INFORMATION TECHNOLOGY FOR GOOD OR EVIL IN SCIENCE EDUCATION

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ABSTRACT
Computers have created new possibilities for experimental and theoretical methods of scientific research. It has been also expected that development in computer technology enables changes in teaching and learning methods stimulating a constructivist approach to learning. However it is a dramatic contrast between the rapid change in technology and relatively slow change in its application to education. Paradoxically enough, the contemporary trend in computers development creates dangers which can spoil benefits of ICT: capability to present different types of information in visual or audio form has shifted attention from handling and processing data to their presentation. As a result computers are considered mostly as multimedia tools, suitable for visual presentations. Animations and simulations are more spectacular and much easier to perform than making real experiments, and therefore, unfortunately, the use of computers is too often limited in presenting facts and information in a pseudo attractive way. Virtual reality created by multimedia replaces the insight to the natural phenomena.

KEYWORDS
Information Technology, Science education, Constructivism, Data logging, Modelling, Data processing

It has been nearly a quarter of century, since microcomputers started to invade schools. Now the conquest is already over. The widespread use of Information and Communication Technology is impacting on global societies and on education systems. When browsing through newspapers and billboards one can believe that nowadays only cellular phones are more important than computers for welfare and happiness of humanity! However, during the past decades of development, the dramatic contrast appeared between the rapid change of computer technology and the slow change in its application in education, between expected benefits and persistence of traditional teaching.

According to Papert (1999) two wings of digital technology have to be recognised: the technology as an informational medium and the technology as a constructional medium. Papert writes: “Of course the two wings are equally important; but popular perception is dominated by the informational wing because that is what people see and ceaselessly hear about and that is what reflects the predominant role of informational media in their lives". These two wings exist also in education, as “Part of learning is getting information which might come from reading a book or listening to a teacher or by visiting sites on the Web. (...) The other part is about doing things, constructing things. However here too is an imbalance: in large part because of the absence of suitable technologies, the constructional side of learning has lagged in schools, taking a poor second place to the dominant informational side”. Despite that “original contribution digital technology could make to education lies in redressing the imbalance, in fact the imbalance is increased by popular perception that so strongly favours the informational sides both of schools and of computers”. As a result “ the image of computers in school becomes one of supporting the traditional role of teaching".

At the beginning the role of computers was to compute. Nowadays it is common to code all information as numbers. Numbers play music, numbers paint pictures, and even humans are numbered! Data in numerical form can be stored, processed, and presented. Paradoxically enough, the contemporary development of computers creates dangers which can spoil benefits of ICT: capability to present different types of information in visual or audio form has shifted attention from handling and processing data to their presentation. As processing of data is connected with constructional wing, presentation of data very often plays only informational role.

For several years much has been said about making use of computers in education, and obviously there is no need to talk about their value. Nowadays computers are so common all over the world that one can think that this dream came true. Their number in schools is growing rapidly, despite economic constraints. However, to find the most effective use of ICT across curriculum it is necessary to develop new teaching methods and approaches, suitable software, and other educational aids.

Following Papert's idea, in Information Technology some strands can be recognised:

- **Processing of Information** (IT serves as a tool for **constructing** new information)
  - Data processing: computations, sorting, conversions, and so on
  - Modelling
  - Data Logging (Microcomputer Based Laboratory)
- **Presentation of Information** (IT enables to see ready information)
  - Internet (Telematics)
  - Multimedia

(Recently the term "Visualisation" is used, which reflects the ancillary role of presentation for data display.)

In the second half of twentieth century in many countries curriculum reform has been undertaken. Advances in cognitive psychology and researches on learning and teaching brought fundamental change in our view about learning goals as well as teaching and learning approaches. It is widely recognised that education should provide understanding of core concepts, and create relevant insight to nature. Education should aim to develop useful skills, necessary in common life.
However computers are mostly considered as multimedia tools, suitable for visual presentations. Animations and simulations are more spectacular and much easier to perform than making real experiments, and therefore unfortunately, the use of computers is too often limited to present facts and information in a pseudo attractive way. This tendency can be particularly harmful for science education, as it can recall old fashioned teaching of factual knowledge, instead of promoting new, constructivist approaches.

Multimedia 3-dimensional display can create Virtual Reality, which more and more influence human life, our impressions and our feeling. It can be discussed how virtual reality will impact common life, arts, or leisure. But it is obviously harmful, when the difference between real and virtual world fades, when there is no distinction between simulation and real experiment, when confusion arises about the sources of scientific knowledge.

Science Education should aim to create the general view of the natural world, integrating the separate disciplines. It is necessary to show the importance of science for understanding of environment and its protection, for society, and for common life. It is also necessary to get insight in the nature of scientific inquiry, and to get understanding of scientific methods and scientific reasoning. To reflect the nature of scientific inquiry, in science education the emphasis shall be put on data-logging, data processing and modelling of physical systems.

It is widely accepted that making use of contexts is a manner, which makes science more interesting and appealing to the young generation (Cambell, 1999). Interdisciplinary approaches in science education are necessary to show how science is related to the real world, and to emphasise the overall unity of the natural sciences (Millar and Osborne, 1998). There is also a shift towards student-centred, constructivist teaching. Both these tendencies can be met by using computer technology, especially modelling and Microcomputer Based Laboratory Dunin-Borkowski, 1996). Computer controlled experiments are less tedious, and the collected data can be easily processed. Instead of measuring discrete quantities the whole process can be studied, and the similarity of different natural phenomena can be enhanced (Dunin-Borkowski, 2002). As a classical example, charging and discharging of the capacitor can be compared to heating and cooling of the temperature probe (fig. 1). It can be studied how the voltage growth and decay depend on the parameters of RC circuit. The temperature probe is heated in hot, and then cooled in cold water. (It is worthwhile to note a remark of a teacher-student: “at last my students would understand that one has to wait, until temperature reading becomes stable”.) Both processes look very much alike. Of course, this similarity is caused by the analogy of the underlying models. The mechanism of these phenomena can be easily analysed and explained by computer models (fig. 2).

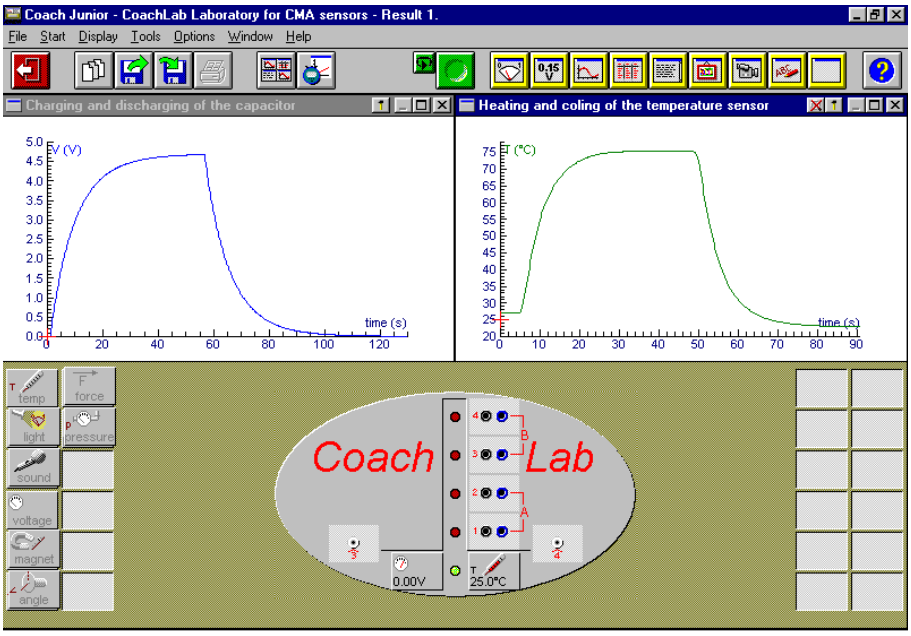
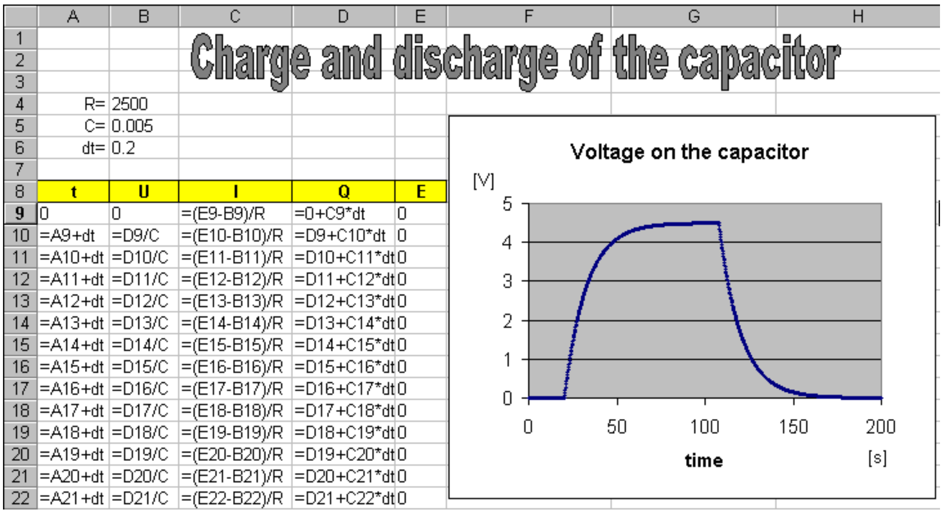


Figure 1. Similarity of different processes as measured with a computer interface

The set of sensors enables one to measure temperature, light, sound level, pressure, pH, magnetic field, and other physical quantities. Such equipment fulfils demands of modern teaching of physics,



	A	B	C	D	E
1			Charge and discharge of the capacitor		
2					
3					
4	R=	2500			
5	C=	0.005			
6	dt=	0.2			
7					
8	t	U	I	Q	E
9	0	0	=(E9-B9)/R	=0+C9*dt	0
10	=A9+dt	=D9/C	=(E10-B10)/R	=D9+C10*dt	0
11	=A10+dt	=D10/C	=(E11-B11)/R	=D10+C11*dt	0
12	=A11+dt	=D11/C	=(E12-B12)/R	=D11+C12*dt	0
13	=A12+dt	=D12/C	=(E13-B13)/R	=D12+C13*dt	0
14	=A13+dt	=D13/C	=(E14-B14)/R	=D13+C14*dt	0
15	=A14+dt	=D14/C	=(E15-B15)/R	=D14+C15*dt	0
16	=A15+dt	=D15/C	=(E16-B16)/R	=D15+C16*dt	0
17	=A16+dt	=D16/C	=(E17-B17)/R	=D16+C17*dt	0
18	=A17+dt	=D17/C	=(E18-B18)/R	=D17+C18*dt	0
19	=A18+dt	=D18/C	=(E19-B19)/R	=D18+C19*dt	0
20	=A19+dt	=D19/C	=(E20-B20)/R	=D19+C20*dt	0
21	=A20+dt	=D20/C	=(E21-B21)/R	=D20+C21*dt	0
22	=A21+dt	=D21/C	=(E22-B22)/R	=D21+C22*dt	0

chemistry, biology or technology.

Figure 2. Model built on the spreadsheet (formulas are displayed to show the model)

Modelling is an important part of scientific inquiry which is to describe phenomena in such a way that the phenomena become better understood (Dunin-Borkowski and Kawecka, 2002). Therefore modelling plays a crucial role in a constructivist approach, as it enable students to forge links between phenomena, and to understand their mechanism. The model permits "virtual experiments" to be conducted as simulations, but they are based on physical principles. A model can be accepted if simulation results match with behaviour observed in real experiments.

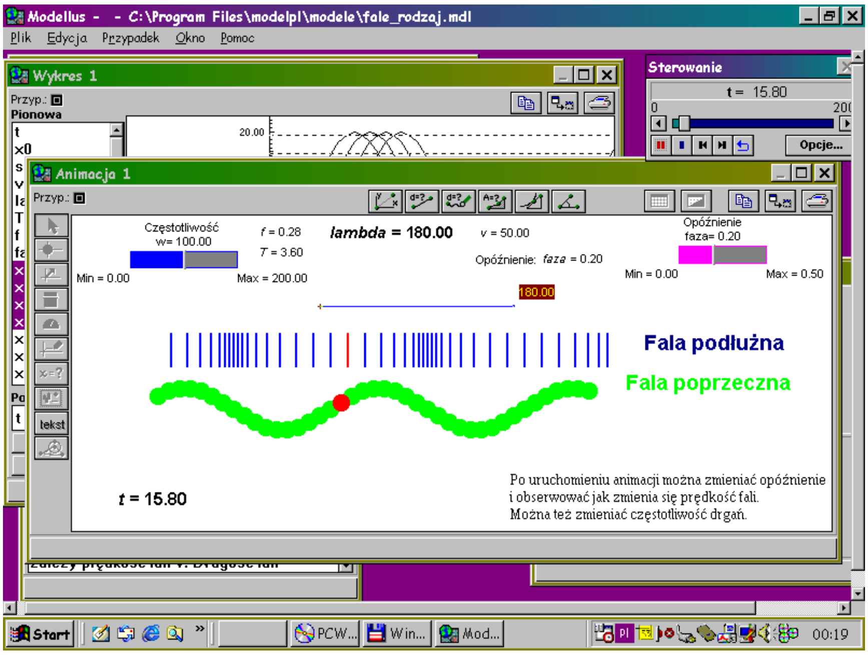


Figure 3. *Modellus* offers animated graphics

Modellus is a modelling program, which offers animated graphics driven by the mathematical model. Such tool pays tribute to the widespread belief in great educational value of animation. But this animation is not like a cartoon-film illustrating scenes concocted by an illustrator. It is visualisation of the model which can be analysed and modified (fig. 3).

Video films provide visual information. But it is possible to analyse motion recorded on video using software, which enables the marking of the position of a moving object at regular time intervals. The constructional value of such technique is to investigate motion phenomena outside the classroom.

Depending on the domain, modelling can adopt different versions. Database tools offer the possibility to sort data looking for pattern, relations, and distribution. Geographic data can be analysed in their spatial distribution. Geographic Information System software enables the representation of different geographic data stored in a database in the form of transparent layers overlapping a cartographic chart. Other databases often contain tools appropriate for specific educational tasks.

The educational values of IT have to be discussed from the point of view of the goals of modern science education. Then it is necessary to consider the activities fostered by different types of software. For such analysis a classification of learning modes describing a student's engagements Newton and Rogers, 2001) can be useful:

- receiver - student is an alert receiver of external knowledge;
- explorer - student is an interested explorer of external knowledge;
- creator - student is an imaginative creator of ideas and their understanding.

Summing up, as the fundamental problem of education is not the lack of information, but the lack of understanding, so for valuable science education the constructional wing of Information Technology has to be developed, as a vehicle for understanding.

All examples of actual teaching show that computer aided experiments and modelling activities induce interest and enjoyment among students. However, the uptake of 'appropriate use' of IT is poor in schools, despite of so many years of development and refinement (Rogers, 2001). The majority of teachers using IT in their lessons tend to use the new tools to solve traditional problems in traditional methods. The informational wing of IT is less demanding: it is easier to gulp ready information then to built new construction. For successfully implementation of new, promising pedagogy it is necessary to provide extensive guidance and training to counterbalance the general deficiency in pedagogical expertise amongst school teachers in using data-logging and modelling techniques.

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