On pedagogical possibilities for the future application of information technology in education

– Memorandum to the Danish Ministry of Education, 16 April 2004

by Robin Engelhardt, Learning Lab Denmark

The thinking on education policy in Denmark and Scandinavia has, for many years, been permeated by a basic approach in which the pedagogical situation is seen primarily as a social situation – one in which democratic values and modes are to be exemplified, including dialogue and communication as equals, as well as the latitude to pursue personal development. It is important to understand education not as rote learning but as a process of learning, which places emphasis on depth of knowledge and sophistication and taking a critical stance toward objectives, rather than merely accepting given goals. In this way, one avoids viewing education simply as teaching and training from a purely instrumental point of view.[1]

Over the past twenty years, concepts such as lifelong learning and competency development have emerged and been touted as crucial elements in the reorientation of the Western world to the age of information technology. During this process, the humanistic understanding of the lifelong learning concept, formulated in the 1960s, which prioritises democracy and personal development, has been replaced, to a great extent, by a more market-oriented interpretation, which views education as an investment in "human capital." This political shift from viewing the person as the focus to viewing the person as a resource has also had a certain amount of influence on educational thinking, particularly through the OECD's analyses of national educational systems during the 1990s. IT was considered here a crucial skill for spurring the advance of the information society in open global competition.

At an international level now, one sees to an increasing degree that the integration of IT into education is being viewed through this lens of economic competition: if one simply creates enough IT-competent citizens and makes a sufficient number of computers available, greater efficiencies and the information society will not be far behind. This is a rather one-sided policy perspective, and one that is quite familiar from many years of struggle to encourage enough people to become interested in studying technology and science. It is one-sided, because the motivation for people to devote themselves to science, or for that matter IT, does not normally reside in the domain of economic rationality. Their motivation rather resides in the desire to understand the subject, to make sense of life, or to make life easier for themselves and others. The perspective may also be unfortunate, because there is a risk of losing sight of these reasons – good reasons that harmonise with potential benefits of the IT revolution, such as greater variation in forms of communication, the construction of a critical sense through the acquisition of information, a more transparent democracy, and a greater capacity to accommodate the individual's style of learning.

To a great extent, however, the educational policy goals defined in Denmark to this point have avoided looking at the development of IT from an economic perspective. Rather, they have

---

[1] See: Om pædagogikkens facettering i informationsteknologiens tidsalder, Hans Siggaard Jensen, Copenhagen Business School, 2001.

been based on traditional humanistic ideals, making the individual the focal point.[2] From an international perspective, this has – in, perhaps, a contra-intuitive but positive way – helped put Denmark far ahead in the IT realm.[3] In other words, the fundamental philosophy of Danish education and its concomitant policy objectives seems to have provided fertile ground for taking advantage of the opportunities provided by new information and communication technology. At any rate, one might very well ruminate on the extent to which Denmark's tradition for public debate, consensus-seeking, and democratic association has contributed to a natural acceptance of the advantages provided by information and communication technology. Many other countries have also been quick to embrace the computer and the Internet; but when it comes to breaking with obsolete structures of authority and educational theories and developing new didactic tools on the basis of the opportunities information technology provides, it appears that Denmark has a head start.[4]

It is a head start that can be built upon. One must continue to define precise political and educational goals with respect to the use of IT and, at the same time, acquire an increasingly better understanding of when IT has a meaningful purpose in a teaching situation and when it does not. Not until this basic point has internalised – that IT must be integrated into education as an aid to pedagogical goals and not as a governing principle for more effective teaching – can IT be used as a tool to promote a higher quality of education for everyone.

International studies

How has information and communication technology been integrated into the classrooms of the world, and what can be learned from the many different approaches? A number of international studies have taken up this issue and many more are on the way. Common to them all, however, is that their perspective is very general, focused primarily on educational policy and structural factors. The studies are generally quite sparing, when it comes to specific recommendations for innovative, didactic/pedagogical principles with respect to IT.

OECD

The OECD has several sources that touch on the use of IT: first and foremost, the PISA study.[5] A number of IT indicators were published in the 2003 version of *Education at a Glance*[6] with analyses of the use of IT at the upper secondary school level (three students per computer, etc.) and an analysis of obstructions to an effective integration of IT (old machines, e-mail, www, insufficient time with teachers, etc.). More recently, there have been several analyses of the integration of IT into upper secondary schools, including the OECD's international ISUSS database (The International Survey of Upper Secondary Schools),[7] with many more quantitative measurements. In general, Denmark ranks high by these measurements.

The Center for Educational Research and Innovation (CERI) under the OECD has published a

---

[2]Danmarks strategi for uddannelse, læring og IT [Denmark's Strategy for Education, Learning and IT], Danish Ministry of Education, 2001.
[3]Completing the Foundation for Lifelong Learning: An OECD Survey of Upper Secondary Schools, 2004, http://www1.oecd.org/publications/e-book/9604011E.PDF
[4]Ibid. p. 137-140.
[5] OECD (2002) *Knowledge and Skills for Life: First Results from PISA 2000*, Paris.
[6] *Education at Glance: OECD indicators* – 2003 Edition
[7] http://www.oecd.org/dataoecd/4/45/27446860.pdf

case study on IT and innovation in education[8] in which there are many conclusions worth embracing, particularly the general conclusion that the simple presence of IT in the classroom does not make a great deal of difference. Only a prepared and flexible educational system that has carefully planned modifications to lesson plans, examinations, school culture, in-service education, etc., can use IT as a lever for change and (as a significant bonus) retain its flexibility. Among the recommendations are the continued construction of an IT infrastructure inside and outside of the educational institution, greater IT skills among teachers and students, and a forward-sighted and competent management that can contribute vision and secure greater permanence for the innovations IT provides. In general, however, it is emphasized that IT infrastructure and IT skills must be defined in relation to pedagogical and educational policy goals, not as goals in themselves.

The latest OECD publication, *Completing the Foundations for Lifelong Learning* (2004),[9] which also includes Denmark, speaks of a "disappointing" use of IT at the upper secondary school level, attributing it to a number of factors, including insufficient access to hardware, insufficient professional development, support budgets that are too small, a limited use of IT due to insufficient knowledge, insufficient pedagogical tools, etc. In relation to the other countries investigated, Denmark is doing well in the areas of hardware and in-service education; but as soon as one moves into more organisational areas (IT support, management, feedback), Denmark is not, in essential respects, any better off than other countries. As to the pedagogical use of IT, the report provides scant information.

Other institutions and countries

The International Association for the Evaluation of Educational Achievement (IEA) has done a comparative analysis, called SITES (Second International Technology in Education Study), divided into Module 1[10] and Module 2,[11] which investigate indicators and innovative pedagogical practice in the use of IT.

The Module 2 study from 2003 reported some very weak positive conclusions, such as the fact that IT and the Internet may contribute to greater proficiency and more student-guided learning. In only a few instances can IT be used to teach something one *could* not previously teach. In general, however, the assessment is that, even though IT in certain instances can improve the quality of existing education, the use of IT does not bring about a change in the form or content of education, making them more up to date. Once again, we find here the point that, if the introduction of IT is not accompanied by general pedagogical objectives, the use of IT in education will continue to be simply a not always pointless intrusion.

---

[8] Venezky, Richard L. & Davis, Cassandra (2001) *Quo vademus? : The Transformation of Schooling in a Networked World,* Paris (Version 8c, March 6, 2002) in OECD/CERI *Information and Communication Technology: Case Studies* http://www.oecd.org/dataoecd/48/20/2073054.pdf

[9] Completing the Foundation for Lifelong Learning: An OECD Survey of Upper Secondary Schools, 2004, http://www1.oecd.org/publications/e-book/9604011E.PDF

[10] *ICT and the Emerging Paradigm for Life Long Learning: a Worldwide Educational Assessment of Infrastructure, Goals, and Practices*, Pelgrum, W.J. and Anderson, R.E. (eds.), IEA, Amsterdam (2001). http://sitesm2.org/SITES_Research_Projects/sitesm1.html

[11]Technology, Innovation and Educational Change – A Global Perspective, Robert B. Kozma (ed.), IEA, Amsterdam (2003). http://sitesm2.org

When Module 3 is published, the focus will be on teacher education: teachers' access to – and relationship with IT.[12]

Finland very early realised in its IT strategy[13] that the future applicability of IT in education demands a shift in focus from hardware to pedagogical innovation. Students and teachers need help using ever more complicated information structures. This requires co-operation, interaction, physical presence, and exploitation of expertise distributed throughout a network. There is a special focus on reformulating teacher plans from a description of content to a description of skills, new IT-supported forms of education and materials, and a necessary change in the form of examination.

Unfortunately, not much has been written about *how* these new IT-supported forms of education and materials and changes in examination form are to be developed in practice. For Finland, it is primarily a matter of developing a "communal knowledge network" in which teaching environments are expanded to interact with other environments and other people in the community. The teacher is to become a "tutor" and "organiser of study arrangements," while students will themselves be responsible for developing often very differentiated learning strategies. Based on its pedagogical objectives, it may be said that the Finnish IT strategy is working in the same direction as the Swedish School 2000 initiative.[14] A good example of a successful use of these new pedagogical principles in Sweden is the "Futurum" school,[15] a little north of Stockholm.

As one can see, European education policy today is divided into two main ideological positions. One is the economic-liberal view that is found, especially, in southern and eastern Europe: the desire to become competitive quickly and effectively in the information society by, among other things, using education to increase IT proficiency. Here, the concept of lifelong learning is understood primarily as an instrument for transforming the individual into an infinitely malleable and capitalism-compatible component in the labour force. The other position, which is particularly found in northern Europe, is the humanistic-pedagogical view: the idea of lifelong learning and competency development is here seen as an instrument for promoting personal development, civil society and democracy.

Now, it is possible that, although these two positions may have different ultimate goals, they overlap – at least, partially – in their use of means. Therefore, the choice today is not an either-or, but simply a matter of finding the right cadence in which both approaches can march. However, there is a problem in that many teachers do not know how to reconcile the idea of acquiring digital skills and proficiency with the humanistic ideal of lifelong learning. While one may be viewed as a deficiency that can be remedied by courses or driver's licences, which one may accept in a pinch, the other is thought to be a radical change in attitude, a fundamental alteration of personality, in which one is to transform nearly everything about oneself. This is more difficult to swallow and, therefore, meets with greater resistance in the

[12] http://sitesm2.org/SITES_Research_Projects/sitesm3.html
[13] Education, Training and Research in the Information Society, A National Strategy for 2000-2004, http://www.minedu.fi/julkaisut/information/englishU/welcome.html.
[14] http://www.skola2000.se/.
[15] http://www.futurum.habo.se. See also Engelhardt, R., "A School for the Future", i *Life of Science – White Book on Educational Initiatives in the Natural Sciences and Technology*, Learning Lab Denmark, 2002-2003, http://changesandchallenges.lld.dk/pdf/Articles/A%20School%20for%20the%20Future.pdf.

educational system.

One consequence for Denmark must be that, if competency and lifelong learning are to be promoted as a pedagogical objective in connection with the use of IT in education, the *justifications* and *preconditions* for lifelong learning must be clearly communicated, so that the necessary organisational and infrastructural changes may continue on a rational and, above all, generally accepted basis.

Observations and consequences

1. But what is a meaningful use of IT in a learning situation? The first observation to be made is that we still have a very deficient understanding of what sort of knowledge information technology really contains and offers. We do not know *how* knowledge via information technology is knowledge, what status and function it has, or how it may best be stored and disseminated. Thus, we have difficulty transforming the content of knowledge based on information technology into a meaningful didactic situation.

> Consequence 1: In order to learn to learn, we must have more knowledge about knowledge.
>
> Consequence 2: Opportunities for using IT in the pedagogical-didactic area are far greater than one might immediately imagine. However, it is unlikely that classical approaches and forms of learning will be remarkably improved by introducing IT. To the contrary, there is much to indicate that IT only comes into its full right through newly-developed didactic and pedagogical designs.
>
> Consequence 3: The continued professional development of teachers must be matched by an administrative culture that supports experimentation with innovative approaches and accepts mistakes. Loss of IT-competent personnel can have catastrophic consequences, if there is not a critical mass of IT skills in the system. Teachers must be allowed to experiment with the medium and receive the necessary support.
>
> Consequence 4: This support must also come from research. We have to know more about *what* possibilities IT offers education. Hence, there must be support for research and development projects that use new didactic principles in the application of IT to teaching and new ways for teachers to work. The use of more open learning environments exploiting many media must also be supported.

2. Another evident observation is that IT is going to penetrate all of society and will demand continuous innovation in knowledge and skills. Moreover, every part of society will become increasingly more complex – from auto mechanics to politics. This means that learning strategies must be developed to handle this complexity, not only by providing more detailed knowledge but by providing more knowledge about detailed knowledge. This is knowledge of different magnitude in which the value of pure information is supplemented by an understanding of its context and relevance.

> Consequence 5: Approaches to and styles of learning will be broadened from processing informational knowledge to processing conceptual knowledge and seeking relevance and contexts of meaning. Greater problem-solving skills will be required,

which include abilities for defining a problem, formulating hypotheses, conceptualisation, programming, engaging in a critical search for information, and working in teams.

Consequence 6: Examination forms are also to be modified from testing informational knowledge to testing conceptual knowledge and discerning contexts of meaning. One should be able to use much more open structures in which IT becomes one examination tool among many and IT skills one examination topic among many. If rote learning and information acquisition become devalued and replaced by "knowledge about knowledge" and "learning to learn," forms of examination must reflect this.

Consequence 7: The applications of IT should be taught very early. An IT driver's licence for students is far from enough. Subject areas from datology and mathematics to English and library science should become part of future IT education.

3. IT requires its users to think and act on the premises of information technology. We must be capable of dealing with abstract concepts and using formal notations. IT is based on digital electronics and systems that contain representations of the contexts in which they take part and solve problems through what is known as recursive stepwise breakdown.[16] We must be capable of dealing with multiple forms of representation and solve problems by being able to define and describe its components. Collecting and processing data will be a central skill. The ability to engage in dialogue about and communication of knowledge will also be a crucial skill.

Consequence 8: The construction of pedagogical content services and portals (beyond being very resource-demanding) has a tendency to limit student-guided learning. They are also often limited with respect to how one can use them and for what. A more important and better strategy is to learn relevant search techniques for the Internet and how to use subject-matter databases, which are already exploited by professionals and are of an increasingly higher quality.

Consequence 9: Educational software has a tendency to make content pedagogical, instead of communicating content. Adequate design of software for use in teaching must support a critical understanding of application and representation. It must support interactivity and open solutions. In addition, software must be, to the extent possible, open (in the sense of "open source"), so that the programs themselves can be manipulated, enabling the student to use them in new and different ways. It is all about wielding power over the machine.

Consequence 10: IT must support student collaboration and dialogue with respect to its content. Information and knowledge become obsolete, if they are not used. They lose value in being hidden away and stored. The exchange of information and knowledge creates common ownership, what we call communication.

---

[16] Jensen, H.S., Den digitale katedral – Et forsøg på en analyse af begrebet 'informationsteknologi' [The Digital Cathedral – An Attempt to Analyze the Concept of 'Information Technology'], Learning Lab Demark, 2002.

Didactic principles in the use of IT

How would an innovative use of IT in the classroom look, if one were to try to implement some of the above-referenced observations and consequences? If one looks at some of the best attempts made, one finds a number of common features, formulated here as five possible didactic principles.

Principle 1: Relevant application of IT. It is important that the application of IT in a given teaching situation take its point of departure in the problem at hand. Instead of offering "entertainment" and "experiences" through the new media, the key words for teaching with IT are rather "seriousness" and "relevance." One must use IT in differentiated and appropriate ways relevant to the topic. The Internet, spreadsheets, word processing, simulations, etc., must only be used *where nothing else makes sense*. An advanced simulation of putting two and two together or watching oil and water separate in a beaker is a misguided use of IT. As a rule, the same is true of slick PowerPoint presentations and infrared pens.

Principle 2: IT as a tool. Teaching and learning must be IT-supported, not IT-based. IT is a tool that makes it easier to reach a goal. In addition, one strength IT has is that it can support a new form of social interaction that is not screen-based but takes place directly between students (see the examples below). This pragmatic use of IT can also support a *functional cross-disciplinary approach* that automatically arises through the multiplicity of subject-matter perspectives a differentiated use of IT makes available with respect to a given problem.

Principle 3: Simulated practice. The classroom approach must not be structured around a representation of the knowledge to be learned but of the situations in which this knowledge has application. Participants must themselves obtain the knowledge to solve the problem. They must form a hypothesis (for example, where this knowledge might be found), test the hypothesis (for example, by finding and testing the quality of the knowledge), and make conclusions with respect to its applicability. Thus, simulated practice resembles the normal scientific method of procedure.

Principle 4: Adidactic learning situation: In an adidactic learning situation, students themselves must find the necessary data and methods for tackling a problem. Students find themselves in a cognitively "unresolved" situation, where the motive for understanding something is supplied by the problem and its necessity to be solved. Education-oriented portals, structured upon a representation of the knowledge to be learned, for example, are often inappropriate for this. It is better to learn search techniques, so that one can make use of the vast sea of databases on the Internet (often, for-pay databases) that contain information of a high quality. An adidactic situation, thus, resembles the theory behind *legitimate peripheral participation*[17] in the sense that the student is (cognitively) placed in a situation that does not seem to be constructed for the sake of the student.

Principle 5: Narrative desire. If one as a teacher is capable of creating connections between the various things to be taught, one tells a sort of story at the same time. As a rule, this supplies an enormous component in *the desire to learn*. The desire to solve the "mystery"

---

[17] Lave, J., & Wegner, E. (1991). *Situated Learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

creates meaning and context in the teaching situation, encourages identification, and helps students to remember what they have learned. IT and other communicative media are very effective in creating and sustaining this narrative desire. In particular, the *interactive use of IT* in a progressive story provides a very powerful motivation for learning.

Example 1: The sunspot theory

Astro- and geophysicists decide they would like to teach about the function of the sun and its influence on the earth. To this point, the assignment has been conceived from a classical approach[18]: one obtains financial support from the ESA to make large colourful charts and expensive simulations of the sun's corona, the magnetic fields that wrap around the earth, and fascinating displays of the northern lights. Small assignments on electromagnetic radiation and weather phenomena are sprinkled throughout the material, hidden away in the colourful student portfolio. The assignments are not open-ended and are expected to be solved, when the teacher has gone through the theory behind them. In other words, a classic didactic situation (theory + exercises) simply becomes "pepped up" by beautiful pictures and 3D simulations.

But if we take our analysis seriously, the teaching must take on a completely different design. One should take one's starting point in a relevant and interesting story. And there is one: the story of Henrik Svensmark and his sunspot theory. It has all the subject matter material one could possibly need. It has a good story, a personal drama, politically explosive material, scientific questions, and more interdisciplinary aspects than one could shake a stick at.

In addition, the story of the formation of the sunspot theory and its critique provides an exceptional insight into how scientific knowledge is constructed and the meaning in practice of such fundamental scientific concepts as correlation and causal connection. One can, for example, illustrate this last notion with the Erasmus Montanus 'Mother Nille is a stone' argument, explaining that simply because there is a correlation between two things, there is not necessarily a causal connection. The same was true for the sunspot theory at the beginning of its career: there were two curves – the number of sunspots and the average temperature of the earth – and they tracked each other in a graph along two different Y axes. However, since the theory was lacking a causal link, when it was proposed – that is, there was no mechanism to explain *why* this correlation exists, criticism rained down upon it. This is not healthy science, said critics who had read their Holberg. Climate researchers in particular were disgruntled, because they felt their livelihood was threatened. Suppose Svensmark was right!? The whole theory of the greenhouse effect might collapse like a house of cards, because it was not so much man-made CO_2 that was the problem, but distant sunspots.

There is a lot more to this story than the sketch indicated here. Svensmark, *et al.*, have since proposed a mechanism, which is now enjoying a lively debate in scientific circles. His theory is actually on its way toward becoming "respectable." A bonus to the story is that we still do not know who is right. Scientific knowledge is uncertain and fallible, and this must also be

[18] This story is based on a meeting at the Danish Ministry of Education on 16 March 2004, in which the major SOHO project, supported by NASA and the ESA, was presented as a possible showcase example for future science teaching at the upper secondary school level. See http://sohowww.estec.esa.nl/

communicated.

Use of IT in this example:
Press clips, websites, documentary films, small subject-specific simulations taken from the Internet, etc. – all applications that may be characterised as relevant to the problem, IT-supportive (not IT-based), adidactically situated, open, possessing a strong narrative component – and, in addition, quite inexpensive to use.

Example 2: Project "Clue"

Project Clue ("Spor") originated from a desire to create relevant, contemporary teaching methods for upper levels in public school in the subjects of Danish, social science, science and mathematics.[19] The project has been translated into the educational game "Homicide/Melved," which was published by Maling-Beck in May 2004. Homicide/Melved is an educational role play game, styled as a criminal investigation, aimed at the seventh to tenth grades.

The game involves the subjects of Danish, social science, biology, physics, chemistry, and mathematics and puts students into the role of detectives who are to solve a series of murders in a small town. The game makes powerful use of narrative elements and is inspired by real events. The content of the game is based on actual forensic techniques, such as DNA analysis, fingerprint analysis, and ballistics. This material is suitable to meet the levels and objectives set forth in the Danish Ministry of Education's Common Goals and central knowledge and proficiency requirements.

The game is constructed as a group work project in which four parallel groups are each to solve a murder over the course of a week. The game is not IT-based, but IT-supported, so that the computer acts as a tool within the framework of fiction, but most of the students' time is spent in traditional group work in which they try to solve various problems. The computer, thus, serves as a knowledge base to which students can go for such information as criminal investigation handbooks with procedures and scientific background materials, data from crime scenes, interrogations of suspects, etc.

Together with the teacher's IT interface, the computer creates an adidactic learning situation in which students themselves must find the necessary data and methods in order to proceed with the case. The teacher acquires a new role, which entails setting the framework for student detective work by entering into the game in the role of a fictive police chief.

The students play the role of a crime task force that arrives in the little town of Melved and must reveal the truth through the use of scientific methods. The game instills in the students a powerful motivation for learning, because it creates a narrative desire that drives them to solve the mystery. Scientific knowledge, for example, of the development cycles of insects suddenly becomes a useful tool in solving the problem. Thus, the game creates a simulation in which this knowledge makes sense and finds application.

Use of IT in this example:
This is a rather ingenious IT-supported role play in which IT has comprehensive but

[19] See http://www.lld.dk/drabssag. The project is supported by the Danish Ministry of Education's ITMF (Public School IT and Media) fund.

nevertheless quite simple applications. A module-constructed interface has been developed with databases, word and data processing tools, and over two hours of video tapes of crime scenes and suspects (total production price, including research, is over DKK 2 million). However, compared with what "normal" educational games with animations and 3-D simulations cost (and can do), this price must be deemed quite reasonable. Moreover, the game is constructed in such a way that it can relatively easily be modified for different murder mysteries, school subjects and age groups.