Informatics *Versus* Information Technology – How Much Informatics Is Needed to Use Information Technology – A School Perspective

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Abstract. We discuss the role of computers and informatics in school education in Poland; 'informatics' generally stands for 'computer science'. Although, our investigations are based on the situation in Polish schools, the conclusions may apply to other countries. The main attention is paid here to didactical approaches in teaching and learning informatics and its applications with the emphasis on preparation for living and lifelong learning in the information society (knowledge-based society). In recent years one can observe many changes in schools regarding the role of computers and informatics education. On the other hand we still have to address fundamental questions:

1. How to teach a changing discipline and how to keep track of developments in the field of informatics and its applications?
2. What to teach, in particular to what extent one should learn a discipline (informatics) to be able to use its applications (information technology)?
3. How to prepare teachers of informatics, IT and other subjects (but equipped with IT) for their new role of advisers to students?

In answering these and other questions we discuss some of the solutions we proposed and which have been introduced to Polish schools and to the system of teacher training. In particular, we focus our attention on the didactical approach to teaching IT-relevant subjects and the integration of IT with other subjects and to teaching informatics (as a process of designing a computer solution of a problem). With regard to teacher preparation, we present the preparation standards and discuss the role of school IT co-ordinators.

We plan to demonstrate also an **e-IT-book**, an implementation of a new approach to teaching and learning of new technology with the help of technology.

1 Technology in Education

1.1 Computers in Education

The development of educational technology closely follows the development of technical equipment. In the case of computers, they were introduced to education in the sixties of the last century. In Poland, first regular classes on informatics were

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organized in two secondary schools in Wroclaw in mid sixties, just 'a day after' the first mainframe computer (Elliott 803, made in the UK) was installed in the country. The main topics were algorithms and programming in Algol. The approach was machine oriented: electronic data processing and computer calculations according to mathematical and engineering formulas.

The official history of computers in Polish schools started in 1985 in the beginning of personal computer era with the first official curriculum proposed by the Polish Computer Society. For about 10 years (micro) computers appeared mainly in teaching informatics as a separate subject and only occasionally they were used as a teaching aid. The main turning point appeared with the development of user-friendly human-computer interfaces, which support user's approach to computer use. Then the Internet became popular and came to schools and since then it has been the main factor which influences the way technology is applied in and integrated with education.

In the mid 90', a big struggle has begun among the education policy makers in Poland to accept the term 'information technology' for 'informatics for all students' as the combination of informatics technology with other related technologies (such as communication technology) and their applications in education and society, and human aspects. Today 'information technology' is widely used in our education system in the same meaning as 'information and communication technology' is used in other countries.

In 1997 in Poland, a national initiative, called the **Education Reform**, has been launched according which schools should be oriented towards across-curriculum integration of computers, information technology, and the Internet with learning and teaching of various subjects. Today one of the main goals of our education system is to prepare all students to actively live in the information, knowledge-based society.

1.2 IT in the Education System in Poland

Formal education starts in Poland at the age of 7 (from 2004 it will be moved down to 6). The formal school system at primary and secondary levels consists now of three stages:

- primary school – 1-6 grades (age 7 to 13);
- middle school (in Polish: gimnazjum) – 7-9 grades (age 13 to 16);
- high school – 10-12 grades (to 13 in certain vocational schools) – (age 16 to 19).

Information technology (IT) as a separate subject is taught in[1]:

- 4-6 grades of primary school, for at least 2 hours per week for one year;
- middle school, for at least 2 hours per week for one year;
- high school, for at least 2 hours per week for one year;

Moreover, in high schools students may choose informatics as a subject of specialization and take an external final examination (matura in Polish) in that subject.

[1] In primary and middle schools the subject is still called informatics, but it will be changed for information technology in two to three years, since its curriculum is in fact on how to use information technology across the curriculum in different subjects and applications.

The national project "Internet laboratory in every middle school" initiated in 1998 put a solid technical basis for IT education in middle schools in Poland. Today all middle schools are equipped with at least 10 PCs and additional equipment. In 2001, a similar project was launched "Internet laboratory in every high school" with 15 PCs for computer laboratory and 5 PCs for a multimedia laboratory connected with a school library.

The EU eLearning initiative [3] has set the target that by 2003 all students leaving the school system (formal education) should be digitally literate. In Poland, this target has been met by all students leaving middle school (when they are 16 of age) since 2002 and will be met by graduates from high schools beginning in 2005.

2 Informatics *Versus* Information Technology – A School Perspective

As already mentioned, the term 'informatics' is used in the sense of computer science and the term 'information technology' has been recently accepted in education in the sense of applications of informatics. For the educational purpose one may assume that informatics deals with producing new products related to computers (hardware, software, ideas, theories, etc.) and IT is on applying and using informatics (computer related) products.

2.1 The Era of Informatics

Informatics (in fact, elements of informatics – EI) was in Poland a part of the curriculum for more than fifteen years (1985 – 2002). It has been taught in elementary schools (1-8 – mainly during the last two years) and in high schools (9-12 – for one, two, three and even four years).

There were three EI curricula approved by the Ministry of Education. The one proposed by the team led by the first author had a very general structure and consisted of a number of modules which could be used to design an instruction plan for teaching EI from one up to four years with the emphasis on different aspects of informatics, e.g. problem solving, algorithmics, application software.

There was also a textbook published (first edition appeared in 1988). It is perhaps interesting to mention that this textbook had a new, unchanged edition every year (two in 1995) and more than 100 000 copies have been sold. It is unusual for a book on informatics to remain unchanged on the market for so long. It was mainly due to the approach adopted in the book. Computers and software tools were not described in full details but only with respect to the main theme (problem) of the presentation and discussion. Therefore, the content of the textbook was universal although there were some key components of the contemporary IT missed, especially related to computer networks and computer supported communication, which have entered schools recently. Let us list chapters of that textbook: history of computers and informatics, how computers are designed and how they work (operating systems), playing and learning (turtle graphics – Logo), from problems to programs (elements of programming in Pascal), designing an own directory (data base), calculations in mathematics (numerical methods), computing faster – efficiency of algorithms

(elements of algorithmics), writing with no pencil and paper (text editing), easy and effective managing of a small business (spreadsheet).

There was also a package of educational software designed and produced to help the teachers of Elements of Informatics in the main subject areas: a model of computer and computations, operating system, programming in Pascal, designing and running algorithms, numerical computations, statistical analysis of experimental data. The Ministry of Education sent the package to high schools and to teachers' colleges.

In recent years one can observe a growing awareness among teachers that the use of computers in schools cannot be limited to a separate subject. It is recognized however that when there were only few computers in a school and there was only one teacher who knew how to operate them, the separate subject and a computer laboratory in one room guaranteed the most effective use of technology. Today however, most of the teachers are interested in using computers in their classrooms.

2.2 Information Technology and Informatics

As a part of the Education Reform, **the education standards** for the main subjects in elementary and high schools have been published in 1997. The main part of the standards consists of the list of education goals (tasks) which are to be realized and met by schools – schools are responsible for supporting and helping students in their cognitive and creative activities, learning, and self-development. In consequence, students should become competent in many areas. For instance, they should: *successfully communicate and use new communication technology for that purpose; search, sort, organize, and use information from different sources; use different information technology and media with competence and responsibility*. With respect to informatics education the main education goal is formulated as follows:

to guarantee students the possibility of using information and communication technology, and to prepare them to live in the information society.

Information technology (IT) is now taught as a separate subject 2 hours a week for one year in all types of schools. Moreover, in high schools students may choose informatics as an optional subject and take an external final examination (matura in Polish) in that subject.

The team led by the first author has published curricula, textbooks and guidebooks for all types of informatics and information technology subjects in schools. Moreover, a book on using computers and information technology in ten other subjects in gimnazjum and two elementary books on algorithmics have been also published.

2.3 IT in the Education Standards

Using IT may effectively support achieving several education goals by schools and competences by students. We briefly review such possibilities.

In primary schools students are supposed to develop a competence in using different sources of information and to use IT in collecting, storing and processing information. Internet is an example of a source of information, other than books, where students can search, store and process information.

In gimnazjum and in high schools there are many opportunities for students to use IT and Internet. For instance, students should be prepared to individually integrate knowledge about the past learnt from different sources of information (history); they should have an opportunity to use different media and techniques for communication; they should learn and have a chance to use educational software, computer networks, electronic mail, Internet, and data bases. The following competences appear in different education areas such as history, physics, geography: use of different techniques for collecting, selecting, storing, processing and interpreting information, critical use of information about public and social life, use of media in personal search for information, use of IT to collect, process and analyze data from experiments, collect and interpret information, e.g. coming from satellite pictures, Internet, and GIS systems.

Moreover in high schools students are supposed to be able to use IT tools and Internet in almost all education areas, and mainly to use libraries with electronic sources of information, video-libraries, computer programs and other information bases. They should be prepared to use a library as a centre for global information.

Social aspects of information age: information as a product and a source of power, global village, and technopol are also considered.

Moreover, the following topics are discussed: multimedia; local and wide area computer networks; searching for information in wide area networks; communication via computer network; preparing presentations with the help of IT tools; creating documents which are accessible in Internet.

Internet is considered as one of the most important elements of IT and of its integration with learning and teaching. It may be both, a subject of instruction and a tool for: information retrieval, global communication, problem solving and decision making in almost all school subjects and off-class activities.

2.4 Methodology of Changes

After computers were introduced to schools, they themselves together with networks have been the main IT topics of instruction. More important, however, is to be able to use a computer as an educational aid in all areas of learning and teaching. With the help of methods and tools of IT, old and traditional teaching material can be enhanced and new topics and skills, which otherwise cannot be learnt and taught, can be introduced and added.

The introduction of computers to schools in the 80's induced high expectations for improving education. Today, however, those expectations have not yet been fulfilled – it is argued that this is mainly due to unrealistic assumptions about learning as a passive process of information absorption. It is believed that to improve the results of learning **computers should be embedded** in, instead of added only to, learning environments as tools that elicit and support in students active processes of knowledge construction and skill development.

Access to information, especially through a network, is not sufficient to enhance learning and teaching. The amount of information is growing in exponential rate. Therefore it is necessary to teach how to critically evaluate its contents. Learning does not simply mean reading and watching, it should proceed through doing: performing tasks and solving problems. To properly operate information, one has to master

several skills, e.g., building an information structure, evaluation of contents of information, information search and retrieval, information processing and presentation. Education should give students knowledge and skills that will enable them to find the proper information they need.

Working with information, students should be aware of social, ethical and legal aspects of unrestricted access to information. It applies mainly to personal data, collected and processed in computers for different purposes. Advantages and disadvantages of computers and computer networks in education have not been recognized completely. Usually, teachers and educators talk about their positive aspects and influence on learning and teaching. One has to take into account also that school is responsible for preparing students for the years to come when they leave school, join society, and are expected to make decisions on their own.

2.5 A Model for IT Development

In developing a curriculum for IT and informatics education it is very useful to have a model for IT development. Such a model has been presented in the UNECSO Curriculum [8][2]. The model is not a curriculum but provides a framework which shows the interrelationship of various components within a system and aids understanding by all parties involved in education: students, parents, teachers, educational administrators and policy-makers.

The model of IT development at the school level [8] consists of four stages: emerging, applying, infusing (integrating) and transforming. It describes also stages of teaching and learning and can be applied to learning and using IT (by students and also by teachers), teaching IT and teaching with the help of IT. The model can also help to understand why students, teachers, schools and other users of IT have to follow a similar route of IT development in their personal and professional life. For instance, in the case of preparation of teachers, they first have to learn about computers (emerging stage) to be able to use them in their subjects (applying stage), and then they begin to integrate IT with other teaching areas (infusing stage) and finally (in fact, after many years) school becomes ready for transforming its role in the community and society.

We successfully use the UNESCO model in designing curricula for schools and teacher preparation courses.

2.6 IT *Versus* Informatics Education

Many people assume that anything related to computers belongs to informatics. In education it is quite popular to use ‘informatics’ as a name for a subject and classes which take place in a computer laboratory regardless of what students are learning and doing (in fact, quite often they are playing computer games and surfing the web). It happened also in our education system: informatics is the subject in primary and middle schools although the curriculum is in fact on how to use information technology across curriculum in different subjects and applications.

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[2] In fact, the first author has published a similar model, also consisting of four stages, in 1999 as a part of the project [4].

Fortunately all parties have recently accepted the term ‘information technology’ in our education system as the name for applications of informatics and its use in other disciplines and in every day life.

In our project on informatics and IT in education (see [4]) we assume that informatics deals with producing ‘new products’ related to computers (hardware, software, ideas, theories, etc.) and IT is on applying and using ‘informatics (computer related) products’. Although this distinction does define neither informatics nor IT, it is very useful in describing methodology of learning and teaching both subjects.

In our approach of teaching and using information technology [4] we convince a learner to elaborate her or his style of working with information. Application software has usually several options, which support a user in improving a style (e.g. styles, templates, wizards, etc.). Elements of style are also very welcome when working with information on the Internet, in searching, publishing and communicating on the net.

In teaching informatics we follow a traditional way of producing a ‘computer product’, which consists of the three main stages:

- define a problem (i.e. its specification) and design its solution (algorithm) – this stage supports an algorithmic thinking;
- build a computer solution (program) of the problem – it is a place for working on programming style;
- test and evaluate the computer solution – also testing the correctness of the solution.

This approach and methodology can be applied to many sorts of problems in informatics, also at the high school level, e.g. in: solving mathematical problems, designing and producing a data base, designing and writing a web page, designing and producing a multimedia presentation.

3 Teacher Preparation and Training

With regard to the level of competences in IT, all teachers in schools in Poland fall into the following categories:

- teachers of separate informatics subjects (under different names: informatics, information technology, computerisation, etc.);
- teachers of all other subjects, who use and integrate IT with different areas of education;
- school IT co-ordinators.

The Standards for Information Technology and Informatics in Teacher Preparation [6] determine what teachers in different groups should know about and be able to do with the information technology (and informatics).

A position (function) of **school IT co-ordinator** was introduced to schools in Poland by the first author in 1998. This IT co-ordinator is supposed to be a teacher of a separate subject on IT or informatics and moreover he or she:

- leads continuous self-learning of IT of all teachers in the school; therefore a school IT co-ordinator is responsible for building professional learning of IT into the workplace (school);

- guides other teachers how to introduce IT to particular subjects and then integrate the technology with different subjects; in the beginning he/she may even help other teachers with the technology in the classroom;
- promotes and co-ordinates all changes in the school which involve IT and its use in education and school management.

A classroom as a working place contributes only a little to teachers' learning, so teachers have to find an extra time for their personal development. On the other hand, learning should happen locally. With respect to technology, school IT co-ordinators are to help other teachers in everyday working and learning in schools.

Based on the standards [6], two types of in-service training courses have been designed for:

- school IT co-ordinators;
- teachers of other subjects on how to use and integrate IT with different areas of education.

It is perhaps worthwhile to mention that 30% of course time teachers attending these courses spend working in their schools in cooperation with other teachers and with school IT co-ordinators.

Higher (tertiary) education institutions are major resources for teachers' professional development. They offer post-graduate in-service courses and training to different interest groups of teachers, in IT and in other subjects. The standards [5] serve as guidelines for accreditation of such courses and are used by the National Accreditation Board of Higher Education Institutions for that purpose (the first author is a member of the Board).

4 School as a Lifelong Learning Institution

The transformation to the knowledge-based society is today very high on the political agenda. The society expects from citizens new knowledge, skills and competences and to be active – self-motivated to pursue own personal and professional development throughout life. Lifelong learning is the most important and promising way to empower citizens to meet these demands. According to EU Memoranda (see [9], and also [7] and [3]), **lifelong learning** is defined as *all learning activity undertaken throughout life, with the aim of improving knowledge, skills and competences, within a personal, civic, social and/or employment-related perspectiv*e. Therefore, lifelong learning is not limited to economic outlook and to learning opportunities for adults only. In the implementation, main emphasis is put on the centrality of learner, equal opportunity, and learning needs. Such approach to teaching and learning requires all education institutions to become more learner-oriented than program (or curriculum or institution)-centred.

Lifelong learning places new demands on all types of learning activities and educational institutions, in particular on schools. Information technology plays an important role in lifelong learning due to its great potential for innovation in learning and in teaching methods, educational tools and environments. We refer the reader to [7] where we discuss a new role of school and information technology in designing a lifelong learning strategy for schools, teachers and individual citizens.

It is still not obvious to students and to teachers in schools, that lifelong learning starts at the very beginning of formal education in primary schools and that tertiary education, learning at a workplace, and adult education are just next stages of lifelong learning, based on the foundation laid down at the beginning of education.

In the rest of this section we shortly comment on the situation of students and teachers in our schools with regard to lifelong learning.

4.1 Students

How to adopt changes brought especially by rapid development of IT and how to make sense and use of the vast amount of information available in the net – two main items on the list of what students should learn in school with regard to lifelong learning, are included in the IT curriculum for different levels of education in Polish schools. Actually, all students have separate classes on IT in primary, middle (gimnazjum) and high schools, so they learn how to adapt to changes in the technology for 9 years of formal school education.

Moreover in high schools, lessons on IT are related to subjects chosen by students as their specialization and one of the curriculum goals is to have students prepare their own personal IT environments which then they use in continuing education.

4.2 Teachers

The role of schoolteachers with regard to lifelong learning is twofold:

- they are lifelong learners themselves to develop their own professional knowledge;
- they should develop their students as lifelong learners.

These two fields of activities need different skills and competencies. To be prepared themselves for lifelong learning and to promote lifelong learning to students teachers should:

- be pedagogically literate in lifelong learning and know its role in changing the learning environment;
- know how to promote and integrate innovations in learning;
- be competent in using IT to support and manage the learning process.

Moreover, in learner-centred environments, teachers become guides, mentors, and mediators, who mainly help and support learners.

In understanding and using IT in teaching and learning, and in education in general, schools, teachers, and students go through four stages (see [9]): first they discover general functions and use of IT tools (emerging stage), second they learn how to use IT in different subjects (applying stage), then they learn how to recognise situations in which IT could be helpful in solving (real world) problems and how to choose appropriate methods and tools of IT (integrating stage), and finally IT becomes integral part of the professional practice in school (transformation stage). These stages are very important to teachers' personal preparation and professional practice with the use of IT: first they become IT literate (awareness stage), second, they begin to apply IT in their subjects, then different teachers begin to integrate and overlap different subjects, and finally they are able to design lessons on larger real-world projects using IT tools, methods, resources.

Regarding technology, the optimal vision of education is to combine best practice of human and machine (e-learning) teaching and providing access to non-local instruction and resources.

5 Other Activities

1. In 2000, **Association of IT Teachers** (AITT) (see [2]) has been founded by a group of school IT co-ordinators. The Association:

- by removing or diminishing geographical and psychological barriers, brings learners closer together at local conferences and workshops, organized all over the country in local communities or in schools;
- contributes to organization of local learning centres for students and teachers;
- promotes continuous education, in particular lifelong learning of teachers,
- promotes examples of good practice from classrooms in other classrooms;
- helps in providing access to IT for disabled students in their homes; in general, puts special emphasis on special education.

2. **Post-graduate in-service courses** (350 hours of instruction) **for school IT co-ordinators** are organized by the University of Wrocław.
3. **Educational Forum for Information Society** was founded in 2003 to co-ordinate and organize continuous in-service training in IT for teachers from the region of Lower Silesia. The Forum will provide infrastructure of access to lifelong learning of teachers and will prepare projects for structural grant from the EU.
4. **Conference "Informatics in School".** Institute of Computer Science, University of Wroclaw, in cooperation with the Ministry of Education, is the main organizer of the annual national Conference „Informatyka w Szkole" (Informatics in Schools). In 2004, more than 500 participants from elementary and high schools, universities, hardware and software companies attended the 20th Conference. Among the main speakers at these conferences were in past: Alain Bron (Switzerland), Ian Carter (UK), Margaret Cox (UK), Eric de Corte (Belgium), Peter Gorny (Germany), Ivan Kalas (The Slovak Republic), Angela McFarlane (UK), Raymond Morel (Switzerland), Bojidar and Evgenia Sendov (Bulgaria).
5. International events to be held in Poland in 2005: EUROLOGO and IOI.

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