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A brief Review and some perspectives of Informatics in Science and Technology Teaching(*)

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Contemporary Societies:

- Are based on Science developments (but not always on Science)
- Are dependent on advances in Technology.

Consequently,

STL - Science and Technology Literacy is:

- Critical for the welfare,
- Necessary to further development,

of the society,

STL is also a prerequisite for the existence of Democracy.

In Democracy, citizens participate actively on decision making process on their own and not as followers of a charismatic leader or being under the shepherd. As the decisions (regulations, resolutions … the legislation in general) are increasingly dependent on the advances in Science and Technology, active participation in democracy means that citizens should be S&T literate having also the cognitive skills permitting to make decisions on issues they are not experts. Model formation and scientific inquiry enhance such skills and they should constitute integral part of teaching, especially of Science teaching. Within this context, the effective Science and Technology teaching may be considered as a 'democratic right', a right to democracy. Otherwise, Science will be confused with religion as in the 'dark' years of Middle ages or as in some parts of the world now, e.g. see for the U.S.A. in http://www.ncseweb.org/ (visited at 29-Jun-2007) where education in Science, especially the theory of evolution, has been made a legal issue contesting religious dogma).

Science and Technology Literacy, especially in Informatics

Is missing from the society

due to the rapid developments in Science and Technology

Society (in a Vygotski context)

can contribute very little to Science and Technology Literacy.

Education: **only alternative** towards Science and Technology Literacy.

Compulsory Education **acquires specific importance**.

Compulsory education addresses all (future) members of the society, having as objective the acquirement of knowledge, the development of attitudes, of values and of psychomotive and social skills, resulting to a smooth integration to the context society. It is the institution of continuation of values and attitudes of a society, that is a conservative by default institution. It may, however, become, in a time depth also a process of society change (think why).

The effective Science and Technology teaching becomes an urgency,

in order :

- to fulfil the need for Science and Technology Literacy,
- to prepare for further education of the experts.

The use of New Technologies, and especially the use of Informatics,

To Science and Technology teaching, constitute and obvious choice to use.

Educational Technology: a process consecutive steps
towards the design of an effective teaching.

it includes:

- ✓the application of knowledge, e.g. from learning theories, cognitive psychology …),
- ✓the development of teaching approaches techniques
according to the model adopted,
- ✓the development, selection and use of the appropriate teaching means.

'New Technologies' in Education refer to **innovative approaches**
in any of the above aspects.

They constitute a system of concepts, means and techniques
that is continuously diversified, in pace with developments in the area [3].

Informatics, in its different forms, constitutes an **important component**
of New Technologies in Education. To many Informatics coincides with New Technologies.

[3]see e.g.: a/'The Encyclopaedia of Educational Technology', http://coe.sdsu.edu/eet/ [29-Jun-2006), http://users.uoi.gr/gtseper/).

The advances in Technology and the need for a **more effective teaching**,
especially in Science and Technology,

lead to the pursuit of new teaching approaches,
using the continuously evolving potential of Informatics.

➔ An especially prosperous activity in
Educational technology using Informatics in Education.

The **development** of a **teaching approach** based on **Informatics requires**:

- Knowledge of the teaching subject (outline),
- Understanding of basic teaching principles,
- Experience with the use of Informatics equipment and Software,

a very rare arrangement.

➔**need for a cooperation between experts in these three fields.**

This cooperation is better when the experts in one field:

- is literate, or – at least,
- is familiar,

with the basics of the other two fields.

A consequence of the previous remark seems to be:

- the introduction of educational technology (teaching design) to the curricula of departments of engineering and of other departments of a technical orientation[5].
- the development of software for the design and application of teaching using Informatics by (school)teachers and educators who are not experts in Informatics.
- the introduction of Informatics courses, e.g. design and development of web pages, quality features of educational software, etc[5].
- the many efforts for the training of teachers to the educational use of Informatics in most countries in European Union and elsewhere[6].

Indicative:

- ✓the massive increase of related works in scientific journals,
- ✓the increase numbers of related publications on the INTERNET.

[5] as an indication the search on 'Educational Technology' returned more than 240 Mio pages (more than 100.000 pages for a similar search in Greek). Many of these pages refer to such courses in various tertiary education departments and in training centres.

[6]For Greece see at http://www.cti.gr/epimorfosi/index2.htm and http://www.pi-schools.gr/epim_tpe/). On a European level see related actions in http://europa.eu/pol/infso/index_en.htm, http://ec.europa.eu/information_society/index_en.htm.

Here we present (briefly):

- forms of the use of Informatics in Science and Technology Teaching,
- (some) examples towards best practices,

- (a few) perspectives on the use of Informatics to Science and Technology Teaching

Some of our works may be found in:

http://www.clab.edc.uoc.gr/sge/

http://www.clab.edc.uoc.gr/oikos/

http://www.clab.edc.uoc.gr/hsci/

http://www.clab.edc.uoc.gr/aestit/

In general:

First education applications of ICT – Information and Communication Technologies:

- On issues of management of school class,
- On issues of school administration,

e.g.:

- Preparation of notes, transparencies, worksheets … for the teaching,
- name lists of students with their marks,
- teaching logbooks,
- formation and adaptation of work- and evaluation- sheets,
- etc.

useful to combat, also, the 'phobic syndrome towards the new' that many educators showed that time (even a couple of decades ago).

An important step (even now) was the use of general software, e.g.:

- Text- and word- processors in language courses,
- Spreadsheets in mathematics,
- Painting and drawing in arts (in geometry also),
- …

In Science and Technology teaching spreadsheets were used early:

- ✓to calculate values and functions,
- ✓to present graphs and tables,
- ✓to process experimental measurements,
- ✓etc.

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- ✓to calculate values and functions,
- ✓to present graphs and tables,
- ✓to process experimental measurements,
- ✓etc.

Disadvantage(?): lack of the feeling of e.g. calculation of mean values, error estimation, axis and scale choice for graphs, …

Possible compensation: a previous manual carrying out similar exercises focused on the process and rules used (e.g. how to choose appropriate scale and axis in a graph, what are the significant factors in error estimations …).

Advantage(?): possibility of trial (and error), more free time for an in depth study, for other issues.

In general, **a positive outcome,** provided that

special care is given to allow time for reflection and feedback

in order to achieve long term learning.

An important step (even now) was the use of general software, e.g.:

- **Text- and word- processors in language courses,**
- **Spreadsheets in mathematics,**
- **Painting and drawing in arts (in geometry also),**
- **…**

Use of general S/W in Teaching + preparation of notes, worksheets, …

➔presentation of whole course in an electronic form,

- **Accessible through the INTERNET,**
- **Especially in universities and training centres,**

➔beginning of 'electronic learning' e-learning (e-teaching a better term perhaps).

➔'electronic books' and electronic bookstores[9].

see e.g. http://books.google.com/books?q=e-learning&ots=cc12140-_K&sa=X&oi=print&ct=title or search for e-learning books

➔European Union and e-learning (teaching)[10]

http://ec.europa.eu/education/programmes/elearning/index_en.html.

Electronic books are usually **trivial - not innovative** in teaching approaches.

However they are:

- Useful to training, initial and continuous, especially in vocational education,
- Possibility of a continuous adaptation and renovation of their contents,
- Ease of use (e.g. a simple mp3 player may contain a whole encyclopaedia).

They are used extensively:

- by most repair workshops that operate using electronic manuals and help i.e. garages, machinery and other complex equipment repair services.
- by Technical Vocational Education and training institutions.

Innovative teaching approaches may be achieved by multimedia applications

Electronic books + drawings, images, sound, animation, video

➔ attractive multimedia presentations.

Advantage: quick creation with simple means[11]

➔ They replace rapidly the 'educational TV'.

[11]One medium personal computer with its accompanying software and a simple digital picture or video machine (e.g. a mobile phone) or a scanner are usually adequate, on the assumption that the software existing in the computer and its use are known to the user. See more in Antonis Plevrakis, "Creation of Educational Application Systems for Computer Aided Learning " post-graduate degree dissertation at the Department for Primary Education, University of Crete, Rethimno 1993 (in Greek).

Advantages of multimedia applications (vs. traditional teaching means):

- **Ease of use with low cost.** A simple computer and a video projector – data display are sufficient. Both cost less from pictures in a multitude of copies or a large display TV and video or a movie machine. The relevant applications cost less than similar (video)tapes, have a larger data capacity and use less storage space.
- **Smooth integration into teaching.** Attending or using a multimedia application may be done in the classroom (e.g. projection on the white board or on the wall) without any special arrangements such as dimming, which unsettle the class.
- **'made to measure' creation.** They may be created by the teacher so that:
  - they fit better the specific teaching requirements,
  - there is no need to seek and select between similar but different materials, and their subsequent adaptation of teaching to the material obtained.
  - simplify the process of enrichment, of adaptation, of updating,
  - modules created may be reused or combined to create more complex applications.
- **etc.**

Multimedia application replace other teaching means.

Prerequisite: knowledge and attitudes of the teacher (see comments later on)

Multimedia applications + modular structure, links and hyperlinks …

➔ Hypermedia applications.

e.g.:

http://aplo.eled.auth.gr/ (University of Thessaloniki – in Greek),

http://www.clab.edc.uoc.gr/hsci/ (The University of Crete - multilingual),

http://www.clab.edc.uoc.gr/aestit/ (The University of Crete - multilingual),

Hypermedia Educational applications:

- may operate (run) locally, on the user's computer,
- may be published (read, downloaded, run) through the INTERNET.

The **expansion of INTERNET** and its **ease of access**

opens **more possibilities in** education also.

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opens more possibilities in education also.

e.g.:

- **Direct on line help – training to educators, useful especially for teachers in rural – isolated areas. Teachers of Science and Technology may explore this possibility, to cover missing knowledge (i.e. safety recommendations for school laboratories), learning on alternative approaches and best practices other colleagues have tried, thus disseminating good practices, especially in relation to experimentation, where expertise is rather in demand.**
- **Forming Virtual Learning Communities of groups of teachers with similar interests being in different schools, communicating through the INTERNET, a feature greatly underexploited. Virtual communities may foster peer discussions on common problems, e.g. how to cope on operational and other issues related to laboratory teaching (limited space, low budget for operation costs, for repair and replacement, lack of multitude of experimental sets, lack of motivation for laboratory time and effort dedicated …). Peer discussions have lead in the past to innovative and effective solutions for laboratory or other experimentation teaching (an INTERNET search on 'cardboard and string experiments' returned about 0.5 Mio pages)[16].**

[16]A prerequisite is 'group culture'. Quite often teachers act on a competitive basis and not as a group with common problems, whose the solution would be a benefit to all of them.

The expansion of INTERNET and its ease of access opens more possibilities in education also.

- The formation of libraries accessible worldwide with an insignificant cost. Most well known encyclopaedias exist on INTERNET with a low cost in comparison to the printed version which, also, is quickly outdated. The on-line updating of Wikipedia makes it almost a news agency. This prompt updating is especially useful to follow up with the advances in Science and Technology.
- A worldwide low cost mentor. It is easy and quick to find on the INTERNET information on any subject from many different sources. For the Science and Technology teachers in schools who, quite often, face questions from their students on issues they have not as yet heard, this is an efficient and almost inexpensive solution. They may also find ideas on teaching approaches for 'difficult' or prone to misunderstandings S&T subjects, and share the experience of other colleagues.

http://www.britannica.com/, Encyclopaedia Britannica:
http://en.wikipedia.org/, Wikipedia
http://scienceworld.wolfram.com/, A 'wikipedia' on Science and Technology subjects:

http://www.webelements.com/webelements/scholar/index.html,

http://www.clab.edc.uoc.gr/aestit/,
http://www.cern.ch,
http://www.eap.gr/,
http://www.uky.edu/Projects/Chemcomics/.
http://www.windows.ucar.edu/windows.html,

The expansion of INTERNET and its ease of access opens more possibilities in education also.

- The creation and maintenance of web pages is now an easy and low cost process, using:
  - General purpose Software (e.g. most text processors and other electronic office applications, may create directly the html code of the web pages),
  - Utilities 'hidden' within the Operating system (e.g. the Movie Maker of Microsoft Windows),
  - Specific software application addressing target groups (e.g. teachers, sales persons, …). They provide professional quality although at a cost.
  - There is also free software applications that anyone may use, although some security issues against malicious exploitation should be always taken into account[20]

[20]Search the INTERNET for free software. The following sites may also be useful: http://www.horde.org/, http://www.apache.org/, http://www.fsf.org/, http://www.gnu.org/.

The expansion of INTERNET and its ease of access opens more possibilities in education also.

- **Facilitation of Distance Education.**
  - **teleconferencing.** Simple teleconferencing software (usually for a limited number of users) is included to the operating system software. Broadband networks will enhance further this possibility.
  - **Hypermedia applications used for teaching.** It may refer either to complementary – additional activities (drills, homework, project studies …) or to (part or whole) teaching course. It may be delivered either locally, through a DVD/CD, or through the INTERNET.

- **Hypermedia applications:**
  - A continuous expansion of their features and possibilities,
  - An even easier creation.

- **The use of INTERNET for teaching is continuously expanding**
  especially in technical – vocational education and training.

- **Creation of related software, e.g. the free software Moodle http://moodle.org/.**

Problems and Concerns on using the INTERNET.

Some concerns (drawbacks) on the use of widely available information and resources at the INTERNET include:

- **Large number of pages returned (hits).** In simple INTERNET searches a very large number of data is returned resulting in a need of selecting the relevant information (*'where is the knowledge we have lost in information?' - from 'The Rock' by T.S. Eliot, 1934*). Even using sophisticated search criteria the returns are still many. A problem similar to the worries of a first time user of a large library. The search on 'exotic' words (e.g. Greek language limits the problem.
- **Dubious validity of the information obtained.** The validity of information is, in many cases, questionable or biased. Note however that any different viewpoint and any criticism on any issue may appear on the INTERNET without, up to now, any effective ban (censorship) impeding it. This problem may be solved by using the same techniques used on checking the validity of information obtained by traditional means.

Problems and Concerns on using the INTERNET.

A problem that may become acute is the possible Bias of Information (Unilateral presentation) due to:

- **Monitoring - censorship** there attempts from governments (e.g. USA, China …) to ban or censor information on the INTERNET on reasons of combating terrorism, pornography or otherwise.
- **'Intelligent' search engines.** The intelligence of the search engines trying to guess the more probable type of information wanted. This intelligence although mostly useful, may hide the (rare) type of information actually wanted, either because it is considered not very probable or because it is of a forbidden to know nature or for other (e.g. commercial) reasons. It is also prone to malicious exploitation; see for example the 'Google bombing'.
- **'Google bombing'.** By exploring the way the Google's (and other's) search engine works it is possible to direct the search results to irrelevant or insignificant web pages. It may be archived by creating a (large) number of web pages with the same words linked to the misleading site. Google bombing is similar to spamdexing, in which the use of 'Meta' flags (a way of keyword indexing the contents of web pages) is exploited by using meta keywords totally irrelevant to the contents of the site.
- **Anti-spam – antivirus checks.** Some antivirus – antispam software may block or otherwise inhibit some features of web pages in order to be safe from malicious exploitation of web information. See in http://www.sch.gr/ page 'e-υλικό' for some relevant safety rules (in Greek).

INTERNET + Course Development ➔ Open University type teaching.

- (partial) response to the problems (especially in tertiary education):
  - of the large and increasing ratio students to teachers.
  - of the shortage in buildings and infrastructure observed.
  - of the non concurrence of time available between teacher and students

    that limit drastically education, especially in the area of continuous education.
- Teaching through INTERNET:
  - in the form of presentation – lecture (usually),
  - aims at learning to the level of (factual) knowledge - information (as a rule),
  - may form good teaching material if multimedia capabilities are used.

- **Teaching of Science and Technology**:
  - they permit multiple representations and explanation

    to subjects 'difficult' or outside everyday experience.
  - plenty of examples exist already in the web[22].

[22]Search for 'Science teaching' or similar. See also the sites (mostly in Greek),
http://www.arsakeio.gr/inf_links.htm, ,
http://iskp.csd.auth.gr/projects/sep/ ,
http://www.sch.gr/
http://public.web.cern.ch/Public/Welcome.html European Centre for Nuclear Research (CERN).
http://public.web.cern.ch/Public/Content/Chapters/Education/OnlineResources/PhysicsIssues-en.html

INTERNET for Science and Technology teaching.

- **Effective for (see also later):**
  - Multitude of presentations.
  - Representation (of the basic parameters) of a phenomenon quickly and in a simple way.
  - Vividness in presenting models of natural world no directly observable - perceptible.

In simple hypermedia applications:

- **Learning related to laboratory teaching is not covered**
  - Psycho motive area (dexterities of performing physical - handy works),
  - Emotional area is also not covered
  - Feeling of quantities and processes.
- **Complex cognitive skills are also not covered**

  e.g. cognitive skills and strategy (Gagné), or problem solving skills.
  - Absence of reflection and deliberation time
  - There is no feedback.

The addition of active elements in hypermedia covers these deficiencies.

Hypermedia and active elements to Science and Technology Teaching.

Active elements: 'objects' (S/W programs and subroutines mainly), that

instead of simply presenting information perform specific tasks to the user's computer.

A simple example:

Entry of data, like (initial) values of physical quantities in a phenomenon

➔Calculating values etc.

➔graphical presentation of a relation or a whole phenomenon,

- Descriptive presentation of not directly perceptible models for the natural world.

They permit repetition ➔ Feedback

Repetition, Feedback and Modular Structure (carry-over depending on the Feedback)

➔Simulations + Virtual Laboratory

a very powerful teaching tools for Science and Technology education

Repetition, Feedback and Modular Structure (carry-over depending on the Feedback)

➔Simulations + Virtual Laboratory

Permit the development of complete application for teaching approaches

with adequate coverage of all cognitive learning levels not factual knowledge only

Simulations + Special equipment ➔ Virtual reality

the User (has the feeling that he - she) 'lives' the plot.

The exploitation of such applications:

- may be used for self – teaching aiming at complete cognitive learning,
- may cover the emotional and psychomotive areas,
- May lead to (new?) social skills when it runs on the INTERNET

JavaScript, Applet, Physlet are examples of Active elements.

that initiate the execution (run) of programs and tasks of any kind to the user's computer

JavaScript 1995 (Mocha) in Netscape Navigator (© Netscape Communications Corporation):

- directives ('commands') to the browser to perform specific tasks
- interpreted by the browser when they are encountered.

Java © Sun Microsystems different from JavaScript:

- a programming language independent of the H/W,
- appropriate for software applications in many smart devices (computers, mobile phones, …)

Applet:

- a set of Java commands integrated into hypermedia applications,
- they are 'executed' (run) as programs by the browser,
- they need the activation of the Java virtual machine software

freeware see http://www.java.com/.

Physlet: Applet designed for the teaching of Science and Technology

- a large and increasing number developed[24],
- many available on the INTERNET
- Many within the free software philosophy[23],

- used extensively for simulations, e.g.:
  - plot of simultaneous changes to the quantities in a Science phenomenon,
  - complete simulation of a phenomenon,
  - simultaneous presentation of similar phenomena under different initial conditions.

[23] http://www.fsf.org/ or http://www.gnu.org/

[24]search for 'physlet'. See also in:

Wolfgang Christian and Mario Belloni, Physlet Physics, 2004, Pearson-Prentice Hall, it contains a physlet CD,

http://webphysics.davidson.edu/Applets/Applets.html

http://webphysics.davidson.edu/physlet_resources/

http://www.swgc.mun.ca/physics/physlets.html,

http://physics.uwstout.edu/physapplets/,

[visited 30-June-2007]

Physlet: Applet designed for the teaching of Science and Technology

Points of attention:

- they show a representation – simulation, not an actual phenomenon: the simulation may be good or better depending on the sophistication and knowledge, reproducing reality but not to its full extent.
- they represent our current knowledge which is approximate. For example, in ballistics the effect of air either it is neglected or it is approximated by the (simplified and empirical) models depending on the velocities, profiles … of the projectiles.
- no critical thinking(?). In direct observations or experimentation, the observer must screen relevant from non relevant data and have an idea of any other parameter not directly studied. This process develops complex cognitive skills (i.e. evaluation in a Bloom taxonomy). In simulations, this opportunity is missing as it is the programmer of the simulation who has already decided what and how to present.

Physlet: Applet designed for the teaching of Science and Technology

They are effective for knowledge – information (Bloom taxonomy):

- **Vividness.** The learner remembers for a longer period.
- **Multitude of representations.** The possibility of running a simulation with different parameters (e.g. initial values) helps to a better understanding of the phenomenon under study. The appropriate exploitation of this (e.g. a simultaneous presentation of the same phenomenon under different initial conditions) may develop a feeling of the relative importance of the different factors of a phenomenon.
- **Preparation - experience**. The previous possibility makes simulations a very good practice tool in technical vocational education (see 'flight simulators') or to prepare for difficult to experience situations (e.g. earthquakes).
- **Substitution.** They constitute the best substitute to direct observations (if properly designed) and, in case a direct observation is not feasible, the only alternative.

Virtual reality: May be effected by using Java capabilities.

e.g. role and/or strategy games like SimCity - SimEarth.

Virtual reality in Science and Technology teaching[25]

- ➔Virtual laboratory
- ➔Virtual class (classroom)

[25]Searching [30-Jun-2007] the INTERNET the hits returned were: more than 40 Mio for Virtual laboratory, more than 110Mio for virtual class (they include the 'virtual class' concept of computer programming) and more than 10Mio for 'virtual classroom'. Even in Greek, the same search returned more than 50.000 hits for virtual laboratory and more than 60.000 for virtual class/classroom.

Virtual laboratory: a virtual class with simulations (only yet).

- a useful tool to Science and Technology teaching,
- with increasing applications.

- Mainly, the simulation of an experiment
- Depending of the sophistication of the application:
  - the student selects the experiment to conduct,
  - then he – she selects the necessary equipment, arranges it, defines the initial conditions …
  - The application implements the simulation.

Another concept is the **Tele-laboratory**

- An actual laboratory where the student through the use of computers, manipulates the equipment and observes the results from a distance.
- It may be used for expensive or dangerous experiments although its efficiency may be questionable

For more information search the INTERNET for '**Telelaboratory**'.

Virtual laboratory: a virtual class with simulations (only yet).

Advantages, especially for teaching large groups of students, are:

- **Familiarization** with the experimental process. It also limits the learning time for the use of equipment and devices, of the experimental process and the presentation of measurements, of the preparation for an experiment, … .
- **Trial.** It offers the opportunity of (virtual) trials and experimentation under varying conditions, a feature contributing to experimental feeling.
- **Time economy** for the understanding of safety rules to laboratory work.
- **Combats shortages** in numbers of devices, in laboratory space, in operational costs, …
- **Facilitates** the 'successful' operation of difficult or time-consuming experiments,
- **Better understanding.** It may contribute to a better understanding of the phenomenon under study by presenting explanations and remarks in pace with the simulation,
- **…**

Virtual Laboratory does not replace completely actual experimentation (not yet)

Virtual Laboratory does not replace completely actual experimentation (not yet)

Laboratory teaching, apart from knowledge, aims also:

- To the development of psychomotive skills and to emotional attitudes.
- To complex cognitive skills (e.g. problem solving skills) that may be developed by 'Scientific inquiry techniques[27].

Also, in small age, the correspondence between the simulated representation and the actual situation is not always one-way and, being abstract to a smaller or larger extent, presents difficulties (for example, think how a simple electric circuit is presented and how its really when viewed in a photograph).

[27]see more in P. G. Michaelides, 'Polymorphic practice in Science',1st Pan-Hellenic Conference on the Didactics of Science and the Application of New Technologies in Education, University of Thessaloniki, Thessaloniki, 29-31 May 1998, proceedings pp. 399-405 (in Greek).

MicroLab.

Developments in microelectronics, especially on the ASIC – Application Specific Integrated Circuits, made possible the construction of devices, especially of measuring instruments, with many capabilities and low cost.

The consequences to Science and Technology education were significant[28]:

- Measuring instruments, Experimentation devices and related equipment are easily obtained permitting laboratory teaching to be feasible.
- Students may familiarize themselves with advances in technology.

ASIC lead to the construction of sensors with low cost and energy requirements

➔Construction of new measuring devices that:

- May measure values of more physical quantities than before (e.g. acceleration, torque),
- May be connected to computers for simultaneous measurement of many variables and over long observation times

➔ MicroLab Microcomputer Based Laboratory - MBL

[28]provided that schools had the responsibility and the means for their equipment. In centralized education administrations, like Greece, where a central authority (usually the Ministry) is responsible, the bureaucracy inhibits this.

MicroLab.

Useful:

- **To learning of factual knowledge especially in technical and vocational education.**
- **To general education, e.g. for a familiarization with the 'smart gadgets' of contemporary life.**

Sensors + programmable controllers → Robot[29]

Artefacts that respond to changes in their environment performing tasks, including physical movement, or controlling other devices.

Robots is another useful tool to the teaching of Science and technology (see later)

[29]Robots may be considered as an evolution of automata. Examples are the probes used to the exploration of space, of earth or in (micro) surgery. They are controlled by computers, part of them or in separated. Although popular perception refers to humanoid forms, robots may have any form appropriate to their function. The word originates from robotovat (=work, slavery in Czech) appeared at 1920 in a work of the Czech writer Karel Čapek to describe humanoid artefacts – servants. Robots are popular in Science Fiction. Robots are also called specific computer programs like those detecting and analyzing web pages (e.g. to locate contents of interest to their user).

LOGO:

- A teaching approach based on computers incorporating constructionism
- Realized in 1967 by the MIT Artificial Intelligence Laboratory with Seymour Papert as a main actor
- A LISP like programming language, used, although on an experimental basis, in teaching young pupils
- Aiming to the development of space understanding and movements (with the 'turtle robot') or to the development of complex cognitive skills (with the 'turtle design' on the display of the computer).
- It included, in principle all school subjects, however the majority of the simple teaching implementations with Logo addressed Mathematics and Science.
- Its structured programming incorporated to Logo with its recursive modules ('routines' and 'subroutines') permitted complex teaching presentations (including graphics, sound and animations) often with feedback from the user (learner).
- In the Science and Technology sector, included visualizations of natural phenomena and, sometimes, virtual experiments.
- This trend peaked after Papert published 'Mindstorms'[13] and facilitated by the proliferation of (personal) computers.
- Complete libraries of routines have been developed (check the INTERNET for 'Microworlds') and distributed with specific Logo implementations addressing school subjects, usually from natural sciences.

[13] Papert, (1980). Mindstorms: children, computers and powerful ideas. N.Y.: Basic Books. Also http://el.media.mit.edu/Logo-foundation/products/books.html#Mindstorms [8-Jun-2007]

LOGO:

- A teaching approach based on computers incorporating constructionism
- Another following innovation from MIT Media Lab was LEGO-Logo in which computers with the Logo environments were connected to artefacts made by Lego© bricks and including sensors, lights, and motors.
- With current advances in Informatics and microelectronics, this has been evolved having now a computer as one of the Lego (or Lego like) bricks making thus possible the **construction of autonomous robots**.

- Courses on 'Educational Robotics' are constantly appearing as a potentially very powerful tool for the Science and Technology teaching.
- Educational Robotics may be considered as the evolution of the LOGO environment.

Educational Robotics as an educational environment

is very useful in **Science and Technology Teaching**.

Sensors + programmable controllers → Robot

Artefacts that respond to changes in their environment performing tasks, including physical movement, or controlling other devices.

Robots in educational robotics:

- **Have a set of basic functions (start a motor, open – close a circuit …),**
- **May be connected to other devices (sensors, other robots, …),**
- **May be programmed.**

- **Continuously expanding applications in home devices and apparatuses**
- **With simple or complex structures may be assembled with a relative ease,**
- **Educational applications already in in-service training.**

Educational Robotics as an educational environment

is very useful in Science and Technology Teaching.

Educational Robotics in Science and Technology Teaching.

Subject: the construction (the assembly) of a robot performing specific functions.

Objectives:

- The development of complex cognitive skills,
- A better understanding of Science and Technology
  e.g. in their effort to make the robot to move responding to signals from its sensors,
- The development of creative and of critical thinking,
- The familiarization – literacy in modern technology.

Courses on Educational Robotics are already available[31]

- To teachers , in-service and pre-service
- to school-students,
- to other educators,
- ...

They are based on the use of low cost, easily available, robot sets[32].

[31]Simos Anagnostakis and P. G. Michaelides, 'Results from an undergraduate test teaching course on Robotics to Primary Education Teacher – Students', paper to be presented to the HSci2007 - 4th International Conference on Hands-on Science, 23 - 27 July 2007, Ponta Delgada, Azores, Portugal (http://www.hsci.info/hsci2007.html).

[32]Search for 'robotics' or 'educational robotics'.

Commentary:

First applications of Informatics in Science and Technology teaching:

- Trivial – a simple traditional lecturing with a computer
- Ignoring the capabilities , although very limited then,
- Disturbed the class – they have to learn the use of the computer in advance

It is still observed although the innovative actions increase exploiting the current capabilities of the technology.

Often Informatics in S&T teaching is used:

- Not always efficiently,
- Without a relevance to learning objectives, e.g.:
  - Impressive multimedia applications with sound, animation, video …
  - Keep the students' interest, possibly,
  - Without, however, corresponding learning outcomes[37].

[37] It seems that although animation and video keep students' interest high, a combination of text and sound (or only one of them) is more effective to learning. Results from Panagiotis Politis, "L'INFLUENCE des divers facteurs et particulièrement des divers médias de logiciel multimédia éducatif expérimental sur le processus de l'apprentissage de l'informatique initial chez des étudiants de niveau d'IUT.", Université PARIS VII, UFR Didactique des Disciplines, (spécialité: Didactique de l'Informatique), Paris Dec.1999.

Informatics in Science and Technology teaching:

Provide new possibilities

to the teaching of subjects considered difficult or outside direct observation, e.g.:

- **Visualization of models** through the use of simulations, for example:
  - **A model of the solar system** and the earths orbit and rotation (S/W available commercially and free on the INTERNET). This is useful to the understanding of the change in the duration of the daylight throughout the year and the succession of seasons[38], to the feeling of relative distances and to the admission of a spherical shape for the earth despite the experience of hills and valleys. The traditional teaching by narration simply substitutes a 'scientific dogma' in place of science.
  - **Bohr's model of the atom.** Many textbooks quote that the atom is a miniature solar system in defiance of the fact that a solar system with the earth orbiting the Sun is outside students' experience. It could equally wrong state that the solar system is like an atom with giant dimensions.
  - **Quantum mechanical model** with the electron orbitals 'visualized' (e.g. as areas with different darkening) and superimposed with the expected Bohr trajectories.

Informatics in Science and Technology teaching:

Provide new possibilities

to the teaching of subjects considered difficult or outside direct observation, e.g.:

- **Use of 'Monte Carlo' simulations** to visualize thermal motion[39]. This technique may evolve to a complete simulation of thermal phenomena on the basis of particles thermal motion in a consistent way, that may eliminate the problem of misconceptions associated with Heat where classical thermodynamics and particle thermal models are intermixed in its teaching. Such an approach may help the transition from the positivistic approach of classical physics to the statistical results of quantum physics.

[39] G. kalkanis, Professor at the University of Athens, private communication.

Commentary: despite their inherent advantages, New Technologies, especially Informatics, they have a marginal role in most schools and they are not exploited in their full capacity. In a recent study[41], it was found:

- There are many teacher training actions,
- Informatics in schools is mostly used on administrative and managerial tasks of the school and, sometimes of the class,
- Teachers' lack of knowledge cannot fully justify the non – utilization of Informatics,
- It seems that:
  - Inertia[43]. Teachers teach according to their experience as students and cannot easily adapt to new situations.
  - Preference to the 'beaten track'[44]. Teachers prefer teaching approaches they have already used instead of the adventure of trying new options.
  - Problem of excess options[45]. In cases of many options available to chose, teachers cannot decide what to do.

[41]A Margetousaki and P. G. Michaelides, 'A seminar on Informatics in schools' proceedings of the seminar 'Didactics of Informatics', University of Thessaly, Volos, 16-17 January 2004.

[43]Somekh B. Supporting Information and Communication Technology Innovations in Higher Education, Journal of Information Technology for Teacher Education, Vol. 7, No. 1, pp. 11-33 (1998).

[44]Mumtaz S. Factors affecting teachers' use of information and communications technology: a review of the literature, Journal of information technology for teacher education, vol. 9, No. 3 pp.319-341 (2000).

[45]Γεώργιος Π. Πολάκης, 'Διερεύνηση Μορφών Διδακτικής Αξιοποίησης Πολυμεσικής Εφαρμογής από φοιτητές του Δ' έτους Π.Τ.Δ.Ε. όπως αυτή προκύπτει από τα σχέδια διδασκαλίας που συντάσσουν, μεταπτυχιακή εργασία στο Παιδαγωγικό Τμήμα Δημοτικής Εκπαίδευσης του Πανεπιστημίου Κρήτης, Ρέθυμνο, Ιούνιος 1999.

Commentary:

Teachers education and training should be effected:

- Using New Technologies, especially Informatics.
- Using as application examples modern Science[46],
- Using examples of teaching approaches that incorporate Informatics,
- Preferring teaching approaches that promote scientific inquiry,
- Associating Science and Technology teaching to everyday life[47].

[46]P. G. Michaelides, Tsigris Miltiadis, On the feasibility to include contemporary Science concepts in the Primary school curricula – a retrospection into two case studies, HSci 2006 - 3rd International Conference on Hands-on Science, 4th - 9th September, 2006, Braga, Portugal, proceedings published by University of Minho, pp 261-266 (http://www.hsci.info/hsci2006/index.html).

[47] P. G. Michaelides, "Everyday observations in relation to Natural Sciences" in Learning in Mathematics and Science and Educational Technology, University of Cyprus July 2001, Volume II pp. 281- 300.

Commentary:

Informatics in Science and Technology teaching:

- **Should incorporate ICT in a smooth way and not as an ad-on.**
- **Should be adapted to the target group (students) considering their abilities and cognitive maturity.**
- **Should be based on a sound learning theory in a consistent way.**

The effectiveness of Laboratory teaching may be enhanced with the appropriate use of Informatics:

- **Making possible complex experimentation,**
- **With ease and a low cost**

- **Making possible the teaching of Science principles within the context of modern Science without following the historical development.**

A basic problem

Change of teachers' attitudes and practice

Towards New technologies, especially Informatics in education

In all levels consistently.

Communication of good practices may help

A view from The University of Crete campus at Rethimno

Thank you