Technology in transforming education

The Opening keynote address

Alexei L. Semenov
Institute of New Technologies, 10, N. Radishevskaya, Moscow, 109004, Russia.
alsemenov@mtu-net.r

Key words: Societal needs, mathematics, co-operative teaching, information skills, emerging technologies

Abstract: This paper addresses the relationship between societal needs and ICT. In particular it identifies how society now has different goals and needs because of the new technologies. These include a recognition of the change in mathematics and the language of reason; thus discrete processes, such as approximation, will be more important than arithmetic. And yet change can be threatening for teachers, even those who are innovative. It will be important that the best of new technologies are harnessed for Information Processing by learners. But also new curriculum projects such as building an address book, should be devised for learning about information and information handling. A model for change is proposed based on co-operation, which builds on willing teachers, who are paired with a technology teacher for certain lessons. Help from the Internet and links with traditional educational ideas, such as the role of the teacher, should lay the foundation for open-ended change.

1. INTRODUCTION

For the last fifteen years I have been involved in the introduction of IT in Soviet Russia, from the different positions of school teacher to purely a bureaucrat and official. From this perspective I will try to elaborate some reflections on what is happening and what I hope will happen in the field in future years.

The original version of this chapter was revised: The copyright line was incorrect. This has been corrected. The Erratum to this chapter is available at DOI: 10.1007/978-0-387-35499-6_29

D. M. Watson et al. (eds.), *Communications and Networking in Education*

In preparing this paper, I searched the Mamamedia site for recent publications of Seymour Papert. I found a paper published in Technos magazine in which Seymour mentioned a question from his closing speech to the Sixth World Congress on Computers and Education in 1990. The question was: Why do we refer to *computers* in the name of our conference; others do not call their conferences *paper-based* educational events? I looked at the title of this conference and discovered that it is not about computers, but about *Communication* and *Networking* and we all agree that communication and networking are crucially important for education. In the title of this paper, *Technology* is compensated by ambiguity.

I have a serious problem with translating the non-linearity of my keynote presentation into a linear paper. So, I will present a site-map of it. There is some correlation between the content of my paper and IFIP/UNESCO recommendations on Informatics in Primary Education. I will start with a general outline on the topic of what influences transformations in schools, the needs of society and individuals, and how they influence the goals for education. Then I will concentrate on changes to the mathematics curricula which lie at the core of our school education. I will then discuss the importance of information communication technologies, the high speed of changes, the question of what is appropriate for schools and some general studies of implementation and cost. I will follow this with reflections on what is happening with respect to learning through the Internet and the role of the teacher and traditional institutions.

2. CHANGES INFLUENCED BY ICT

Let us start with the general goals of education and in particular the emerging needs of society and individuals with the introduction of ICT, and how these goals are or will change schools. An average primary school in Russia today is still attached to the goals of teaching writing, reading and arithmetic in the same way as it was in the 19th century. At that time, the acquisition of these skills was important for the most prestigious jobs. Now, or in the near future, the needs of society and individuals will be both much less, and much more.

2.1 New needs

Let us consider the new needs. There is a greater emphasis on needing the abilities to search, collect, analyse, organise, present and communicate all kinds of information, to design objects and processes, and to implement plans. We need more independence, self-confidence and responsibility. We

need less routine information processing skills, like handwriting skills, and less mental arithmetic. In an educational perspective, this means that self-discovery of the multiplication table is more important that memorising it. There is nothing wrong in memorising, but it is best when used deliberately, as a conscious act, and not as a pre-requisite.

This shift in needs, and consequently, in the educational goals, is happening now as the result of global changes in civilisation, but especially due to the progress of ICT. Text input, spell-checking, outlining, technical drawing, as well as arithmetic and algebra are now done with a computer. Literally, computers can 'do' the old skills of reading, writing, and arithmetic; progress in speech recognition over last years has completed the picture.

The whole situation implies changes in the content of education and the curriculum structure which are deeper and more long-lasting then just using today's ICT. Let us consider the changes in mathematics and language. This also gives as a new view on the theme of the conference. In essence I propose a new literacy – mathematics and languages for the next century.

2.2 A change of mathematical focus

Traditional primary school mathematics is oriented towards numbers, while in the secondary school this includes continuous and infinite objects. The contemporary 'high-end', adult mathematics is much broader and its focus is different. The applications of current ICT exploit mostly discrete, finite objects.

The place of numbers is taken by finite strings (words). In this sense, numbers are taken to also be words. The realm of human languages and reasoning is one of the major environments for mathematical studies. At the same time human language is one of the major realities surrounding the child from their very first days. To study its logic and mathematics is both more interesting and adequate for the future applications than traditional arithmetical problems. I am suggesting that although arithmetic should not disappear, an ability to estimate roughly the value of a complex expression, or the number of seeds in a jar will be more important than long multiplication.

Hyper-text and other hyper-structures of the information objects were always quite natural for human thinking. Children find them in fairy-tales and construct in their own drawings and writings. But only the advent of ICT into adult business practice gives hyper-structures a chance to become legitimate subjects in the primary school both in mathematics and language arts.

Mathematics and science in our schools is concerned with processes. In the 19th century, it was continuous processes, described by differential equations. In the 21st century, it will be discrete processes. These processes do describe many social and natural phenomena; approximate continuous processes are essential for computer science. Approximation is associated with a very general type of discrete system in which global behaviour is determined by local laws of evolution. A classic example is heat transfer and its discrete approximation. The most impressive and famous example is the Life game. As you remember, the game is the process of evolution of an infinite, or big enough, squared plane. The laws of the evolution are:

- Any cell of the plane can be in two states – living or empty.
- Each cell has eight neighbours.
- The living cell which has two or three living neighbours stays alive.
- The empty cell which has exactly three living neighbours becomes live.
- All other cells become empty.
- In each step this happens for all cells simultaneously.

By iterating steps we can observe the process of global evolution of the initial configuration, that is, a set of living cells. You can choose an initial configuration and see what is happening on the computer screen. It can be done on paper as well, but only with a huge amount of work.

Children would start with some simple small configurations: one, two, etc. cells. First they find configurations which disappear (die) soon, then those, which behave periodically (in life cycle). If they draw arbitrary configurations of living cells they probably will discover soon a non-cyclic configuration – they find movement which appears in the evolution of different configurations. Then they can discover or design configurations which generate moving things ad infinitum – so this is a replication. Then an interaction between moving creatures and streams of them can be investigated. At the end of the day we find that the game is as complex and universal as any computer. You can call it consciousness. It is amazing how complex behaviour can appear out of an initial configuration of five cells only (the genetic code).

Generally, the mathematics needed for practical life and for child development in the next century is more real, visible, palpable, and audible than mathematics of the past. To decide how to compare two bags of LEGO bricks is a mathematical task which gives to a primary school student more insight into future mathematics than working on dozens of long divisions and 'word problems'.

2.3 The reaction to changes

As you can see here we are discussing not what is usually called 'content', but also what is called 'method'. This latter, in our understanding, is a very important part of the content that is acquired by a student in the process of learning. Both the content and the method are now changing, influenced by ICT. The general direction for changes was outlined by Jean Piaget. Most of the teachers and administrators of education consider this direction, the constructivist approach, in a positive light. The problem is – how it is reflected in their practice?

Here is a story from our own practice in Moscow. We were looking an elementary-school teacher in a good school in Moscow to work with us. We found a young, progressive, intelligent one. We discussed with her different aspects of the educational process and agreed that there should be more freedom in the classroom. In the process of implementation we changed the arrangement of tables in the classroom. We made a square out of them, with the teacher's position closer to students inside the square. She tried to work in this new arrangement and gave up. We asked her "Why?"; she answered "I do not feel myself as the master and the leader, I do not have control over the situation." We exclaimed "But weren't we talking about freedom?". She replied "Yes, but not to that extent!".

3. WHY ICT ARE RELEVANT FOR EDUCATION?

3.1 Educational applicability

Information and Communication Technologies (ICT) are constructed not for education, they are designed for 'serious' jobs, that is business applications. But most of the activities in school are information processing activities. Although as an aside, this is not so good; perhaps we need more physical, practical, hands-on activities. However, the reasons why adult technologies are relevant for education are:

- Any computer is universal – it is a finite approximation of a universal mathematical machine, a Turing machine, which, by a given programme, can do any IP (Information Processing, not just Internet Protocol) job.
- The human mind is universal by its very nature; we use the same hard and soft-ware for different kinds of IP, including learning.
- The human interface with the outside world is universal; we use the same senses all the time, and connection with this machine interface is universal also.

– ICT make human IP more effective and creative.

A recent example: computers provided a non-linear tool-kit (HTML, etc.) for non-linear human IP. The consequence of this is that using ICT for IP in learning is inevitable.

It explains also why all technological advances have immediate educational applications. What is interesting, is that such advances influence even schools which do not have access to them. So, one of the issues I address is: What is the level of technology appropriate for the process of school transformation today, and in what manner does the high-end technology influence the low-end school?

3.2 What level of technology is needed?

Here is an example of what could be called scale-down of technology and its influence on content. In some Russian schools the very first school year for the six-year old students starts differently. They come to school and receive badges with their names, as do their teacher and the school principal. It is promoting the concept of name tag, which is a part of the information society culture and of mathematics as well. The children sit at computers and try to input something about themselves: name, parents' names, place where they live, favourite song. Now the information about all children from the class is collected in a computer network, or just in the only computer in the classroom. Then it is printed out in the form of loose pages for an address book. Each child in the class receives a set of these pages and makes their first nice address book, with a needle and colouring pencils. For the children it is one of the lessons on an information culture, both in the traditional sense of an address book, and in a very advanced sense of a Net metaphor. Indeed, each child tells the computers about themselves only, but gets back the information about everybody in the class. The address book project is the beginning of an expanding set of educational activities to learn about your body, your family, place where you live, the Earth, the History. Some of the information can be found by a child in the Net and placed into the Net, to constitute shared knowledge.

3.3 Do we need new and emerging technologies?

Are computers for schools today really different from the computers we had five years ago? Here are the dimensions of this difference: adequacy to human interface; connectivity; price and size; peripherals; software; general applications; information sources; virtual construction kits; and tutors, such as touch-typing, languages.

This means that we are arriving at computers with the picture quality approaching the limits of the human eye, which can sound human and store enough of sound, which can recognise basic things you are saying to them, and use full-scale GUI on new Windows or Mac. These computers can easily access the world information which is coming into the Net. Video-conferencing for schools is almost real; inside school we can use radio and infrared networking.

The computers are small, they do not require a special school desk, are not noisy, and do not need special cooling. They are notebooks you can carry easily. You can attach to a computer all sensors, digital cameras, colour printers, and bright projectors to work in daylight. All this is relevant for school applications.

4. A STRATEGY FOR CHANGE

4.1 Use only willing teachers

So we associate technology with a radical educational transformation. Only a minority of schools and teachers are ready for this. We cannot expect many teachers today to use computers effectively. We do not even expect many teachers to use computers at all. But which teachers actually transform school today who become originators of the future school? Many of them use ICT naturally and ICT constitutes the context of this transformation. The transformation itself is not about computers; it is progressing along the lines available for centuries.

So the simplest strategy, and the most rare in practice, is to give technology to those who can use it and want to do so. There are many aspects determining this readiness and willingness, including results achieved in the past, previous training, ability to plan, and team work. As an oversimplified solution I suggest some contexts should use, as a quantitative indicator, a percentage of teachers in school who learned touch-typing in the last two years. More seriously, we can use a Vygotskian term 'zone of proximal developmen', not only for learners but for such developing social entities as schools. So we are speaking of providing adequate support and social interaction for schools in accordance with their zone of proximal development.

There are also many teachers who are innovative enough to think about new ways of learning with computers, but responsible enough to expect serious difficulties along the way. There are several approaches to this. One is to introduce ICT not into the regular classes but into out-of-class activities, like preparation of presentations, components of websites, and

other materials by teachers or a homework student. For this we need, of course, computers outside the classrooms. Computers in homes (maybe notebooks) is one approach. Having enough computers in the school library, teachers' room, technology resource centre, and other premises for learning will be especially efficient. The use of the computer by the principal is helpful, both for them and for the whole school.

Another approach is based on co-operation of teachers. Out of class, it can be productively combined with the previously described approach, including team work on environmental and other research projects. In the classroom it generates a productive two-teacher model. This is an officially approved (non-experimental) model for the city of Moscow, with a population of 10 million. In this model two teachers, such as a technology teacher and a language, physics, or history teacher, combine their resources. They use technology hours and language hours to master the technology of text-processing and to apply this technology to language matters. In these hours they come to class together. Both are paid; this is important, not because of material reasons, but because it makes their joint activity automatically legitimate. Then both teachers and their students learn intensively and comfortably. The technology teacher introduces and demonstrates technical skills, provides trouble-shooting and learns what technology is needed for and what problems there are with using it seriously. The language teacher learns how to use it and invents new ways of learning the subject, not depressed by the technicalities. The role of technology teacher can be played by the technology co-ordinator of the school for whom organising and conducting these co-operative activities is a major responsibility.

4.2 Relative cost

There is a disadvantage in this kind of gradual approach because most of the educational and other authorities like simple solutions. "Let us put 13 computers into each school of our district, train all teachers to use MS DOS, or Windows 2000, and teach all students to programme in BASIC." As we know, this approach does not work so well. Even more, it usually causes much negative reaction in public. As an alternative we can give ICT, hardware, software, training, and support, to schools who really need this and are qualified for this. The cost for the educational system to put computers to schools in accordance with their zone of proximal development is relatively small.

We should expect that more and more teachers and schools will communicate and co-operate in the diversified process of school transformation supported with ICT. The different level of ICT gradually

coming to schools can be managed by a combination of scaling-down and sharing the most advanced resources. With this approach you can meet the problem of lack of funds in some years. It can be easier to find 10 million dollars once than 10 thousand each year. In some countries it is possible to establish an endowment or to use a respectable private foundation to manage the money issue and provide the constant support and upgrading for technology in schools over several years.

5. LEARNING IN THE NET

One important aspect about using the Net is that we come to it when we need to find something, because we want to do something – to buy a ticket, to make a meal. We learn something and we do it in the way we found out from the Internet. We can extend this situation further from a single action to the ability to act in some way, for example, to speak a foreign language. Then learning starts to dominate over immediate doing, but we should think how to exploit the doing component. The most obvious cases are different kinds of design and performance – such as music, poetry, interiors, and Internet sites. Learning games, like chess can be another type of a balanced activity. Here are some more areas of learning and doing: literacy, international languages, health, first aid, legal advice, tax paying.

The Net can be used as a mirror or a self-portrait of learners, which reflects their dynamically changing personality and their goals and targets to achieve. It is an active mirror providing advice, connections, and follow-up for the process of learning and development. The Net is a genuine environment for co-operative learning and doing. Eventually we are talking about lifestyle and further, the civilisation of learning. There is a strong tendency for more free information on the Net; John Barlow is the most famous and eloquent speaker about this. It includes even sophisticated software (like Finnish LINUX).

In the educational area one possible scenario is that the price of educational services will be determined mostly by the individual interaction between student and teacher. This price policy means that the information resources are free in general. The computer is used to answer typical questions (80%) and to pass the rest (20%) to a human. It is well known about home appliances and some other cases, that the type of advice in this 80% is routine and simple. At the same time to recognise the level of human presence can be a hard task, as in Eliza software.

The Net can be a very good mirror to learn more about yourself, to make more of yourself. The Net can give you advice in different situations or connect with people who will give you advice. Moreover, it can check how

you are following the advice and decisions which you and the Net made together. We can see a continuous spectrum of individual involvement of the teacher: vis-a-vis talk, video-conference alive, postponed telecommunication, individually planned computer-supported communication, interactive software with human involvement in evaluation, information resources only.

6. TRADITIONAL EDUCATIONAL INSTITUTIONS AND NEW WAYS OF LEARNING

What can a school – primary, or university, or any other – provide in addition to the Internet? I do not think that school will die in the next century. The situation is not as simple as is implied sometimes from Seymour's statements like "... the presence of digital technologies is rapidly moving us into a period where learners can learn what they need to know on their own agenda rather than on the predetermined agenda of a curriculum. We will soon be able to give up the assembly line model of grade after grade, exercise after exercise." Two things are evidently important, but in different ways: human relations and formal recognition.

6.1 Teacher as the master of leaning and doing

The wish and ability of a human being to learn is not a result of the pure curiosity of an isolated mind. It is a result of constant interaction with other humans, primarily with the mother and hopefully with a teacher. So, the ability of a student to learn depends on the ability to know and to use the knowledge, and the ability of the teacher to learn. So we need the teacher as a partner in learning enterprise, as an advisor, guide, and a source of inspiration and behaviour to follow. The student will learn from the teacher how to learn. The problem is – can we provide enough teachers of this kind? I think many communities still need a socially responsible and paid class of people who will support the children's ability and willingness to learn.

In my country the majority of teachers are not paid their salaries for many months and some years. They come to their schools every morning. In the Soviet time when they were paid regularly they constituted perhaps the only big sector of workers who were doing a real job. The Russian joke about the whole country was that we look like working and they look like paying us. The teachers were working in reality. At the same time I agree with Seymour in his evaluation of children as the driving force of change.

The strategy should involve the whole community in the process of learning and an adequate structuring of priorities.

6.2 Formal recognition

The whole situation with formal exams, diplomas, certificates, and licences will change radically in the next decades. We can expect a whole range of approaches, from traditional Chinese exams and American bar and medical corporations to diploma baking factories and complete inflation. Indeed, testing with no access to information for the student becomes less and less natural and relevant, so testing with access to all information needs to be developed. The most popular Russian educational sites contain essays. It makes more difficult, and possibly kills, one of the methods of evaluation.

7. THE OPEN END

So links have to be constructed to develop an open-ended approach. Poor and weak content of educational resources in the Net needs addressing. Learners themselves will contribute into learning cyberspace; there will be cyber agents and human information managers; there will even be co-operative games and a re-creation of the world and culture. There will be Net forms of lifestyle and a stereotype of continuous learning for what you need. Placing success stories on education on the Net is the start to this open-ended change.

REFERENCES

Papert, S (1990) The Perestroika of epistemological politics. In A. McDougall and C. Dowling (eds.) *Computers in education.* Amsterdam, The Netherlands: North Holland.

Mamamedia site: www. mamamedia.com

BIOGRAPHY

Alexei L. Semenov, graduated from Moscow State University, and worked at the Department of Mathematical Logic in the field of mathematical logic, theory of algorithms and theoretical computer science. He was involved with the introduction of computers into all schools of the Soviet Union in 1985-87. He founded the Institute of New Technologies (INT), Moscow in 1987, and led the team which developed and implemented a course in mathematics, languages, and computer science for primary schools. Since 1993 he has been the Rector of Moscow Institute for

Teacher Development. In 1998 he received the President's Prize for the work of introducing IT into the Moscow region.