Seymour Papert and Us: Constructionism as the Educational Philosophy of the 21st Century

In memoriam Seymour Papert (February 29, 1928, Pretoria, South Africa — July 31, 2016, Blue Hill, Maine, USA)

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Abstract

Seymour Papert — a major philosopher of education, a great educator of the modern age, and the father of constructionism — passed away in the summer of 2016. The floor and screen turtles he added to the Logo programming language helped to visualize and objectify processes as well as to make programming more concise. As a result, Logo developed into a unique environment that millions of children in dozens of countries use today to learn algorithmic (or computational) thinking. Professor Seymour Papert visited the Soviet Union and Russia several times. He played a key role in the development of the philosophy of education of the post-Soviet school. The present article describes a number of key ideas and milestones associated with the development of Papert's education philosophy, the implementation of his education conception in Russia, his visits to Russia, and his meetings with Russian educators, many of which were attended by the author.

Keywords

philosophy of education, constructionism, mathetics, Logo, international cooperation in education

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I would like to thank all the people who helped me with this text and especially L. Bosova, S. Soprunov and V. Uspensky. I am grateful to I. Froumin for supporting its publication in *Educational Studies*. My special thanks go to all those who preserved Andrey Ershov's archive and made it available on the Internet. I should also take advantage of this opportunity to honor Dr. Ershov's wise decision to retain all these documents.

The most serious and extensive practical result of Seymour Papert's work may well be the changes that have already occurred, are occurring and will continue to occur in Russian schools.

1. Background. Perestroika. School Interim Scientific and Technical Group

Mikhail Gorbachev became General Secretary of the Central Committee of the Soviet Communist Party on March 11, 1985. On March 28 of the same year, the Central Committee of the Soviet Communist Party and the Soviet Council of Ministers promulgated Resolution #271 "On Measures for Assuring the Computer Literacy of Secondary School Students and the Broad Introduction of Computer Technologies into the Study Process."[1] The list of organizations responsible for executing the decree included the Soviet Academy of Sciences, while the Academy's Vice-President and Gorbachev's adviser Evgeny Velikhov was charged with overseeing its implementation at the Academy. In accordance with the Resolution, the subject "Basics of Informatics and Computer Technologies" began to be taught at all Soviet schools in the fall of the same year. The initiator and ideologist of this subject (and of the whole resolution) was Andrey Ershov, who coined the slogan "programming is the second literacy" [Ershov, 1981]. I was the organizer and a member of the team of authors (A. Ershov, A. Kushnirenko, G. Lebedev, A. Semenov and A. Shen, all alumni of the Faculty of Mechanics and Mathematics of Moscow State University) that wrote the first informatics textbook, which was published the same year (1985) in a print run of millions of copies (the decision to create this team of authors was taken by Andrey Ershov on April 1, 1985). Nevertheless, the introduction of the new subject was only the first step. A much bigger and much more complicated task was the informatization of the education process (referred to as "broad introduction" in the decree). Moreover, it was becoming increasingly clear that informatization was no more than a tool and an element of the reform of school education in the country.

In November 1985, Reagan and Gorbachev met in Geneva. Velikhov was a member of the Soviet delegation. It became clear to him at the time that school reform would require major international (including US-Russian) cooperation.

The next year, the School Interim Scientific and Technical Group was established under E. Velikhov's leadership; I was appointed its deputy director.[2] The group members came from research institutes, universities, and industry. The group's activities were overseen by Al-

[1] Resolution #217 of the Central Committee of the Communist Party of the USSR and the Council of Ministers of the USSR of March 28, 1985, "On Measures for Assuring the Computer Literacy of Secondary School Students and the Broad Introduction of Computer Technologies into the Study Process" in *Educational Studies Moscow*, **3**, 2005, pp. 341-346 (in Russian).

[2] Resolution of the Academy of Sciences of the USSR, the State Committee of Science and Technology of the USSR, and the Ministry of Education of the USSR

exander Uvarov, Head of Informatization at the Ministry of Education. We got support for our activities at the Academy of Sciences from Yuri Vishnyakov, head of the Department of Computing Technologies of the Presidium of the Academy of Sciences and academic secretary of the Section of Informatics, Computing Technology and Automation, headed by Velikhov.

One of the main elements of the new school model was the participation of students in research and creative activities (similar to the work of scientists and engineers) with the support of teachers. We also believed that it was essential to use information and communication technologies (ICT) in all aspects of school life.

2. Papert in Sofia. Meeting

It was the year 1987. The USSR began to open itself up to the world, albeit only through "socialist countries" for the moment. The Second International Conference "Children in the Information Age: Opportunities for Creativity, Innovation and New Activities" took place in Sofia, Bulgaria, on May 19-23, 1987 [Sendov, Stanchev, 1988]. Held under the aegis of the Lyudmila Zhivkova International Foundation (daughter of the country's leader Todor Zhivkov, Lyudmila had died at an early age), the conference was organized by Academician Blagovest Sendov, a mathematician who filled different positions during his lifetime, including Rector of the University of Sofia, President of the Bulgarian Academy of Sciences, and Minister of Education. At that time, he was most likely Vice President of the Academy of Sciences. He gave a dinner party, to which he invited twenty or so people, as I recall. At table, I sat next to Seymour Papert.[3]

That's how we met. I had previously read Papert's articles on automata theory (this was one of the principal topics that I had worked on as a mathematician from 1970 on) and his book *Perceptrons* [Minsky, Papert, 1969] — in preceding decades, I had taken part in the work of an artificial intelligence group headed by Dmitry Pospelov and my mother Evgenia Semenova. (In 1954-1958, Papert studied mathematics at Cambridge, where he defended a thesis on lattice theory; he apparently began to work on automata theory and artificial intelligence after moving to the USA.) During the dinner, Seymour told me about a school where children made bread themselves beginning with the grain — there was nothing surprising about it for him. This story and his way of telling it, as well as many of the other things he said, made a big impression on me. Fifteen years later, my children would grind flour and bake bread in Anatoly Pinsky's Waldorf School in Moscow.

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of November 20, 1986, "On the Establishment of the School-1 Interim Group," signed by G. Marchuk, A. Aleksandrov and S. Shcherbakov.

[3] A video about the preceding period of Seymour's activities is available here: https://www.youtube.com/watch?v=bOf4EMN6-XA.

The next day, Papert gave the keynote talk. In the archive of Academician Andrey Ershov, there is a photo of Papert during this talk.[4] I was sitting in the front row and noticed that Papert was standing on one foot. The talk made a big impression on me, and I fell asleep almost at once, as it always happens to me at interesting talks when I am even slightly sleepy, and woke up only towards the end. Papert was still standing on one foot.

3. Constructionism

The content of Papert's talk at the conference "Children in the Information Age" is echoed by his article "A Critique of Technocentrism in Thinking about the School of the Future" [Papert, 1990], which I shall therefore take as the starting point of my description of his thinking. Papert notes that, while education currently lies at the periphery of political discussions and teacher training is at the periphery of university education, things must change in the new information society. Today, learning is becoming a key form of human activity. A country's international competitiveness is increasingly dependent on the effective use of computers and ICT in general in the learning process.

In the first part of the paper, Papert sets out the key oppositions: a child developing — a child acquiring knowledge from the curriculum, a child learning — a child being taught in school, a child expanding his opportunities through independent activity that makes use of the tools of the activity — a child being taught something with the help of a machine. Referring to Jean Piaget and Ivan Illich, Seymour voices his preference for the first element in each opposition. He says that such types of oppositions have existed for a long time and that computers have only exacerbated them.

The second theme of Seymour's paper refers to what he calls the "scientistic" approach to education research. In an education study, one usually proposes an innovation and uses statistical methods to show that it is useful. According to Papert, such an approach works only if you change a child's learning a little. If you radically change the goals and methods of education, this approach becomes meaningless and ineffective in particularly important situations. The latter require a holistic approach to education and education reform. Here Papert speaks about Logo, a language for the interaction between a child and a computer that includes different tools, especially drawing tools. "One does not introduce Logo into a classroom and then do everything else as if it were not there.… Logo is an instrument designed to help change the way you talk about and think about mathematics and writing and the relationship between them, the way you talk about learning, and even the relationships among the people in the school — between the children and the teacher and among the children them-

[4] Archive of Academician A.P. Ershov. Folder 458, f. 91/7. http://ershov-arc.iis.nsk.su/archive/eaimage.asp?did=3097&fileid=84035.

selves." "It is important to realize that the scope of these changes could rival those we have seen in transportation, in communications, and in medicine. We used to move around on foot or on horseback; now we go by jet plane." Papert asks about the extent to which technology shapes people's thinking and communication and about the extent of the inverse process, citing Marx: "Does the material determine the idea? Or does the idea determine the material?" L. Vygotsky followed a similar path, which eventually led to his wonderful lecture "On the Instrumental Method in Psychology" [Vygotsky, 1982].

Seymour gives one of his famous examples in the paper. Computers had become commonplace in his principal experimental school in a poor area of Boston. The biology teacher began a new topic: anatomy. In previous years, she had invited children to draw in their notebooks one of the human bones whose models were on display in the classroom. This time, she invited them to do the same thing yet with the help of a computer. As it turned out, all children decided to draw a whole skeleton instead of a single bone, and many of them formed groups in which each child drew a separate part of the skeleton. In other words, they decided to do something that they had not been told and, secondly, they organized into groups for teamwork and the division of labor. Thirdly, as Papert notes, the teacher did not have to motivate the children — on the contrary, she eventually had to cut short their work on the skeletons. Finally, it is important that the children did something that they enjoyed, and each of them did something different. Seymour constantly used the skeleton story along with other real and imaginary examples to explain important general concepts.

The most important general concept for Papert was "constructionism." The word and notion of constructionism is linked to the "constructivism" of Jean Piaget, Seymour's famous teacher in the field of education psychology. Seymour studied and worked with him in Geneva in 1958-1963 after completing his mathematics studies. Piaget argued that learning is not about simply transferring something from the teacher's head to the child's head — for example, in the form of a lecture. Learning always requires pupils to construct their own knowledge. While people (teachers, other pupils) and material objects (books, instruments) can be helpful or even essential for such construction, a person always constructs his knowledge himself. This is the idea behind Piaget's constructivism. Papert's notion of constructionism stresses that an important element of learning or the pupil's construction of his own knowledge is the pupil's creation of something outside his head. This "something" must be important for its creator — it would be great if he developed an affinity for it and good if it were interesting for others. In such construction, the computer, the Logo language or LEGO building blocks may play an important role, yet the meaning of the activity lies not in them but in what the child creates

with their help in the surrounding world and in his own self. The tools become "invisible."

The principle of *fabricando fabricamur* ("by creating, we create ourselves") had already been instilled by John Amos Comenius in his time. Piaget made it more concrete in his notion — it is no coincidence that he mentions this principle in his article on Comenius [Piaget, 1993]. Papert underlined the importance of the result. One can say that he launched the "mover movement" in education. In our opinion, one of the most fruitful subsequent developments of this theme is the work of Professor Wassilios E. Fthenakis from the GDR,[5] who began to speak about co-construction and co-constructionism, stressing the role of others in jointly building knowledge [Fthenakis, 2015]. Of course, we also see here the development of Vygotsky's ideas.

In the conclusion of his talk at the conference "Children in the Information Age," Seymour recounted his visit the day before to a Bulgarian school where computers were widely used. There the children showed him their work and then asked him if he could give them an interview. One of the questions they asked Papert went as follows: "Do children anywhere else have such a great teacher as we do?" The question made such a big impression on Seymour that he did not know what to say but only thought, "Isn't that wonderful? There was something about the kind of work they were doing that made them feel this way about their teacher. Of course, their teacher is a wonderful person, but we can create educational environments that bring out the love for the teacher and the love for everyone else there. If you love what you learn, you'll get to love yourself more. And that has to be the goal of education, that each individual will come out with a sense of personal self-respect, empowerment, and love for oneself, because from that grow all the other loves: for people, for knowledge, for the society in which you live." In the paper based on this talk, Papert cited Einstein's words, "Love is a better master than duty."[6]

After the conference session was over, I managed to continue my conversation with Papert, which allowed me to get acquainted with constructionism. As it turned out, I was already familiar with it from my studies at the Konstantinov School,[7] although I had never called it by its name. However, this did not make the "shift of paradigm" any less profound. I saw the light and understood the generality and veracity of ideas that I had known only from examples as well as of ideas of which I had not even had an inkling. Our conversation continued in a Japanese restaurant. Papert took an interest in what was happening in the Soviet school with regard both to computers and informatics

[5] http://www.fthenakis.de/c2/

[6] This was said about music lessons. Cf. http://library303.narod.ru/third/rebirth117.html.

[7] For more information on N. Konstantinov, see, for example, http://www.mccme.ru/head/news/konst80.htm.

and to the Perestroika taking place in the country. He was no stranger to politics, as he had grown up and done his studies in South Africa in the mid-20th century, participating in anti-government sociopolitical movements.

4. Logo and LEGO

During the period in question (the late 1980s), the Logo programming language was quickly becoming popular in Bulgaria — in particular, thanks to the work of the Research Group on Education headed by Blagovest Sendov. (This group and its interaction with the School Interim Scientific and Technical Group are a subject in its own right.) In the USSR, Logo (in its French version) became available to Ershov in Novosibirsk in 1985 along with French Thomson computers, and Yuri Pervin [2005] devoted a lot of time and effort to learning and diffusing the language. The development and popularity of the French version of Logo was most likely the result of Papert's work in France, where he established the Center of Informatics and Development in 1981–1983.

Papert is often considered to be the father of Logo. This is true to some extent, yet it would be more correct to call him its godfather.[8] Let me say a few words about what I heard from Seymour, Wally Feurzeig and other participants in this story.

Logo had been developed twenty years before the conference in Sofia by the staff of BBN Technologies, Inc., which had been founded by the MIT faculty members Richard Bolt and Leo Beranek and the MIT alumnus Robert Newman. The abbreviation BBN was quite familiar to me, as I had participated as a school and college student in the implementation of the Lisp programming language in its specific version BBN-LISP on the Soviet computers of the time (M-220 and others). In addition, BBN Technologies played a key role in the development of computer communications, the Internet, acoustics (including military acoustics), and other fields. In 1967, the Lisp language was used by BBN Technologies personnel Daniel G. Bobrow, Wallace (Wally) Feurzeig and Cynthia Solomon with the participation of Papert for creating the "children's" programming language Logo. The name "Logo" (from the Greek word λόγος) emphasized the non-numerical nature of the activities for which the language was created (just as the Lisp language). Seymour Papert added to Logo the computer-controlled turtle on the floor and on the screen. This helped to materialize and visualize processes and make the programming results more meaningful, turning Logo into a wonderful environment for learning algorithmic thinking for millions of children around the world.

In subsequent decades, computers with the Logo environment became points of development for the constructionism movement in education systems all over the world. Today, the Logo community con-

[8] See Cynthia Solomon's account: http://logothings.wikispaces.com/.

tinues to serve as a unique example of the unification of hundreds of thousands of people from dozens of countries around a common education philosophy and a "shared language" of activity. Of course, such a language must be developed and supported. Naturally, this could not have been done by the BBN Corporation with its enormous military contracts or by Papert's group at MIT (we will describe it in greater detail below). This task was undertaken by the Canadian company LCSI (Logo Computer Systems, Inc.) founded in 1980 in Montreal by Papert and several of his MIT colleagues. For twenty years, Seymour was Chairman of the Board of this company. The Boston group of developers was headed by Cynthia Solomon, while Michael Tempel was in charge of education support. Subsequently, Papert's student Brian Silverman, a brilliant mathematician and programmer, became the company's ideologist (he left LCSI a few years ago), and Michael A. Quin was appointed as its business motor. In the same year, Seymour published his famous book *Mindstorms: Children, Computers, and Powerful Ideas* [Papert, 1980] that was subsequently translated into dozens of languages. The book presented Logo as a tool for children's development and self-expression. The language became popular all over the world. For example, British primary school standards mention Logo as an activity environment for primary school.

Even a brief description of the education philosophy of constructionism makes it clear that LEGO building blocks (as well as some other children's construction toys) are useful for implementing this approach. At the beginning of the Logo story, Seymour initiated the design of a "real" turtle that could move around on the floor under the control of a computer. In the mid-1980s, Seymour got in contact with the director of the Danish company LEGO. Mitchel Resnick and Steve Ocko, who were working in Papert's group at MIT, created an interface between Logo and different LEGO elements such as motors, lamps and sensors. This is how LEGO TC Logo appeared. The participation of Papert and his colleagues from the MIT group in developing the philosophy of "educational LEGO" and implementing "computer LEGO" led to the creation of the position of LEGO Professor at MIT MediaLab. It was first filled by Papert, who then passed it to Mitch Resnick (Mitch is now the LEGO-Papert Professor of Learning Research). In 1985, LCSI released LogoWriter: a word processor was integrated into Logo to provide the child with an important tool of cognitive activity. Many different turtles appeared, and they could take on various forms, providing new possibilities of animation and allowing each turtle to behave in an individual manner. In 1993, LCSI released a brand new version of Logo called MicroWorlds. The term "micro worlds" was already being used in Soviet school informatics on a large scale, as our friends in the USA and Canada undoubtedly knew. However, they, too, had most likely used this word and concept before. MicroWorlds made use of all the principal tools for creating children's multimedia

projects that existed at the time. The turtle learned to assume different forms. Moreover, parallel processes became possible. At about the same time, the LEGO Programmable Brick was created at MIT. A program could be written on a computer and loaded into the brick via a wireless channel. The LEGO Company made use of it to create the product LEGO Mindstorms. In 1994, Mitch Resnick developed StarLogo, in which thousands of turtles could act and interact simultaneously [Resnick, 1994]. In 2004, the Logo principles were implemented in the Scratch environment[9] by the Lifelong Kindergarten group headed by Resnick at MIT MediaLab. In subsequent years, Scratch would supplant Logo in many schools.

5. Seymour at MIT. MediaLab

Let us go several more decades back into the past.

In 1960, while he was still working with Piaget, Papert met Marvin Minsky at a cybernetics conference in London. Minsky was one of the founders of the artificial intelligence group at MIT.[10] This marked the start of their close work together, which brought Papert to MIT. As he recalled, "In 1964, I moved from one world to another. For the previous five years, I had lived in Alpine villages near Geneva, Switzerland, where I worked with Jean Piaget. The focus of my attention was on children, on the nature of thinking, and on how children become thinkers. I moved to MIT into an urban world of cybernetics and computers. My attention was still focused on the nature of thinking, but now my immediate concerns were with the problem of artificial Intelligence."[11]

In 1967, Papert became co-director of the Computer Science and Artificial Intelligence Laboratory (CSAIL) at MIT. Seymour remained very close to Marvin in subsequent years, despite the fact that they were totally different people. For example, Papert's apartment was, I would say, quite minimalistic, while Minsky's house resembled a museum of sorts: a huge stuffed crocodile, an organ… (Their hairstyles were the exact opposite.) In 1969, they coauthored the book *Perceptrons* [Minsky, Papert, 1969]. Today, the field of study that continues the philosophy of *Perceptrons* has become one of the foundations of the new technological revolution involving neural networks and machine learning.

In 1968, Seymour met Alan Key and introduced him to the ideas of Piaget, Bruner and Vygotsky, the education philosophy of constructionism, and the Logo language. Their friendship continued for many years, just as Alan's interest in education. As one knows, Alan pro-

[9] https://scratch.mit.edu

[10] Marvin Minsky (August 9, 1927 — January 24, 2016). I first became acquainted with Minsky when I read the Russian translation of his 1967 book *Computation: Finite and Infinite Machines* (Englewood: Prentice-Hall). In my opinion, this is one of the best introductions to mathematical computer science, at least in its time.

[11] Seymour Papert, *Mindstorms: Children, Computers and Powerful Ideas.* New York: Basic Books, 1980, p. 280.

posed many approaches and solutions that shaped the modern computer world, including the Dynabook (1971), whose graphic interface opened the way to the Mac, Windows, notebooks and tablets and influenced their design.

In 1985, Seymour's main place of work where he implemented his ideas shifted to MIT MediaLab, which had been founded that year by Nicholas Negroponte and Jerome B. Wiesner. Seymour was also a co-founder of MediaLab, where he headed the Epistemology and Learning Research Group. Today, the group, renamed the Lifelong Kindergarten Group, is headed by Papert's student Mitch Resnick. Wiesner served as President of MIT in 1971-1980 and continued to exert a major influence on it in subsequent years (before his presidency, he had held high-level positions in the US administration and key government programs; in a conversation with me, he recounted his memories of Kolmogorov). He invested a lot of effort into the creation of MediaLab; the building specially constructed for the latter now bears his and his wife's names. The lab's other founder Nicholas Negroponte[12] was an outstanding visionary and popularizer of scientific projects and results (13 of his talks have been posted in TED[13] since 1984, his book *Being Digital*[14] has been translated into numerous languages, etc.). He managed to launch and maintain a high level of commissions from businesses that completely assured the financing of the lab, which he headed from its foundation to 2000.

I have mentioned only a few people that worked with Seymour. In actual fact, a multitude of talented and energetic individuals gathered around Seymour's group and the Logo community. It is hard to speak about Seymour without mentioning the women that helped him and cared for him. For 28 years, everyday life at MediaLab was organized by Jacqueline Karaaslanyan, Director of Special Projects. Among her other work, she nurtured relations between MIT and Armenian programmers and education specialists and also put us in contact with them — in particular, with the wonderful Quant High School in Yerevan. Our first contacts with the MIT group were greatly facilitated by Sylvia Weir. Sherry Turkle,[15] a prominent psychologist, introduced us to the subtle and profound problems of human interaction in modern information society. Carol Sperry did a lot to help teachers in Russia and especially Lithuania. Idit Harel, a talented student of Papert, told us a lot of interesting things about mathematics in primary school. Edith Ackermann introduced us to the world of Piaget and constructivism "from the other side of the fence" [Ackermann, 2001]. Thanks to Marilyn Schaffer, a series of four seminars entitled "East-West by Invitation" was organized. The first two were held on river cruise ships trav-

[12] http://tech.mit.edu/V115/N47/negroponte.47n.html
[13] http://www.ted.com
[14] Cf. https://en.wikipedia.org/wiki/Being_Digital
[15] http://sherryturkle.com/about/

elling from Moscow to Saint Petersburg, the third (in Prague) began on the day of the coup d'état of August 21, 1991, and the fourth took place in Budapest in 1994. These seminars gave us many new contacts, ideas and friends.

6. Mathetics

Many of Papert's discoveries and observations seem to be simply the result of common sense. The same thing can be said about other outstanding results in the humanities and social sciences, such as Vygotsky's zone of proximal development. Thus it is all the more surprising that school education still ignores many of these common-sense principles.

A case in point is Papert's mathetics. Introducing the concept of mathetics, Seymour begins by referring to the great scholar and teacher John Amos Comenius. His book *Spicilegium didacticum* [Komenský, 1895], published posthumously in 1680,[16] consists of two parts: Mathetics and Didactics. Mathetics, according to Comenius and Papert, is the science, art, know-how and technology of learning. In contrast, didactics deals with teaching others.

In his 1993 book *The Children's Machine: Rethinking School in the Age of the Computer*, Papert notes that professionals totally disregard mathetics and learning in general as a key human process, preferring to focus on how one person teaches another, i.e., on didactics [Papert, 1993]. He compared this attitude with the way people during the Victorian Age passed sexuality over in silence in their thoughts and conversations. He asserted that today there is something of a taboo about discussing how exactly a person learns.

It was Papert that attracted my attention to Comenius's book, which we continue to study today. Comenius' ideas have turned out to be also extremely important for the reform of teacher training. Today, the majority of professors in teacher training colleges are still a lot more concerned about what they tell students than about what students assimilate, what they will do with this knowledge in school, and what pupils will get out if it [Bulin-Sokolova, Obukhov, Semenov, 2014].

7. Papert in Russia

While he was still in Sofia, Papert wrote to E. Velikhov, "Since seeing you at the Media Lab, I have been in Bulgaria where I have learned much more about educational and other movements on this side of the world. In fact I have the exciting sensation of a long conversation that began with you in the U.S. and has continued in Sofia with your colleagues, particularly Yershov, Semenov[17] and Uvarov as well as

[16] First edition: Comenii J. A. (1680), Spicilegium didacticum collectum et editum a C. V. N. Amstelodami.

[17] Part of our conversation with Papert is found in Ershov's archive: http://ershov-arc. iis.nsk.su/archive/eaindex.asp?did=38999

members of the Bulgarian Research Group on Education. I am writing this letter because I want to do everything possible to make sure that this very fruitful conversation does not stop."[18] Soon afterward, Papert with the help of his aforementioned Russian and Bulgarian colleagues drafted a proposal for the creation of an international research group.[19] Although this proposal was never fully implemented, Papert continued to take an interest in our work and participate in it for many years to come.

In December 1987, Seymour Papert came to Moscow at the invitation of the School Interim Scientific and Technical Group and gave a series of talks on the philosophy of education. He used LogoWriter as the implementation environment and illustration tool. His visit led to the integration of the ideas of constructionism into the education philosophy of the Interim Group.

The world continued to change, and, in February 1988, I took part in the Soviet-American Citizen Summit in the USA. The Soviet delegation included 100 prominent scholars, artists, politicians and religious figures. I asked the security officers accompanying our delegation to permit me to go to Boston for a few days. They let me go in the company of a "translator." We came to Boston, where we stayed at Seymour's place. This is how I first visited MediaLab, which, along with Technical Education Research Centers or TERC, another key education organization, later became a second professional home for me and my colleagues.

Seymour's next visit to Moscow took place in May 1988.[20] He subsequently came to Russia many more times.

In 1989, a group of colleagues from the School Interim Scientific and Technical Group (B. Berenfeld, V. Noskin and A. Semenov) founded the non-governmental Institute of New Technologies (INT), which, over the next couple of decades, became the principal center of research, development, experiment and practical work for implementing the ideas and diffusing the practice of constructionism in Russian schools.

The Institute continued the support of the Russian version of LogoWriter that the Interim Group had begun. This work was directed (and is still directed today for new computer environments) by Sergei Soprunov.[21] Of course, the institute's main task was to draft Russian texts and translate international works on Logo and elaborate projects for teachers and schoolchildren.[22] Naturally, other LCSI products

[18] http://ershov-arc.iis.nsk.su/archive/eaindex.asp?pplid=5106&did=42271

[19] http://ershov-arc.iis.nsk.su/archive/eaindex.asp?pplid=5106&did=27965

[20] Papert's letter to Ershov about Papert's work with the School Interim Scientific and Technical Group (in particular, at School #57) is available at http://ershov-rc.iis.nsk.su/archive/eaimage.asp?lang=1&did=38546&fileid=206979.

[21] Seymour Papert's interview to S. Soprunov in Moscow on February 16, 1998, is available at http://www.int-edu.ru/logo/texts/papert.html.

[22] For a list of works on Logo, see http://www.int-edu.ru/logo/books.html.

such as MicroWorlds and LEGO-Logo MindStorms were subsequently adapted for Russia, and Russian students successfully participated in the World Robot Olympiad and other events.

During certain periods, Logo products were apparently the most popular programs installed on school computers in Russia, not counting office applications. Without a doubt, most of them were pirate versions. Programmers from Soprunov's group took part in LCSI activities, so that Russians contributed to many of the company's products that were popular all over the world. In the early 1990s, the Institute also became the promoter of educational LEGO in Russian schools.

One of Papert's ideas that I proposed to Sergei Soprunov in the 1990s was the creation of a language that a child who could not yet read or write would be able to use while learning. Such a language was created under the name PervoLogo ("First Logo"). Seymour and LCSI supported its creation. In his book *The Connected Family* [Papert, 1996], Seymour mentioned it under the English name IconLogo. The later language Scratch Jr. may be considered to be a version of IconLogo.

In Russia, Seymour often met and talked with school and university teachers and software developers. He participated in the children's Computer Club that Stepan Pachikov and I had created in response to Garry Kasparov's initiative, which was supported by E. Velikhov. He visited the Zodiac Children's Club, and his autograph can still be seen on the wall of the TekhnoLogia Moscow Teacher's Club (or so I hope). In 1989, the Pedagogika Publishing House released the Russian translation of his best-known book *Mindstorms: Children, Computers, and Powerful Ideas* [Papert, 1980]. Although the translation has been severely criticized (it may well be worth making a new one), the book undoubtedly contributed a lot to spreading Papert's ideas in Russia.

The research work of Papert's group at MediaLab always focused on real children, real teachers and real schools. Let me give an example (from the early 1990s) of how this was done. Seymour organized one of his traditional training courses at MIT for teachers from different countries who took part in his projects. To begin with, all course participants were taught to dance the lambada, a new dance that was quickly gaining ground at the time. In the evening, everyone was invited to watch the 1987 American movie *Dirty Dancing*. The aim was to show course participants the importance of the emotional involvement of students for successful learning. Although the further agenda of the session naturally included the demonstration of new technologies, the main focus was on practical (constructionist) activities — constructing little cars and holding racing competitions, learning the basics of tying knots — and discussing them. Teachers from different countries and regions were invited to cook national dishes, and a competition was held to identify the spices used in the dishes (I won this competition :-)). My participation in this and other MediaLab learning sessions

as a trainer taught me a lot. When I subsequently became Rector of the Moscow Institute of Continuing Education for Educational Workers (later renamed the Moscow Institute of Open Education), my experience in these sessions gave me the strength and confidence to do things differently than they are usually done. Later, at the Moscow Pedagogical State University, we began the academic year with "learning immersion." I recalled Papert's lessons and how he taught. (He liked to cook, and one of the things he taught me was to peel garlic by first squashing the clove with the blade of a knife.) When students subsequently take practical classes, they learn to teach from their own experience — and this approach is also due to Papert [Bulin-Sokolova, Obukhov, Semenov, 2014].

Thanks to Papert, the Institute of New Technologies struck up ties with other education leaders and centers: Judah L. Schwartz at Harvard, Robert F. Tinker at TERC and the Concord Consortium. We also developed independent relations with William C. Norris (founder and former CEO of Control Data Corporation), Paul E. Resta (International Society for Technology in Education, ISTE), Sylvia Charp (THE Journal) and others.

Papert and our other American colleagues took a real interest in our results, including our approach to mathematics and computer education and our shift of emphasis from numerical mathematics to the mathematics of visual, symbolic and linguistic objects (in particular, the course "Mathematics and Language" that I developed together with Anna Polivanova and several of our younger colleagues — a direction in which we are continuing to work today).

As an acknowledgment of Russia's major role in the global process of the informatization of education, the UNESCO International Congress on Education and Informatics that was held in Moscow in 1996, and the UNESCO Institute for Information Technologies in Education was established in the Russian capital. A further result of the work of our group was the ICT in Education Prize that I received from UNESCO in 2009. Our joint work with UNESCO, in which our American colleagues also participated, developed in large part thanks to Evgeny Khvilon, who worked at the UNESCO Headquarters in Paris for many years, and Mariana Patru, who essentially supervised the entire area of ICT in education at UNESCO.

When Papert came to Moscow at the invitation of the Institute of New Technologies, he often visited Saint Petersburg, too. This city played a major role in his personal life. He married Suzanne Massie, a woman who was very attached to Saint Petersburg, with which her family was connected. As she recounted, "My mother, a young Swiss girl, was advised by doctors to change climate and go, for example, to Russia. She lived at the home of friends in Moscow and went every evening with them to the Bolshoi Theater, where they had seats in loge 8. Then World War I broke out, followed by your Revolution, and

she returned home only six years later. All her life, my mother said that Russia is a land of the heart. However, it wasn't romanticism but, as you know, misfortune that first brought me to Russia."[23] Suzanne's son had hemophilia, and she and her husband Robert Massie came to Russia to learn how Rasputin had treated Prince Alexis, who had had the same disease.

Massie wrote books about Russian history, Saint Petersburg and Pavlovsk, which became bestsellers on both sides of the ocean, and engaged in charity in Russia. From the mid-1990s, Seymour usually came to Russia together with Suzanne and often visited Saint Petersburg. He said that they had gotten married thanks to Russia. Seymour's memory is also cherished in Saint Petersburg, where his constructionist approach is still used.

8. Vietnam

One of the working formats of the International Commission on Mathematical Instruction (ICMI) was groups devoted to the study of key problems such as *ICMI Study 17: Digital Technologies and Mathematics Teaching and Learning: Rethinking the Terrain.* This group convened in Hanoi on December 3-8, 2006, under the chairmanship of Celia Hoyles, a leading British specialist on mathematics education and education technologies (today, she is one of the leaders of the constructionist movement), and Jean-Baptiste Lagrange, the main designer and developer of Cabri dynamic geometry software.

In early 2006, I told Seymour about the upcoming event (I was a member of the ICMI Executive Committee at the time). This subject was of interest to both of us: in our conversations, we often discussed the Russian traditions of mathematics education and the possibility of applying them to computers. Seymour decided to attend the group meeting. He was naturally invited to give the prestigious opening talk. His closest disciple Uri Wilensky accompanied him to Vietnam.

In Hanoi, we were awestruck by the cyclists on motor and regular bikes moving down the broad streets forty lanes or so in each direction — seemingly, without any traffic rules. After trying to cross the street a couple of times, I abandoned the idea, and we began to travel by taxi from and to the hotel, although it was only a short distance away by foot. I was probably saved by my experience in Russia, where cars did not yield to pedestrians at the time. In contrast, Americans had the stereotype that cars respect pedestrians. In the end, a tragic accident occurred: a cyclist ran into Seymour, who was walking together with Uri at the time. Papert was immediately brought to the best hospital in Vietnam. Clinton arrived soon afterward to organize medical assistance and bring Papert back to Boston in his private plane as soon as his condition permitted. Nevertheless, the best

[23] https://rg.ru/Anons/arc_2001/1120/hit.shtm

American doctors, the care of Seymour's family, and the attention of friends could not really alleviate the effects of the accident and make Seymour healthy and able to work again.

9. Papert's Impact

One of Papert's obituaries was called *Remembering Seymour Papert: Revolutionary Socialist and Father of A. I.* This title refers to Papert's political activism during his student years in his native country of South Africa and his work with Minsky on artificial intelligence. However, not everyone is aware of the great contribution that Seymour made to education.

What was Seymour Papert's actual impact on education all over the world? One of the indicators of his influence is the Internet newspaper *The Daily Papert*.[24] Once after a long discussion about current trends in international education (which apparently took place at a meeting of the TekhnoLogia Club in the Taganka district of Moscow, where the Institute of New Technologies was situated at the time), I asked Seymour, "What is the most important thing for implementing all the changes we are discussing?" After thinking for a moment, he answered, "The main thing is leadership."

Seymour was a thinker, prophet and leader. People listened to him, tried to understand him and attempted to follow him. Others did not take him seriously. The slogans of constructionism and other principles of humanistic education became the official credo of many education systems and were cited as clichés in conversations on education. They continue to be uttered by ministers, teachers, and businessmen who want to change things, such as German Gref and Alexander Kuleshov in Russia.

To what extent are Papert's views, experiments, projects, texts and talks determining the real development of education in the 21st century?

They uncover problems and make people discuss and think about them. It no longer goes without saying that children have to learn the multiplication table in school rather than constructing it themselves or that learning only takes place in the classroom and is a hard and boring activity.

Papert's philosophy found a wonderful medium for its implementation in Logo and a popular companion in mass children's culture — LEGO.

Seymour constantly worked with teachers, researchers and professionals from different countries. They spread his message all over the world.

He also implemented several major projects that were realized on a large scale in individual countries, leading to major changes in their

[24] http://dailypapert.com/

school systems. Examples of the impact of the philosophy of constructionism and Logo technologies on education systems can be found in a collection of essays by teachers from different countries [LCSI, 1999]. In particular, this collection contains a chapter in which S. Soprunov and E. Yakovleva recount the history of Logo in Russia.

In the late 1980s, Costa Rican President and Noble Prize winner Oscar Arias implemented the Programa Informática Educativa, a massive improvement program for schools, especially in poor and remote areas of the country. The program's goals were to stimulate the creativity of children and develop their basic skills and teamwork. The key tools of attaining these goals were increasing teacher motivation and assuring ICT access. The program was implemented by the Ministry of Education and predominantly financed by the Omar Dengo Foundation, which covered expenditures on technical support and teacher training, among others. IBM Latin America also participated in the program. Papert and his MIT group made the initial program design in cooperation with a group of specialists from Costa Rica and subsequently participated in program management on a running basis. The Papert group trained the key program participants from the Ministry of Education, the Omar Dengo Foundation and the University of Costa Rica. LogoWriter was used as the main learning environment until 1997. The program covered about 30% of primary school pupils in the country. Secondary schools subsequently joined the program, too. The Costa Rican school reform program was used as a model by other Latin American countries. Today, Costa Rica has made its way from a "banana republic" to the region's IT leader, and its education system is still based on the traditions that Papert inculcated.

In the late 1990s, Papert and Massie moved to Maine, and Seymour continued his activities at the Learning Barn and Seymour Papert Institute that he founded in 1999 as well as in LearningLab, which he organized at Maine Youth Center. During the 2002-2003 school year, Seymour got the support of Maine governor Angus King for implementing the One Laptop per Child program in the state. Through this program, every seventh-grade and eighth-grade pupil in Maine schools got an Apple laptop. Seymour was particularly inspired by how these laptops were used by juvenile delinquents in the school at the state's prison.

Papert and Alan Key were among the originators of the initiative advanced by Negroponte in early 2005: establishing the One Laptop per Child (OLPC) non-commercial organization to launch the production of inexpensive computers for all children. The target price was $100. Although this target was not literally attained, its discussion had an "ideological impact" on both computer manufacturers and education professionals. Seymour invited me to take part in elaborating the conceptual design of the new computer. This project was largely based on Seymour's experience, including his experience in Maine.

10. Russian School Reform

Seymour Papert's books, international activities and contacts with Russian specialists had a lot of impact on the development of Russian education and especially its key elements: the elaboration of an education philosophy for the post-Soviet school and the use of technologies.

In these two areas, the Russian education system meets international standards or even surpasses them today. Of course, this success would not have been possible without the large-scale changes that took place in the country and without international cooperation in the development of technologies.

10.1 Foundations and First Steps

In 1931, Lev Vygotsky clearly described the impact of the technology of intellectual activity on the principal mechanisms of this activity. He developed a cultural and historical approach to the study of mental development and uncovered the effect of the zone of proximal development and the role of the "more experienced other" in the learning process (i.e., the social nature of learning). In the second half of the 20th century, Piaget and Papert discovered Vygotsky's work; at this time, Soviet researchers were continuing the latter's approach, and the entire tradition of Russian psychology, whose foundations had been cast in the 1920s, was still preserved. Elkonin, Galperin and Leontiev's article [Elkonin, Galperin, Leontiev, 1959] on school reform and the goals of psychology may be justly called a constructionist manifesto that Papert would have endorsed, without a doubt.

The long-felt need for the modernization of Russian society, the development of an open network culture and information society, and the creation of a knowledge economy gave rise to initiatives in different areas of the education system: the development and introduction of new teaching approaches to mathematics education in the 1960s (N. Konstantinov, I. Gelfand, A. Kolmogorov), the mental activity methodology of G. Shchedrovitsky's circle, A. Ershov's "Programming Is the Second Literacy" campaign and the aforementioned steps taken by the new government after it came to power in 1985.

10.2. Start of Reform

Seymour Papert and the experience of the Bulgarian Problem Group on Education played a key role in the development of the ideology of the School Interim Scientific and Technical Group (E. Velikhov, A. Ershov, V. Belikov, B. Berenfeld, Y. Vishnyakov, V. Davydov, A. Zvonkin, A. Kushnirenko, S. Pachikov, L. Pereverzev, A. Polivanova, A. Semenov, S. Soprunov, A. Uvarov and others). Subsequently, the School Interim Scientific Research Group was formed along the model of the School Interim Scientific and Technical Group; its members included E. Dneprov, A. Abramov, B. Bim-Bad, O. Gazman, Y. Gromyko, V. Davydov, V. Zinchenko, I. Ilyasov, A. Petrovsky, E. Saburov, V. Sob-

kin, V. Slobodchikov, A. Tubelsky, V. Firsov, A. Tsirulnikov and others. Both groups (especially the School Interim Scientific Research Group) and all the innovative activities implemented at Russian schools in the late 1980s and early 1990s contributed a lot to the development of the goals and means of education reform and to training teachers and educational administrators who were ready for change.

10.3. Government Action

The powerful Moscow minister L. Kezina took a series of steps that clearly showed the government's determination to make radical reforms in the education system. These steps included the 1993 appointment of A. Semenov, director of the innovative non-governmental Institute of New Technologies, to head the Moscow Institute of Open Education, the regional teacher development and support system; the appointment of A. Abramov as director of the Moscow Institute of the Development of Education Systems; and the establishment of the non-governmental Moscow Center for Continuous Mathematical Education, headed by I. Yashchenko. In the mid-1990s, the government introduced the Moscow Education Standard (developed by V. Firsov, A. Abramov and A. Semenov), which was based on constructivist principles of ICT use (they were also at the root of the UNESCO recommendations that had been elaborated under my direction [UNESCO, 2000]).

In the 1990s, the Institute of New Technologies and its branch in Saint Petersburg continued their systemic work under the direction of E. Bulin-Sokolova, a Russian linguist who had worked as a teacher in ordinary schools and in the experimental school of the School Interim Scientific and Technical Group (Moscow School #57). The Institute had standing direct working relations with Papert's group at MIT as well as the National Geographic Society, TERC, Concord Consortium, LEGO, Apple, Spectra, Key Curriculum Press, Fourier Education and dozens of other innovative structures. The solutions proposed by the Institute were adopted and diffused by other organizations participating in the informatization of the Russian school. It is of crucial importance that this process has continued without interruption for several decades: all of the country's leaders have considered informatization to be a national priority. This stance has been shaped in part by the fact that the technologies proposed by the Institute of New Technologies have been implemented in many Russian schools and presented at key forums and exhibitions. Our achievements of the 1990s were officially recognized by the Russian Presidential Prize awarded to a group that developed the regional education informatization program under my direction.

A network of innovative schools and teachers was officially set up in Moscow. It worked with the Moscow Institute of Open Education and the Institute of New Technologies and strove to implement the

educational philosophy of constructionism. The teachers' direct contacts with Papert played an important role in this process. This philosophy was also at the root of the model of the "informatization school" that was widely applied in Moscow schools in the 2000s. The main tenets of this model was the constructionist philosophy of ICT use, the information environment of school life (which implemented blended learning, among other approaches), and the strategy of the target allocation of resources to schools and teachers who needed them and were prepared to use them. The administration of the Moscow city education system commissioned the Center for Information Technologies and the Education Environment headed by E. Bulin-Sokolova to develop a strategy for shaping the school education environment and training specialists. This initiative led, in particular, to the creation of a system of general and extracurricular education for children with disabilities that was based on the blended learning approach. It provided education opportunities for children that were physically incapable of attending school.

In the mid-2000s, the Russian government took determined steps to provide Internet access to the majority of the country's schools. The Ministry of Education launched a major project for informatizing the education system, which was developed and monitored with the participation of international experts. The project was implemented by the National Training Foundation, which had extensive experience of international cooperation, and coordinated by Isak Froumin, a mathematician whose pedagogic approach had been shaped by the Russian school of Davydov and Elkonin. I. Froumin invited me to take part in the project, which gave a constructionist bent to many of the resulting solutions. The project team under my leadership got the Prize of the Russian Government in 2010 for its work.

At the end of the 2000s, the Russian Ministry of Education and Science adopted the Federal State Education Standards. These standards did not give a detailed description of the conditions or outcomes of education; rather, they aimed to define the general vector of development of the country's education system. Thanks to A. Asmolov, the general education standards reflected the main tenets of L. Vygotsky's cultural and historical approach. Similarly, I formulated the role of ICT in education in a constructionist vein.

These standards were first introduced in primary school. Over 500 Moscow teachers with long-standing experience in applying the constructionist approach were involved in the process; many of them were personally acquainted with Papert. From the first day of school, teachers and pupils took part in constructionist activities, one of whose key elements was the use of ICT. Rather than spending their time practicing handwriting in calligraphy notebooks, pupils went outdoors, captured what they saw with their cell phones and video cameras, edited their videos on computers, recorded their stories, and showed oth-

ers what they found interesting themselves. During nature lessons, they built their own instruments to discover the laws of the physical world. That year, the "teacher of the year" prize was awarded to Mikhail Sluch, headmaster of a school whose work was organized along the constructionist model and which also continued the Waldorf tradition. At the awards ceremony that took place in his school (this is the school, by the way, where children bake bread themselves), he received the Crystal Pelican from the country's president Vladimir Putin.

Along with the use of ICT, the education philosophy of constructionism is one of the elements of the program for modernizing teacher training that was launched in 2013. This modernization process has spread to most teacher training programs in teacher training colleges and teacher training departments in the country's leading universities.

In upcoming decades, the implementation of the Russian National Technology Initiative and its education support program will lead to the realization of Papert's ideas on artificial intelligence, his approaches to education, and his ideas about the future of mankind.

Thus a series of key areas of the development of our country's education system is based on the principles of constructionism, which are combined with the foremost achievements of Russian pedagogical and psychological scholarship. Constructionist ideas are implemented at all levels of development of the education system:

- They get the support of the country's leadership through national priorities and programs
- They are used for elaborating education philosophy and development methodology
- They serve as the basis for scholarly research and development
- They are part of the best international practices and educational products that have been adapted by the Russian education system
- They are used in the system of teacher training and continuing education
- They shape the norms that are used by a network of experimental and innovative schools
- They are used for elaborating federal and regional education system development projects
- They are part of the Federal State Education Standards for general education
- They are implemented in the learning environments of schools that are shaped by regional government in cooperation with companies which use the constructionist approach in their activities

The adoption of Seymour Papert's and Lev Vygotsky's ideas by a growing number of schools shows that these ideas continue to be viable and meet the interests of Russian education.

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