the foundation of your critique, because we thought that the work of a physicist always included the use of formulas. So our reconstruction of the physical way of thinking was wrong: We didn't take note of the difference between physical and mathematical ways of thinking. We tried to assert that Newton had thought and acted as a physicist, because he had used models (such as the parallelogram). The physicist who was working with us, however, criticized this understanding. We had to reconstruct the physical way of thinking and action, which is impossible without designing and carrying out experiments. At this stage, we are supposed to distinguish between a physical experiment and a test. A physical experiment is a mentally designed situation, in which one can determine the validity or invalidity of some physical model. The model is used to predict the phenomenon, which will occur in the experiment. If the prognosis coincides with reality, then the model is assumed to have been experimentally validated; if not, the experiment determines that it is problematic. A test is part of any physical experiment and includes actions and measurements, which are necessary for conducting the experiment.

"Thus, we tried to solve certain questions, in order to test the universality of the law of gravitation. We discovered that Newton's law works in cases of weightlessness, but in some cases it does not work, e.g., in the case of Mercury, the orbit of which changes with time, and this change cannot be explained by the gravitational attraction of other planets. If we act in Newton's paradigm, we have to suppose that the orbit of the planet changes because its velocity changes. But if the velocity changes, that means that some force has acted. But it is unclear why this force does not act on any other planet, except for Mercury, from which it should be supposed that Newton's law of gravitation is not universal.

"But our doubts about Newton's position on gravitation do not make clear for us your own position on this subject. You oppose the correctness of the Newtonian relationship $1/r^2$. You write that Newton just gave a mathematical restatement of Kepler's laws. You oppose his way of work, but you don't write a word about the correctness of Kepler's laws. We suppose that means you agree with Kepler. Otherwise, your critique would be just a reproach against a clumsy mathematician, who had tried to so something for which he wasn't competent. We should be grateful for your assessment of the accuracy of our reconstruction of your position.

"The main question is: What is your own concept of gravitation? After reading the fragment of your article 'How Newton Parodied Kepler,' in the textbook *Metasubject: Knowledge,* this concept is still unclear for us. If it coincides with Newton's, and you are merely criticizing his method of work, then we are very disappointed in your work. We think that it is absolutely uninteresting from the standpoint of science, albeit entertaining from the standpoint of the history of science, and the history of human delusions."

I hope very much, that Mr. LaRouche will be able to reply to this letter, and that we shall continue to work with our schoolchildren on his approach to gravitation.

6. In conclusion, I would like again to emphasize that the cultivation of the value of theoretical thinking, under conditions where mass-media technologies are aggressively influencing our minds, is of utmost urgency. It is just as necessary to unite our efforts in this endeavor, as for the solution of other problems that remain to be solved.

—N.V. Gromyko