ACTA ACADEMIAE STROMSTADIENSIS

Aadu Ott

World Wide Workshop in Science Education

No. VII, AUGUSTUS MMXII **ISBN 978-91-86607-07-4**

World Wide Workshop in Science Education

Contents

Preface

1. Interaction between Culture and Technology in Informal Learning
Aadu Ott and Lars-Göran Vedin
Department of pedagogic and didactics, University of Göteborg
Paper presented at the Conference "Lernort Deutsches Museum: Koncepte, Inhalte, Methoden von Lern- und Lehrerveranstaltungen im Kerschensteiner Kolleg", von 22 - 25 October 2000. (English version). ***Page 10.***

2. World Wide Workshop - A Sociocultural Odyssey
Aadu Ott and Lars-Göran Vedin
Department of Pedagogy and Didactics, University of Göteborg
Paper presented at the ETEN Conference on Technology Education in Schools and in Teacher Training in Munich 10 - 12 November 2000. (English Version). ***Page 23***.

3. From Antiquity to Affluence
Aadu Ott and Lars-Göran Vedin,
Department of Education, Göteborg University, Sweden.
Paper presented at the second ETEN conference on" Technology Education",8TH to 9th February, 2002 at the University of Greenwich, London. (English Version). ***Page 37.***

4. Orlando – Science, Technology, Design and Edutainment in Interaction
Aadu Ott, Erik Ott and Lars-Göran Vedin,
Department of Education, Göteborg University, Sweden
Paper presented at the ETEN Conference on Teacher Education in Grooningen 13-15 February 2003. (English Version). ***Page 51.***

5. Technology Education on the European Theatre, utilizing Museums and Science Centres
Lars-Göran Vedin, Department of Education, University of Göteborg
Paper presented at the ETEN conference 12 – 14 February 2004 on "Mobility in Teacher Education – What are the challenges?" in the subgroup for "Technology Teaching and Learning" in Viano do Castelo, Portugal. (English Version). ***Page 67.***

6. The introduction of Design into Technology Education
Aadu Ott, Erik Ott and Lars-Göran Vedin,
Department of Education, University of Göteborg
Paper presented at the ETEN conference 12 – 14 February 2004 on *"Mobility in Teacher Education – What are the challenges?"* in the subgroup for *"Technology Teaching and Learning"* in Viano do Castelo, Portugal. (English Version). ***Page 73.***

7. Reflection on Interactions between a Cognitive Mind and Distributed Cognition in Artifacts in Museum Contexts
Aadu Ott and Lars-Göran Vedin. Göteborg University
Paper to be presented at the Conference "Technology in Time, Space and Mind. Aspects of Technology Transfer and Diffusion".
Halmstad University, 27-28 October 2005. (English Version). ***Page 81.***

8. Nature of Science and Nature of the Mind, should they be Married?
Aadu Ott, Department of Education, Göteborg University, Sweden
Paper presented at the NNORSC, Nordic Network of Research in Science Communication, Conference 2 – 3 June 2006, at Dalarnas University in Falun, Sweden. (English Version). ***Page 93.***

9. Lärande ur ett neurovetenskapligt perspektiv
Peter Baeza, Bengt Johansson och Aadu Ott, Institutionen för Pedagogik och Didaktik, Göteborgs universitet.
Paper presented at the National Conference "Utbildning i utveckling" for teacher trainers in Science "NALUT" on 22-23 Mars 2007 in Umeå. (Swedish Version). ***Page 109.***

10. Interaction between Brain & Poetry in Science Education originating in the Space Epic ANIARA
Aadu Ott, Göteborg University, Sweden
Paper presented at the Workshop November 2-3, 2007:"Storytelling in Science Lessons at School as a Bridge between Mental and Physical Dimensions" at Kerschensteiner Kolleg, Deutsches Museum in München. (English Version). ***Page 130.***

Appendix: Comments, in Swedish, from organizérs, students and participants in seminars in: 1. Munich; 2. Paris; 3. London; 4. Athen; 5. Rome; 6. Florence. ***Page 142-167.***

Preface

During the years 1980-2007 Aadu Ott and Lars-Göran Vedin from Göteborg University have been leading seminars and workshops in different cities in Europe with teachers and students. Professor Aadu Ott has been the scientific leader of "*The World Wide Workshop"* project and Lars-Göran Vedin has been the project coordinator. During the first years, Ingemar Brodén from the School Board of Karlstad, was also coordinator of that part of the project, which included Deutsches Museum in Munich, were Professor Jürgen Teichmann participated as pedagogical leader. Professor Aadu Ott has as author of this report put together and summarized some of experiences from these 28 years of travels and activities within the project "*World Wide Workshop",*

This presentation of the project *"World Wide Workshop"* takes as its point of departure ten presentations at different conferences and an appendix, which describe form and content of these activities. These papers were mainly presented at conferences arranges by ETEN, European Teacher Education Network, which is an organization between about fifty European Universities. This work might be regarded as a metastudy aimed at creating a synthesis and overview of the evolution of the content in these articles.

The study starts with an overarching presentation of the didactical perspective according to which we have worked. These perspectives utilize an *eclectical* approach. This is characterized by our aim to try to integrate knowledge in neuroscience and cognitive psychology with pragmatic pedagogy. Therefore we start the metastudy with a paper which makes a presentation of our basic area which consists of the sequence of seminars at Deutsches Museum in Munich. After this introduction, the presentations will appear in chronological order.

Pearls on a necklace

We are of course conscious about the fact that certain issues are repeated in the papers presented. It might thus be more relevant to regard the papers more as pearls in a necklace than as separated chapters in a book. Pearls have always some aspects in common, but they will even display some important and notable differences. This is also the first time as a comprehensive presentation of our 28 years of joint venture together with Deutsches Museum has been made accessible for those who are interested in the project and to those heirs who want to continue with the project – for maybe the next 28 years?

This project is founded in Science of Learning, History and Philosophy of Science in Science Education with an increasing utilization of Cognitive Neuroscience and Neurodidactics. The basis of our activity emanates from the School Subject "Technology" as it is presented in the Swedish National Curriculum.
The targets for our teaching activities have primarily been teachers who have participated in in-service training programs and students who participated in teacher training in mainly Science and Technology. The language in nine of the presentations is English but the tenth of the presentations is written in Swedish, but with extensive quotations in English. The Appendices are however all in Swedish.

A Sky of Pearls…..

It seems adequate to start the presentation by drawing attention to different points of departure when developing the Science of teaching Technology which we have utilized. These points constitute a background in personal mental cognitive networks and are:

#. We chose to take as a starting point for theoretical and practical aspects of teaching and learning the concept "**eclecticism"**. This means that we will not just utilize one single pedagogical approach but adapt our theoretical approaches to the demand of a situation. We pick up appropriate parts out of different theoretical theories:

#. One appropriate starting point for teaching science and technology is to start with David Ausübels´ words: *Examine what the students know and start from there!* Regarding this expression from a neurodidactical perspective, we conclude that students have preconceptions in the shape of neural networks. The only way to promote learning is to merge new information with the existing networks and thus allowing the students to construct their own personal knowledge.

#. The well known Brazilian borne philosopher Mario Bunge has extended the key pedagogical questions: What? How? Why? by adding: Who? Wither? Whence?

This urges us to use history of science and technology in order to try to find the roots to modern technology. It also urges us to try to find out future consequences of application and utilization of this technology. Who will be winners and who will be losers? What about environmental and ecological consequences of an anthropocentric application of modern technology? This aspect is especially important as the teaching which our teacher students will do during their professional life-time inevitably will cast shadows far into the future.

#. Michael Matthews, who is a philosopher from New Zeeland, urges us to pay attention to the HPS perspective, this means History and Philosophy of Science.
This renders a subjective and humanistic approach to science and technology, subjects which often are regarded as hard, impersonal and objective.

#. An other point of departure is the American cognitive psychologist Lee Shulmans´ concept *"Pedagogical Content Knowledge"*. This concept stresses that it is not sufficient with just content knowledge in a subject. We need to make a unification of content and pedagogy in order to be able to interact with students in teaching and learning. This concept is especially important to be regarded when teaching science and technology.

#. From the Swiss cognitive psychologist Jean Piaget (1896-1980) we inherited the theory about cognitive mental structures within the brain. Piaget stressed the necessity of always establishing connections between the students´ preconceptions and the issues taught. Piaget expressed this with the two processes *assimilation* and *accommodation*. These mental structures could be interpreted as parts of neural networks within the neurodidactical theory. Assimilation means that we just add a piece to the existing network. Accommodation means that we have to rearrange our mental network.

#. From the Russian psychologist Lew Vygotsky (1896-1934) we will incorporate his concept "*The Zone of Proximal Development",* ZPD, within our teaching practice. ZPD could be illustrated as a certain mental range. There is a mental range in which the pupil is able to solve

problems by himself. This range might be characterized by being very concrete. There is also a range in which the student is not able to solve any problems, even if he gets help. This range might be very abstract. In between these ranges there exists, according to Vygotsky, a range were the pupil is able to solve problems, if he is supported by a teacher or more able peers.

From the perspective of neurodidactics this might be explained by the fact that the myelinization of brain cells starts with those functions which are necessary for basic life support. Later on myelinization is taking place within the areas devoted to senso-motor activities. This means that the pupil is able to perform concrete actions. The prefrontal lobe, were the abilities for abstract thinking are situated is myelinized late in the teen ages. This means that the pupil is not ready for abstract thinking before well into adolescence.

From Vygotsky we also incorporate the concept *"extended mind"*. This means that a team of students might enhance their learning when cooperating, by socially stimulating each other. Within our seminars we always stressed this aspect of learning.

#. From the American cognitive psychologist John Dewey, we borrowed the expression *"learning by doing",* thus stressing the importance of practical work. Dewey pointed out the importance of integrating manual and mental activity. Practical work is highly theoretical and the saying goes that "*There is nothing more practical than a theory*".

Theory has a Latin origin, which denotes, in a metaphoric way, that one should get up on a mountaintop to get an overview. This means that when studying a subject, it is important to study different aspects of this subject. Metaphorically this could be compared to climbing up on different hilltops to get different perspectives on the same phenomenon. In the seminars we used this methodology and climbed up to hilltops named: Physic, Technology, History, Philosophy, Religion etc. These different perspectives rendered a picture which was more informative than to just be on a Technological hilltop. This method is efficient when wanting to integrate different neural networks in order to achieve a relationally constructed memory of a subject. In this way a sustainable long-time memory, which is easy to recall may be consolidated.

We did however also utilize the results from cognitive neuroscience which points out that a student could learn a lot by just observing when a teacher manipulates equipment or demonstrates an experiment. This process of "*learning by looking*" does however only work when the student is highly *motivated.*

#. The Swedish professor in Physics, Bodil Jönsson, has created the concept *"searchology"*. She points out the importance and the possibilities of "*learning by searching"*. In the modern world we have a lot of "*secondary knowledge"* on Internet. This information is possible to be reached by using different Search Engines. This information is however only useful if the student has a lot of personal knowledge. This means that we nowadays should to try to provide students, not only with subject knowledge, but also with general aspects on knowledge. In America this approach to learning is called *"liberal education"* and means that before specialization within a field, the student has to take courses on a general level.

#. From the sociocultural tradition in pedagogy we incorporate the concepts *artifact* and *mediation* and utilize these concepts in the seminars. Learning implies, in technology, mainly to be able to handle artifacts. Artifacts mediate information. The term mediation has its origin in the German word "*Vermittlung"*.

#. From the American scientist Cole we incorporate the concept *"mediational triangle"*. This visualizes the process were an artifact acts as a mediating object between the subject and the environment. Glasses might be regarded as an example of a mediating object.

#. From the American scientists Jean Lave and Etienne Wenger we incorporate the concept "*Legitimate Peripheral Participation"* or for short LPP. This concept denotes that when a student enters the school educational system, then he has a legitimation to act within this field. He has however to start at a peripheral position in the system and step by step advance towards more central and professionally more demanding positions.

#. From the English neuroscientist Richard Gregory, we incorporate his three cognitive levels within our eclectic approach to teaching. Gregory calls the first level for *"hands on"* or *exploration*. He stresses the importance that the students should have possibilities to manipulate the material studied. It is however important not to stop there. The English teacher trainer Rosalind Driver points in her book *"The Student as Scientist"* out how one student wh,o had hands-on experience said *"I do and I get more confused"*.

Gregory has created two more levels: the next is called *"hand waving"* or *explanation.* Gregory stresses the importance of explaining the content of a concept in an intuitive way. This is a point of learning when, according to neuroscience, the process of metacognitive reflection will help a student of create connections between his preconceptual neural networks, with new information which enters the brain in the form of proto neural networks.

The third level is called *"handle turning"* or computation. Handle turning is an association to early models of handle turned calculators. Gregory stresses the importance of having reached the level of intuitive understanding of a phenomenon before approaching the more advanced and abstract level of theory and computation.
This in accordance with experience from neuroscience in which the German neuroscientist Manfred Spitzer points out that it is important to establish knowledge at the concrete level before trying to approach an abstract level.

#. The English professor in Technology Education, David Layton, has published a book with the telling title: *"Technology Challenges Science Education"*. He points out that students may describe their relation to science as to "*a Cathedral, a Quarry or a Company Tool shop"*. Layton means that it is of no use to regard science as a Cathedral and to just admire its content. It is far better to regard science and scientific concepts as a Quarry from where the student might get some useful items. Scientific concepts might also be found in a Company Tool shop from where the student might get useful tools for his work.

In our seminars we have tried to utilize Laytons aspect on science and stressed the usefulness of the tools which scientists have developed during centuries and handled to us for use, During the last decades a development of tools within the neuroscientific field has also taken place and even those tools are important to hand over to the student.

#. From the German scientist Edmund Husserl and the phenomenological school we have incorporated within our theoretical approach how phenomenon appear as different kinds of representations within the mental and cognitive mind of the student.

According to the spirit of the German philosopher Immanuel Kant we have to separate "*Das Ding an Sich"* from *"Das Ding an Mich"*. This means that there is a difference between things within the objective world, and how our perception interpretes makes *constructs as mental representations* of them.

#. From the Swedish professor in pedagogy Ference Marton and the Theory of Phenomenography we incorporate within our theoretical and eclectical approach the importance of *variation* and regard the *intentionality* of actions and learn how to constitute a phenomenon within a few categories.

#. The Austrian physicist Ernst Mach pointed, hundred years ago, out the importance of studying a subject in a thematic way. He pointed out, that when building a mental cognitive web it could be regarded as a spider's web, but it had to be so strong that it could accommodate the spider, but not so weak that it just entangled the spider.

Here we have an early association to the modern concept of constructing cognitive *neural* webs. These webs have to be made strong by metacognitive reflection which acts as a process, and which creates connections between neurons within associative areas of neural brain substrate.

#. From the Ancient philosopher Plato we incorporate the thought that all expressions have to be possible to be verified. Anybody may put forward idiosyncratic ideas. But what separates science from non-science is that science is able to motivate its statements by reference to an underlying level. In a way this parallels, to a certain degree, the Austrian philosopher Carl Poppers´ idea that a reliable scientific theory should be possible to be falsified.

#. The English science author Lewis Wolpert discusses this by saying that in *common sense* a new concept is explained by reference to what is *known* – in science the new concept is explained by reference to what is *unknown*. It is also important to pay attention to the fact that technology rests on scientific knowledge and not on knowledge in sociology. It is however important to try to develop technology so that social aims are respected.

#. From the Ancient philosopher Socrates we incorporate the idea: always to try to challenge own and other peoples ways of thought and values.

#. From neuroscience we incorporate concepts like *neural plasticity, reward systems, etc* This means that the concept neural plasticity within neurodidactics has come to be one of our main theoretical points of departure. The brain and mind are undoubtedly the most important parts to regard in learning and also in teaching.

Reports and Reflexions

The project World Wide Workshop was initiated by seminars at Deutsches Museum in Munich. We therefore start with a presentation of a paper which yields an introductory overview of the project.

The papers presented here have to a certain degree been re-edited in order to harmonize within a common context. They have also been updated and the neurodidactical approach has been emphasised. During the sequence of seminars we have been more and more aware about how the pedagogical and theoretical journey towards *"The Age of the Brain"* is taking place.

It might be natural to make an association to the Nobel Prize Laureate and neuroscientist Gerald Edelman who in the book *"Second Nature - brain science and human knowledge"* writes *"The brain is embodied and the body is embedded"*. This expression implies that body and brain are inseparable units. It also implies that the human body is in continuous interaction with the environment. In this report we will show how the learning brain might be used in a most efficient way by being immersed in an "*enriched technological environment"* during a seminar at a technical museum..

We do not avoid the established didactical or pedagogical paradigms, as for example the sociocultural paradigm for learning. The historical roots to this paradigm go back to the Russian psychologist Lew Vygotsky. This paradigm was developed further by his friend Alexandr Luria who however applied a more pragmatic approach as he was educated as a neurosurgeon. This neuroscientific tradition has then been developed further by a student of Luria: Elkhonon Goldberg who has written two books:*"The Executive Brain"* and *"The Wisdom Paradox"*. In these books Goldberg explains how learning, memory and consciousness operate entirely on terms given by the biological brain.

Goldberg describes in a vivid narrative a turning point in the lives of Vygotsky and Luria. This turning point happened as a consequence of how Luria, after a scientific study in the inner of Siberia, telegraphed to Vygotsky the results of this study using the fatal words: "*Natives do not have illusions."* The security police in the Sovjet Union became alarmed by this text and reacted. The communistic society was a society built around illusions which people were not allowed to unveil.

Sävedalen, 20 August 2012

Aadu Ott

1. Interaction between Culture and Technology in Informal Learning

Aadu Ott and Lars-Göran Vedin. Department of Pedagogic and Didactic, University of Göteborg
Paper presented at the Conference **"Lernort Deutsches Museum: Koncepte, Inhalte, Methoden von Lern- und Lehrerveranstaltungen im Kerschensteiner Kolleg**", von 22 bis 25 Oktober 2000.

Abstract

A model for informal learning in a science and technological landscape is discussed from a sociocultural perspective. The model defines four levels: Cultural, Communicative, Transmissive and Didactical level and discusses key concepts in the sociocultural theory of learning at these levels. Different aspects of the exhibitions in Deutsches Museum are discussed in the light of this model. The importance of input from the teacher emerges.

Knowledge is regarded as the creation of an internal individual mental matrix, which by communication is linked to the external sociocultural and technological matrices, which are presented by exhibitions in Deutsches Museum. Learning is regarded as appropriation of intellectual and physical tools, which act as mediational means in teaching concepts of technology. Learning is enhanced by communication and interaction with other participants in the seminars. This mixing of a scientific and a sociocultural perspective on teaching of technology has proved fruitful and has been appreciated by the participants in the seminars.

Background

Since 1980 a joint venture between the University of Göteborg and Deutsches Museum in Munich has been going on. Up to spring 2007 almost one hundred seminars, with the duration of one week, have been performed. The seminars have had a total of about 3000 participants from all over Sweden. The participants have mainly been teachers, teacher trainers and students who aim to teach science and/or technology at university level or in the comprehensive school-system in Sweden.

The Program

During these seminars a pragmatical and pedagogical program for teaching and learning in the technological landscape of a science- centre or museum context has been created.

This program consists of the following three parts:
The program starts with a seminar during one week at Deutsches Museum. During this part of the program the participants take part in "f*ührungsvortragen*" and "*eigenstudien"*.

For the second part of the program, the participants choose a theme for a paper. This paper has to focus on some technological artifacts or process in their own local surrounding. The paper should also include history and philosophy of technology in the extent that is relevant and connected to the chosen content. This content has also to be regarded from a theoretical and applied didactical perspective aiming at teaching.

The participants finally present their papers and their empirical studies during the third phase of this learning program. In this phase of the program the participants gather at a conference centre for a two day seminar, present their papers and evaluate, from an applied pedagogical perspective, the content.

The Model for Informal Learning

The aim of this paper is to regard this approach to learning from different points of view and especially to regard the interaction between a mentalistic and a sociocultural perspective on learning and thus, in a tentative way, to discuss the background for the content of a theoretical Model for Informal Learning (MIL) in a museum context. We focus in this paper on the empirical work which is done during the first stage of the Program: The seminar at Deutsches Museum.

Proponents for a sociocultural perspective on learning are for example Best et al (1990), Kvale (1992) and Kelly et al (1993). These ideas have also been discussed by Feyerabend (1975, 1995).

The sociocultural perspective on learning is characterized, according to Wertsch (1991), by substituting *individual* with *individual(s) in action in a context with mediational means.* This perspective has among its roots the publications of Kuhn (1962, 1970, 1992). In his last article Kuhn however takes, to a certain extend, a stand against his earlier thesis': "*I am among those who have found the claims of the strong program absurd; an example of deconstruction gone mad."*

The sociocultural perspective finds its way into the school system via the concept Legitimate Peripheral Participation (LPP). This concept was proposed by Lave & Wenger (1991). This implies that a student is legitimized to enter a profession in a peripheral position. By interaction with his professional colleagues, the student will take over more and more of the work included in the profession, until he is ready to undertake the full responsibility for teaching all by himself.

In view of the fact that the Swedish National Curriculum for the comprehensive school system is strongly influence by the sociocultural movement, it seems fruitful to study the applicability of this approach to learning in a museum context.

The application of a sociocultural perspective in education is however a field which is highly controversial, as discussed by for instance: Matthews (1994,1995) who criticises the constructivistic way of constructing knowledge. Matthews claims that it substitutes objective knowledge, which refers to the external and real world, with subjectively constructed mental patterns with no criteria for truth: knowledge becomes personal opinion; Ogborn (1997) points out that a metaphorical change has taken place were scientist's complicated and hard to understand theories are substituted by personal opinion; Holton (1996) claim that postmodernism questions the objectivity and truth of scientific knowledge. The controversial nature of postmodernism is also discussed, in a provocative way, by Sokal and Brickmont (1999) in a book with the telling name *"Eleganter Unsinn".*

The Model. Definition of Concepts

The Model for Informal Learning is subdivided into four levels and concentrates on the interaction between fundamental concepts, in these levels:
The Cultural level: Social - technological - cognitive.
The Communicative level: Language - communication - discourse.
The Transmissive level: Mediation - artifact - appropriation.
The Didactical level: Knowledge - teaching - learning.

The Cultural level

On the cultural level, the interaction between social behaviour and culture, in the form of technology, is presented with a focus on informal learning about history and philosophy of technology.

The sociocultural approach stresses that human beings are biological as well as social creatures. This approach points however out that, from early age, the social and cultural influences takes command over the individual biological evolution. Nelson (1996) states:
" …these years (2-3) that biology hands over development to the social world" .
The social context as well as other individuals thus strongly influence the child in her interaction with other human beings and thus affect her in her learning process.

A tool, in the form of language, customs and artefacts, locates and orients the individual in and about her historical position. Culture could in this case be regarded as an internal formation of subjective mental structures. Culture results as well as of an externalization of these structures into language and into artifacts within the social world. This also implies an interaction of culture with technology. Technology may be regarded as cultural actions performed within a social context. Man has thus, according to this perspective, created technology as well as culture. These creations of the human mind will then, in their turn, act as an interface between man and the natural world.

There is an interesting difference between the external sociocultural approach, which is discussed in this paper, to science and technology learning, and an internal and more traditional cognitive or mentalistic approach.

The Communicative level

What foremost characterizes man is her ability to communicate with other human beings. Man is also a tool making creature. These tools are physical as well as intellectual. The most important tool is however the human language. With the help of her language human beings are able to communicate with each other. They also contribute to the constitution of a worldview, by creating concepts. This is for example described by Goodman (1992) in a book with the suggestive name: "*Ways of World Making"*.

An interesting critic of this perspective is given by Phillips (1995) who discusses the question about construction of knowledge from different points of view, among these the two points: *Nature as instructor - man as constructor.* This sentence points out the line of conflict between constructivism as a psychological theory of learning, regarding the changes made in

the mind of a subject, and a more traditionalistic and positivistic approach to objective knowledge in science, which regards laws and regularities in the surrounding world.

Knowledge and the subsequent learning about objects are however, according to the sociocultural theory, not only connected to objects per se, but to discourses about the objects. Concepts are not regarded as unique and general but are regarded as situated and thus defined by other concepts in every discipline.

These disciplines are according to Feyerabend (1975) incommensurable: alchemy is by this definition as valid as a science as physics. Searle (1996) comments this:
"…the rejection of realism, the denial of ontological objectivity is an essential component in the attack on epistemic objectivity, rationality, truth and intelligence in contemporary intellectual life".

In the context of informal learning in Deutsches Museum, it is fruitful to supplement the material objects which are encountered in the exhibition, with an immaterial narrative which places the objects, as well, into a functional, historical and social context as within the minds of the participants. The objects are functional in order to illustrate the internal technical function and the external utilization of the objects. The objects are historical in order to explain the process of the development and evolution of the technology in question. In this process it is also fruitful to give justification to technological processes by references to laws in nature and to successful utilization of technology in applications.

In this context it is of importance to have a coordinator or teacher of the studies who, using the concepts of science and technology, together with everyday expressions of these concepts, helps the participants to create a personal discourse in relation to the artifacts exposed. The terms and concepts of technology are often unfamiliar to the participants. The role of teacher or coordinator is to personalize and make technological knowledge familiar to the participants in the context of learning.

The presentation of the evolution of objects is not aimed to treat history for the sake of history itself. If the historical evolution of a certain technology, up to contemporary days is known, then it might be possible to make important interpolations into the future. Thus maybe be able to predict future technological changes and even shed light on efficacy and technological potentials as well as technological shortcomings.
One demarcation line between science and non-science or anti-science is the success of practical technological applications of science in our everyday world.

The concept*"discourse"* is important. The discourse of science and technology is often in conflict with the everyday discourse. Wolpert (1992) expresses this by stating that in everyday explanations one explains the unknown in terms which are known. In science, on the contrary, the known is explained in terms of the unknown. In science, there will always be an unknown ontological level to explore.

This difference between discourses also point to the fact that pure informal learning in a technological landscape is difficult to achieve. It is not easy to reflect over artifacts and technological laws without access to conceptual tools and to an adequate language. Thought and language are intertwined and a need for relevant conceptions of phenomena is obvious.

If none of the participants in a group, which regards and discusses a technical item, is knowable about its foundation on scientific or technological principles, then the discussion will be moot. Science and technology take no interest in individual opinions about artifacts, but there is instead a need for hard facts and rational knowledge.

It is however also important to discuss the value ladeness of different artifacts and about the ultimate development of a special technology and of the consequences involved in the application of that technology in the local or global society.

The Transmissive level

On this level, the concepts mediation, artifact and appropriation are introduced. An artifact is a material construct or a tool, with the help of which certain aspects of the natural or designed world are mediated to the individual. These tools constituted the fateful might and power which changed Homo Faber into a "kosmiurg".

Knowledge about the world around us is, according to the sociocultural paradigm, as expressed by Voloshinov (1930/1973) in a metaphorical way, not simply *reflected* as with the help of a mirror. Knowledge about the world is more likely to be *refracted* as with the help of a optical lenses. This leads to a philosophical position which is criticised by Matthews (1998) who stresses the need for justification of knowledge and warns for the use of personal cognitive lenses which may distort the view.

In a designed and technical world there is however always an artifact between the observer and the observed world. In the sociocultural paradigm the term mediational triangle is introduced for this behaviour. In the corners of this abstract triangle there are the observer/the subject, the observed/the object and the mediating artifact. Mediation may thus be regarded as one of the focal points in learning about technology. Mediation includes teaching of scientific laws and technological rules, which are not obvious or possible to find out by mere observation of an object.

On this level a discussion is made about how it is possible to get reliable knowledge and to come in touch with the world. Leaving the philosophical discussion about the mind-world problem, it is notable that in technology we always put a material or immaterial artifact between us and the world. This item may be immaterial as language or a concept or material as for example metallic artifacts. When studying technology we study discourses about artifacts and contexts in which they appear. This combination mediates the world to us. Mediation is thus at the heart of the communication process between a visitor and an exhibition in a museum .

The concept appropriation implies that the social or historical context, within which an artifact exists is not possible to be identified by a student or visitor by simply regarding the object. The significance and the utility of the artifact in different contexts have therefore to be narrated by someone who has relevant knowledge. This renders an increased value to the role of the teacher and to the importance of giving meaning to mechanical artifacts by allocating them into appropriate discourses.

Appropriation thus means that a knowledgeable teacher is needed in order to put the artefact into an appropriate discourse in which its present and historic utility and construction principles are to be identified. This stresses the fact that pure informal learning in a

technological landscape is a problematic enterprise. This is not easily performed by a student who is without protoconceptions to build more elaborate knowledge structures on.

The Didactical level

On this level, a discussion is undertaken between the interaction between knowledge, teaching and learning. With regard to the fact that the school system in Sweden is loosing parts of its resources due to Governmental savings, it is of interest to find other material and immaterial resources when studying technology. This implies that the science centre movement and the utilization of museums for learning might be able to give an even more important contribution to the well needed infrastructure of the learning society.

The comprehensive school system does not any longer have a monopoly on the creation and transmission of knowledge. Media will play an increasingly more important role in modern society. This is a challenge to teaching and indicates a break with the modernistic project, with its roots in the French revolution. A post modern and post industrial society is in creation around us and new ways of organizing teaching and learning are affecting traditional school systems. This continuously ongoing dynamical process of change creates problems as well as it will create opportunities.

To the traditional aspects, which regards knowledge as empirical or rational, has during the last centuries different constructivistic aspect been added. These are foremost based on the theory of mentalistic constructivism which, according to Piaget, regards learning as the creation of mental patterns in individual minds and the sociocultural theory of constructivism, originating from Vygotsky, which also includes social interaction between different individuals in different contexts.

Kvale (1992) expresses the changing from the Piagetian point of view to the Vygotskian approach with the sentence:
"From the archeology of mind to the architecture of a sociocultural landscape."

Learning in the technological landscape within Deutsches Museum is during the seminars utilized with the intention to try to make a synthesis between these two approaches. The aim is to link individual internal mental matrixes to the external sociocultural matrix in order to create a knowledge base, in the form of dynamical neural networks, for learning.

From the constructivistic point of view, which is partly used in this study, knowledge is defined as the mental structures which an individual mind possesses. Knowledge without a human agent is regarded as information. The first crucial step is to create knowledge from information and second step is to perform the metacognitive transformation of knowledge from a one-dimensional scientific array to an interlinked multidimensional mental network which includes social and historical perspectives.

The interaction between learning and teaching is a fundamental question in didactics. Within one branch of the multifaceted sociocultural paradigm, this coupling is questioned and the possibility and fruitfulness of *learning without teaching* is pointed out and discussed by Nielsen & Kvale (2000). This is an aspect which is interesting to regard in relation to informal learning in the context of a museum. There are however other complementing aspect to learning which have to be regarded in order to be able to reach a consensus.

Under the influence of the Piagetian traditions the role of the teacher was diminished and the student was regarded as a mini-scientist, who all by himself could find out the truth about the world within a context which was appropriate for this undertaking. Studies of students behaviour give however support to the opinion that no student has for example ever been able to find anything comparable to the laws of Newton by simply observing or manipulating bodies in movement. Science, as we define it, is created by hard work, which is performed by skilled scientists during lifelong activity in science.

On this didactical level we want to stress, that the definition of knowledge as a multilinked network within the mind of a learner, is possible to be connected to the sociocultural network of interactions, which is taking place between participants in social interaction. This is in accordance with Vygotsky´s thought about the "*Zone of Proximal Development"*. This concept may be defined as the region between what a learner, on one hand can achieve by herself and on the other hand what he may obtain with the help of a more knowledgeable peer or a teacher. Informal learning in a technological landscape may thus be enhanced by interaction in a group of participants and with selected input or scaffolding from a teacher.

The sociocultural approach, discusses also the importance of the role that the teacher plays, not only because of the knowledge he possesses, but attention is also given to the influence on the interaction between participants that he is able to create.

Theory and Experiences

In the discussion of how teaching and learning takes place, and the aim of constructing knowledge from information in the technological landscape of Deutsches Museum, it is interesting to apply the Model for Informal Learning (MIL) to some cases.

Interpersonal interaction

The participants who take part in the seminars are generally subdivided into small groups. In this way the participants interact with each other continuously during the seminars. This inter-individual interaction causes reflections on the subject presented by the participants. This aims, by a multitude of interacting perspectives, to create knowledge, in the form of a multidimensional relational network within their personal and collective minds. This process is in accordance with that part of Vygotsky´s theory, which claims that inter-individual interaction could be regarded as if an extended mind was created. This concept is fruitful as a metaphor for interpersonal interaction.

The participants also value the possibility to reflect upon demonstrations and lectures. They point, without exceptions, out that the interpersonal communication between the participants is of utmost importance for the process of learning. This is in accordance with that part of the theory of Vygotsky in which he claims that the internalization of knowledge is achieved in two steps: the first step is the interpersonal or social phase and the second step is the intrapersonal or psychological phase. The first phase of learning is according to this theory accomplished through discussion between the participants and the second phase is obtained through subjective metacognitive reflection resulting in the creation of neural networks.

One important aspect in this case is the importance to pay attention to the emotional or affective component. If an affective connection to a subject is not achieved, then a cognitive process will probably not take place. There is thus a heavy responsibility for the coordinator

to present the artifacts exposed in the museum in a positive way. This means that the interests of the participants and the coordinator have to coinsidred. Within neuroscience cognition and emotion are regarded as equally important in the process of learning.

The coordinator has to have an ability to link the internal mental schemes of the participants to the *exosomatic* learning which may take part in a technological landscape.

The sociocultural paradigm is thus helpful in this process, in which mind and thought are linked to body and action in the interactive and tactile context of the exhibitions in Deutsches Museum.

Example: A holistic view of the museum

In order to give the participants a holistic view of the museum through which they, during the seminar, can find pieces of information to transform to knowledge, the seminar starts with an overview of the exhibitions in the museum.

A "*führungsvortrag"* is made which starts from the deepest levels of the exhibition of the earth which humans have reached: the technology to reach the deepest sea-bottom is exhibit in the lower region of the museum. In a sequence the technology for underwater, surface, air and land transport is presented.

This presentation ends in the upper part of the museum where a stone from the Moon is to be found. This symbolizes the farthest away part in space that man has conquered. During this exposé utilization of peaceful as well as wartime technology is demonstrated.

As part of this overview, short oral presentations are made about the semantic language of the museum and about the sequential exhibitions of the historical development or evolution of technology.

This means that the seminar, through interaction between the participants and the leader of the seminar aims at *enculturating* the participants into the technological culture which is surrounding them. The concept enculturation could be utilized as a metaphor for the linking of the internal mental matrix to the exosomatic and external sociocultural matrix.

In this overview all the four levels of MIL are affected in an informal way, as the cultural interaction of technology with society is a leading theme. Discourses are created and language used for communication and knowledge is mediated via artifacts resulting in the appropriation of knowledge which results in learning.

Example: The development of technology for building ships

An outstanding example of how different generations of technology have succeeded each other is exhibited in the department of ship building. Here the development of ships from ancient days to contemporary time is presented in a führungsvortrag. Historical and social aspects are pointed out. In this exhibition the principle for maturization of technology and the ever changing aspect of technology is possible to regard: Steele is succeeding wood as construction material and steam is succeeding sail for powering ships.

From the evaluations of the seminar which the participants wrote, it seemed clear that they highly regard the oral presentations or führungsvortrag that the leader of the seminar makes these narratives were aimed at creating a matrix into which the different pieces of information, which the participants got from their eigenstudien were aimed to fit into. It is in this case of importance that a lot of linking between internal mental patterns and the sociocultural and technological mainframe are created.

Even this example may be analyzed in terms of MIL: Social, cultural and technological interaction is narrated. Artefacts are utilized for mediation. Knowledge is created in a situated context within a discourse.

Example: Aircraft engines

In the department for air transport it is, for example, interesting to study the development of airplane engines. Combustion engines tended to become more and more complex and an endpoint for their development is reached by a monstrous contraption, which contains 28 cylinders with four valves per cylinder and an immense amount of control function, which however all may malfunction.

At that time the jet engine, with its simpler and thus more reliable design emerged. This illustrates how generations of technology follow each other in the eternal search for a more functional and efficient construction. Often this is a smooth development but sometimes an abrupt change causes development to take another way.

A parallel could be found within Piaget's´ theory of assimilation and accommodation of knowledge in the mind of a learner. This comparison highlights the fact that learning and developing technology could be regarded as taking part *inside* as well as *outside* a creative mind.

This presented sequence stimulates the participants to contemplate the question about how the next generation of different technologies, on which we rely in our daily existence and which surround us, will look. The only certain thing is that the technological world of tomorrow will be different from that of today.

This in its turn creates questions about the content of knowledge and ways of learning. Why learn facts when everything is changing in such a fast rate? Are there rules, principles and laws which are invariant for change? Is it possible to only concentrate on learning of how to learn? What might be the sociogenetic origin of knowledge?

As biological creatures we have, according to Piaget, a limited ability to learn. From a sociocultural perspective we have, however no limits to learning as learning implies appropriation of new technologies for mediation, and not the reaching of the mental and cognitive peak of formal operation.

Learning of specific skills differs from development of generalized mental cognitive patterns and it is possible to have different capabilities in different fields of action. This implies also that participants in a seminar may react in very different modes to different inputs from the museum. In order to take advantage of that it is favourable to try to have a blend of inputs of different pieces of information. This may very well be achieved by utilizing the different exhibitions in Deutsches Museum.

In the department for air transport it is also interesting to contemplate the utilization of modern technology for war and to study how political decision making may affect the development of different technologies. This demonstrates the fruitfulness of a sociocultural perspective, when regarding development of technology.

An interesting point for a lecture is found, when we are standing close to the jet fighter Me 262, with the pulsejet air torpedo V1 above and the rocket powered Me 165 close by. If the German generals in Die Luftwaffe had been allowed to utilize the Me 262 jet aircraft as a fighter instead of as a light bomber, as decided by Der Führer, this would have affected the allied bombers heavily during WW 2 and maybe prolonged the war.
The philosopher Bertrand Russell has pointed out that since the 18th century all main wars have been won by the most democratic side. This thought seems to have validity also in contemporary time.

Close to this point, an intersection of a modern passenger jet is supported from the ceiling. The engines have very big intakes for air, in comparison to the small intakes of the Me 262. Why?

It is, in this context, fruitful to explain this change in design in terms of some scientific laws which govern technological applications, for example laws about physical momentum and laws of kinetic energy. This may be discussed in relation with the energy crisis in the 1970th.

Here we find a productive combination of knowledge in physics and technology in interaction with society. This combination of knowledge from differing fields stresses the utility of the multi-linked mental insight of a teacher who is a generalist. At the same time it shows the participants that technology includes social, as well as humanistic content.

Nobody is in the privileged position of being excluded from the utilization of technology. This is a way of explaining technology from the sociocultural perspective and this approach does not leave the participants unaffected. This affective approach helps to start the participants to take their informal studies in the museum seriously.

As a conclusive remark on this example, all levels of the MIL approach are involved in the führungsvortrag and in the subsequent learning process.

Example: From Gutenberg to Gates

An interesting visit may, in this context be made to the department of printing. This exhibit shows how oral language has developed into written language, how the alphabet was created and further on to the digital revolution which is going on in our contemporary time.

This department also demonstrates how letters are integrated into artifacts and how more and more intelligence was being builds into these artefacts until computers evolved. Three revolutions for information interchange may thus be studied: *from oral to written*; *from manual to printing* and finally *the global digital revolution*.

An analytical study of this example, according to the analyzing tools of the MIL approach, shows how all four levels are affected in the visit to this department. The importance of regarding of the cultural level is obvious, as no technology has affected society as

fundamentally as printing. Language, communication and discourse are the very items of printing. Mediation of knowledge is achieved by artifacts in the technology of printing. Teaching and learning are to a great extend affected by the different revolutions of information interchange, from the alphabet to the ASCII code.

Example: From micro - to macrocosm

The electron microscope mediates the micro world and instruments in the astronomical department mediate aspects of the macroscopic universe.

An interesting exhibit of the emergence of unexpected dynamical action, which happens when passing between different levels of size and organization, is to be found at the physics department. Here an electron microscope shows how, for example, how a simple fly is composed of intriguing and complicated small parts. Life emerges unexpectedly at a certain level of organization, when stepping up from atoms, molecules and cells to greater complexes. When we are killing a fly, then we destroy a very complicated biotechnical organism.

The immaterial formulas of Einstein, which are exposed in the astronomical department, are tools, which helps us understand the fabric of the universe. These immaterial tools are as real as the material telescopes for widening the scientific horizon for mankind.

The importance of the teacher is obvious when standing in front of the apparatus with which the scientists Wilson and Penzias in 1965 detected the 3 K radiation in the Universe. This gave a strong support to the theory about Big Bang. Even here it is important for the teacher to help the participants to create a mental matrix with the help of which they are able to go on with their individual informal learning.

The MIL approach is valuable here for a teacher as a way of putting attention to important aspects to include in a führungsvortrag. The artifacts which mediate aspects of the world to us affect our culture deeply. They are communicated in a language which sometimes is complicated but at the same time acts as a tool for research as Einstein's formulas exemplify.

Example: From Athens to Los Alamos

That the role of a teacher is important, is in this context exemplified by a presentation in the physics department of the development of mechanics, from antiquity, over the contributions of Galileo Galilei and Otto von Guernike and the crossing over from science to technological applications when developing steam engines. This presentation ends in the atomic pile and a discussion is opened up about new and renewable sources of energy. The participants often take this as a starting point for their own informal studies.
Environmental problems, sustainable development and renewable sources of energy have been includes in most of the presentations.

The MIL approach is applicable here too. Society changed fundamentally during the Scientific/Technological Revolution with the help of artifacts like the steam engine. Different discourses were created and language and communication changed. A new view on knowledge emerged from a change from an Aristotelian to a Newtonian discourse. Learning and teaching changed from speculation about phenomena to experimentation.
Nature could be regarded as instructor and man as constructor.

Conclusion

It is apparent that in the study of the applicability of the intentions of the Model for Informal Learning, the sociocultural approach is fruitful in combination with a mentalistic view of learning. Informal learning is enhanced if it is initiated by the creation of a mental matrix with the help of a teacher. The participants link, in their informal learning, the results of their own informal studies into this matrix, by the processes of interpersonal and interpersonal communication, mediation and appropriation.

Acknowledgement

We want to express our sincere gratitude to Professor Jürgen Teichmann at Deutsches Museum for his kind help and cooperation in this project and to the Mathematical and Scientific Faculty at the University of Göteborg for their economical support.

References

Best, S. & Kellner, D. (1990). Postmodern Theory: Critical Interrogation. New York: MacMillan/Guildford.
Feyerabend, P. (1975). Against Method. Outline of an Anarchistic Theory of Knowledge. London: New Left Books.
Goodman, N. (1992). Ways of worldmaking. Indianapolis: Hackett.
Gross, P. R. & Levitt, N. (1994). Higher Superstition: The Academic Left and its Quarrels with Science and Reason. John Hopkins University Press. Baltimore.
Gross, P. R., Levitt, N, & Lewis, M. W. (1996). The Flight from Science and Reason. New York: Annals of the New York Academy of Sciences.
Kelly, G., Carlsen, W. S. & Cunningham, C. M. (1993). Science Education in Sociocultural Context: Perspectives from the Sociology of Science. Science Education, 77(2), 207-220.
Kragh, H. (1998). Social Constructivism, the Gospel of Science, and the teachning of Physics. In Matthew, M. R. (Ed.): Constructivism in Science Education. Dordrecht. Klüwer Academic Publishers.
Kvale, S. (Ed.) (1992). From Archeology of Mind to Architecture of a Sociocultural Landscape. In Kvale s. (Ed.): Psychology and Postmodernism. London: Sage Publications.
Kuhn, T. S. (1962,1970). The Structure of Scientific Revolutions. Chicago: The University of Chicago Press.
Kuhn, T. S. ((1992). The Trouble with Historical Philosophy of Science. (Robert and Maurine Rotschield Distinguished Lecture) Cambridge, Ma.: Harvard University Department of the History of Science.
Lave, J. & Wenger, E. (1991). Situated Learning: Legitimate peripheral participation. New York: Cambridge University Press.
Matthews, M. R. (1995). Science Teaching: The Role of History and Philosophy of Science. New York: Routledge.
Matthews, M. R. (1995). Challenging New Zealand Science Education. Palmerstone North: Dunmore Press.
Matthews, M. R. (1998). Constructivism in Science Education. A Philosophical Examination. Dordrecht: Klüwer Academic Publishers.
Nelson, G. (1992). Ways of worldmaking. Hackett. Indianapolis.

Nelson, K. (1996). Language in cognitive development. The emergence of the mediated mind. Cambridge, England: Cambridge University Press.
Nielsen, K. & Kvale, S. (2000). Mästarlära. Studentlitteratur. Lund.
Ogborn,J. (1997). Constructivist Metaphores of Learning Science. Science & Education, 6(12), 121-133.
Searle, J. R. (1996). The Construction of Social Reality. London. Penguin Books.
Sokal, A. & Bricmont, J. (1999). Eleganter Unsinn: Wie die Denker der Postmoderne die Wissenschaften missbrauchen. Verlag C. H. Beck, München
Solomon, J. (1994). The Rise and Fall of Constructivism. Studies in Science education, 23, 1-19.
Voloshinov, V. N. (1930,1973). Marxism and the philosophy of language. New York Seminar Press.
Wertsch, J. V. (1991). Voices of the Mind: A Sociocultural Approach to Mediated Action. Cambridge, Mass. Harvard University Press.

The Emergence of a Sociocultural Odyssey

This educational program, which was realized during a sequence of years at Deutsches Museum in Munich, became in a natural way connected to the evolving European cooperation with the title *"History and Philosophy of Science in Science Education*".
The first International Conference on the theme "*Science Education and the History of Physics"* was organized in Pavia in Italy in 1983. The second conference took part in Munich 1986 and then biannual conferences were organized in for example: Paris, Cambridge, Madrid, Kingston in Canada etc, in which the author of this report had possibility to participate.
This participation inspired to workshops in other cities with interesting scientific centres, preferentially in Europe but even in the US.
The next paper will give an overview of these activities.

2. World Wide Workshop - A Sociocultural Odyssey. (2000)

Aadu Ott and Lars-Göran Vedin
Department of Pedagogy and Didactics, University of Göteborg
Paper presented at the ETEN Conference on Technology Education in Schools and in Teacher Training in Munich 10 - 12 November 2000.

Abstract

As part of teacher education and teacher in service training in technology education at the University of Göteborg a project, called World Wide Workshop, has been going on for 20 years. Within this project museums and science centres in Munich, Paris, London and Athens as well as other relevant authentic environments have been utilized for teaching and learning by students and teacher trainers. The project has focused, from a pedagogical perspective, on different aspect of history and philosophy of science and technology in interaction with society. An analysis of the communicative process has been made and it has been found that a theoretical approach which is based on a mixture of a Piagetian mentalistic and a Vygotskian sociocultural model for learning is fruitful to utilize. An extension of the concept Zone of Proximal Development has been developed as an analyzing tool. Informal learning is being found to be benefited by being supported by input from a teacher who provides structuring resources to the learning process.

Background

Since 1980 a joint venture between the University of Göteborg in Sweden and Deutsches Museum in Munich has resulted in about 80 weeklong seminars (fall 2000) with teacher trainers, teachers and teacher students from all over Sweden as the main group of participants. These seminars have been extended to include seminars of the same kind, but in different European museums including for example:
in Paris: Cité des Sciences et de l´Industrie (La Villette), Palais de la Decouverte, Musee Carnavalet and Conservatoire des Artes et Metieres; Appendix: Bilaga Paris.
in London: Science Museum, Imperial War Museum, British Museum, London Museum, London Transport Museum and museums in Greenwich; Appendix: Bilaga London.
in Athens: Akropolis, National Archeological Museum, War Museum together with historical sites. Appendix: Bilaga Athens.
These visits to science and technology museums have in these cities also been complemented by visits to classical art galleries.
During these visits the participants have, in the different museums, focused their studies on aspects and consequences of how science and technology, as a specific art of human culture, may interact with society.

The theme of the ETEN conference is formulated with the words:
"Together with colleagues from different countries to compare technology in Schools and Teacher Training and to plan the first step for further ETEN cooperation", may be regarded as a suitable context for a discussion of the concept World Wide Workshop.
This approach aims at testing and utilizing the possibilities of these museums and settings regarding their potential for science and technology education in teacher training in different countries in Europe.

In order to create a wide platform for discussions we hade utilized a sociocultural perspective for learning which regards biological as well as sociocultural aspects of learning. This is done in a sociogenetic paradigm were learning is regarded as mainly occurring in the form of exosomatic activity in interaction with mental cognitive activity.

The importance of this perspective is that it discusses the possibility of making a break with a designed world on paper. In such an approach, the world is regarded from the unique perspective of one author or interpreter. The aim is to try to create a direct and non-interpreted approach to the real world. The participants themselves regard the real world from many different, but personally relevant and via group discussions, complementary perspectives. This is a process of constructing a useful mental worldview.

The Odyssey in Space and Time

In Athens we take a step backwards in history for about 2500 years. The focus of this seminar is on the early development of philosophy of science and technology in connection with culture. This development may be regarded to have started at about 500 years before Christ when the ancient philosopher Thales from Miletos began to ponder about the matter, which constituted the world.

We thus aim to make a study of the early *Cultural Revolution*, which was initiated in ancient Greece and started a development, which later on affected the whole Western cultural sphere. This was a development which was based on rational and logical thinking. The process was powered by curiosity about phenomena in the natural world.

In Munich, we step forward about 1500 years from ancient to medieval times. The focus of this seminar is on *the Scientific and Technological Revolution* which took place during the years after the Renaissance in the 16th century. This may be regarded as a starting point for the ongoing changing of the Global Society, which was created by application of the technical potential inherent in Western World. This turned, in due time, the traditional agricultural society over into a fast changing industrial society.

In Paris, we step forwards 200 years further in time. The focus of this seminar is on the beginning of the modern era and its origin in *the French Revolution* in the fateful year 1789. This contributes a socio-economic perspective to the sequence of of our seminars on technology education. This is a perspective which originates in the Enlightment movement.

The French Revolution also created a foundation for the Modern Project were reason and rational thinking, together with the application of science and mathematics to technology, challenged the metaphysical influences which originated from Church, Royalty and Aristocracy. The sociologist Max Weber created the word *"Enzauberung",* abolished enchantment, for this movement. This movement contained an optimistic belief in the power of humanity which, together with rational thought gave rise to a renewed hope for the development of society, which was to be characterized by: *liberté*, *egalité* and *fraternité*. This vision was brought to an end when Napoleon entered the scene ten years later.

Two sentences describe the Zeitgeist of that time: The French philosopher Jean-Francoise de Condorcet expressed, while he was chased by the Jacobines, his optimistic view of the future with the sentence:

"Tout decouverté dans les sciences est un bienfait pour l´humanite."
The words of the ancient philosopher Horatio: *"Sapere aude!"*(Dare to thrust your own Wisdom!) should, according to the German philosopher Immanuel Kant, be regarded as the leading theme for the Enlightment movement.

In London, we step forward in space-time into our own contemporary time. The focus of the seminar in London is mainly on technology in interaction with society in the post modern era. The 20th century with its two World Wars brought a doubt to the Modern Project of rationality and optimism. A time of postmodernism emerged, Kuhn (1962), Best et al (1990), Kelly et al (1993), Kvale (1992), which implies a negation of the modern project.

The world is according to the postmodern paradigm to be regarded as a colleague with no grand uniting narratives. According to Feyerabend (1975) for example physics is of no more value than alchemy. This postmodern era and the consequences of these ideas on life in the 21st century is one of the focal points for the seminar in London.

This described sequence of seminars is based on our hypothesis that in order to be able to predict the future we have to regard the patterns emerging in the past. This is a precondition for being able to understand how they may affect contemporary life. If no *grand narratives*, according to the postmodern worldview, are to be found we have to compose our own story about the past. This might for example be done in a productive way by visits to authentic places were history once was made.

This way of visiting historical sites could also be interpreted as an indication of the inherent semantics of a historical place. We make all of us, our own interpretations and mental constructions. With the help of a more knowledgeable peer or teacher some of the misinterpretations, which are unavoidable in informal learning might however be avoided. Therefore it is fruitful to visit historical sites together with a leader of a seminar who is well acquainted with cultural as well as historical development of technology, which took place at that place and in that time.

Aspects on the Subject

When discussing learning, and especially informal learning, it may be fruitful to start from the 6-W model, proposed by the philosopher Mario Bunge. He proposes that, in a learning context, it is important to raise the following six questions:
What? How? Why? Wither? Whence? Who?
These questions give an approach to the subject, which shows the importance of analyzing the subject from different perspectives and to use the result in a creative way in a teaching context: What shall we teach? How can we organize the teaching? The most important question is however the analytical question: Why should we teach this subject? The historical origin of the subject is included in the question Wither?
The important question about the future is in Whence? To what ends will this lead? It is important to question what kind of a target group might be involved. This is pointed out by the question: Who?

Technology as Culture

Culture may, according to for example Dobzhansky (1956) be regarded as that human behaviour which is learned. It may however be fruitful to regard culture in a wider context.

When discussing this subject it is thus valuable to approach the question from the point of view of human beings, who are in interaction with nature and society. Culture could in this case be regarded as a formation of mental structures within the minds of the individuals, as well as of simultaneous externalization of these structures into immaterial concepts and languages and into material artifacts.

The operational definition for technology to be used in the Swedish school system it that: *"Technology is everything that a human being places between herself and her surrounding, in order to fulfil different needs together with those knowledges and skills that she develops and has appropriates in this problem solving process*." According to this definition there is a strong similarity between culture and technology.

Artifacts, which surround man have a discursive content of *distributed knowledge* and might act as physical tools, which could be utilized in mans interaction with the natural world. This perspective also points at the strong coupling between culture and society and also to the interaction between culture and technology.

The word technology itself is composed of the Greek words techne, to make, and the Latin logos, which means word. Technology could thus be regards as the words of technique. Thus the word refers to formal conceptual and discursive development of science of technology. Application of mathematical methods to science is also at the heart of applied technology. Mathematics is utilized as communicative language in engineering.

Push – Pull

When utilizing technology there is always a demand from the users of technology, this could be called *pull.* There is also a demand from the manufacturers of technology to market their products, which could be called *push.* When studying technology in interaction with society, one of the focal points is the relation between push and pull in a historical and a social perspective. A discussion of this might shed light on the development of the differently designed multi-cultural habitats which are encountered in seminars like World Wide Workshop. To what extend do we have a demand for these artifacts, which the affluent technological society creates? How about mobile phones? Was there a demand before it was marketed? What will come next? How about environmental questions and *sustainable development* in a global society with an abundance of people and scarce resources? How about the threatening Climatological Changes?

Maturization

Another focal point is the maturization of technology and how different generations of technology tend to follow each other and phase out each other in a never ending succession.

From a theoretical point of view one could regard these different phases of the evolution of technology in the following way: in the first phase a new technology is introduced and develops; during the second phase it reaches a level of maturity and during the third phase it declines. At the same time this obsolete technology will, however, step by step, be substituted by a new technology which phases out the old technology.

Comparative studies over time and space in technological museums may lead to insights into this situated nature of technological evolution. Deutsches Museum has excellent examples of this process, for example in the departments of Air transport and Ships.

Human technology

Another point of interest in these seminars is the aspect of regarding technology in its interaction with human beings. To what extend are human beings adapted to the fast changing pace of modern society? Comparative studies in different environments and visits to authentic environments, which have been saved from destruction might render material for valuable reflections on this aspect.

Contextual conflicts in technology education

The participants in the WWW seminars are not engineers but teachers who teach technology in the Swedish Compulsory School System. There is a marked difference between teaching of technology to future industrial engineers and teaching of technology to teachers. The teachers will in their profession, preferentially, teach pupils how to understand technological principles in the designed world which surrounds them. The aim in this context is also to teach students to be able to utilize technology in an efficient way in their everyday lives.

Stages in teaching technology

This difference in aims of education means that a different approach to technology teaching for teachers in relation to engineering education has to be taken. In the conceptualization of learning in the WWW seminars, a three stage model described by Gregory (1997) has, to a certain extend, been utilized.

Gregory suggests that *the first stage* of his model should include *hands-on* activities or *exploration* by the student. This mode of learning is well adapted for learning in a science centre environments were a lot of experiments could be performed by the student in interaction with objects in an exhibit. As savings in the school system, has affected the resources in the comprehensive school system in a negative way, then teachers have to try to find other resources for teaching. This means that science centres certainly will become more and more important for teaching and learning. Utilization of science centres also promotes a focusing on possibilities of developing different ways of utilizing informal learning. This means also that attention has to be given to a change, from formal teaching, in which the teacher is an agent for activity, to learning were the student in an informal way takes responsibility for his own learning.

This hands-on exploration could however not be performed in a museum were handling of objects is not possible. Instead a *minds-on* approach could be used. The students are allowed to start the visit to the museum on their own, lead by their own curiosity. They are asked to write down as many questions as possible, which will be the starting-point for the next stage of the visit.

The second stage in this model is, as expressed by Gregory, called *hand-waving*: this is a situation where *intuitive explanations* to the phenomena studied are given. At this stage, it is observed, that the activity of the teacher is important. This is a stage where social aspects of learning are interesting to pay attention to.

In the sociocultural paradigm it is pointed out that the artifacts, which the students have explored by a hands-on way, by no means automatically give away neither explanations of scientific nor technological principles or hints to any inherent historical development. These artifacts do by themselves not include a minds-on activity. Knowledge about utilization or evolution of artifacts is not included in an artifact. This knowledge is to be found in the discourse about the artifact. Only a teacher or a guide has the possibility to place an artefact in a relevant context.

In the same way it has been found valuable to present a narrative about the items presented in a museum in a minds-on approach. The teacher points out how the systematic exposition of objects in an exhibition is based on a certain theory or tradition. This approach has proved to be especially valuable for students in the museums in Paris as the Swedish students generally do not understand or speak the French language.

In one way, experiencing this kind of a non-linguistic non-communicative situation is a valuable experience for the students. They are for once in the same position as their pupils are at many times. The pupils do for example often not fully understand neither the language not the concepts which are used in the discourse of science. Pupils come nowadays also often from a foreign country and do not fully understand the native language in Sweden, with its many idiomatic implications. This, multicultural and multilinguistic situation, is important to reflect upon from a metacognitive position.

The presentations which are performed by a teacher are also valuable in a museum like La Villette, which is built upon a post modernistic concept given by the French post modern philosopher Jean- Francoise Lyotard as described by Caro (1996):
"…we live in a world characterized by the end of the belief in liberation stories…we are left alone with no directions for the future. A fragmented society results from the lack of collective hope…technologies promote new values such as speed or translate every reality into images. Harmony and/or hierarchy of values fade…Natural and artificial cannot be distinguished anymore. Things present themselves on the same plane, without perspective…"Explora" was built on this juxtaposition of fragments…the meaning for a visitor depends on the particular fragments he encounters during his visit. And the meaning is for him alone…It leaves the opportunity for people to get different answers from the same material…Such style of exhibition does not need completeness, it gives points of views, particular examples, which are enough to grasp the basic tendencies in the domain considered."

In order not to become too influenced by a postmodernistic and relativistic view on science it is of value to discuss what real science is and how it differs from diverse aspects of pseudo-science or anti-science. This is extensively discussed by Kragh (1998), who is critical of the post modernistic approach to science.

It is also important to point out the potentials and shortcomings of technology. Students should understand what might be possible to achieve with the help of modern technology. A connection to scientific laws is of outmost importance as these laws under no circumstance are possible to be broken. It is, for example, not possible to make intergalactic travels with velocities exceeding the speed of light. It should be clear for participants in a seminar that science may not yet give answers to all sorts of questions, but that science still knows quite a lot.

The third stage in this way of thinking, proposed by Gregory, is called *handle turning*: this is a stage where mathematical and computational methods are applied to science and technology. It is however important in teaching, that proper attention is given to the first and the second stage before entering this third stage.

With the help of computer simulation and modelling of scientific laws in the micro world of a computer, this stage may however be possible to be reached even without profound mathematical knowledge. More and more of mathematical and algorithmic knowledge is being includes in artifacts. It is however important to be able to understand, in a generalized way, how mathematics makes connections between variables and the possibilities and limits of inter- and extrapolation.

Theoretical Considerations: From Behaviourism to Cognitivism

The cognitive revolution which took place about 1960 was characterized by a change from a behaviouristic view on learning to a cognitivistic. The mind was no longer to be regarded as a closed black box. Two main different branches of cognitivistic theories of learning have evolved.

The first is the Piagetian or individual mental constructivistic theory originating from the Swiss epistemological researcher Jean Piaget (1896-1980). The second is the social constructivistic theory originates from the thoughts, which were brought forward by the Russian philosopher Lew Vygotsky (1896-1934).

The theory by Vygotsky has later on been transformed by for example Wertsch (1991), Best et al. (1990) and Lave et.al. (1991) into a sociocultural theory. In a theoretical approach to interpret the dynamics of the WWW-project the following concepts from the sociocultural theory have proved to be fruitful to take into account:

The Extended Mind

During the years of performing seminars and teaching in museum contexts we have, to a certain extend, been influenced by and thus tailored the courses according to a sociocultural way of regarding the content of the seminars. We have however always paid attention to the metaphor which says that as little as a mass produced costume fits every person, a seminar has to be tailored to the needs articulated by a specific target group.

The learning process has to be understood as a situated process depending on communication in and between the participants, who all of them bring unique experiences to the seminar. In communication between the participants there seems to be an ongoing and continuous creation of an interindividual development of knowledge, which might solve problems more efficiently than individual minds might do. Vygotsky interprets this process of interaction between individuals in terms of an *extended mind*.

The Zone of Proximal Development

Certain aspects of the WWW-project could be interpreted in accordance with another aspect of the theory, given by Vygotsky. This includes the Zone of Proximal Development (ZPD). In interpreting the resulting learning in the WWW-project, the concept ZPD is regarded as the

difference between everyday knowledge in technology and scientific technological knowledge.

It is also possible to connect the concept ZPD to the theory given by Gregory and thus to regard the utilization of the ZPD concept in two steps. The first step may be regarded as a first order process in which the learner passes from an explorational level to an explanational level. The second order is a process when the learner passes further on towards a more generalized and abstract level which also may serves as a potential computational level. This is in accordance with learning based on neuroscientific insights. Concrete activities, which are activated from the sensomotoric system, precede abstract thinking which is controlled by the frontal lobe. The frontal lobe reaches its maturization later than the sensomotoric system.

Towards a sociocultural perspective

These methodological approaches to analyze and deconstruct the object and its interaction with a subject, to make it suitable for learning, have however in the WWW seminars been complemented by a constructivistic or mentalistic approach.

Within the WWW-project we move in a sociocultural and designed landscape. We utilize the environments, which we encounter for the construction of knowledge in the form of linked mental neural networks.

In the WWW seminars attention is given, as well to the individual mind as to the sociocultural context in which the mind is interacting with technological artefacts as discussed by Wertsch (1991) and Lave et al (1991). Here the concept *individual* is changed to the concept *individual in action in a context*. Thought and mind are supplemented with body and action.

This fits well with the fundamental concept of the WWW seminars in which the participants often interact and learn within authentic contexts. The participants may not be at the critical point in the time-space continuum at the very historic moment. They are however at the actual spot which, with the help of a coordinator, will help imagination to recreate the scene and the scenario.

Mediational means

In the sociocultural theory it is pointed out that a biological individual can only participate, in a very weak way, in acts which for example require physical - or intellectual power as for example for lifting weights or doing computation. If the individual however has some form of mediational means then she may be able to increase her ability many times. A person with a mini calculator is for example able to make mathematical calculations much faster than an individual without this mediational mean.

This implies that learning in a sociocultural context, to a great extend is about learning to utilize mediational means. In a museum context this approach is fruitful as a lot of tools which may act as mediational means are possible to be studied there. As an example one could regard one of the most important human inventions, which is the invention of the written language.

According to the sociocultural perspective language is the most important of the mediational means which is used by human beings. In a museum context language in the form of

alphabetic and written representations is built into many artefacts, from the printing press to the computer.

When working in a museum context it is fruitful to utilize a mix of these theoretical approaches: from Piaget we borrow the ideas about *mental structures* and the ideas about *assimilation*, *accommodation* and *adaptation*. This implies that the coordinator of the seminar has to make different presentations of the content of the museum in order to create a mental matrix into which the participant, through informal learning, may place pieces of information in order to adapt to the new environment. From the development of Vygotsky´s theory into a sociocultural theory, we borrow for example the concept of utilization of *mediational means* as *intellectual* and *physical tools.*

From information to knowledge

In this context there is an important difference between the definitions of knowledge and of information. We define, in this discourse, knowledge as the content in a persons ordered subjective mental matrix. Information is found outside the individual mind.

Human beings construct personal knowledge out of information by the process of interaction, which is taking place between their mental patterns and information which comes from the outside world. This means that different persons construct different meanings of different objects.

From a didactical point of view it is interesting to pay attention to the theory of Vygotsky, who in his theoretical approach to learning pointed out that the learning process includes two phases. The first phase is a social and interpersonal phase when persons interact with each other socially and develop their conceptual understanding as they communicate about a subject. The second phase is a psychological and intrapersonal phase, when a person, with her internal language, mentally reflects over the previous social interaction originating in discussions about an object. In this way a learner appropriates knowledge.

In the WWW-project both of these phases are utilized and interpersonal discussions have been performed as well on the steps in Science Museum in London as on a boat trip on the river Thames or in breakfast rooms in different hotels in Paris. These discussions have been highly appreciated by the participants according to evaluations of the seminars.

Quality of knowledge

In this context it may also be possible to discuss the quality of knowledge. Knowledge which is linked to different disciplines in multiple ways is in this context regarded as knowledge of a higher quality than knowledge which is only linked to a single discipline. That means that technology in interaction with history and philosophy of science and society might be ranked higher than knowledge in just one of these subjects.

We are however aware of the fact that in, for example applied engineering, this approach is in conflict with the common view of technology with its focus on intra-disciplinary linking. There is a difference between knowledge *in* a subject and *about* a subject.

Technology for teachers implies the view of a generalist as opposed to a specialist in order to be able to create interest in a wide range of pupils in schools. Pupils have a wide spectrum of

interests and it is important that a teacher can communicate with all of them on their own terms. The teacher should have the ability to act as a constructor of communicative bridges between individual mental structures and not only to strive after constructing mental structures in the minds of the students. Technology has thus to be presented from a lot of different perspectives in order to create linking to as many parts of the mental structures of the students as possible. In cognitive psychology as well as in neuroscience it is pointed out that one way of enhancing the memory is by creating relations to related objects in the personal neural network, which starts with preconceptions.

Enculturation

From Vygotsky we also borrow ideas about interactive learning in a social and technological context. In this case the concept enculturation is of value. This concept means, in this context, that the participants are introduced into ways of regarding technology as a culture. The process of enculturation seems to be enhanced by the process of informal learning in authentic settings.

The participants in our seminars have, according to Piaget´s theoretical point of view, different mental schemas in general and specifically about technology. These mental structures are being constructed as results of experiences which they have had in their everyday social lives and in schools. Many of the participants in the seminars do not have a strong scientific background. They thus enter a different culture and as they feel to some extend threatened by this culture, it is important to show them that this culture does not imply any threat against them.

The slow process of enculturation might favourably start with a personal experience of the fact that we, all of us, are technicians and that we all utilize technology in our daily lives. This turns the sociocultural way of regarding technology into a fruitful theoretical approach which is useful in order to understand the learning process which occurs within this project. Through understanding of this learning process from a theoretical point of view it is also possible to try to enhance it.

This way of pronouncing interaction and communication within the group of participants, also means that it is fruitful to divide the participants into small study group in order to create possibilities for them to reflect in action on different aspects of an exhibit in an exhibition. In a small group the level of interaction might be optimized as everybody in the group has a possibility to make her voice heard and to contribute with her personal perspective in the process of communication which aims at uniting perspectives. This is one of the target points in our informal learning approach. In a way a positive result of the evaluation of the ideas on which the project is founded is indicated by the pure fact that the project has being able to continue for a couple of decades.

Authentical Settings: Athens: The Cultural Revolution

In Athens the seminar focuses on Acropolis and its surroundings, including the hilltop Areopage, the ancient square Agora and the original place for democratic voting, the Pnyx. A walk up to the Acropolis includes passing the magnificent remains of the Parthenon and the other temples. Down beneath are the theatres of Dionysus and Herodotus to be found

Close to the entrance to Acropolis, the hill called the Areopage is situated. It is with a solemn feeling of awe that one climbs the well used steps up to the top of this hill. These are the steps that Socrates used in 399 B.C. on his way up to the trial in which he was sentenced to death. These are the steps that the apostle Paul used in 59 a.c. in his famous preaching about the unknown Good.

A small road leads from Acropolis down to the ancient Agora, the central square of Athens, were philosophers like Plato and Aristotle discussed the early foundations of science and the differences between science and technology. The buildings are mainly destroyed through warfare and mostly only ruins remain. One rebuilt house, Herodotus Stoa, gives however a clue to what the imposing surroundings looked like in ancient times.

A small road, close to Acropolis leads up to the Pnyx hill were once Perikles, Demostenes and Alchibiades among other leaders spoke to the free men of Athens in an effort to apply early democratic rules. The view from this place reveals manifold perspectives on ancient life. When looking upwards, one regards the magnificent Acropolis, which was the seat of power and which was sacrificed to the Goods. When looking downwards one regards the Agora where the principles of democracy were discussed and commerce was being done.

The Archeological Museum, in downtown modern Athens, shows artifacts from the golden ages of the ancient times. As an outstanding technological artefact the Antikythera Mechanism, which is interpreted to be a prehistoric computer, is presented.

A walk in the city of Athens includes a visit to the old part of the city centre, the Plaka. It is also suitable to make a walk through the remains of the huge Zeus temple. Close by this temple is the old Stadium situated, were the modern Olympic Games were initiated.

A wonderful view of the city is presented from the Leukippos Mountain. In good weather a view of the Egeic Sea, the harbour town of Piraeus and the historic site of the battle of Salamis may be seen.

The War museum shows among other items how ancient Greek fighters, the hoplites of which Socrates was one, fought against each other during the Peloponnesian wars between Sparta and Athens.

Modern time may be enlived by a trip with the new underground line to the harbour town Piraeus, from were lots of ferryboats go to different islands. In ancient times, a stone wall surrounded the important road from Athens to Pireaus.

The questions to be discussed in these surroundings are among others why, what we call modern science, started in this setting. What characterized Greek science in contrast to modern science? What was the difference between the philosophers and the workmen in the Antiquity? What type of interaction between technology and society was necessary in order to build Acropolis or the Zeus temple? What were the advantages of democracy? Why do we put the cradle of our civilization in ancient Greece? Why did the ancient Greeks build such huge theatres?

Munich: The Scientific and Technological Revolution

The WWW seminar in Munich has as its focus the scientific and technological artifacts in the collections in Deutsches Museum. Through führungsvortragen and eigenstudien the participants are presented to the great changes which took place around the Renaissance when science and technology started to create a new way of life for mankind.

Among the memorable artifact at Deutsches Museum are the Magdeburg Half Spheres, which may be regarded as a starting point for the physical and mental evolution of the steam engine. Originals of James Watts´ constructions are shown in Science Museum in London. The steam engine was an important component in the Technological Revolution, which finally was one of the artifacts that made it possible for England to become the workshop of the world in the 20th century.

The city of Munich, as a part of modern Europe, with a dramatic history is also presented. The rise of the Nazi movement is discussed and a guided tour through the city passes some of the important places were history was made, as for example the Feldherrnhalle outside which the coup de etat of 1923 was stopped; the monument over Die Opfer der Nazionalsocialismus and the two squares: Professor Huber place and Geschwister Scholl place which commemorates the movement against the Nazis. For those who volunteer a visit to the remains of the concentration camp Dachau is organized.

A visit to the remains of the life and time of the nobles of the 18th century, Schloss Nymphenburg, gives a vivid picture of the difference between the lives of the aristocracy in their affluence and that of the poor common people.

The modern Munich with its industries, as for example Siemens telecom laboratory, may also be visited. The focus of industry and production in Munich is mostly focused on high-tech and on information technology.

The questions to be studied in Munich include the dramatic change which took place from a static agricultural society into a modern industrial society and further towards a post industrial society. Very good possibilities are offered to illustrate the different sources of power, which affected society at different times as they were emanating from aristocracy, Nazism and economics.

Paris: The French Revolution

In Paris the WWW seminar starts with a visit to Place de la Bastille and a historical exposé is presented of the chain of events that initiated this revolution. A visit to the Musée Carnavalet, close by, shows with pictures and artifacts the drama. A visit to Conservatoire des Arts et Metieres which was founded in 1794 gives a realistic view of the Enlightment movement and of the applications of its ideas.

A subsequent walk in the historic centre of Paris, starting at the Louvre were the ancient regime reigned, to Place de la Concorde were the guillotine was placed and were about 1100 persons lost their heads during the Terror and on to l´Arche de la Triumphe, which marks the end of the popular part of the revolution, leaves no one unaffected.

This is a seminar on technology in interaction with society. Therefore we contemplate from different perspectives the 100 year anniversary of the revolution which was commemorated with the erection of the Tour Eiffel. These reflections are aimed to render insight in the technological level of that time. It is a memorable experience to go up to the top of the Eiffel Tower by the original one hundered old escalators and to reflect over the 20th century technology onto which one relies.

In order to commemorate the 200 anniversary of the French revolution, the Grand Archer in the part of the city called la Defence was erected. This arch is in line with the Arch de Triomphe and with the main road through Paris, the Champs Elysee. In good weather the obelisque at Place de la Concorde and the Arch du Triumphe du Carrousel outside La Louvre, were Napoleon liked to march his soldiers may be observed from the top of the Grand Arch.

London: The Postmodern World

In London the river Thames is a guideline for the seminar. Travelling on the river from Whitehall to the Thames River Barrier gives a lot of impressions of development and change.

In London the bustling life of the modern and multicultural city is a point in itself to study. Different ethical groups are obviously able to live side by side. London is characterized by its historic background as centre for a world wide empire. This empire has however, in the post-colonial time, lost most of its colonies and this change is possible to observe and study.

London was also heavily bombed just as Munich, during the Second World War and the reconstruction of the city is due to this. An interesting expose over the history of London from Roman times to modern times, together with a presentation of the development of the modern city is presented at the London Museum. This magnificent building is situated in a newly developed area of the City, close by the old St Paul's Cathedral.

A trip by underground from Piccadilly Circus to Tower Hill Station and then by Dockland Light Railway past St Kathryn's Docks to Dog Island and followed by a walk underneath the Thames in a tunnel and then to Greenwich takes the participants through different ages and technologies.

A boat trip from Greenwich further on to the Thames River Barrier shows how man continuously has to fight the powers of nature. A visit to the Greenwich Meridian Museum and the Naval Museum shows how England once ruled the seas.

The castle named the Tower casts light on the life and fights of the aristocracy and the Tower Bridge shows the level of the technology of the 20th century.

At the London Transport Museum it is possible to study how the crucial question of transportation in urban areas has been solved at different times and with different technologies.

A question to be regarded in this context is to what extend should the negative use of technology in wars be treated in school? The students, in the seminars, have however pointed out that war has always been an integrated part of the development of modern society. It would give a false picture if this aspect is avoided in teaching of technology in interaction with society. This way of thought may be applied to the visit to War Museum in London.

However negative this application of technology is, there one may study the levels that high technology had at different times by studying the artifacts utilized in war as these artifacts always included the use of the latest generation of technology.

The questions to be asked are among other, how a big city may be changed in order to adapt to changes in the world. How are problems of transportation being solved?
What are the most urging problems of our times? In what direction will technology lead?

Acknowledgement

We would like to express our sincere thank to Professor Jürgen Teichmann who has been of invaluable help in the foundation of this project.

References

Best, S. & Kellner, D. (1990). Postmodern Theory: Critical Interrogation. New York: MacMillan/Guildford.
Dobzahansky, T. (1956): The biological basis of human freedom. Columbia University Press
Feyerabend, P. (1975). Against Method. Outline of an Anarchistic Theory of Knowledge. London: New left Books.
Gross, P. R. & Levitt, N. (1994). Higher Superstition: The Academic Left and its Quarrels with Science and Reason. John Hopkins University Press. Baltimore.
Gross, P. R., Levitt, N, & Lewis, M. W. (1996). The Flight from Science and Reason. New York: Annals of the new York Academy of Sciences.
Kelly, G., Carlsen, W. S. & Cunningham, C. M. (1993). Science Education in Sociocultural Context: Perspectives from the Sociology of Science. Science Education, 77(2), 207-220.
Kragh, H. (1998). Social Constructivism, the Gospel of Science, and the teachning of Physics. In Matthew, M. R. (Ed.): Constructivism in Science Education. Dordrecht. Klüwer Academic Publishers.
Kuhn, T. S. (1962,1970). The Structure of Scientific Revolutions. Chicago: The University of Chicago Press.
Lave, J. & Wenger, E. (1991). Situated Learning: Legitimate peripheral participation. New York: Cambridge University Press.
Matthews, M. R. (1995). Science Teaching: The Role of History and Philosophy of Science. New York: Routledge.
Matthews, M. R. (1995). Challenging New Zealand Science Education. Palmerstone North: Dunmore Press.
Matthews, M. R. (1998). Constructivism in Science Education. A Philosophical Examination. Dordrecht: Klüwer Academic Publishers.
Nelson, K. (1996). Language in cognitive development. The emergence of the mediated mind. Cambridge, England: Cambridge University Press.
Wertsch, J. V. (1991). Voices of the Mind: A Sociocultural Approach to Mediated Action. Cambridge, Mass. Harvard University Press.

From Göteborg and Lund to Athens

During the fall of the year 2001, a group of teacher trainers from Göteborg University and from Lund University made together a weeklong seminar to study History and Philosophy of Science in Science and Technology Education in Athens. During daytime, guided studies were performed on different historical sites in Athens with surrounding cities as the harbour city Piraeus and the mythological city Delphi. In the evenings seminars were held at the Swedish Institute in Athens. These seminars treated different aspects of life and time during Antiquity.

3. From Antiquity to Affluence

Aadu Ott and Lars-Göran Vedin, Department of Education, Göteborg University, Sweden.
Paper presented at the second ETEN conference on "Technology Education", 8TH to 9th February, 2002 at the University of Greenwich, London.

Abstract

A theoretical and didactical model has been created in order to be able to reflect on what knowledge is and how it differs from information and how learning and teaching interact in the contemporary educational paradigm. This is done by a comparative study of variations in technology and technology education utilizing a comparison between the conditions for technology in antiquity and conditions for technology education in contemporary times. This model contains four interfaces to illustrate key factors in the comparison of technology between antiquity and modern times. These interfaces are in a symbolic way based on four critical aspects: *epistemology, ontology, praxis* and *potential.* The model also provides possibilities to analyze and to discuss consequences of changes over time, which have occurred in these different aspects. The model might, in a tentative way, be helpful when discussing the content of technology education for teaching and learning in teacher education, teacher in service training and the utilization of these aspects of technology in teaching in comprehensive schools in Sweden. The model also aims at highlighting some of the many dimensions of technology and to stress the fact that technology is more than just applied science and to expose the broad field of technology in its interaction with our pupils in their future everyday lives.

Background

During the fall of the year 2002 a seminar with Swedish university teachers from different disciplines was organized by Göteborg University and held in Athens (Ott, Vedin 2002a). This project was a follow up of the seminars using authentic environments for technology education in Munich, Paris and London as presented by Ott & Vedin (2001a, 2002b). The aim of the seminar was to study the interaction between science, technology and culture in Ancient Greece and to compare this with trends in contemporary science and technology education in Sweden. This comparison highlighted some fundamental differences and equalities and resulted in the attempt to create, in a tentative way, an approach for teaching technology in the comprehensive school system in Sweden. A theoretical model for teaching and learning technology was thus created which took its starting point in a reflection on the differences between these two culturally different ways to develop and utilize technology.

The Provocation

The provocative thought on which this theoretical model is founded is:
Technology in ancient Greece might be visualized as comparing better to technology education within classrooms, than to how the contemporary classroom teaching might compared to utilization and application of technology outside the school system.
This comparison might be valuable as people in their everyday lives interact with the technology which surrounds them in their homes and in their immediate neighbourhood, as

well as when they interact with technology in the institutionalized Big Technological Society were large scale Techno-Science is ruling. Decisions in the latter, the Systemic World, might in a profound way affect the Life-World of people (Husserl 1970).

One way of avoiding problems, in the personal range, is to be able to predict some aspects of future influences of changes, created by utilization of technology. This also implies ability to be able to take appropriate measurements and consequently to get a suitable education while time is, in order not to become jobless and helpless in our ever faster changing market dominated global world which inevitably affects the Life world for all of us.

The Model

The model may be visualized in the form of a square which has its sides slightly elongated outside the intersections between consecutive sides. The sides are marked according to the orientations given by a compass. The symbolic and semiotic signification of the sides, are discussed below. **Antiquity** resides inside and **Modernity** outside the square.

North: If a comparison with the orientation of an ordinary map is made, then the upper-northern side denotes the factor **praxis** or production and illustrates how production of artifacts and goods has changed over time between Antiquity and contemporary times.

West: The western side will then denote the factor **epistemology.** This interface illustrates the question about how knowledge is created, what knowledge is and how knowledge may be justified.

South: The southern side denotes the factor **ontology**. This side regards the fundamental question about what the content of scientific and technological knowledge really is.

East: The eastern side denotes **potential.** This interface illustrates the potential of technology, its possibilities and its shortcomings in different contexts.
To these aspects are added the overlaps between the crossings of the sides outside the square. Four such intersections are thus created: North-west, south-west, south-east and north-east. These overlaps illustrates the integrated effects and consequences of the factors mentioned above.

Discussion: Praxis. From handicraft to mass-production

The **northern interface** with the factor Praxis aims at illustrating how production in Antiquity mostly was performed as handicraft with minor industrialization. This is exemplified by the manufacturing of amphorae or other items out of clay in some sort of pre-industrially organized way.

What is important for an affluent society is however the possibility for mass production of items aimed for mass consumption by middle class people and thus also a production of means for mass production. A comparison could be made with the developing world were a hindrance to development is the export of raw material and import of luxury items for the ruling class as analyzed by the economist Samir Amin. This type of development can also be noticed in the Baltic States, where after 1989 the Soviet and now the Russian regime have lost its political and economic domination.

An interesting example from ancient Rome is the widespread use of Terra Sigillata, which consisted of mass production of ceramics for use preferentially in the Roman army. An important technological innovation for mass production in Antiquity was the rotating wheel on which ceramic pots were moulded.

Design

In teaching and learning reflections originating from this interface renders a clue to discussions about how to design items so that means for mass production could be applied to them. Mass production of goods for everyday use is a critical factor in a modern society and has, as mentioned, to a great extend affected the development of the Affluent Society in the Western World.

Decreasing interest in science and technology

A notation may be added about the decreasing interest of youth in Western industrialized countries to study science and technology. This trend is analyzed by Sjoberg (2001). According to this discussion young people find more interest in the use of artifacts created by modern technology, for example mobile phones, than to take the effort to study the technology which made the construction of this item possible.

Empirical – theoretical

Teaching of technology in modern schools relies however, as in antiquity, more on empirical than on theoretical foundation. Students are individually or in small groups active with practical moments for example in "slojd" in the context of the classroom. Students, in schools thus mainly develop their knowledge by personal experiences in a decontextualized way. Students thus make items while utilizing fairly primitive technology. They do this work on a small scale just as in Antiquity.

Research

This reliance on handicraft could in itself be utilized as an aspect of research in design and technology by stressing the fact that technological production in Western countries often is modelled in a way so that prototypes are made in industrialized countries. Mass production of the product is on the other hand however done in developing/underdeveloped countries with lower wages and thus lower production costs.

This is in itself a trend which is important to notice as this trend is affecting the work market of today in a way that will affect the young pupil's possibilities to get a job later on in life as more and more of production of artifacts is moved to low-cost countries.

This opens up a field of possibilities to utilize the classroom as a laboratory for action- and participatory research by the teacher and the students on learning of content and methodology of technology education.

As an example we would like to mention that at the University of Göteborg, we study technological products and use of technology on a small scale with the help of LEGO kits. The artifacts made are then compared with authentic parts in a realistic context formed for example by the use of these artifacts in the production and utilization of Volvo cars. Students

have in this context even done some research on different ways of learning with these items. The results of this activity are even used for examination of the students.

This process illustrates how reproduction of knowledge on an individual level which commonly is labelled learning may be transformed to production of knowledge on a collective level, which may be labelled research as discussed by Bowden & Marton (2000, chapter 1).

The evolution of technology

In this context we also stress the importance of visits to modern industrial plants with large scale production lines. This part of technology education about the evolution of technology is subsequently analyzed from different historical and social perspectives as discussed by Ziman et al. (2000).

Regarding the history of industrialization in Göteborg we ask ourselves why a certain industrial culture has evolved in this city: The development of industrialization on a large scale started with textiles, Gamlestadens Textilindustri was, for example first founded, and as a spin off, the development succeeded to the worldwide and well known ball bearing industry SKF, and then further on to the car manufacturing plants of Volvo and Saab. This development includes a lot of subcontractors and a whole industrial region has been created which depends on the two big automotive assembly plants.

These automotive plants are however nowadays owned by the multinational companies Ford and General Motors, a development, or global trend that also is interesting and important to notice. Is it a benefit or a problem if stockowners in faraway countries own the tools by which you and your family make your living?

Is it possible to predict what will happen with the production industry in the near future? Even if this question is difficult to answer fully, it is however important to frame questions about this sort of development in our fast changing and dynamic society. Are there any trends which we may be able to identify? How should teaching and learning be organized in order to yield knowledge which is relevant for the future lives of our students? The theory of variations might give a tentative solution (Bowden and Marton, 2000): Teach for variations. Utilize these variations in subsequent actions.

Future studies

The philosophy underlying these studies is that in order to be able to predict the future it is important to understand the roots of the present state of conditions and not to take for granted that there exists a predictable and reliable steady state in the real world. Especially in a small country with a small interior market, as in the Nordic countries, is it important to try to analyze the global business situation in order not to lose jobs and businesses when industrial systems are restructured or rationalized. This is valid as much on a collective as on an individual scale and affects processes and products for study in the selection of content for teaching and learning in technology education.

This way of reasoning stresses the importance of regarding that interface of technology education which is directed towards market, economy and world politics. Questions of this kind may also be found in Ancient Greece, which was an imperialist state and extremely dependent on the import of food, mostly cereals, and export of olive oil and wine. When the

interests of the state and the city of Athens were threatened by other states, for example by Persia or Sparta, this inevitably had to lead to war as the very lifeline of the state was threatened. Are trends like these to be found in contemporary times when, instead of an all out war, guerrilla wars are fought by small terrorist groups?

Imperialism

Some interesting parallels may thus be drawn between politics and economy in the past and contemporary market competition within and between the industrialized countries and with dominant relations towards the developing/underdeveloped world. Of special interest would be a comparison between imperialism originating in England and Athens. This line of reasoning opens up for possibilities and needs for cooperation with other subjects like social sciences in technology education in the comprehensive school system.

Broad approach

This thematizing of technology education to include historical, economical and political dimensions also draws attention to the benefits of a broad approach to this subject as it contains so many different aspects of the Life-worlds of our students now and in the near and more faraway future.

The other side of the coin

The question is also to what extent technology education in an affluent society should or ought to regard the destructive side of technology. This includes the destructive powers of modern technology in small or large scale utilization, as well as on the vulnerability of an open society in respect to attacks or threats from small but desperate group of terrorists. To what extend should student be confronted by questions of this kind? Maybe the problematic sides of modern technology should be dealt with more extensively than usually? At any rate it seems to be important to raise questions about the counter productivity of some applications of modern technology. Technology assessment and the pros and cons of the application of different technologies should maybe be given more attention.

Ideology

Behind this argumentation lies an ideological divide: do we believe in a stable world order without dramatic changes or do we believe and prepare for a world system, which might at occasions be threatened and affect the community in such a dramatic way so that the citizen for a while have to survive by their own ability, means and knowledge? This was certainly simpler in Antiquity even if the small Greek states at that time fought an endless succession of wars which maybe in a way was not very unlike the competition in our times about market dominance.

On the international seminars, which the students from University of Göteborg undertake to London, a visit to Imperial War Museum draws attention to the destructive potential dimension of modern and contemporary technology. This visit exposes the enormous amount of technology which was created for destruction and for defence by the giant military and industrial complex.

Innovations

From this *innovative nexus* sometimes however items emerge, as spin-offs, which affect our lives in non destructive ways as for example the Internet communication system and the GPS navigation system. We have however to bear in mind that the same type of microprocessors are to be found in cruise missiles as in personal computers. Even in Antiquity we are able to find this parallel of peaceful and warlike use of an item: even an axe could be used for offensive and defensive means. An artifact is always part of praxis and the interaction of artifact and praxis in a given context will also affect the mentality of the user.

Survival

In our northern country it is not unusual that the winter weather causes interruptions in for example electricity deliverances to homes. Snow might also make roads unusable for shorter periods of time. We therefore have discussions within our courses about how knowledge for survival could be included in technology education. This means that we in a way might learn from life in the Antiquity were the interconnections between man and nature were more transparent. Man was not believed to be omnipotent. Not even the Goods in Antiquity were omnipotent. Modern man seems however sometimes to regard himself as omnipotent with the help of his technological skills.

Robotics

LEGO has beside toys, also developed a computerized kit with which it is possible to build simple computer activated robots and production lines. These models may be used to visualize the changing patterns in production in factories and plants.

Our experiences are that the students who aim at becoming teachers take this development and utilization of computerized items and systems very seriously. Even if they have just a little bit of rudimentary knowledge's in computer technology when starting their studies, they are able to increase their knowledge during the course in technology markedly and express subsequently a positive attitude to this subject which is at the roots of our Affluent Society. We all rely more and more on computers and applications of the technology of electronics. In a picture from an amphora from Antiquity we may regard a boy sitting and holding an artifact, which from the side is very like a laptop computer. This artifact is however a portable wax table with which the boy is able to practice spelling.

The change to contemporary time is that a modern artifact, which looks like the ancient one, even if the outer appearance is the same, contains lots and lots of computing power. This is built into the microstructure of the artifact. Thus we are able to identify an important contemporary trend: the artifacts surrounding us tend to contain more and more of information processing power. At the same time man and artifact together will have the possibility to interact in order to perform tasks which none of them could do separated. This is one main point in the sociocultural theory of learning. Cole ((1996).

Learning

Learning nowadays is, according to the sociocultural perspective, an occupation in which the students learn to handle and use different artifacts. This implies that there is no end to learning and no final state for mental development. This is in contrast to the ideas about learning

originating from the cognitivistic the theories of Piaget (1973), were a final stage for intellectual development was predicted. Learning was in this theory thus regarded in terms of development of mental structures. When the highest level of abstract thinking war reached the development of intelligence might be regarded as having reached its optimal level.
The sociocultural theory of learning regards learning as an act which is partly situated outside the individual mind and which is in interaction with artifacts and functioning together with other individuals, who participate in the learning process.

In a way this is an interesting theoretical approach to learning in technology education as technology always implies the use of artifacts and team building around the development of a project. Mankind will always encounter new artifacts, which we have to learn to handle. Thus there is no end to learning in a modern society in contrast to learning in Antiquity were a lot of knowledge was invariant from generation to generation.

Nemesis

In this context it is also important to take into account environmental consequences of mass production. We try in our courses in technology at Göteborg University to teach students not only to be able to master technology in order to dominate and to be able to manipulate nature in order to get benefits. We also try to teach an underlying philosophy of coexistence over time with the given environment i8n what is called sustainable development.

In this case it is interesting to return to the philosophy of the ancient Greeks. The natural philosophers among them searched for a level, metro, which was sufficient for living. If a person passed over that level, then the Good of revenge, Nemesis, interacted.

In our affluent society we try to maximize the benefits in a short time perspective. The question is if Nemesis is not starting to interact with us with for example the global heating which emanates from the Greenhouse effect. Maybe discussions around this interface could be utilized with the effect of us attaining a more careful attitude towards the environment?

At the same time, when studying the Golden Age of Antiquity from about 490 to about 400 BC we encounter the devastating Peloponnesian wars, The great Greek leader Themistokles did build a large fleet of triremes to fight off the Persian invasion with the victory at Salamis as a positive outcome. But the destruction of forests to get raw material for shipbuilding has however had a lasting a negative outcome on the environment. We may, through this example, learn how philosophical intentions are counteracted by actions in the real world of politics and power.

The imagination of our individual dependence on three trees per person for our personal oxygen consumption should lead everyone to ask were the very trees on which he depends might be located.

Episteme

The **Western interface** which is labelled epistemology draws attention to how knowledge has changed from "*experience led knowledge"* in Antiquity towards "*science and theory led knowledge"* in contemporary society. Applied mathematics plays a more and more important role in this process. Our modern knowledge becomes more and more abstract and symbolic but acts also as a mean for efficient production.

Magic and Mystery

The laws of nature define the boundaries of possible options and constraining restrictions for the application of technology. In our days a lot of non-scientific and magical thinking seems to surround us more and more. New Age prophets are supported by the fictional character Harry Potter. It becomes therefore increasingly more important to examine information and to seek justification for presumed scientific knowledge. With the introduction of Internet this became an even more important question.

Sjoberg (2000) proposes that one of the factors underlying the flight from science and reason towards magic, which we encounter today, is that this opens up a much more interesting field for young people than science does. This field interacts also better with the youth culture in an affluent society were young people often do not have to bother about basic needs as these are provided for by family and society. Magic might also answer some of their existential questions about phenomena in our world.

Information refined to knowledge

It also becomes important to scrutinize the differences between information and knowledge. This question may be thematized by asking if the Internet contains any knowledge at all. We thus need a definition of what knowledge is. One fruitful way of thinking is to postulate that knowledge is what an individual bears in his mind. Then knowledge can act as a tool for problem solving for the owner of appropriate knowledge. This dichotomy between knowledge and information leads also to a need to have own and personal knowledge in order to be able to refine information on the net into useful knowledge.

The Matthew effect and the Net

This way of regarding knowledge will also annihilate argumentation that students do not have to learn anything as everything may be found on the World Wide Web. An interesting effect has been given a Biblical name: The Matthew effect. In the chapter written by the Apostle Matthew in the Holy Bible it is expressed that those who have much will gain even more. This expression seems to be valid also in contemporary times. The more you know and the more prepared you are, the more you will get from the World Wide Web. A paradigmatic change might be observed, as teaching and transfer of knowledge from teacher to pupils tends to change into possibilities for pupils to search for knowledge by themselves.

This way of thinking, keeps however the teacher still at the centre of the interactions between students and teacher in the classroom. This way of thinking will also question the possibilities to have virtual classrooms with students interacting with computers as a way of learning. At the same time the changing role of the teacher from a transmitter of knowledge and facts into a coordinator of knowledge for learning is more marked:

"From the sage at the stage to the guide at the side." This implies also that a teacher has to have a broad view in technology in order to be able to coach her students in the different fields of technology, which they are studying. From then Antiquity we hear the echo of Hippocrates words: "*Ars longa, Vita brevis."*

Maybe an observable trend in pedagogical thinking towards a non-dualistic view of the man-world interaction might prove to be fruitful. In this way of thinking different subjects are viewed as aspects of reality and a change of perspectives is in the forefront of learning. Learning might in this context be regarded as acquisition of many perspectives on the world. This is a phenomenographical approach to learning. It could be complemented with a sociocultural approach, were learning is regarded as participation in an activity. Sfard (1998) introduces a discussion about the *acquisition* and the *participation metaphor for learning.* In technology education an enculturation into a technological discourse is also predominant. This is discussed by Lemke (1990).

Newtonian in mind – Aristotelian at heart

In teaching the laws of nature, which limits the possibilities of utilization of technology, are discussed. For example we analyze in our courses in Göteborg the functions of constructions, which student make, utilizing Newtonian mechanic. This is in contrast to Aristotelian physical laws. Aristotle said for example that you will need a force for movement, while Newton said that you needed a force for change of movement. In the Aristotelian view, a force creates a change from a steady state to movement. In the Newtonian view, a force creates a change from movement by acceleration. This is however a more abstract way of handling the problem. It is however only by utilization of Newtonian mechanics that it is possible to understand for example the dynamics of impacts and thus the possibilities for construction of safer cars.

Studies of students´ conceptions of mechanics however indicate that even if they express themselves in Newtonian terms, they seem however often to have Aristotelian concepts in their hearts.

A lot of studies are undertaken about the interaction between a scientific approach and an everyday approach. First it is important for the teachers to understand that there are different ways, originating in different discourses, for dealing with a concept. Even if the student expresses himself in an everyday discourse, he may be thinking correctly, but talking in a discourse, which is as foreign for the teacher as the teachers scientific discourse is foreign for the student. It is also important for the teacher to understand that the content of the concepts change for the student as he becomes more used to them. Wittgenstein has pointed out that the meaning of a word is given by its use in the language.

A lot has been written about conceptual change and consequences of this. One conclusion may be that it is not fruitful to try to eliminate the everyday concepts but instead it is important for the student to try to be able to learn to regard a phenomenon from varying and different perspectives.

Ad Hocness

For instance one student, in our courses in technology, made a vehicle which operated with the utilization of the Magnus effect. She needed however insights into the theoretical background to understand the behaviour of the construction in order to be able to improve it. This is an example of an ad hoc or genuine question were the student actively tries to gain theoretical knowledge. The Magnus effect generates a force on a rotating cylinder which is translated relative to the surrounding air. It is a real pleasure for an educated teacher to be confronted with questions of this kind.

Technology is a very wide subject. It is not possible to teach all aspects of the subject but the subject however contains an ad hocness which challenges the knowledge of the teacher. This focuses on the need for another way of interaction with the student than the traditional teaching- learning interactive and traditional transmissive process of knowledge transfer. The teacher and the student have often to try to seek out relevant information together and refine this into appropriate, useful and situated knowledge. This is labelled situated cognition. Another student worked with questions about how to get more power out of a combustion engine. In this case insight into the law of Carnot, which the teacher introduced, proved useful. This law showed that the important factors in this problem were to raise the maximum temperature in the combustion chamber and to reduce the temperature of the exhaust gases.

All temperatures are however in this law expressed in degrees of Kelvin. This should however not be a nuisance, but contribute to makes a close connection to physics. This might create a meeting ground between teachers in applied technology and in the theoretical fields of physics. This example illustrates how science and technology may meet and interact fruitfully in technology education.

Ontology

The Southern interface “ontology” draws attention to how a change from knowledge about matter in the visible and everyday world is transferred into knowledge about atoms and molecules in the invisible microcosm. A transformation has thus been done from the surface into the interior of matter. The atom, first proposed by the ancient philosopher Democritus as a philosophical entity, which was undividable, has become a real part in modern technology. The atom is nowadays splitted into even smaller parts and energy is gained in that process. A technological science called nanotechnology has also emerged.

FEM and Models

An interesting demonstration may be performed by the use of a Field Emission Microscope, FEM. This is an artifact, which also has been developed, and may be purchased, for use in school labs. It has an enlargement factor of about one million and it is possible to regard the shadows of atoms in a single crystal of tungsten on a screen. In order, for the students, to be able to interpret the picture on the screen of the microscope it is however fruitful to place a model of an atomic lattice on an overhead projector. This demonstration illustrates how invisible atoms may be visualized and the picture interpreted with the help of this model experiment, which should be demonstrated in parallel with the actual experiment.

In teaching a discussion about technology at the following different levels would be appropriate to undertake: the atomic, the molecular, the cellular and the macroscopic level. Technology, developed at these different levels, give rise to different applications in our everyday world. We boil, for example, our potatoes with the help of electricity from atomic power which emanates from splitting of uranium atoms. We eat gene modified food and may get cellular diseases like cancer which however may be cured with the help of irradiation by high energy photons.

In our classrooms, like in Antiquity, the students mostly concentrate on phenomena, which are exposed at the surface or macroscopic level of matter. The way towards the affluent society utilizes however, in applications of modern technology, smaller and smaller entities of matter. Even if it is difficult it has a value to try to explain for the students the function, of for

example, the diminutive integrated circuits which are manufactured with photographic means. In this way we may counteract the feeling of magic in the application or utilization of technology.

Western science and technology?

Another strand to pick up is the question about Western science versus other ways of regarding and developing science. Is Western science the only kind of science which is possible to develop and use? Does this way of regarding science and technology have to lead to an imperialistic and dominating effect on other cultures in the world? Is there a divide between male and female approaches to science and technology? The question is also about how technology evolves. The traditional way of thinking is that more advanced technology evolves out of less advanced technology. How is it then possible for the emergence of entirely new technologies to occur?

Potentia

The Eastern interface "potentia" denotes how application of technology has developed from the local impact on nature around the settlings as in Antiquity, into a global impact which needs a global awareness. Nowadays it appears important to discuss for example phenomena like ozone holes and the greenhouse effect. If technology is to be regarded as science for citizen, then these phenomena are important to take into account. In this context we reencounter the dominance of Western Science.

Power

The English medieval philosopher and Lord Chancellor Francis Bacon once said: *"Knowledge is power."* In our post modern time the French philosopher Michael Foucault has rearranged this expression and says: *"Power is knowledge."*

In teaching it should be fruitful in this perspective to interact with social sciences as there is no doubt that a dimension of power lies behind the selection of certain technologies.

Consequences of technology

The extension and integration of interfaces define four areas, which show the consequences of interaction of the different approaches to application of technology in our contemporary time.

North-west
This intersection may be said to illustrate how large scale industrial production interacts with the possibilities and limitations which the laws in science implicate. A didactical discussion about possibilities and consequences may start here. The question about Big Science and Techno Science emanates from here. Is man passing the boundaries given by nature? Is it possible, in this case, like in Antiquity that the revenge from the goodness Nemesis shows up?

North-east
In this intersection the industrial production shows its effects on the global scale. The mythological figure Demiurg, who according to the Russian philosopher Bachtin is a metaphor for man in his recreation of the world, emerges with an overwhelming power, which

he uses for the recreation of the world. Our Lord once created the world in seven days – now man may be regarded as recreating the world in the eights day.

South-west
In this intersection a discussion may start about the possibilities to extend the natural laws into the microcosm and develop more sophisticated technological artifacts and applications. We have examples from ITC, gene manipulation, nuclear power, lasers etc. Maybe we are only at the start of an overwhelming phase of technological development?

South-east
From this intersection, a discussion may start with world wide molecular environmental problems. The environmental problems have changed its face from visible pollution, which was possible to regard with our senses, to molecular, heat and radiation pollution to which we have no senses. This means also that we have, to a greater extent, to rely on experts.

Summary

In this discussion we may follow how technology, which in Antiquity was limited to handicraft in a local and experiential context, has changed its face. Mankind will now encounter the results from utilization of technology on a worldwide scale. It seems thus appropriate to take this as a starting point for teaching of technology in comprehensive schools.

References

Bowden, J, & Marton, F. (2000). The University of Learning – Beyond quality and competence in higher education. Kogan Page Limited, 120 Pentonville Road, London N1 9JN
Cole, M. (1996). Cultural Psychlogy. – A once and future discipline. Cambridge, MA: The Belknap Press.
Gregory, R. (1997). Science through Play. In Levinson, R. & Thomas, J. (Ed.). Science Today – Problem or Crisis? Page 192. Routledge, London.
Husserl, E. (1970). The Crisis of European Sciences and Transcendental Phenomenology, Northwestern University Press Evanston.
Lemke, J. L. (1990). Talking Science: language, learning and values. Norwood, NJ: Ablex.
Ott, A. & Vedin, L-G. (2001). Interaction between Culture and technology in Informal Learning. Proceedings from the Conference "Lernort Deutsches Museum: Koncepte, Inhalte, Methoden von Lern- und Lehrerveranstaltungen im Kerschensteiner Kolleg, vom 22 – 25 Oktober 2000.
Ott, A. & Vedin, L-G. (2002a). World Wide Workshop – A Sociocultural Odysssé. Proceedings of the ETEN Conference "Technology Education in Schools and in Teacher Training" Munich 10-12 November 2000.
Ott, A. & Vedin, L-G. (2002b): Antiquity and Paradigmatic Changes in Science Education. Reflections on a Seminar in Athens. Department of Science Education, University of Göteborg. (In manuscript).
Sjoberg, S. (2001). Science and Technology in Education – current Challenges and possible Solutions. Paper presented at the meeting of European Ministers of Education and Research, Uppsala 1-3 March.
Piaget, J. (1973). The child´s conception of the world. Frogmore, St Albans: Ppaladin. (Originally published in 1926).

Vygotsky, L. s. (1986). Thought and language. Cambridge MA: MIT Press. (Original published in 1934).
Ziman, J. (2000). Technological Innovation as an Evolutionary Process. Cambridge University Press.

From Learning about the Past to Visions about the Future

The seminars have up to now been limited to be within the boundaries of Europe. They have also mainly aimed at studying the development of European science and technology. The development we have studied has been from Ancient to Modern times. It would however be of value to try to study the Future of Technological and Social Development. Therefore we found it necessary to make a visit to were the most modern science and technology might be found: America. And the place we choose to visit was Orlando in Florida. There we would be able to study social and technological projections into the future as they were exposed in Thematic Parks. This project was only done in an explorative way in order to explore possibilities for making a seminar with participants later on.

4. Orlando – Science, Technology, Design and Edutainment in Interaction.

Aadu Ott, Erik Ott and Lars-Göran Vedin
Department of Education, Göteborg University, Sweden
Paper presented at the ETEN Conference on Teacher Education in Grooningen 13-15 February 2003

Abstract

A study of possibilities for learning science and technology in interaction with entertainment in different thematic parks has been undertaken. The parks visited, in Orlando in Florida, were Sea World, Epcot Centre, Magic Kingdom and Kennedy Space Centre. The thematic contents in the parks were discerned according to four variables: *Fiction, Authenticity, Entertainment* and *Technology*. Learning options were discussed according to different didactical theories. It seemed obvious that the visitor's preconceptions were of importance for discernment of critical aspects of the content exposed. Indications may be found that our Western Society is moving from the ICT based "*Information Society"* towards a more visionary *"Dream Society",* based on stories, imaginations and emotions. A discussion is initiated about how the school system should respond to such a change. Such a societal change might emanate as a transition from a modernistic towards a post modernistic school structure.

Background

As a case study of science and technology in authentic environments, a visit was made to Orlando in Florida. Earlier parts of this project have included visits to Athens (Ott & Vedin, 2002) where the initiation of the Western Cultural Development and Western Science took place; to Munich, (Ott & Vedin, 2002a) where the Scientific and Technological Revolution in the 1700-century was well documented and possible to study at Deutsches Museum; to Paris (Ott & Vedin, 2000) where the political French Revolution, which was a prerequisite of Enlightment and modernism, took place in 1789 and to London (Ott & Vedin, 2002b), where the postmodern reaction to modernism was studied. These projects began in 1980, starting as a joint venture between the Göteborg University in Sweden and Deutsches Museum in Munich.

As Göteborg University is member of the European Teacher Education Network, it is fruitful to explore and utilize the unique and authentic sites in different countries of Europe, which might be used for the promotion of teaching and learning science and technology in teacher education.

During these visits the participants have focused their attention and studies on aspects and consequences of how science and technology, as a specific art of human culture, might have interacted with society in a sociohistorical way to create the starting point for what we call "the modern era".

We have, as an overarching theme, been looking for the roots to our own contemporary civilization in order to try to predict, in a tentative way, the future development of our society

in order to be able to adapt our teaching in science and technology to needs in an unknown future.

We felt, after having made visits to museums and historical sites, which enlightened the modernistic and historical past together with contemporary postmodernism, that a postmodernistic stage was lacking in this sequence of studies. What type of society might succeed the Information Society? Are we able, for instance, to detect traces of the predicted *"Dream Society"* as envisioned by Rolf Jensen (1999)? This is a society, which has left its materialistic roots and turned into the realms of emotions, stories and narratives. This might take part in a process in which the Information Society might be morphed into something which might be labelled Dream Society.

The first aim of this study was thus to change focus from historical issues to contemporary issues. This included reflection on what people, participating in the mass tourism movement, could possibly learn about Science, Technology or Design in interaction with contemporary societal development, when visiting a mega amusement or thematic park together with their families at the same time as they were surrounded by a large number of other people. It might be possible to coin a concept named "mega-learning" for this process. One question to be raised and reflected upon in this context is: Might mega-learning in a way be compared with some sort of intended indoctrination by some powerful actors?
Another aim of the study was to try to find out to what extent the potential availability of the highest and most advanced levels of technology which could be studied in the thematic parks could also be utilized in teaching and learning processes. We thus wanted to make, on the site, an exploration of possibilities to utilize the facilities at Kennedy Space Centre in "distance education".

This is a teaching mode where the coordinator may be situated in Göteborg and the students may participate in courses from their homes which may be situated all over Sweden. The item of study might for example be located at Kennedy Space Centre, far away in Florida. The concepts *"Net University*" and "virtual classroom" are widely discussed in this context and they imply promises as well as problems.

The aim of the study was also to explore to what extent visits to "virtual museum" sites might be possible to utilize in distance education by using computers and Internet. The visit to Kennedy Space Centre made it possible to make a comparison between the "real" Space Port and images of it as visualized on Internet. It is, for example, possible to roam around in a Space Shuttle in the "virtual cybernetic world" and even to zoom in on different items in the shuttle. At Kennedy Space Centre it was however possible to get onboard on a mock up model of a Space Shuttle in full scale. You will get a personal physical experience of this crowded environment instead of just viewing a picture of it.

The Belgian modern artist Renée Magritte has painted a picture of a pipe and written on the painting: "Ce n'est pas un pipe". A picture is not the same as reality. We are however in our postmodernist world encountering a lot of attempts to translate reality into images of it.

The French philosopher Baudrillard (1988) discussed the differences between simulation and reality and created the concept *hyper reality*. This denotes the stage where the simulated reality might appear as more real than reality itself. He also discusses the difference between the terms *dissimulation*, where we pretend not to have what we have and simulation, where we pretend to have what we do not have.

The Italian author Umberto Eco (1990) has been inspired by this analysis and has for example written an entertaining story about a visit to a Zoo in San Diego, the story is retold in Hargreaves (1999, p. 95). The inspiring name of the novel is “Travels in Hyper-reality”.

Some emerging questions to reflect upon and to discuss were thus: What is the main difference between a nearly authentic item of study and an image of it on Internet? What are the pros and cons of images on Internet? In what way should we complement our images of the Space Shuttle in cyberspace with some sort of educational aids? In what way may the interface between cyberspace and reality be transgressed without loosing the sense of authenticity in learning and teaching?

The empirical study – A descriptive and reflective approach

In order to fulfil the aim of studying our experiences of the interaction between Science, Technology, Design and Entertainment, in a hyper-reality, as mass tourism encounters it, we choose to visit Orlando in Florida. We describe in this part of the study our experiences and some reflections in order to be able to formulate some genuine questions, which might act as a starting point for a more extensive study.
In Florida, a great amount of different amusement parks have been created and the visitors amount to tens of millions every year. It thus seems appropriate to reflect on what they learn in a visit. Learning could be visualized as a change of mental states. But what might the content in the final state possibly be? We wanted to try to explore what we thought might fascinate JPF (just plain folks). Their participation in activities in the amusement parks might be regarded as true signs of a mega movement and maybe mega learning in a context which might be regarded as a sign of hyper reality with simulation as well as dissimulations included. One question, which we framed, was: What might be possible for the visitors to learn by participating in such a situated context and simultaneous exposition to all the different discourses in such a mega context?

The thematic parks

Jensen (1999, p. 69) makes comments about the philosophy behind the thematic parks from the point of view of the emerging theory about the dawning of concept about Dream Society. He argues that the Disney thematic parks are for the entire family and that the shared experiences strengthen family cohesion.
The question is however, from the point of view of learning, what the learning potential is of these shared experiences. Maybe it is enough to get just the emotional aspect of togetherness?

Walt Disney World

Walt Disney World consists of a number of theme parks such as Epcot Centre and Magic Kingdom, where **Epcot Centre,** Experimental Prototype Community of Tomorrow, is the park, which is striving to give an impression of being utterly scientific and technological. The park tries to render the visitor a vision of how modern technology might affect, in a positive way, human life and existence in the future.

Magic Kingdom on the other hand creates 100% experience of fantasy and imaginations and tries to communicate just different kinds of emotional experiences.

Epcot Centre might be regarded as appealing to the external material world while Magic Kingdom to a greater extent appeals to the inner spiritual world of emotions. Might it still be that they are complementary, and that one needs the other in order to be able to communicate some sort of subtle message?

Are the parks together able to transgress the boundaries between the spiritual – and material worlds in order to create a unified worldview? Is this a revisitation to a premodern religious worldview where the material- and the spiritual worlds were merged together and predicted the lifespan of people?

By appropriate good deeds in the material world you were in the middle-ages imagined to be able to reach the spiritual realm where God, the Almighty, reigned. This rendered people in these days a comforting meaning and counterpart to the hardness in their often very competitive everyday life. At the same time this religious worldview justified injustice and inequality in the material world as you will be compensated later on, after your death, in the spiritual world.

Epcot Centre

Almost 12 million people visit Epcot Centre every year: it is a very popular place to visit. Hargreaves (1998) notes at his visit to Epcot Centre that the creators of the park have created advanced simulations in hyper-reality. Robots look and act as humans, in some aspects they are, on a superficial level, even more perfect and human than human beings. In their way of communication, the robots communicate even ethical messages about history, nature and human relations. These are messages, which are implicit, subtle and seductive. These messages are thus not apparent or explicit and not open for discussions. You just do not start to argue with a robot.

A communicative robot has a fixed program to argue from. A robot lacks flexibility, which is the hallmark of a human being. You are thus asked to take part in some sort of a transmissive cultural event. This is not in a discussion club. You are enculturated into a special tradition and not asked to think for yourself and not to communicate in a dual way in which your own experiences may count.

A model for attempts to foresee the future is described by Bowden and Marton (2000, p. 6) by utilizing scenarios and variations and not just describing a unique and simpleminded way: *"The most important thing about learning…is to prepare students for handling situations in the future…These future situations are more or less unknown. The more rapidly the world changes, the less can be said about them…The instruments we have for preparing students for an increasingly unknown future is our current knowledge. We have to prepare them to the unknown, by means of the known and we have to work out how that can be done…We act and react to a situation as we see it and the way we see it decides how we act. The central point is …that the most important form of learning is that which enables us to see something in the world in a different way."*

The main question, when visiting Epcot Centre might thus be: What aspects do we discern, that Epcot communicates, about the future? What messages are communicated in an open or in a covert way?

Is this a subtle way of applying principles from the theory about *situated cognition* and *Legitimate Peripheral Participation* as described by Lave & Wenger (1994)? This means, in this case, that you are legitimized to participate in the activity by posting your photograph at the entrance. Then you start to move further in the direction of the centre of this technological Dream World where everything, which is based on the application of technology, seems to be possible. Or is this just the last wisp of the materialistic worldview, which seems to be fighting for its own survival before it might be overtaken by a more non-materialistic era?

The Russian author Fjodor Dostojevsky expressed another view when he wrote in one of his books "*Notations from the Cellar*": *"Beauty will save the world."* This quotation is thus in opposition to the tendency of Epcot Centre to preach the gospel that technology will save the world. A discussion emanating from this dualism in opinions about future development of our Western world might be fruitful when teaching "Technology and design" in our schools.

The participants in one of the activities in the majestic globe at the entrance to Epcot Centre take place in small cars, which are transported on rails through the globe. The interior of the globe is filled with attractions to be watched. These attractions describe, with the help of computer controlled showcases, how technology of communication has developed during the years from utilization of light signals in Antiquity to the normal mail and the 19th century Morse telegraphs and further on to today's cell phones, Internet and e-mail.

We encounter an example of the theory of transmission of knowledge or: *Learning by looking.*. This is in contrary to the Deweyan learning theory, which states how learning should occur, which is: *Learning by doing.* An interesting discussion may emanate from a time-dependent comparison between these different aspects on learning.

It seems that the designers of the shows which are presented, in general do have an idea of learning and communication, which is based on the container or transmission paradigm of learning. This means that they possess and apply an idea which is implying that sense impressions are transported directly to the brain as if information was contained in the form of small packages which were stored in words which themselves acted as containers. There are however also pictures and expositions which the visitor may interpret and reflect on. For cognitive process function there is a need for time for metacognitive reflection, as well as appropriate preconceptions by the visitors.

This way of learning is contrary to the neuro-physiological approach, which builds on interaction of interconnections between synapses in the mind of the learner. What you know beforehand decides what you may discern. Pieces of knowledge are not simply transported from the senses to the brain. Instead the brain makes a critical selection among sense impressions according to individual preconceptions and neural networks, which are allowed to interact in the process of constitution of the content of the cognitive mind and the neurophysiological brain. This matter is extensively discussed by the neurophysiologist Antonio Damasio (1999) and even by a Swedish author Arne Malthén (2002) in his novel about interaction between pedagogy and mind.

Another impressive showcase at Epcot Centre is the popular attraction *Test Track,* which describes how family vehicles are tested for safety. The participants are first introduced to some testing equipment. Finally the show ends up with a thrilling test drive experience: You are sitting in a small car and are transported together with ten other people through a very hot

room, an extremely cold room, and winding mountain roads and, of course, finally you make the exciting high speed test on a breathtaking racing course.

In this exhibit the visitors participate and experience how information is communicated to them through all of their senses and experienced with their whole body. This is contrary to the Cartesian heritage of splitting of mind and body. You cannot possibly remain unaffected by this experience and you might learn in some kind of deconstructed and reconstructed way in a nearly authentically case the benefits of using the safety belt in your car.

Is this an efficient way of teaching JPF important ways of behaving in a technological society, on a mega scale? This experience displays however the potential of giving important learning experiences to visitors in an amusement park. Even if these experiences may be based on some kind of a behaviouristic theory of learning then they are so realistic that they might act as valuable *secondary experiences*. It is far better to find out the need to use a safety belt in a non-realistic situation in an amusement park than in a realistic situation out in the traffic.

This exhibit thus shows how it is possible to design an efficient teaching environment on a mega scale even if people are processed through this attraction in the same way as material commodities are processed, as in a processing factory. In this case the concept hyper-reality might prove fruitful to utilize.

In another attraction, *The Universe of Energy*, visitors will meet the young and attractive pop star Ellen, who is competing in the quiz game of Jeopardy. Unfortunately she does not know much about energy resources so she gets an impressive energy lesson which obviously is inspired by the Flintstone effect. This means, that a popular TV show teaches, that people and dinosaurs lived and interacted during the same geological epoch.
You have the opportunity to attend and listen to this fabulously staged energy lesson, where no money is saved in the staging of the show. During this lesson you may learn about utilization of different kinds of energy resources. These aspects on utilization of energy are presented by the sponsor of the show - a Big Oil Company.

In this case it is however important to ask yourself a question about who has designed the content of the show. Whose perspectives on energy sources and energy consumptions is it that the big oil company tries to mediate to you? In what way are you able to express a critical view or think for yourself? Here we encounter a typical need to have relevant scientific preconceptions about what energy is and also about the consequences for life in the future world which is characterized by an increasing consumption of fossil fuels.

In no way was for example, in this enormously impressive show, is the problematic issue of global heating mentioned. We were stunned by the mega design of this gigantic show, where even Albert Einstein finally had to yield to the superficial knowledge about energy, which a pop star possessed after a short lesson.

This is a typical example of a *quick fix*, and not applicable to a real learning situation where understanding is composed of and constructed in the form of a conceptual network of interconnected synapses. This construction takes long time. The Roman author Cicero has remarked: *"The roots of knowledge are bitter but its fruits are tasty"*.

In this context hyper-reality seems to be used in a propagandistic way where controversial messages are hidden and implicit, and not made open to discussion or evaluation. You are by

this impressive show, in a way enculturated into the traditional way of regarding energy sources as infinite and inexhaustible and you are not inspired to think for yourself in a critical Socratic way of examining ones own values and ways of thinking. A superficial view on energy is communicated to you. Appearance is substituted for substance, just as postmodernism describes: *"Il n´y as pas autour le texte."*

The American philosopher Martha Nussbaum (1997) discusses question about learning. She proposed a valuable way to regard knowing, knowledge and enculturation and emphasizes the need to examine oneself and one's own traditions and values critically.

Nussbaum also created the concept *"narrative imagination",* meaning the ability to think what it might be like to be in the shoes of another person. Nussbaum comments, ibid, also on learning to act as above, by applying the ideas from *"liberal education"*. This is an education which strives at the activation of each student's independent mind and urges them to think critically for themselves.

It does not seem that the creators of Epcot Centre have studied the philosophy of "Liberal Education". In this super-materialistic world there is a continuous fight between companies about getting market shares and publicity for their own products.
It seems thus however important that the innocent consumers in some way may be inoculated against this massive commercial force. The vaccine against this disease of our time is knowledge, insight and education. The Roman author Horatio expressed this with the words: *"Sapere Aude."* Trust your own wisdom. Wisdom is however not just a gift but is the result of a lifelong critical search for truth.

Magic Kingdom

Magic Kingdom is the centre of Disney World. You cannot find anything problematic or controversial here that might bother the minds of the visitors the least. This is a place for dreams. A place where your dreams may come true, in the friendly company of the funny and fictitious figures called Mickey Mouse and Donald Duck. Everything is nice and clean and only the positive parts of an imaginative world are exposed. Suddenly all your worries about problems in the real world elapse. The visitors get an impression of living in the best of worlds. A world as already imagined and described by the French Enlightenment philosopher Voltaire in the 18-th century in his famous, but highly ironic novel *Candide.* This theme park indicates that the predicted visions about a coming Dream Society might already have been materialized.

Certainly the visitors will enjoy the magnificently designed nostalgic and artificial small town, which is the middle of Magic Kingdom. But why should people not be given a nostalgic sanctuary, of a pastime which never existed, to retreat to when world problems lift up their ugly face everywhere and terrorism and war are imminent threats?

Hargreaves (1999, p. 288) pointed out that nostalgic means the abdication of memory. Once Henry Ford expressed his view on history and said: *"History is bunk!"* The ahistorical and timeless appearances in Magic Kingdom are really worth to be discussed from different aspects.

All over Orlando visitors encounter large advertisements, which are posted by the Disney Corporation: *Let me show you the world!* The question remains however: In what state of

mind will people find themselves when getting the impression that Disney's presentation of the company's view of the world describes the real world? Fiction might really take overhand over reality.

The French philosopher Baudrillard (1988) expresses this paradigmatic change of worldview with the concept *simulacra: fiction and imagination about the world are substituted for the real world – fiction becomes even more real than the real world the real world is*. Magic Kingdom might perhaps be regarded as the outmost incarnation of the Designed World.

Sea World

If you want to get a marine wild life experience outside the Disney area, you can go to Sea World. This is another aspect of Disney's superficial and simpleminded worldview.

Instead of fictitious ducks and comical mice you imagine that you encounter "the real thing". But how real is it? All the animals are kept in captivity and their only reason for life is their duty to entertain the people who visit the park. The animals are as far away from reality as Donald Duck and Mickey Mouse. Maybe even more far away as Donald as well as Mickey behaves in the "natural" way as prescribed by Disney Corporation.
What we regard as natural behaviour is just simulations in a designed world. The animals have, in the shows, properties that they do not possess in the real world. This is a world, which is tamed and possible to be manipulated according to for example ideas about our presumed preconceptions about the existence of ecology and harmony between wild animals in the wilderness.

Whatever visitors may learn here has nothing to do with nature or natural life of wild animals in freedom. This experience might also be regarded as an example of dissimulation where some natural habits of the wild animals are neglected or manipulated to be missing. These are habits, which are not regarded as fit for the nice and friendly behaviour, which the animals should pertain in an amusement part.

Kennedy Space Center

Jensen (1999, p. 44) reflects on and comments at the activities at Kennedy Space Centre and writes:
"The American space administration's official vision is as follows:
"NASA is an investment in America's future. As explorers and pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on earth."
"This is remarkably reminiscent of the famous vision which is introduced at the beginning of every episode of Star Trek. It demonstrates NASA's real product: Adventure."

You will however be able to get a more authentic and scientific experience at Kennedy Space Centre than in any of the Disney theme parks. Kennedy Space Centre is the facility where technicians maintain, prepare and launch Space Shuttles. This is also the place from which they used to launch the Apollo moon rockets.

Visitors are able to watch remains of authentic rockets and spaceships, which have actually been out in space and also some full-scale mock-up copies. Visitors will also be able to take part in fascinating demonstrations of artifacts from the tale about the history of the *"conquest*

of Space". Spectacular and exciting Imax movies are shown about the brave astronauts and the first landing on the moon.

These presentations aim at creating a heroic narrative about the conquest of Space. Those who have studied even a small amount of astronomy may however relate the small jumps out of the earth's atmosphere, to the vastness of Space. Man is, according to physical laws, bound to her blue planet and the "close environment" of the solar system. All of the rhetoric about conquering space is just a modern fairy tale and in a way not too different from the fairy tales which are told in Magic Kingdom.

The tales in Kennedy Space Centre are however emanating from a different era and aimed to affect a different target group. But when the Space Saga is told with the aid of modern media, this fairytale might seem real for many people. We encounter anew a simulation in the way Baudrillard has explained – the tale about the conquest of space is a simulation and adds facts to the story that it does not possess.

In the same way as in the other parks, this is in a more subtle way also a designed world aimed at creating illusions, dreams and imaginations. The difference is that, on the surface, this site does not pretend to be anything other than what its hardware seems to stand for. The likeness is the software, the narratives.

This site is thus, in a way, an exponent of a real world, even if it is a highly designed place. Even here dreams are made to come true, dreams about the conquest of Space, surpassing a last frontier, in the same way as cowboys once conquered the West. The Dream Society is revisited here.

Even the association of the site to the fabulous Kennedy family has something nostalgic and dreamlike over it. The heroes at Kennedy Space Centre are the people who are made of "the right stuff". A saga or narrative is in the making about these heroes who even sacrificed their lives for a holy cause, which is greater than man himself. This is masterfully expressed by the famous sentence: *"A small step for man – a great leap for mankind."*

It is however difficult to remain emotionally untouched by a visit to Kennedy Space Centre – but even here it is important to retain a detached view and to try to widen the individual personal horizon, to look for subtle messages and to try to regard the site from as many different critical aspects as possible, as for example: the American, the Global, the Environmental, the Military, the Utilitarian.

First when we are able to apply all of these perspectives at the same time, we might be able to get a more general and unifying picture of the site. This parallels how knowledge about the world, as encountered in the school, is subdivided into different subjects. Only a combination of all of these views and a transgressing of the often artificial borders between the subjects, may create a more comprehensive picture about the world. Then maybe the superficial enchantment at KSC might disappear and we might be able to get a look behind the curtain and get a glimpse of "the real thing". Which, in itself, is very impressive?

The famous Nobel laureate in quantum physics, Richard Feynman said, when commenting the earlier occurring Challenger fatality: *"Nature does not care about public relations."* When all public relation and advertising stuff is abolished we meet at Kennedy Space Centre human beings, who with the help of genuine knowledge in Science and Technology try to design

spacecrafts which have to endure in the hardest of environments. This is the real challenge and the real stuff.

Comparative theoretical approaches

It might be fruitful to try to interpret the visits and the learning processes of the visitors in the thematic parks as different aspects on the creation of science according to different paradigms as proposed by Kuhn (1962 and 1992). Kuhn points out how concepts in science have emanated from interaction with sociology of science. Scientific concepts emanate according to Kuhn from negotiations and discussions between scientists.

In what way does a family group discuss and negotiate about their experiences in the parks? They certainly are not just looking in a mindless way. Are they able to create some kind of fruitful science-like concepts or are they just looking at the different expositions in a fully non-scientific way? In what way may they be able to surpass the critical border or interface between everyday concepts and scientific concepts?

In what way may they be able to cross the critical interface between the limbic system in the brain which reacts on emotions and neocortex were cognitive functions preside. In what way are they able to use the frontal lobe of their brain, where functions for evaluation resides?

An interesting starting point in this discussion is to think in terms of narratives. According to the French philosopher Jean-Françoise Lyotard the age of the great narratives has come to an end. Lyotard writes about the science museum "Cité des Sciences et de l'Industrie" in Paris as described by Caro (1996) were it is told that we live in a post modern world characterized by fragmentation and lack of collective pictures. Meaning is created by and for the person himself. Different people get different answers from the same material.

One interpretation of the visitor's experiences in a thematic park is thus that they all get different answers and a fragmented personal meaning. People may however strive to get a unifying collective grand narrative. Do the narratives, told by Disney, take up the empty place for the lack of other liberating stories when belief in the Christian and Jewish biblical stories is declining?

A visual model

When making a comparative study of visits to the four different sites in Orlando, a theoretical model for comparison appears. In this model the sites are discerned as characterized according to four critical aspects: ***Authenticity, Fiction, Technology*** and ***Entertainment.***

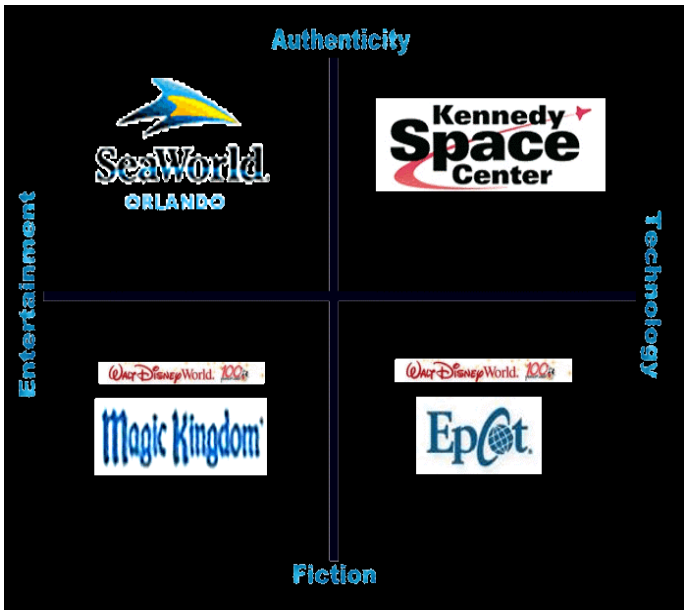
Technology is of course to be found in every site. Maybe technology is even more utilized in Magic Kingdom than in Kennedy Space Centre, but in this case technology is concealed and not exposed as a leading theme. Technology just serves as a mean and not as target for the presentations.

Merton (1957) has discussed the connection between target and mean or means to meet an end. A change from target to mean may occur when we become so fascinated by the means we utilize in order to reach our target that these means finally take the place of the target. This leads to the consequence that the original targets might be forgotten. The main aims of Magic

Kingdom are however within the realms of fiction and entertainment, even if the means are technological.

The model which compares the different theme parks may be visualized as constructed of two intersecting axis. One, from North to South, is on its upper northern end marked "**Authenticity"** and is on its lower Southern end marked **"Fiction".** The horizontal intersecting axis is on its Western or left end marked "**Entertainment"** and on its right, or Eastern, endpoint marked "**Technology".** Thus the plane is subdivided into four squares. The four visited sites may thus be regarded as situated within these squares. Each of the sites is characterized by two of the critical aspects:

Northeast or "Authenticity and Technology": Kennedy Space Centre
Northwest or "Authenticity and Entertainment": Sea World
Southeast or "Fiction and Technology": Epcot Centre
Southwest or "Fiction and Entertainment": Magic Kingdom



Narratives

From the point of view of narratives, ***Sea World*** tries to live up to authenticity as well as entertainment. Its aim seems to be to mediate a picture of the natural world as independent of man. This aim is of course not possible to fulfil when the grandiose shows are presented where for example killer-whales perform together with their trainers. Target and means have changed place.

When walking around in the park you encounter lots of animals in an artificial environment, which is made to look as natural. A critical way of looking at the exhibits mediates a picture of nature as being there for the sake of entertaining man in a non-problematic way. When leaving the park it might be easy to carry with you an impression of a non-problematic natural world.

At least we did not find any trace of Darwinian evolutionary aspects. Maybe this is natural as there is a heated debate still going on in the US between proponents for creationism and proponents for the theory of evolution. By avoiding this debate, which is the key factor in biology, an amusement park may appeal to both sides. But at the same time it tries to avoid

the very fundamental issue about the emergence of life. It seems obvious that a visitor might learn that there are no controversies in biology. From a metaphysical point of view it is the real world, which is exposed and the ontological aspect yields stuff from our own world.

Magic Kingdom on the other hand does not even try to live up to any authenticity. People visiting the park get the impression of a happy co-existence between man and the fantasy animals in a surrounding with no problems here either. The metaphysical aspect of the park presents itself as different from the natural world and the ontological aspects turn out to be fantasy figures
.
The preconceptions of earlier encounters with Walt Disney's world are certainly strengthened and the gospel of Disney is everywhere and seducing and immersing you. We learn that we live in a fairy world where everything is possible and where everybody, almost, is nice and kind. In a way this is an American Dream come true and an example of the subtle and covert epistemology of the park.

The narrative of ***Epcot Centre*** is even more subtle. But at the same time this is a site, which also expresses the American Dream of a future, which is filled with sophisticated gadgets and ruled by high technology. The gospel of Epcot is that science and technology have no limits. Engineers in big companies will create the best of worlds for you. Just trust them and everything will remain good.

Even the energy resources seem to be unlimited in this version of the American Dream. A new word: *"Brightmare"* might however be applicable to this projection of trends into the future. The metaphysical aspect implies a technological world view based on Contemporary natural laws. The ontological stuff is high technology.

There is however a question about power. The French philosopher Michael Foucault has changed an old and well-known quotation from the medieval philosopher Francis Bacon to: *Power is knowledge*. In Epcot Centre this seems to be true. Epistemology as well as the relations between teacher and learner is affected by this way of regarding power.
Some question to be raised, are of course: What is the other side of the coin? What other aspects should be taken into account when evaluating the picture of the future as it is visualized and expressed at Epcot? Is it certain that the visitors get a widened perspective on the future development of society when visiting Epcot? Or do they just be indoctrinated into one and only one possible way for future development of our society? And in this case: Who is dictating this orthodox canon?

The narrative told by ***Kennedy Space Centre*** is also a part of the American Dream. The site expresses the conquering of Space through sacrifice and hard work. America is showing its flag in Space. From the metaphysical point of view it seems that there is a mixture of natural science with fantasy.

The ontology at KSC emanates from knowledge about contemporary science and technology. All four sites express different views about the American Dream of trying to dominate the following different dimensions of the world:
 # The natural world at Sea World;
 # The inner subjective world of imaginations at Magic Kingdom;
 # The World of Science and Technology at Epcot Centre;
 # The last frontiers at Kennedy Space Centre.

This implies that there is always an aspect of power and indoctrination involved.

Theoretical aspects on learning

One aspect, which characterized man, is his predisposition for learning, adaptation to an environment and the construction of individual meaning. Fürth (1969) expresses this as an interaction between *knower and known*. He claims that knowledge is neither in the subject nor in the object but is constituted in between them.

When walking around in a thematic park, the obvious question to ask might be: What do we learn? What knowledge do we constitute? Sfard (1998) asks if we do learn by *acquisition of information* or by *participation in an activity*. When looking at the theme parks, from an individual constructivists view, it might be obvious that, when visiting Sea World we are mostly there as spectators. There is no real interaction between the visitor and the animals.

When visiting Magic Kingdom you might visit for example the parts named Future Land or the Old West – you may thereby get the impression that this is for real. We encounter a fictitious world, which by the act of technology, appears more real than the natural world. Then the crucial boundary between reality and fiction might however be hard to figure out.

When visiting Epcot Centre it is however not certain that you really might encounter anything that might astonish you, if you have been around in the world. In some way you have a sense of a "deja vu". In a way the things exposed might be labelled "more and more of the same". You encounter, to a certain extent, just an uncritical traditional extrapolation of trends in our contemporary time.

The experiences gained in Epcot show us mostly how things are, but not how they could eventually be. A Western and American worldview is exposed – but America is not the whole world except maybe in its own imagination. There are signs showing that the resources in the world are scarce and thus do not permit such an affluence or future development which is exposed at Epcot Centre.

Maybe other scenarios for the future would be necessary in order to initiate an unbiased discussion. There is however few signs of anything like this at Epcot Centre. All innovations start with a dream, are fulfilled with technology and are nor there for discussion.

When visiting Kennedy Space Centre you enter however into a more realistic world. The rockets are truly gigantic and the mock-ups of space vehicles are impressive and it is rewarding to encounter the real thing.

The participation metaphor (Sfard, 1996) might also be appropriate to discuss in this context. The visitors are participating in an activity and learning is taking place in that process (Lave & Wenger, 1991) and Kvale (1992). Kvale uses, in order to point out the differences between learning theories, the metaphor of changing from the archeology of mind (Piagetian constructivism) to the architecture of a socio-cultural landscape (the socio-cultural approach to learning).

In **Sea World** eventual learning might occur when the visitors are watching the shows. This does however not include much communication between visitors or between visitors and artifacts.

In **Magic Kingdom** you get some feeling of being a part of the story. The perfectly created surroundings of copies of an authentic small town with Main Street and Main Square render an impressive impression of authenticity.

In **Kennedy Space Center** you get some feeling of participation as you move around on the original site and watch the Space Story of our own time enfold before your eyes. You may encounter real astronauts and stand in meditation in front of a memorial which is erected in memory of those young and brave men and women who gave their lives in the conquest of Space and, as the tale says, for the benefit of mankind. You may learn that you are not only part of your own family but also part of mankind's brave struggle in the conquest of Space.

At **Epcot Centre** it is possible to participate in different activities or at least to feel as if you participated in them. You may visit restaurants and other exotic places which surround the lake in the middle of Epcot Centre and are expected to render the place an international flair and which might give you some cultural snippets from different countries.

In this process you might however get some sort of fragmented and unconnected impressions from different parts of the world. As there is no historical or social background given to these experiences then all of this seems exotic and strange, as these presentations are isolated from their cultural and historical context.

If you are not having any real knowledge about authentic places abroad then these intended image at Epcot Centre might serve as a substitution for reality and in a way be fairly like the imaginative world which is displayed at Magic Kingdom. You might feel that America is the only really sensible part of the world to live in.

To regard and to internalize the picture of the world in the Disney way might render a smoothening feeling, but at the same time it might create a wish to live in isolation from the real and problematic world, which you really do not understand. ***The world is not in the parks – the parks are in the world.***

Conclusions

The issue of mega-learning in mega parks has been studied. We are of course aware of the fact that what we really studied were our own experiences of what the parks might offer. It would therefore be of value if a more detailed study could be undertaken involving questionnaires and interviews with visitors.

We found that mass tourism in amusement parks offers the visitor's hidden messages, which should be carefully analyzed. It is therefore important to analyse the visit from different perspectives.

We learn all the time, but the question is what we really learn. A designed world appears to us – this world might however even be difficult to discern from the real world.

Maybe a visit to the theme parks might show how values, signifying a new society slowly are emerging into our contemporary society. There might be a new set of emerging values, which are not based on just information and data processing. These emerging values may instead be based on emotions, dreams and stories.

The question still remains how we, in the educational community, should respond to this challenge and maybe be able to actively participate in this process of changing values. The declining interest of students in the industrialized world to study science and technology might be a sign of warning. Is this just a sign of the emergence of a post-modernistic Dream Society, which in a fundamental way challenges our traditional values? We might be on the edge of the start of a new era. This might even be an era into which our students already have entered, unknowing to us. Quo Vadis?

Maybe we could unveil a little of the future world by learning from the works done by artists and authors, instead of only from peers in science and technology? A well known quotation from Einstein is that he stressed that imagination is more important than knowledge. Einstein meant of course imagination based on knowledge.

Acknowledgement

We want to thank Henrik Ott for his careful reading of the manuscript and his valuable comments.

References

Baudrillard, J. (1988): America. Verso Press, London & New York.
Bowden, J, & Marton, F. (2000). The University of Learning – Beyond quality and competence in higher education. Kogan Page Limited, 120 Pentonville Road, London
Bunge, M. (1977): States and events. In Harnett, W. E. (ed): Systems: Approaches, Theories, Applications, Boston: Reidel
Caro, P. (1996): Informal Education through Science Museums. Paper presented at the 8th IOSTE symposium, August 17-22, Edmonton, Alberta, Canada. (Vol. 3, p. 42-48).
Damasio, S. (1999): Cartesius misstag. Natur och Kultur. Stockholm.
Eco, U. (1990): Travels in hyperreality. Harcourt Brace Jovanovic, San Diego.
Furth, H. (1969): Piaget and Knowledge, Theoretical Foundations. London: Prentice-Hall.
Hargreaves, A. (1998): Läraren I det postmoderna samhället. Studentlitteratur, Lund. Original: Changing Teachers, Changing Times: Teachers´Work and Cukture in the Postmodern Age. Ontario Inst. For Studies in Education, Toronto, Ontario, 1994.
Jensen, R. (1999): The Dream Society – How the coming shift from information to imagination will transform your business. McGraw – Hill, New York.
Kvale, S. (Ed.) (1992). From Archaeology of Mind to Architecture of a Socio-cultural Landscape. In Kvale s. (Ed.): Psychology and Postmodernism. London: Sage Publications.
Kuhn, T. S. (1962,1970). The Structure of Scientific Revolutions. Chicago: The University of Chicago Press.
Kuhn, T. S. ((1992). The Trouble with Historical Philosophy of Science. (Robert and Maurine Rotschield Distinguished Lecture) Cambridge, Ma.: Harvard University Department of the History of Science.
Lave, J. & Wenger, E. (1991). Situated Learning: Legitimate peripheral participation. New York: Cambridge University Press.
Maltén, A. (2002): Hjärnan och pedagogiken – ett samspel. Studentlitteratur, Lund.
Nussbaum, M.(1997): Cultivating Humanity. Harvard University Press, Cambridge, Massachusetts.
Merton, R. K. (1957): Social theory and social structure. The Free Press, New York.

Ott, A. & Vedin, L-G. (2001). Interaction between Culture and technology in Informal Learning. Proceedings from the Conference “Lernort Deutsches Museum: Koncepte, Inhalte, Methoden von Lern- und Lehrerveranstaltungen im Kerschensteiner Kolleg, vom 22 – 25 Oktober 2000.
Ott, A. & Vedin, L-G. (2002a). World Wide Workshop – A Socio-cultural Odyssey. Proceedings of the ETEN Conference “Technology Education in Schools and in Teacher Training” Munich 10-12 November 2000.
Ott, A. Ott, E. & Vedin, L-G. (2002b): From Antiquity to Affluence. Paper to be presented at the annual ETEN conference, 8TH to 9th February, 2002 at the University of Greenwich, London.
Ott, A. (2002c): A Conceptual Matrix for Science Education. Journal of Baltic Science Education No 1, 2002, p. 7-14.
Sfard, A. (1998): On Two metaphors for Learning and the Dangers of Choosing Just One. Educational Researcher, 27(2), 4-13.
Wertsch, J. V. (1991): Voices of the Mind: A Socio-cultural Approach to Mediated Action. Cambridge, Mass. Harvard University Press.

5. Technology Education on the European Theatre, utilizing Museums and Science Centres.

Lars-Göran Vedin, Department of Education, University of Göteborg
Paper presented at the ETEN conference 12 – 14 February 2004 on "Mobility in Teacher Education – What are the challenges?" in the subgroup for "Technology Teaching and Learning" in Viano do Castelo, Portugal.

Abstract

As a part of teaching "Design and Technology" an extensive activity of the project World Wide Workshop, has focused on possibilities to utilize museums and science centres in mainly Europe. Seminars with teachers, teacher trainers and students have been held in Munich, London, Paris, Athens and Rome with the aim to communicate highlights in science and technology. The study stresses the value of mobility in teacher education in technology education as this makes it possible to utilize the unequal and authentic sources for learning which are located at the museums in different countries.

Background

As a case study and as follow-up of studies of science and technology in authentic settings or environments, a visit was made to Orlando in Florida. Earlier parts of this project have includes visits to Athens (Ott & Vedin, 2002) were the start of the Western Cultural Development and Western Science once was initiated; to Munich, (Ott & Vedin, 2002a) were the Scientific - and Technological Revolution in the 1700-century was well documented and possible to study at Deutsches Museum; to Paris (Ott & Vedin, 2000) were the political French Revolution, which was a prerequisite of Enlightment and modernism, took place in 1789 and to London (Ott & Vedin, 2002b), were the post-modern reaction to modernism was studied and the era of post modernity also to some extend might be studied.

These projects have been going on since 1980, starting as a joint venture between the University of Göteborg in Sweden and Deutsches Museum in Munich. The projects have resulted in almost 100 weeklong seminars (spring 2007) with teacher trainers, teachers and teacher students from all over Sweden as the main group of participants.

These seminars have utilized visits to different European museums including for example:
In Munich: Deutsches Museum, Siemens Museum, Alte Pinakoteke, Neue Pinakoteke, Pinakoteke der Moderne, Schloss Nymphemburg Science Museum and Dachau Memorial Camp;
In Paris: Cité des Sciences et de l'Industrie (La Villette), Palais de la Decouverte, Museé Carnavalet, Conservatoire des Artes et Metieres and Le Louvre;
In London: Science Museum, Imperial War Museum, British Museum, London Museum, London Transport Museum and the Maritime Museums in Greenwich;
In Athens: Acropolis, National Archaeological Museum and War Museum and in the port of Athens, Piraeus: the Naval History Museum.

In all the cities authentic historical sites, as for example Place de la Bastille in Paris, have also been visited together with visits to different classical art galleries.

During these visits the participants have, in the different museums, focused their attentions and studies on aspects and consequences of how science and technology, as a specific art of human culture, may have interacted with society in a sociohistorical way and thus created the starting point for what we call *"the modern era"*. We have been looking for the roots to our own contemporary time in order to be able to predict in a tentative way the future development in order to adapt our teaching to an unknown future time.

Discussion

The question is of course why we are undertaking the task of utilizing the options, which the European theatre offers as a challenge for learning and teaching of technology.
There are many answers to that question:

1. Sequential context

In a small country as Sweden we do not have possibilities for exposition of artefacts in the same way as in large countries in Europe. The Technical Museum in Stockholm is an ancestor to Deutsches Museum in Munich. The founder of that museum, Thorsten Althin was a friend of Oscar von Miller, who is the founding father of Deutsches Museum, but there is a difference in size and content, which motivates journeys to Munich for the presumptive guides in Technical Museum in Stockholm who wants to learn terms of the trade.

After the international sojourn, it is of course very good to use the national museum. The international outlook provides the metalevel which is necessary for interpreting the distributed cognition, inherent in the objects exposed. This metaknowledge of missing links makes it also possible to put the artifacts exposed into a logical and sequential historical context, which is of importance for understanding of the problems the inventors once faced. This metaunderstanding provides the glue, which makes it possible for a teacher to provide her students with a conclusive narrative.

2. Original artefacts

In a small country there has of course not occurred so much of development in technology as in a larger country. In an international museum, lots of original, well known and famous artifacts are displayed as for example the Magdeburgian half-spheres.
In Malmö Technical Museum in Sweden, a display is made in the form of a diorama showing how Otto Guericke made his demonstration and this expo is a good exposition, but the real thing is of course more impressive. The real thing has some flavour of undefinable metaphysical authenticity, which a reconstruction, how well it even may be done, lacks.

3. Size of artifacts

Many of the most interesting authentic artefacts are very large. This means that only a few museums in the world are able to expose full-scale original aeroplanes, rockets and automobiles. It is thus very rewarding to visit a museum, which exposes full scale items. Specially imposing is it when for example a full-sized Newcomen "Dampf-maschine" is made to run, as in Deutsches Museum. Even more impressive is of course the full scale Saturn

rocket, which is exposed in Kennedy Space Centre in Florida – it is first when watching the real thing that the huge size of the objects and the tremendous effort invested in the space project will be apparent.

4. Cultural aspect

When going to cities in Europe we do naturally not only dwell in museums or science centres. When visiting the cities a lot of technological culture is exposed. For example in Athens we visit the Archeological Museum and look at the Anti - Kythera Mechanism, which is exposed there. This is an early analogous computer from the time around the birth of Christ. Pictures and drawing just do not make justice to the three dimensional object.

But it is just as interesting to walk up to Acropolis and regard the Parthenon temple and contemplate the culture, which for more than two millennia ago was able to create this wonder.

Thoughts are going in the direction of the persons involved in the project both from the political perspective, for example the Athenian statesman Perikles and the artist Phaidon. Reflections are of course also going to the time and political situation, which was the context in which this masterpiece was erected.

This means that a visit to an authentic place inspires to a contemplation of the whole historical and social context. Parthenon is of course a fantastic creation of technology and art. But at the same time it constitutes a starting point for an analyze of the time and situation in which it was created.

This is the metalevel of knowledge, which is very important for a teacher to apprehend. The question is not what we look at, but what we see, and we do not only see with our eyes, but with our preconceptions.

Especially for teachers it is important to try to widen the associative sphere in which human conceptions are folded. In the same way, we feel awe and wonder when visiting the ancient sacred place, Delphi.

During antiquity this place was as famous as Athens. After the Roman conquest of Greece, and the introduction of Christianity into the Roman Empire, this place was, by the order of the Emperor, deserted. This desertion led finally to the result that the place totally disappeared. First in the 20th century it was rediscovered.

This aspect of emergence and disappearing of a famous and scared place gives reasons to reflect over the time dependence and durability even of our own civilization.
In this case it is also interesting to reflect over the famous novel written by Oswald Spengeler: *"Die Untergang des Abendlandes*", in which the author shows how different civilizations have emerged, culminated and disappeared. Maybe we should also reflect over this possible fate for our own civilization?

When visiting the Hellenic Science Centre in Athens, we are struck by how the cultural aspect is emphasized there. This science centre does expose different artifacts in another way than to which we are accustomed in the Nordic countries. This might also render to a regarding of cultural diversity, even in science centres.

5. Historic aspect

Every country has in a way a unique cultural flare of vision and history, which is manifested in a subtle way in the exposures of their culture in the different museums.

In Deutsches Museum a vision of German superiority in technology might be visualized.

In Paris, something is in the air of the heritage from the French Revolution.

In London one might find something about the emergence and fall of the British Empire. Lots of monuments are erected in London, to show how the Britain's, during the Victorian era, conquered great parts of the world. There is a subtle feeling of a great past, which dominated during the time of the rule of Queen Victoria when "Britannia ruled the Waves".

In Imperial War Museum remains from the last great wars are exposed. Technological applications into weaponry led to superiority in power, which made it possible for a small nation to play a dominating part in the history of the world during a short époque. This feeling of authenticity is of course impossible to reach without travelling to the museum.

6. The Future

During these visits the participants have, in the different museums, focused their attentions and studies on aspects and consequences of how science and technology, as a specific art of human culture, may have interacted with society in a sociohistorical way and thus created the starting point for what we call "the modern era".
We have been looking for the roots to our own contemporary time in order to be able to predict in a tentative way the future development of our society. We need to be able to adapt our teaching of science and technology to an unknown future time span.

We felt, after having made visits to museums and historical sites, which enlightened the modernistic and historical past together with contemporary postmodernism that a post-post modernistic stage was lacking in this sequence of studies.

What type of society might succeed the Information Society? Are we able, for instance, to detect traces of the predicted Dream Society as envisioned by Rolf Jensen (1999)? This is a society, which has left its materialistic roots and turned into the realms of emotions, stories and narratives.

The American female philosopher Martha Nussbaum (1997) discusses the question about learning and proposes an interesting way to regard knowledge:

"Three capacities above all, are essential for the cultivation of humanity in today's world. First is the capacity for critical examination of oneself and one's traditions – for living what, following Socrates, we may call "examined life".

This means a life that accepts no belief as authoritarian simply because it has been handed down by tradition or become familiar through habit, a life that questions all belief and accepts only these that survive reason's demand for consistency and for justification.

Citizen, who cultivate their humanity, need further, an ability to see themselves not simply as citizen of some local region or group, but also as human beings bound to all other human beings by ties of recognition and concern. The world around us is inescapably international.

But citizen cannot think well on the basis of factual knowledge alone.

The third ability of the citizen can be called *"narrative imagination"*. This means the ability to imagine, what it might be like to be in the shoes of a person different from oneself."
"Liberal education in our colleges and universities is, and should be, Socratic, committed to the activation of each student's independent mind and to the production of a community that can genuinely reason together about a problem, not simply trade claims and counterclaims."

Nussbaum points out that conservative forces in our societies are in favour that:
" .. An education that promotes ***acculturation*** *to the time-honoured tradition of "Western Civilization" is being defended against the more Socratic education that insists on teaching students to think for themselves."…*

We encountered those forces when visiting the Theme parks in Orlando.

7. Fiction

Our most extreme travel brought us to Orlando in Florida. We just wanted to see for ourselves what might be studied in the big theme parks which are visited by millions of Americans. All over Orlando we meet Disney's advertisement: *Let me show you the world!* The question remains however: "*In what state of mind will people find themselves when getting the impression that Disney's world is the real world?"*

Fiction might take overhand over reality. Baudrillard (1988) expresses this paradigmatic change with the concept simulacra: fiction and imagination about the real world is substituted for the real world – fiction becomes more real than the real world.

We visited also Kennedy Space Centre. Jensen (1999, p. 44) reflects on the activities there and writes:

"The American space administration's official vision is as follows: "NASA is an investment in America's future. As explorers and pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on earth."

This is remarkably reminiscent of the famous vision that is introduced at the beginning of every episode of Star Trek. It demonstrates NASA's real product: "Adventure." We found that now, when the flight costs are descending, it could be motivated even to make transatlantic journeys to reach authentic and challenging environments for learning as discussed by Ott, A., Ott, E. & Vedin L-G. (2003a, 2003b).

Concluding remarks

We find, in an empirical way that it is highly rewarding to try to visit authentic sites and museums as a part of teacher education. The challenges and problems to be overcome might mostly be in the economical sphere.

References

Baudrillard, J. (1988): America. Verso Press, London & New York.
Bowden, J, & Marton, F. (2000). The University of Learning – Beyond quality and competence in higher education. Kogan Page Limited, 120 Pentonville Road, London N1 9JN
Caro, P. (1996): Informal Education through Science Museums. Paper presented at the 8th IOSTE symposium, August 17-22, Edmonton, Alberta, Canada. (Vol. 3, p. 42-48).
Eco, U. (1990): Travels in hyperreality. Harcourt Brace Jovanovic, San Diego.
Nussbaum, M.(1997): Cultivating Humanity. Harvard University Press, Cambridge, Massachusetts.
Ott, A. & Vedin, L-G. (2001). Interaction between Culture and technology in Informal Learning. Proceedings from the Conference "Lernort Deutsches Museum: Koncepte, Inhalte, Methoden von Lern- und Lehrerveranstaltungen im Kerschensteiner Kolleg, vom 22 – 25 Oktober 2000.
Ott, A. & Vedin, L-G. (2002a). World Wide Workshop – A Socio-cultural Odyssey. Proceedings of the ETEN Conference "Technology Education in Schools and in Teacher Training" Munich 10-12 November 2000.
Ott, A. & Vedin, L-G. (2002b): From Antiquity to Affluence
Paper to be presented at the second ETEN conference on "Technology Education",8TH to 9th February, 2002 at the University of Greenwich, London.
Ott, A., Ott, E. & Vedin, L-G. (2003a):Theme parks in Orlando – Science, Technology,Design, Education and Entertainment in Interaction. Paper presented at the ETEN Conference on Teacher Education in Grooningen 13-15 February 2003.
Sfard, A. (1998): On Two metaphors for Learning and the Dangers of Choosing Just One. Educational Researcher, 27(2), 4-13.
Wertsch, J. V. (1991). Voices of the Mind: A Socio-cultural Approach to Mediated Action. Cambridge, Mass. Harvard University Press.

From Technology to "Technology and Design"

When working with the continious evolution of syllabi in the school subject "Technology" we became more and more aware of the interest in society and by students for design. To be competitive within the global market it is important to have a modern design in the products manufactured. The next paper is about the introduction of design into technology education and the possibilities to add this strand to our project.

6. The introduction of Design into Technology Education

Aadu Ott, Erik Ott and Lars-Göran Vedin, Department of Education, University of Göteborg
Paper presented at the ETEN conference 12 – 14 February 2004 on *"Mobility in Teacher Education – What are the challenges?"* in the subgroup for *"Technology Teaching and Learning"* in Viano do Castelo, Portugal.

Abstract

Since 1994 the curriculum for technology education in Sweden aimed at teaching technology from five perspectives: a historical and international perspective; an interactional perspective taking into account the interaction between man, technology and nature; a functional perspective taking into account the ability of technology for storage, transportation, transformation and control; a perspective regarding infra-systemic aspects between components and a system a perspective of making practical constructions and achieving solutions to different technological problems.

Since the beginning of the year 2003 a *perspective of communication* has been tentatively added to these perspectives, as we introduced an aspect of design into our courses at Göteborg University.

We thus analyze and apply these six perspectives when we teach design and technology. We regard design as a *product* and as a *process* in our course on technology and design. Designing is not only applicable to materialistic products but in an increasing amount to products in the virtual cyber world, which is, to a certain extend, becoming increasingly more integrated with our real life world.

Background

Since 1980 the department for Technology Education at Göteborg University participated in a joint venture with Deutsches Museum in Munich. This cooperation has been described by Ott & Vedin in (Ott and Vedin 1, 2, 3).

As the number of prospective students interested in Technology Education in Sweden diminishes after the millennium shift, as in other western countries Sjöberg (2001), an attempt to increase the figures for recruitment took place by adding the design aspect to the curriculum. This has, during the first year, turned out to withhold the number of students in technology education at our university.

We are regarding the changing aspects of our world, which emanated in Hagerman's discussion about the *Life World* and the *System World*. These aspects are discussed by the Finnish philosopher George-Henrik von Wright (1993). We feel that we have to take into account, not only the real world, but even the virtual world, as this is becoming increasingly more important in recent times in connection with as well, learning in schools as in activities outside the school system.

The design process

In our design course, we introduce the process of design as it is presented by James Garrett in *"Design and technology"* (Garrett 1996). Garrett presents the different stages in the design process in the following way:
1. Analyse of the situation; 2. Write a brief; 3. Carry out research; 4. Write a specification; 5. Work out possible solutions; 6. Select a preferred solution; 7. Prepare working drawings and plan ahead; 8. Construct a prototype; 9. Test and evaluate the design; 10. Write a report.

Garrett's book is a good handbook for plain constructions. The Swedish approach to design takes however another way and widens the process of design, to include historical as well as social aspects. The content of the Swedish curriculum was expanded in relation to the following five perspectives, which defined the content of the subject in the Swedish National Curriculum.

1. The historical and international perspective

This perspective was enriched, from focusing on an internal perspective on technology to include aspects emanating from the process of globalization. This means, for our teaching approach, that we have to regard that our pupils will, later in their lives, experience a change from a stable traditional industrial society into a multicultural and pluralistic society in interaction with a postcolonial world.

This globalization implied a hardened competition between companies, were the technological content in the artifacts produced, no longer does have any national preferences. What however could discriminate between products at the international market would be the design of the artifacts. This process is described by Naomi Klein, in her bestselling book *"No Logo"* (Klein, 2000).

At the same time there is, in the Western world, a change from a modern into a post modern era, as described by Andy Hargreaves in his book *"The teacher in the postmodern society"* (Hargreaves 2000). This implies a change from a society, based on a materialistic foundation into a nonmaterialistic society. This transition is described by Rolf Jensen in his book *"The Dream Society"* (Jensen, 2000). These exposures, of a changing society, points at the need to reconsider the content, which is taught in Technology Education.

The aspect of design might, according to some authors, be said to have taken its starting point during the Industrial Revolution in the 20th century. This has had a significant importance in connection with the French Revolution in 1789, when the middle class entered the mass consumption market and thus created a need for machine made and mass produced goods.

In the 20th century of course a conflict was created between the cheap, but qualitatively inferior products and the qualitatively superior items made by handicraft. The counter movement, which emanated, was called "*the Arts and Craft"* movement and started in England, were observation of the bad living conditions for the multitude of factory workers initiated some influential persons to take action.

Other design movements, to be studied because of their implications on living conditions, were among other "*the Art Noveau"* or *Jugend", "the Art Deco", "Modernism"* and "*Postmodernism".* Studies of these movements, in our courses, has been partially done

theoretically by studying books like Vihma *"Design historia – en introduktion"* (Vihma, 2003), Hauffe *"Design, A concise history"* (Hauffe, 1998), Sparke, *"A Century of Design"* (Sparke 1998). A couple of recently published books in Swedish were also used: Österlin, K. (2003), Löfgren, B. (2002) and Birgerstam, P. (2000).

The field of design seems to be growing rapidly and may be regarded as a postmillennial phenomenon. The year 2005 is proposed to be called *"The Design Year"* in Sweden.

The studies in design were partly performed in different design museums of which the foremost was Pinakotheke der Moderne in Munich as described in *"Pinakothek der Moderne, Das Handbook"* (Pinakothek der Moderne, 2001). We have had possibilities to visit this museum together with our students. Material from the *Design Museum* in London and from the *Rösska Museet* in Göteborg was also utilized.

2. The interactional perspective

According to this perspective the interaction between man and society is studied as it also depends on the effect which technology has on nature. When the design aspect is applied to this perspective, the action and power of new technologies and new materials is studied. Focus is in this case on how the process of designing products for differing uses has affected the interaction between man, society and nature.

Material collected from the Millennial World Exposition in Hanover 2000 was utilized in this context. This exposition had as theme to present the interaction between: *"Mensch – Technik – Natur"*.

This interaction is highly controversial. There is an internal tension between for example representatives for big companies, working in the field of high technology, and those who strive for Sustainable Development, as described in Agenda 21 from the United Nations Conference on Development in Rio 1992. It was there that the former president George Busch utterered the fateful sentence: "*The American Lifestyle is not negotiable."*

In our courses in technology we pronounce the aspect *"Designing for the Real World"*. This approach, which aims at selecting material to study, initiates of course a discussion of what the rhetoric expression "The Real World" really stands for. Does this expression denote the Western world or a Global world? Who has the power to make decisions about future developments of our world?

3. The functional perspective.

According to this perspective the effects of design on *storage*, *transportation*, *transformation* and *control processes* is studied.

Storage could be studied with a starting point originating in the activities of the English industrialist Joshua Wedgewood and his ability to create an industry around ceramic pottery. Nowadays a lot of discussions are about storage in computer memories. This change underpins a discussion about the *crossover from the real world and into the virtual world.* One might also regard this as a change from Poppers world nr 1, which is the real world, to Poppers world nr 3, which is the world in external memories. Poppers world nr 2 is the mental and cognitive world.

Transportation could be studied by references to the possibilities for international exchange of goods. When steam engines were put on rail and at sea, they united cities and continents. Even here we encounter how the virtual world via for example the Internet, transports a lot of valuables and information. It is thus challenging to try to do research on how pupils in our schools utilize Internet for different purposes. The mode for transportation thus crosses over from a pure materialistic into a nonmaterialistic area.

Transformatio*n* could focus on the introduction of new materials and methods exemplified by introduction of steel and plastic. Even here the virtual world makes its entrance into the studies undertaken in schools. The pupils are transforming information from Internet into different constructions in the memory of computers.

Control could be discussed from the point of view of the division of labour in factories and also from the point of view from the introduction of the *"Volksempfänger*" radio receiver during the 30-th in Germany. This was done by the Nazis in order to enable them to spread their propaganda. In our everyday life we encounter control functions when ironing clothes, heating up our house or driving a car.

A new aspect of control is emerging: What restrictions should the teachers put onto the activities of their students when gathering information from Internet? What feedback could the teacher reasonably give as support to the pupils, when they work with computers? In many cases the pupils know quite a lot more about computers and software than the teachers. How is it reasonable to organize teacher training, of skill and content, within this rapidly changing field?

4. The component – system perspective

Interesting examples are the Thonet chairs, which were manufactured by a company founded in the 20th century. These chairs were designed to be foldable when transported and were cheaply constructed with the help of wood processing machines. This is an idea, which the Swedish company IKEA utilizes in its highly successful expansion on the world market. This is a success story based on functional design of useful and cheap everyday household items.

In the virtual world pupils may be creating cities with programs as for example SIM-City. With the help of this and similar programs the pupils are able to design big systems of interacting components. In Sweden there has been publishes on Internet a freeware which enables pupils to create traffic systems. Presumably they get, in the process of creating these systems, a feeling for the possibilities and shortcomings of the congested large cities of today.

5. The perspective of practical construction

This perspective is, in our course in Technology and Design, studied by thematic studies of shelter, tools and systems. This means that design is not just a cosmetic and superficial application of colours and texture, but aims at creating an understanding of the inherent construction of artifacts.

One area, which has attended a lot of attention, is designing in Cyber Space. Our courses utilize computer power to a great extend in construction, as well as in control systems. Our students study, for example how interactive robots function. One especially interesting, and

for our students relevant area, is *web design*. Specifically in working with robots, using Lego Robotic material, the students encounter the problems created within the process of designing software programs in a computer memory in interaction with hardware in the form of a robot made from Lego hardware.

6. The perspective of communication.

This perspective is added to the original five perspectives, as they are expressed in the curriculum. This perspective discusses the communication, which is taking place between an artifact and man. This perspective focuses on the metalevel of the subtle signals, which a designed product sends out. In this field semantics as well as semiotics is studied.

One important aspect in this field is to create interactive web sites in order to communicate with students participating in distance education, in contrast to campus education. This form of studies is becoming increasingly popular, as Sweden is a country, which has a large area. Via computer and Internet it is possible to overcome barriers in time and space.

Discussion

Design renders a perspective of the world, which penetrates all aspects of our life world. We could just as well refer to our world as a *Designed World*.

The question is, in this case, according to an extension of the didactical troika, to ask: **What** is designed? **How** is it designed? **Why** is it designed? **From where** does the design originate? **To what ends** does it lead? **Who** is making the design? **For who** is it designed? A graphical representation of these questions might be called a *didactical hexagon*.

Answers to these questions do of course lead to discussions of interesting aspects of our world. These discussions might render the students a deeper understanding of the technological changes which currently take place in our contemporary world. These changes will, in the long run, affect all of us, not least the pupils, which the students ultimately will be teaching.

There are a lot of different areas into which design has extended, for instance, (Hauffe, 1998): *corporate -, interface-, industrial-, public-, fashion-, automobile-, commercial-, conceptual-, computer-, information-, packing-, communication-, avant-garde-, hardware-, tabletop-. counter-, radical-, media-, food-, anti-, re-, film-, sound-, object- and software design.*
The question is how to approach this enormous field, in the process of designing teaching and learning in science, technology and design.

One way might be to utilize the *contextual matrix* (Ott 2001) as an intellectual tool. This matrix is constructed by nine elements, organized in three sections describing philosophical, practical and interactional aspects of knowledge. The element in the centre is content. The content will in this discussion of course be *design* in interaction with technology education.

If we start with the *philosophical* level, then it is interesting to regard the **metaphysical** aspects of design. The metaphysical starting point expresses differences in knowledge if its origin is based on religious considerations, magical beliefs or on scientific underpinning.

Why do some designed artifacts appear at a certain time in history? One example is the mixture of folklore and neoclassicism during the Nazi regime in the 30th. Somewhere in this historical context, we have a connection with the mystical linguistic phrase "*Blut und Boden"*.

The closing of the Bauhaus movement in 1933, the murdering of the members Hans and Sofie Scholl of the White Rose Anti-Nazi movement has a connection with the later creation of the famous Ulm Design School after the Second World War. This school was created on the initiative of Inge Scholl, a relative to Hans and Sofie. This aspect could also be pointed out in connection with the perspective of historical development and internationalism.

Contrary to this way of regarding design, could be to argue that history and philosophy of design does not influence contemporary design. It might only consume valuable parts of the space time which is reserved for teaching if we discuss a subject from this widened perspective. But if one has an impression of history as being built up of a chain of interacting occasions and not of just of discrete and fragmented happenings, then this way of understanding and handling contemporary design is fruitful. At the same time, this approach might be a little towards the metaphysical side. It is thus not possible to have this assumption verified as well as facts in for example physics.

On the philosophical level, which also contains ***epistemological*** and ***ontological*** aspects, it is also interesting to include into the discussion, and questions like: How do we reach knowledge about design? What is a design process? What items does a design process contain?

In this discussion we find that design is not just a cosmetic way to affecting the exterior of a product. Design is a process, which contain special procedures. Design affects the whole process of production, from the first faint idea and to the final artifact. Sketching is an important activity in this process. The design process utilizes special intellectual tools when applied to technology education.

On the uppermost level in the conceptual matrix, we discuss the factor ***preconceptions*** which the teacher as well as the student possesses. All of us have preconceptions about design. These might be a help in teaching and learning as it is possible to identify and to reflect on a metacognitive level over them. At the same time these preconceptions might act as hindrances as they might give a wrong idea about what design really implies. Many persons may just regard design as an external and visual or tactile aspect and not as part of a process, which affects all aspects of construction.

In the middle section of the model we find on the right hand side the factor ***theory***. In this context this factor refers to theories of learning, as well as to theories of the content, which affects our conceptions of the concept design. The theories of learning contain different aspects of constructivism, as well as cognitivism. The theories of design refer to different aspects of the design process.

To the left we find the factor ***praxis.*** This factor refers to what is done in the classroom. In teaching technology and design in Sweden we urge the students to study theory as well as to construct artefacts. Our aim is to strive towards a unification of these aspects. We want the students to construct an artifact, according to the design process, as described above, and then to be able to analyze this artifact, according to the perspectivepentagon regarding the didactical questions as given by the didactical hexagon as described above.

Summary

The important factor is to regard the fundamental change of discourse when moving from applications in school, which often are characterized by questions about *"know how to do"* , to research and theory based activities at the university level, which are characterized by questions about *"know why to do"*. This means that the students should, beside the material tools, which they use in the process of construction of artifacts, also be able to utilize the three sets of intellectual tools:
the ***perspective pentagon*** with five perspectives on technology with an added complementary perspective of communication,
the six aspects on didactics as given by the ***didactical hexagon***.
the ***conceptual matrix*** with its nine factors.

Concluding remarks

It seems, after the first year of teaching a course on "Design and Technology", according to the curriculum described, that the students are content with the course. Evaluations by the students shown that this addition of design to technology was a necessary step in order to create a foundation for teacher education and teacher in service training which is up to date with our contemporary *"Zeitgeist"*. This Zeitgeist is characterised by an aim on research, in order to try to match current activities in our schools with possible demands in the future, and the unpredictable future needs in the lives of our pupils in a rapidly changing society.

References

Birgerstam, P. (2000): *Skapande handling – om idéernas födelse.* StudentlitteraturBunge, M. (1977*): States and events.* In Harnett, W. E. (ed): Systems: Approaches, Theories, Applications, Boston: RCaro, P. (1996): *Informal Education through Science Museums.* Paper presented at the 8th IOSTE symposium, August 17-22, Edmonton, Alberta, Canada. (Vol. 3, p. 42-48).
Danielsson, M. (2001): *Teknisk psykologi.* Natur och Kultur.
Eco, U. (1990): *Travels in hyperreality.* Harcourt Brace Jovanovic, San Diego.
Egglestone, J. (1998): *Teaching Design and Technology.* Open University Press
Garrett, J. (1996): *Design & technology.* Cambridge Univ. Press.
Hargreaves, A. (1998): *Läraren I det postmoderna samhället.* Studentlitteratur, Lund. Original: *Changing Teachers, Changing Times: Teachers´Work and Cukture in the Postmodern Age.* Ontario Inst. For Studies in Education, Toronto, Ontario, 1994.
Jensen, R. (1999): *The Dream Society – How the coming shift from information to imagination will transform your business.* McGraw – Hill, New York.
Hauffe, T. (1998); *DESIGN –A Concise History.* Calmann & King Ltd, London.
Löfgren, B. (2002): *Design och produktutveckling.* Liber
Ott, A. & Vedin, L-G. (2001). *Interaction between Culture and technology in Informal Learning.* Proceedings from the Conference "Lernort Deutsches Museum: Koncepte, Inhalte, Methoden von Lern- und Lehrerveranstaltungen im Kerschensteiner Kolleg, vom 22 – 25 Oktober 2000.
Ott, A. & Vedin, L-G. (2002a). *World Wide Workshop – A Socio-cultural Odyssey.* Proceedings of the ETEN Conference "*Technology Education in Schools and in Teacher Training"* Munich 10-12 November 2000.
Ott, A. & Vedin, L-G. (2002b): *From Antiquity to Affluence*
Paper presented at the second ETEN conference on "Technology Education",

8TH to 9th February, 2002 at the University of Greenwich, London.
Ott, A. (2002c): *A Conceptual Matrix for Science Education.* Journal of Baltic Science Education No 1, 2002, p. 7-14.
Pinakothek der Moderne (2001). Pinakothek – Dumont.
Sievers, C. & Schröder, N. (2001): *DESIGN Des 20 Jahrhunderts- 50 Klassiker*Gerstenberg Verlag, Hildesheim.
Sjoberg, S. (2001). *Science and Technology in Education – current Challenges and possible Solutions.* Paper presented at the meeting of European Ministers of Education and Research, Uppsala 1-3 March.
Sparke, P. (2001): *DESIGN – 1900-talets pionjärer.* Bonniers förlag.
Vihma, S. (2003): *designhistoria – en introduktion* .Raster förlag.
Wright, G. H. (1993): Myten om framsteget. Bonnier Pocket.
Österlin, K. (2003): Design i fokus för produktutveckling – Varför ser saker ut som de gör? Liber

7. Reflection on Interactions between a Cognitive Mind and Distributed Cognition in Artifacts in Museum Contexts

Aadu Ott & Lars-Göran Vedin, Department of Education, Göteborg University

Paper presented at the Conference: "Technology in Time, Space and Mind. Aspects of Technology Transfer and Diffusion".
Halmstad University, 27-28 October 2005**.**

Abstract

This paper reflects on and discusses the didactical intentions and implications of an extensive project in science and technology education, which has been going on between the years 1980 – 2007, mainly as a joint venture between Deutsches Museum in Munich and the University of Göteborg. The actors in this paper are of two kinds: first, the introducers and inventors of new aspects of science and technology, the scientists and technically minded people, and secondly the intermediaries, for example teachers, who act as communicators of science and technology.

Learning is, in this paper, tentatively regarded as an interaction between *cognitive neural networks,* in the minds of those persons who participated in the seminars, and *distributed cognition* in artifacts in science and technology museums.

The aim is to try to enhance learning and retention processes by taking into account changes in synaptic connections within the brain which leads to neural plasticity.

This project has involved student training and in-service teacher training and has included weeklong seminars in science and technology museums in different countries.

The results of this project unambiguously underscore, as found by evaluations and papers produced by the participants, the importance of having qualified guidance in museums in order to create a fruitful interaction in these four main dimensions:

1. Inventions and inventors: This part of the project studies emergent *"quantum jumps"* of science and technology in space and time.

2. The Mind: The Mind as it is affected by changes in cognitive neural networks of participants in the seminars.

3. Museums: The distributed cognition in the artifacts, which are exposed.

4. The Curriculum: The national curricula in technology, which guides the selection of topics. The visits to authentic environments also enhanced the retainment of the content which was taught, as facts were placed into historical and developmental contexts focusing on genesis and evolution of science and technology.

The results also pointed to fruitful possibilities to operationalize the concept *"Pedagogical Content Knowledge"* (PCK), in order to make a transfer from Technological Content

Knowledge to Pedagogical Content Knowledge in science and technology education, and in learning processes, utilizing museum contexts.

In this paper, the evolution of technology was thus regarded as dependent on time, space and mind in interaction with society. The aspects of technology transfer and diffusion were regarded from a point of view of creation of artifacts and learning by the participants.

Background

Since 1980 a project has been going on at the University of Göteborg, called: *"World **Wide Workshop in Technology Education."*** Weeklong seminars, in with together more than 3000 participants from all parts of Sweden have participated, have been performed in different cities in Europe. The places chosen were such, were notable historical events in the history of technology development have occurred. The content of World Wide Workshops is described in Ott, A. & Vedin, L-G. (2001), Ott, A. & Vedin, L-G. (2002a), Ott, A. Ott, E. & Vedin, L-G. (2002b), Ott, A., Ott, E. and Vedin, L-G. (2003).

Eight strand in science and technology evolution

1. The Naissance of Science;
Athens and Greece: *From Aristocracy to Democracy;*
Sites visited: Acropolis, National Archaeological Museum and War Museum and in the ports of Athens and Piraeus: the Naval History Museum.
Actors: Thales with static electricity and magnetism – the origin of electricity; Aristotle with the elements earth, water, air, fire and ether – foundation for electromagnetism, Plato, Perikles, Themistokles, Heron and the steam sphere, which was the first steam turbine. Democritus, who proposed the first atomic hypothesis for matter.

2. The Constitution of an Empire;
Rome: *Mare Nostra & Roman Law;*
Sites visited: The Pantheon; The Capitol Hill; The Coliseum; The Circus Maximus; Piazza Navona; The Vatican; Forum Romanum.
Actors: Caesar, Nero, Seneca, Cicero,
The rise and fall of the Roman Empire was studies together with the conflicts between different kinds of theological issues.
Appendix: Bilaga Rom.

3. The Renaissance;
Firenze and Italy: *Man as Creator; Birth of Bourgeoisie;*
Sites visited: Palazzo Vecchio, Piazza della Signoria; Museo di Storia della Scienza, Palazzo Pitti, Santa Croche. The Uffizi Museum, Duom or Santa Maria de Fiori.
Actors: Leonardo da Vinci, Michelangelo, Benvenuto Cellini; Galileo Galilei (1564 –1643) and the start of modern science with optics, astronomy and mechanics, introduction of mathematics in science and technology;
Luigi Galvani and Alessandro Volta – development of electricity.
Appendix: Bilaga Florens.

4. The Scientific - Technological Revolution
Munich and Germany: *The Scientific and Technological Revolution.*

Sites visited: Deutsches Museum, Siemens Museum, Alte Pinakoteke, Neue Pinakoteke, Pinakoteke der Moderne, Schloss Nymphemburg Science Museum and Dachau Memorial Camp;
Actors: Otto von Guernike who challenges Aristotle´s theory about "Horror vacui" and shows how power could be gained from empty space; Johannes Kepler who challenged the Platonic astronomy from antiquity which contained perfect spheres. Joseph Fraunhofer who constructed optical instruments and found the "Fraunhofer lines" in the Sun's spectrum.

5. The Birth of Modernism
Paris: The Political Revolution: *Liberte, egalite, fraternite*.
Sites visited: Cité des Sciences et de l'Industrie (La Villette), Palais de la Decouverte, Museé Carnavalet, Conservatoire des Artes et Metieres, la Defence, The Eiffel Tower, Le Louvre and Maison Pompidou;
Actors: Foundation of Ecole Polytechnique by Napoleon, Michael Foucault, Marie Ampéré, Antoine Lavoisier, Madame Curie, Irene Joliot Curie,
Appendix: Bilaga Paris.

6. The Postmodern Reaction
London: *England as workshop of the world;*
Sites visited: Science Museum, Museum for Natural History, Victoria & Albert Museum, Imperial War Museum, British Museum, London Museum, London Transport Museum, Thames Barrier and the Meridian- and the Naval Museums in Greenwich; War Room in Whitehall, Design Museum.
Actors: Isaac Newton who expressed four fundamental laws in physics; Thomas Young; Michael Faraday, with his invention of induction in electricity, James Clerk Maxwell who founded the theories of electromagnetism; Thomas Newcomen with the first steam engine; James Watt who improved the steam engine. Stephenson, who built the Rocket; J.J. Thompson who found the electron; Ernest Rutherford who challenged the established model for the atom and created a new atomic concept.
Appendix: Bilaga London.

7. The Future
Orlando: *Science and Technology as an Adventure;*
Sites visited: Sea World, Epcot Centre, Magic Kingdom and Kennedy Space Centre.
The thematic contents in the parks were discerned according to four variables:
Fiction, Authenticity, Entertainment and Technology.
Actors: Military: Werner von Braun who, with a starting point in the V2 rocket directed the work on the Saturn rocket which acted as the main workhorse in the American space program; Donald Duck: who renders a picture of American life.

8. The Rise and fall of a Dystopia;
Berlin and modern time: From Fascism to Democracy;
Sites visited: Brandenburger Tor; Checkpoint Charlie; The Parliament; The Pergamon Museum; Deutsches Technical Museum; The Zeiss Planetarium;
Actors: Heinrich Helmholtz, Heinrich Hertz who argued that the Ether was the medium in which electromagnetic waves moved; Max Planck who challenged the idea from Antiquity that nature does not make jumps by having to introduce the quantum concept; Albert Einstein who challenged the Ether concept and created two new fundamental theories: the Special Theory of Relativity according to which we live in a four-dimensional space-time and the General Theory of Relativity according to which this space-time is bent by the mass; Military:

Werner von Braun who created the rocket weaponry. Werner Heisenberg who tried to make an Atomic Bomb.

Problem to be discussed

This paper will focus on and analyze the interaction between Mind, Science and Technology by the visitors in these seminars. This will be made foremost from experiences from one of the visited places: Deutsches Museum in Munich. The identity and importance of the actors – introducers and intermediaries is discussed with the focus on the intermediaries.

Theoretical aspects of learning

Instead of beginning the discussion from a theoretical staring point in the established theories of constructivism, sociocultural aspects of learning or phenomenographical aspects of learning, this paper will regard and treat learning from the point of view of how the human mind functions in a learning process.

Brain, mind and learning in a museum context

It might thus be favourable to try to highlight some of the factors, which, according to theories about the function of the mind, would be valuable to consider in the process of learning in a museum context. A museum in itself might be regarded as a sort of actor as it acts as an intermediary between the visitors and the artifacts presented.

It is clear that, according to the constructivist theory of learning, a learner does construct his own mental structures. There is no doubt about that.
But what are these constructions made of? How are they constructed?
A learner does at the same time learn by the process of interpersonal mediation and intrapersonal construction of knowledge. But how and why do these processes act?

The world, in which we live and interact, could be regarded as an *experiences world,* according to the theory of phenomenography. But what does this mean, from the point of view of cognitive psychology or neuroscience?

By regarding the function of minds and brains of visitors in interaction with items in a museum, we hope to be able to reach a deeper insight into the fundaments of these theories and thus try to create a neurobiological understanding for the process of learning.

1. Brain and learning?

The brain is always interacting with the environment. It is recording experiences and proposing solutions to problems and thus helping the individual to adapt to the surrounding world. This interactive process will rewire the internal connections in the brain and thus affect the cognitive processes in the mind. The process of changing the synaptic connections within the brain by experiences could, at a fundamental level, be regarded as learning. The information processing activity, which we call learning is the main function of the brain. The question is however *what* the brain learns, *when* it learns and *how* it learns.

The *"atom"* of learning is, according to modern neuroscience, the construction of connections between brain cells. These connections are called *"synaptic connection"* and function as intermediaries between the neurons within the brain. Learning takes place by changing or strengthening these connections.

Learning is founded on the summation of those experiences, which human beings make during their *whole lifetime*. It is thus adequate to talk about *Life Long learning.* A general concept in this case is *"neural plasticity"* which denotes the neurophysiological changes in a brain, which affect the behaviour of the learner.

The brain creates, depending on these synaptic changes *"neural networks"*. We might recognize the results of the action of these neural networks in our brains in the form of our mental *"Representations"* of the surrounding and experienced world.

These representations will be of two kinds: Representations, which are *bound* to empirical evidence. This is in contrast to *free or unbound* representations. The unbound representations have been of importance during the evolution of our specie as they render possibilities for the action of *imagination* and *fantasy*. At the same time it is an important key factor that our representations in technology have to have a foundation in the real and empirical world around us, which represents our *objective ontological reality.* On the contrary, it is not possible to create a functioning technology on an ontology, which is based on fantasy, imagination or fiction. Concepts in *hard* sciences give a firm foundation to our technological creations.

To be regarded in this context is also that learning might be considered as a dangerous and threatening business. By changing neural networks, learning might affect the personality of the learner. It might also be so, that the often regarded negative attitude to learning, which might be observed by elderly people, is just a result of such a standpoint. Personal changes of an identity might affect the personal social network, within which every person is embedded.

The Noble Prize Laureate and neuroscientist Gerald Edelman has created the one liner: *"The brain is embodied and the body is embedded."* (Edelman 2005). This means that we have to take into account the interaction between body and brain/mind, together with the interaction between body, brain/mind and the sociocultural environment. Brain contains the *hardware* or material neural substrate, which is studied in neuroscience and in which the immaterial Mind acts as *software*, which is studied in cognitive psychology.

The most efficient learners are on the other hand the very young children, who do not have any identity to protect, nor any social network to consider except their close family. Small children are, because of their innate curiosity, great scientists. Maybe great scientists, in their turn, are mentally like small children and filled with childlike curiosity?
Einstein once said:"*I do not have any special talent. I am only very curious."*
An important question to be formulated might thus be: How does a visit to a technological museum affect the brain and mind of a visitor?

2. Technological Authenticity – Mind prefers narratives.

During the whole project we have tried to utilize authentic surroundings and to study authentic artifacts.

Within a museum, an artifact is always *decontextualized* from its original context and then *recontextualized* into a new context. Often however, this process of recontextualization adds valuable dimensions to the contex it is contained in, or the story communicated by the artifact. The artifact tries to bring into light the *hidden distributed cognition* within which the artifact once was constructed and used and where it once constituted an important item.

For example, at the Deutsches Technical Museum in Berlin, parts of original aeroplanes, which were shoot down during the Second World War are exposed. This adds a dimension of the drama and history of our time to the exhibited items.

It is found to be of great value to be able to move around in an original historical site, for example in the fortress and sacred place Acropolis in Athens; the Dachau Concentration Camp outside Munich; the Eiffel Tower in Paris; the Coliseum in Rome, The kennedy Space Centre etc. It is however important that the guide, at the same time, tells the story about the site and thus places the site into its original historical context.

Such a visit gives a multisensory learning experience. A multitude of incoming sensory channels send signals to the brain. These signals interact with associative areas in the brain, creating perceptions and thus influence many parts of the cognitive mind simultaneously. The whole body could be experienced as embedded in the historical context of the site. The context itself renders bound representations, while the narrative might render unbound representations. These representations will interact and thus, by the process of metacognition, create an optimal mental information processing situation. This process, will in its own turn affect the synaptic connections within those parts of the brain were “memory engravings” are retained and thus result in efficient learning.

In this case it is also of value to utilize personal stories, which might be told by focusing on key actors in history. When having a seminar in Athens, we visited the places were The Lyceum of Aristotle’s was thought to have been once; were the Academia of Plato once stood; were Themistokles had his triremes stored, before the naval confrontation with the Persian fleet at Salamis; Delphi, were the oracle once made her predictions; the Areopage hilltop, were Socrates once was doomed to death; the Bema were the silver-tongued Perikles once held his immortal speeches. All of these places are heavily laden with emotional content. This could be used by a skilled guide in order to *merge emotion and cognition* and thus stimulate the long time memory in the listeners.

When visiting Rome, we looked at Coliseum were Nero once ordered Christians to be slaughtered; Circus Maximus were Caligula once raced his horses; The Pantheon were Raphael is buried; The Vatican, which exposed the tremendous Worldly power of the Pope; The Mausoleum of Augustine’s, which still is controversial because Mussolini wanted to be buried there, and the Neofascists regard this place as a holy Shrine; We stood in reverence in front of the graves of Galileo Galilei, Machiavelli, Michelangelo and Dante Alighiere in the Florentine Church Sancta Cruce. History casts long shadows into the future of mankind.

When in Firenze we also studied the works of art made by Leonardo da Vinci, Michelangelo, Botticelli etc.

When in Munich we followed the development of science and technology and studied the important contributions made by scientists and technicians like: Galileo Galilei, Otto von

Guericke; Rudolf Diesel, Nicolai Otto, Werner Siemens, George Simon Ohm, Hans Christian Örstedt etc.

When in Paris, we visited the Eiffel tower; the tomb of Napoleon; looked at modern science in Centre d´Industrie et Science (La Villette), Palaise de la Decouverte and the achievements made by Madame Curie and Irene Joliot Curie.

When in London, we visited Science Museum and its expositions on Isaac Newton, Charles Babbage, James Watt, George Stephenson etc.

When in Orlando we studied how the activity at Kennedy Space Centre in a way was an inheritance from the German V 2 era. This started in Germany during the Second World War under the direction of the German scientist Werner von Braun, who later on became leader of the American Space Program.

When in Berlin it was interesting to visit the Pergamon Museum and to study the Isthar Gate which originated from the old Babylon during Biblical time and was robbed by German scientists at the beginning of the 20th century. It was also rewarding to visit the Deutsches Technical Museum in Berlin, The Brandenburg Gate, and Memorials from the Holocaust.

Our minds remember facts much better if they are embedded within a story. The history of science and technology has plenty of vivid possibilities for catching the imagination of the participants in this way. This stresses the fact that it is important to utilize the possibility to pay attention to the key actors and original sites in history.

Reflection: It is fruitful to teach facts in a context which generates interest with the help of multimodal connections to the learners own pre-existing associative neural network.
These new experiences will create a neural network, which will be integrated with the existing preconceptions and form new connections and allow abstract conceptions to be formed in the cortex of the brain. We must as teachers let the learner have ample time for this integrative, reflective or metacognitive phase to take place.

2. Design and technology - Emotion

The prefrontal lobe of our brain is the place, were decisions and evaluations are made. These are often enhanced by an emotional aspect of the content of what is aimed to be learned. If we do not have a positive emotional attitude to a subject, then it is difficult to learn this subject. This means that it is important that the guide or teacher always tries to create a positive atmosphere, so that participants in a learning process are in a positive mood towards the subject which is studied. One may say that for optimal learning a situation has to have high *Challenge* and low *Threat.*

Negative feelings which originate in frightful experiences, are routed to the *Hypothalamus* and the *HPA-axis* (Hypothalamus -Pitutiary Gland- Adrenal Gland), via the *Amygdale* and the relay station called *Thalamus* and an attitude of either *"fight or flight"* may thus be created, instead of a positive and creative approach to a problem.
This shortcut via the Amygdale is of value when we encounter a situation were we just have to act fast via a fast reflex, as for example when we encounter a poisonous snake. This reflective behaviour has been of great value during the evolution of our specie, but this

shortcut is not of value in creative learning of complex subjects. We are here able to identify a conflict between learning and acting in a natural environment and in a learning situation in a modern society.
Reflection: It is fruitful for learning if we add a positive emotional touch to the content of subject which is studied.

3. Living on a Technotope - Preconceptions and associations

Different kinds of memories, information processing units, the consciousness are to be found in the cognitive cortex of the brain. This is the thin layer on the surface of the brain, were higher cognitive, sensory and motor functions are situated.

The participants in seminars have a broad range of preconceptions in their minds and learning would be functioning best, if new items of knowledge could utilize and connect to these already establishes basic neural networks.
.
We are all surrounded by technological artifacts, which we utilize daily. It is thus important that everybody realizes that he or she, in her daily lives utilizes a broad repertoire of technical knowledge and is conscious of the broad technological knowledge base, which she is in possession of. This means that it is of great help if the guide or coordinator of a seminar tries to make connections, and tries to build bridges, between the items studied and these preconceptions which the participant have. A dialogical approach to teaching is, on the grounds of Educational neuroscience to be favoured.

Each brain is of course unique, but with a seminar group consisting of teachers there are a lot of common points of view, for example aspects on how to interpret and apply the instructions in the curricula. This makes it also important to utilize analogies and metaphors, in order to be able to build bridges between the cognitive minds of the participants and the distributed cognition, which is to be found in the artifacts, of which the technology around the visitors in a museum is composed.

Reflection: It would be fruitful for the process of learning to take into account preconceptions and common denominators of learners.

4. Rules and laws in science and technology - Mind as rule seeker

The mind does not store every single item, which it encounters. Instead it stores *generalized* representations of concepts and artifacts. Learning of a language is a pregnant example – young children do not study grammar, still they learn how to speak their native language in a correct way. This works well, because brains are characterized by having an ability to distil information from the surrounding environment and to memorize common aspects, which are possible to generalize.

This way of functioning of the brain, point at the importance of exposing learners to a multitude of different artifacts in different contexts. This facilitates the learning process in which the brain tries to categorise and to distil common aspects.

Deutsches Museum in Munich has more than 10 000 different artifacts exposes in different compartment. A visitor has to walk about 20 km in order to be able to get an overview of all these artifacts. This immense amount of artefacts points at a need to be able to *categorize*

these artefacts. This is done with the help of intellectual tools, in order to be able to memorize, at least a part of them.

At the same time it is important that the leader of the seminar tries to direct the attention of the participants to the most important parts of a technological construction or item. Thus he will expose how surprisingly few fundamental technological laws have been utilized in the construction of different artifacts. These laws might be thermodynamical laws of energy, laws in optics, difference between stress and strain, laws for friction etc.

Reflection: It will be fruitful to utilize the fact that brains always optimizes its information processing by searching general rules and categories.

5. Technology in historical evolution – Brain as novelty seeker.
In Deutsches Museum there are expositions, which expose the evolution of some technologies, for example construction of ships and the development of engines for aircrafts. The exhibits showing shipbuilding starts with ancient Egyptian ships on the river Nile, goes further on to Greek warships from the time of the naval battle at Salamis and to modern ships of different kinds.

The exhibit with aircraft engines starts with small Otto engines, exposing how they become bigger and bigger until they have about 30 cylinders and a couple of thousand horsepower. In the last stage these engines have become overwhelmingly complicated, which by the sheer number of parts, of which anyone may malfunction, no longer are as reliable as would be needed.

In both exhibits the process of *maturization* of technology is well exposed. It is exposed that when the constructions of an engine become bigger and bigger, a need to change to another engineering technology or other construction material becomes obvious. Ships have, for example to be built of steel and to utilize another source of energy than power from the wind.

An aircraft with propellers for propulsion will not be able to exceed about 800 km/hour, because when the ends of the blades reaches the velocity of sound they do not function any more for propulsion because of "*cavitation"*. Development and utilization of the jet engine is then a proper solution. But even jet engines have their limits of velocity. An exposition at Deutsches Museum shows how a ramjet might be connected to a hydrogen rocket to boost the speed of a flying object well above Mach 5.

One question to be discussed in this context is: What are the limits of a certain technology? Another question to be raised might be: Why should mankind strive for these ever faster and faster velocities? Our Earth is a limited Globe, with limited resources and limited possibilities to take care of the ever bigger amount of vast. A striving for Sustainable Development should be more important that striving for higher velocity.

The brain has an inherent function so that it acts as a novelty seeker. The brain creates all the time hypotheses and tests them against empirical facts. To follow a historical development, and at the same time to actively interact with an exhibition is a way of learning which fits the brain. The participant might ask himself, when standing in front of an artifact: What will the next step in the development of this very artifact be?

Reflection: Utilize developmental sequences and look for changes in constructions when studying technical constructions.

6. Explicit and implicit memorizing

When visiting a technological exposition it is not always certain that a participant is able to verbalize his experiences consciously. The memory functions however on a couple of levels: for example on the *explicit* level, were knowledge is possible to be verbalized and on the *implicit* level: *We know more than we than we may be able to express verbally.* We have, what is called, *"tacit knowledge"*. This might be regarded as that kind of knowledge, which an expert in a profession has. The expert relies mainly on "*Pattern Recognition"* when solving a problem.

This means also that the very visit to a technological museum might give the visitor *"A tacit frame of reference",* which in an intuitive way will help him to find his way, when judging different and often controversial aspects about technology.

A lot of the tacit knowledge is stored in the brain in the form of skills: Try, for example, to explain for somebody how to lace your shoes or how you could manage to ride a bicycle. The Austrian philosopher Ludwig Wittgenstein once asked: *"How does a flute sound*?" Here we have a field of knowledge, which is named *"knowledge in action"*. A lot of of knowledge, which a teacher possesses, is of that kind. This is a knowledge base, which is founded in experiences and skills and based on pattern recognition and which is situated within the left hemisphere of the brain.
Reflection: You know more than you might be able to tell, and you do a lot of judgements unconsciously.

7. Whole and parts

The seminars always started with guided tours, for example in Deutsches Museum with an introductory overview of the content and aim of the expositions in the museum. Even if the participants, on this occasion, were not able to create an interaction between their explicit memory and the items exhibited, then they were still able to get an implicit representation of the museum in their minds.

The psychological term for this is *priming.* The bounds between these representations in the minds of the visitors became more and more bound to the content of the exhibitions during the duration of the seminar. Mind and neural matter interacted in order to create meaning from the multitude of artifacts exposed and presented. The brain and mind is continuously busy with the process of creating meaning as this is a process which is vital in the act of human adaptation to the environment.. There might however emerge problems when the mind is creating meaning were no meaning is to be found, for example in superstition.
Reflection: An inherent property of the mind is to try to create meaning.

8. Motor – and premotor skills

Deutsches Museum is characterized by having a lot of interactive and tactile experiments, which the visitors may test. When operating these experiments an attitude of *"hands on and minds on"* is favourable to have. The visitor might form a hypothesis, in the prefrontal cortex, about the outcome of an experiment and then put this hypothesis to an empirical and

experimental test. In science and technology it is of outmost importance to develop skills in the manipulation and operation of experiments. The educational approach in Deutsches Museum was once laid by its founder Oscar von Miller who said: "*Hier können alla tun was Ich will."* The exhibitions were meant to inspire and gifted but poor student in their studies by giving them opportunities for getting experiences from experiments.

In the parietal, upper, part of the brain we have centres for motor skills in the form of synaptically connected neurons, which form real maps. These maps are possible to affect, so that a motion, which is repeated many times, might get a bigger part of the parietal cortex of the brain for its control. In the premoter area of the cortex, the activation of motion of different parts of the body is planned in the form of motional sequences to be performed. These signals are then relayed to the "*basal ganglia"* which operate functions of the body. Making experiments gives the experimenting visitor possibility to get experiences, which will affect the configuration of her brain.

Reflection: The brain is changeable and learning depends on experiences. This is called "*neural plasticity"*.

9. Reward systems in the brain

When we understand something, or when somebody utters a positive word about our actions, then we will get a positive feeling of wellbeing. This feeling emanates from a part, deep within the brain, it is called: area A 10. From this area, the substance *dopamine* is sent to the prefrontal cortex, were the reward system of the brain is situated. This dopaminergic system has the effect of creating a positively experienced emotion. This positive emotion will then affect the associative parts of the cortex and thus enhance the creative ability of the brain. The development of technology is a highly creative activity, which, for its optimal development, will need an emotionally positive atmosphere.
Reflection: It is fruitful to utilize the brains inherent rewarding system by creating an emotionally positive atmosphere in the workshop or in the classroom.

10. Social aspects on learning

The brain has, phylogenetically, been developed in a social setting and functions best in interaction with brains of other human beings. This is a fact, which is utilized in the seminars at Deutsches Museum by the creation of possibilities for the participants to interact with each other in informal ways. This interaction takes part even after working hours in the museum. Informal reflection, together with other participant in informal settings, on the formal program has been a valuable forum for reflections on a metaplane over the experiences.

Reflection: It is fruitful to utilize the social and mediational aspect of learning in a museum context.

Conclusion

When discussing learning, it seems that a point of view, which takes as its starting point the function of the brain is a fruitful way of regarding the learning process.
One of the main points of view of learning in a museum context is the importance to regard the difference between *Content Knowledge* and *Pedagogical Content Knowledge*. Content knowledge is pure technological or scientific knowledge. Pedagogical Content Knowledge is

on the other hand, knowledge which a teacher or communicator has in order to be able to teach. It is seldom possible to utilize content knowledge directly for teaching. The content has to be transformed into a structure which may interact with the neural networks in the brains of the learners.

This draws attention to the important function of the guide in a museum. He has to be able to transfer the distributed cognition within the artifacts exposed so that they make meaning to the participants. As the field of technology is a very wide field, then he has to make some sort of selection of content. This means that he has to be knowledgeable about the field of interest of the visitors in order to be able to make a relevant selection.
This means that three dimensions have to be considered in order to make a good seminar: *Mind; Distributed Cognition* in items; *The Curriculum* which the participants in the seminar have to follow.

References

Ott, A. & Vedin, L-G. (2001). Interaction between Culture and technology in Informal Learning. Proceedings from the Conference "Lernort Deutsches Museum: Koncepte, Inhalte, Methoden von Lern- und Lehrerveranstaltungen im Kerschensteiner Kolleg, vom 22 – 25 Oktober 2000.
Ott, A. & Vedin, L-G. (2002a). World Wide Workshop – A Socio-cultural Odyssey. Proceedings of the ETEN Conference "Technology Education in Schools and in Teacher Training" Munich 10-12 November 2000.

Science Communication and the Nature of Mind.

The next paper discusses the nature of interaction between Science and Neuroscience in a Science Centre context. A "light" version of the interaction between learning and neuroscience is presented. The paper discusses how learning in a Science Centre environment might be more natural for a learner than learning in a classroom context, if viewed from a phylogenetic and neuroscientific point of view.

8. Nature of Science and Nature of Mind; Should they be Married?

Aadu Ott, Department of Education, Göteborg University, Sweden

Paper presented at the NNORSC , Nordic Network of Research in Science Communication, Conference 2 – 3 June 2006, at Dalarnas University in Falun, Sweden.

Abstract

The first aim of his paper is to discuss different aspects of science communication from the perspective of neuroscience and learning in a Science Centre environment. A hypothesis is that a neurological underpinning to pedagogical theories might enhance the process of learning. The second aim is to describe experiences from a university course in neuroscience, which was mainly aimed at science education and science communication. The third aim is to demonstrate the power and value of adding an approach from a neuroscientific perspective to the other research tools as Constructivism, the Sociocultural theory and Phenomenography,

Background

There is a great international interest in the field of neuroscience. By using Google and making a search on a combination of the words: *"Brain – Mind – Education*", a lot of interesting information will appear. The problem is to make a verification of what could be reliable knowledge. The international interest is for example manifested in a report from OECD (2002).

In Swedish some novels in this subject have appeared, for example (Gärdenfors, 2005), (Lagerkrantz, 2005). A couple of interesting papers are written by Peter Baeza (Baeza, 2005), (Baeza, 2006). That the field of "neuroscience and learning", is however neither uncomplicated nor uncontroversial is pronounces by a seminal paper written by the American psychologist John T, Bruer (Bruer, 1997).

The interest in this field has been triggered by the development of methods for possibilities to study how the brain works in real time via techniques like PET, Positron Electron Tomography and fMRI, Functional Magnetic Resonance Imaging. For a presentation of these techniques, see for example Reichel, M. E. (Reichel, 1999).

In the same way as the Cognitive Revolution dethroned Behaviourism in about 1960, it might be relevant to talk about a Neuroscientific Revolution which might dethrone cognitivism at about the change to the 21st century. This revolution implies that psychological speculations about the working of the brain in learning could be enriched by addition of neuroscientific aspects, relying on natural sciences as biology, physics and chemistry in interaction with cognitive psychology, philosophy and medicine.

Soft sciences as psychology and pedagogic are thus complemented by hard sciences, for understanding the process of learning. Overviews of the field of neuroscience are to be found in (Gazzaniga et al, 2002), (Spitzer, 2005), (Peterson, 2005), (Kolb et al. 2001) "*Scientific American Mind"* is a periodical publication which helps to keep us updated in this field.

Overarching ideas & science communication

Among other concepts and conceptual creations, Ilon Chabay who is professor in Sceince Communication at Göteborg University stressed in a lecture the importance of paying attention to the following points:
Core concepts: It is important to focus on a few core concepts and principles in science when trying to communicate the content of a specific subject;
Mental models: We will always try to understand science with the help of mental models and metaphors. It is however important to realize that these models present a statical and simplified picture of the dynamical process under study.
Context: The importance of context was emphasized;
Curiosity: The importance of making students curious and to provoke questions was stressed; it is fruitful if questions and answers lead to further questions in a never ending succession which deepened the understanding of the subject and creates relations within the associative neural network of the student.
Multimodality: The importance of using different sensory modes to illustrate a phenomenon was emphasized;
Emotion: It is fruitful to integrate cognition with emotion.
Challenge: The experiments professor Chabay showed, exposed that they functioned as cognitive challenges;
Motivation: To be able to manipulating objects is motivating;
Making sense: The different items in the expositions presented, seemed to make meaning;
Understanding: Understanding could be achieved by creating a relation to existing preconceptions in the listeners mental associative network.

Brain and Mind – a "light" version

It might be fruitful to try to create some mental representations of some functions of *"Brain and Mind"* in order to be able to analyze and discuss this theme in interaction with "*Communication of Nature of Science"*. The strange point about the brain is that we are, in our daily life, not aware of how it functions. Information processing is performed at an unconscious level. We are only aware of the resulting mental or physical behaviour, which results from this covert information processing. A question to be formulated is: *Would we be benefited by insight into the real function of the brain and mind?*
My hypothesis, in the field of an amalgamation of neuroscience and learning, which is called *"neurodidactics",* is that we will. This paper tries to argue for this conclusion.

These mental representations have their point of departure within the biological hardware, which constitutes the *material* brain. Within the brain we have the *immaterial* mind. The American psychologist Steven Pinker (Pinker, 1999) expresses the connection between brain and mind with the one-liner: *"Mind is what brain does."*

There is thus no *"Ghost in the Machine"* in the form of a soul or a Homunculus which is having control over the operations within the mind. This question has been extensively discussed by Gunnar Windahl, (Windahl, 2002).The American neuroscientist Antonio Damasio describes this topic extensively in his bestselling novel "*Cartesians Error",* (Damasio, 1999). The mind might thus be regarded as a material and biological entity, which performs information processing.

Steven Pinker writes (Pinker, 1999): *"The mind is a system of organs of computation, designed by natural selection to solve the kinds of problems our ancestors faced in their foraging way of life, in particular understanding and outmanoeuvring objects, animals, plants and other people."*

According to this aspect, learning in schools is a biologically unnatural activity, for which our natural constitution is badly adapted. Maybe it is therefore, that for example visits to science centres might be inspiring for learning. This environment is more like the natural environment in which mankind has evolved and which she successfully has explored..

Anatomical & Macroscopic view

The human brain is a very complicated item. Even if it only weights about 2 % of the body's mass, it will need about 20% of the energy, which the body is using. The brain has about 100 billons of nerve cells, neurons, which perform the cognitive functions. The brain has also about 1000 billon glial cells, which support the neurons. Every neuron is on the average connected to many thousand other neurons. The Central Nervous System, CNS, which consists of the brain and the brainstem, is connected to the body via bundles of nerve fibres. The interaction between body and brain is called *proprioception*.

Lobes

The brain is constituted by different parts, which perform different tasks. One way of characterizing the brain is to subdivide it into four lobes: the *frontal lobe*, were higher cognition and emotional evaluation is taking part; the *temporal lobes* at the sides of the brain, were information is distributed to different parts of the brain; the *parietal lobe* at the top of the brain, were sensory and motor signals are activated and the *occipital lobe* at the back of the brain, were the vision system is located. The vision system is hierarchically composed of about 30 interconnected areas were different aspects of incoming information is processed in feed-forward and feed-back modes.

Hemispheres

The brain could also, anatomically be divided into two hemispheres which are slightly asymmetric in relation to their function. These hemispheres are united by a thick nerve bundle, *corpus callosum*. The main brain is called *cerebrum,* and its surface, were the main cognitive, somatosensory and motor activity are located, is called *neocortex.* We have also a hindbrain, *cerebellum*, which among other activities coordinates the motions of the limbs.

Neuronal & Microscopic view

The information processing within the brain is performed by systems of neurons, which make up networks in which we may identify different nuclei. The networks are parts of local systems, which are parts of even more extended systems.

Information processing

Every neuron receives information input from a dendrite network, which is connected to other neurons. The information handling within a neuron is performed by integration of incoming signals. The output signal, which is created when a neuron is firing is transmitted via a single nerve, called an axon. This signal transmission is carried out electrically via ions, which pass through the cell membrane of the nerve cell, and form the electrical *action potential*. Connections are made from the axon fibre to dendrites and to other neurons. A connecting point is called a *synapse*. A synaptic connection is made up of three parts, the presynaptic part, the synaptic gap and the postsynaptic part. The action potential at the presynaptic side releases *chemical neurotransmitters,* which transfers the signal to the postsynaptic side, were a new action potential is created which transfers the signal further to other neurons.

Neural Plasticity

When a child is borne she has in principle all the neurons she will need during her lifetime. What is to be done, in order to fully develop the brain, is however to create synaptic connections between the different neurons. This process is affected by experiences that the child makes in her interaction with her environment.

By nature, the child has a genetic predisposition for adaptation to an environment. After the birth it is however her experiences which create most of these specific connections which makes her brain unique. This means that learning at the "innermost" level could be regarded as the result of the creation and strengthening of synaptic connections.

Learning and *synaptogenesis* are two sides of the same process. The process of synaptogenesis will also lead to flexibility of the brain, which is called *"neural plasticity"*. Our brain is thus not a static item but is changed on a daily basis by our experiences, which creates the associative networks within our minds. A stimulating or enriched environment is thus of great value.

Maybe stimulation of synaptic connections might be achieved better in a science centre than in a classroom as the science centre is more enriched with stimuli, which will interest the learner?

Myelination

One special aspect of cognition is expressed by the speed of the transmission of signals between neurons. This is a process, which is carried out by action potentials. When a child is born, her axons are not fully developed and they are not insulated. This insulation is performed via special cells, *Swann cells* and *oligodenderoglial* cells, and result in a cladding the nerve fibres by a fatty insulation called *myelin.* In the brain we may thus visually observe grey matter, which is composed by neurons and white matter, which is composed of myelinized nerve fibres.

This process of myelination increases the speed of signals from about 4 m/sek up to about 100 m/sek. Myelination takes part first in these parts of the brain, which are most important for life enduring functions as breathing, heart rate and digestion. The last part of the brain to be myelinized is one vital part of the forebrain, the prefrontal cortex, where the highest

intellectual functions take place. This process is completed first when the child has passed the upper teenages. (Spitzer, 2002).

This increase of the speed of the signals is important. It makes it possible for signals within the brain to interact with a great part of the associative network in the neocortex, during the timespan of those seconds that a cognitive issue resides in the *working memory*. This means that the possibility for a youngster to change from concrete description to abstract levels of cognition is facilitated by increase of speed of signal transfer. Teachers know this by experience. Experienced teachers therefore always start from a concrete level in their teaching when they introduce a new subject. It is also important to give the learners ample time for reflection as this process takes time as it connects different and often distal part of the neural network. Information processing is not performed in one location in the brain, but is widely distributed and involves many parts of the brain.

Reward system

Within the brain there is a reward system. This system sends out, from the nucleus in the *limbic* system, a neurotransmitter called *dopamine* to the prefrontal cortex of the brain. This "*dopaminergic"* system gives the brain a lustful feeling, which is recognized as stimulating. This neurotransmitter is released when a person is satisfied with his work and thus he gets an endogenous reward for his achievement.

It has been observed that this reward centre might be "kidnapped" by experiences, which create positive feelings, for example different activities as gambling on the Internet. In the interaction between a teacher and a pupil even a word of appraisal will affect this reward system in a positive way.

Hebbian learning

The Canadian neuroscientist Donald O. Hebb proposed, in a speculative way, already in 1949, a neurological underpinning for learning (Hebb, 1949). This hypothesis has been verified and is regarded as an important neural foundation for the process of learning. Hebb expressed his hypothesis with the words:
*"When an axon of cell A is near enough to excite cell B or repeatedly and consistently takes part in firing it, some growth process or metabolic changes take place in one or both cells such that A´s efficiency, as one of the cells firing B, is increased."*The essence in Hebb´s bold proposition may be caught with the one-liner:*"Cells that fire together wire together."*

Learning is thus, according to the function of the brain, based on creation of new synapses and strengthening of old synaptic connections, as described by Spitzer (Spitzer 2002). This underlines the importance of creating stimulating environments, were learners may make experiences and thus enrich their synaptic connections.

The American neuroscientist Joseph LeDoux, (LeDoux, 2003), expresses his view on learning with the words:"*… the essence of who you are, reflects patterns of interconnectivity between neurons in your brain. Connections between neurons, known as synapses, are the main channels of information flow and storage in the brain. Most of what the brain does is accomplished by synaptic transmission between neurons, and by calling upon the information encoded by past transmission across synapses."*

We have in this context to be aware of the fact that this synaptic connectivity by neurotransmitters might be strongly affected by different substances and thus change the personality of a person. We know for example how use of alcohol may change the character of a person. In pharmacology there are however much more potent drugs.

Unconscious

LeDoux also points out that this process, to a large extent, is performed at an unconscious level (LeDoux, 2004): *"The brain, in other words, learns and stores many things in networks that function outside of conscious awareness. These learned tendencies affect all aspects of mind and behaviour, and are probably at least as important for day – to – day functioning as what we know about ourselves consciously."*

This implies that learning beside its overt and conscious part has a covert and unconscious part. What is learned in for example a Science Centre context might be unconsciously memorized, but still be able to affect future behaviour of visitors.

Hippocampus

Within the brain there are some areas, which are of special interest for the process of learning. In the limbic system there are, at each side of the brain a small neural configuration called *"hippocampus"*. This part is a *convergence zone* for information and is regarded as important for spatial and relational learning. Hippocampi are connected to the cortex via a relay-station in the *thalamus*, which acts as a *divergence zone* for information.

This means that the process of learning, which may be regarded as functioning in a couple of steps, first activates the hippocampus and stores temporarily the content to be learned there. Hippocampus might thus be regarded as a *"gatekeeper*", which sorts out useful information, which makes meaning, from not useful information. Useful information is then, during sleep, transferred to the cortex for long time memorization. The unconscious processes which take part during sleep are thus of outmost importance for learning.

Amygdala

Learning might also involve another part of the brain, the amygdala. This is an organ, which might create a *"short and dirty"* connection between sensory input and action. When a dramatic event occurs it might not be time to ponder different solutions in a creative way. In dramatic incidents, the amygdale will take command and contributes to a fast solution. The American psychologist Steven Johnson (Johnson, 2003) has analyzed a couple of such incidents. When we are learning via the amygdale, then fear is always connected to the memory of that incident. Fear decreases creativity, which has been of value for our ancestors, when encountering for example hungry predators. This way of learning is however not fruitful if the aim is to achieve a situation which enhances creativity. This means that it is important to try to create a positive atmosphere for learners.

Maybe this is what characterizes science communication in a science centre, provided that you are able to manipulate objects and explore phenomena on your own terms?

Memories

We might learn and store information via utilization of different kinds of memory systems. This might partly be done in the *explicit* memory, which we are able to interact with consciously. We have also an *implicit* memory, which we may not reach consciously, but which might be activated by some stimulating words or some sensory stimulation. We have also a *procedural* memory, which is autonomous and is, for example, activated when we learn to drive a car and perform different driving operations unconsciously.

We may also talk about a *semantic* memory, which contains content to be learned and an *episodic* memory which contains episodes of our life.

An important aspect of memories is that they do not store facts as if it was a question of an engraving in a disc. Memories are instead *reconsolidated* every time they are recalled. This makes memory systems volatile. What we remember might be reconstructed in the process of reconsolidation. This means for example that statements of witnesses might be affected by exterior factors and other people. The concept of *"false memories"* is important to have in mind.

In the utilization of our memory systems it is important to pay attention to the importance of trying to place different concepts in a meaningsful context. Our memory systems have a preference for remembering *narratives.* Maybe this is an inheritance from our ancestors who, long time ago, were sitting around a fire and telling stories, which contained their most important and life-saving experiences. Those of the young listeners, who paid attention to these narratives, increased their possibility for survival and reproduction.
For science communication in a science centre it is thus beneficial to use narratives and to concentrate on a few "grand ideas".

Multimodality

Many researchers (Damasio, 1999), (Spitzer, 2002), (LeDoux, 2003) have pointed out the importance for learning of creating multimodal and simultaneous inputs from different sensory systems. If we get inputs from visual, auditory and haptical senses at the same time, then the memory formation is stronger, than if we just get input from a single sensory system. Neurons in different sensory systems will fire together and thus wire together. It is also of value if we are able to get sensory information from the somatosensory system, which is activated if we experience something with our whole body.

It might therefore be beneficial to try to communicate different aspects of the "grand ideas" to the visitor in a science centre through different sensorial input channels.

Usable representations

Damasio (Damasio, 1999) discusses an interesting hypothesis in this context. He creates a way of regarding the content in the mind, which he calls *"usable representations"*. We have, according to Damasio, in our minds earlier memories stored in the form of *usable representations,* which are composed of *systems of neural networks*. When a new experience enters the mind in the form of firing neurons then there is an act, in accordance to Hebbian strengthening of connections, between the neuronal networks in the usable representations and the new neuronal networks, which are carriers of the new experiences.

An association might be made to the research field of "*conceptual change"*.

Is it easier to achieve a conceptual change if we have a mental model for their neural underpinning? Could experience, which is gained, during a visit to a science centre affect and provocate preconceptions and thus create a possibility for conceptual change?

Associative network

The resulting neural information will then be transferred to the neocortex were it will be integrated into associative networks within the brain. Understanding might be understood as the result of information clusters, which might be retrieved from this associative network. The more extensive the neural networks are, which are involved in information retrieval, the deeper and qualitatively better will understanding be. The quality of the process of understanding could thus be regarded as a result of the amount of associations or connections, which exists within the neural network, which could be activated in a cognitive process.

The Hebbian rule about learning at the neuronal level states is applicable here: *"Those who fire together – wire together"*. This implies that the brain has a certain resistance for accumulating "erroneous" facts. These facts will not fit into the associative networks in our brain because an erroneous fact is very seldom repeated. The drawback is however that if an erroneous fact is repeated often enough, then it might be stored in our brain. In this way the Hebbian learning opens up for propaganda. That depends on the fact that something, which is repeated many times creates neural connections, which might affect the content in the retrieved information and thus be regarded as a true statement. This is used in ideological "*brainwashing"* It is thus important to have a solid neural associative network containing so much "correct" information that propagandistic disinformation will be stopped by the gatekeeper hippocampus and will not be able to find neurons to fire together with.

Curiosity

The *phylogenetic* development of the human species has left many traces in our minds, which once were of value for survival of our ancestors. One interesting remaining faculty is our *curiosity.* The origin for this might go back to our ancestors who might be regarding, for example, a strange waving of branches of a bush. It might then be of vital importance to find out if there was a predator hiding in the bush or if it was only the wind, which was moving the foliage. Those of our ancestors who made the right decision were able to reproduce. This implies that we have a predisposition to try to find out about things, which are presented in a fragmented way. If everything is fully explained we might find the subject boring.
For science communication it might thus be of value if a presentation does not aim at exhausting the subject studied, but leaves parts to be completed by learners. When guiding in a science centre it is important for the guide to pay close attention to the attention of the audience and not to explain too many things too carefully.

Chunking

We have a limitation in the capacity of our minds to keep things simultaneously in our *working memory*. The amount of information, which we may store there is, in accordance with the law, which was formulated by the American psychologist George Miller (Miller, 1956), is 7 plus/minus 2 items. It is however possible to utilize the principle of *"chunking"* by

letting every item in the memory function as some sort of container for a number of other related items.

Challenges

One special thing about the brain is that it, in some aspects, could be regarded as a computer, which is operating the control system of a process. This means that in a memory section of the brain, there are "normative" values for data, which are stored from sensors in our body. The brain cheques many times every second inputs from these different sensors in our body via a multitude of incoming, *afferent,* nerve fibres. When the input data are the same as the expected normative values, then nothing is performed by the brain. When, however, there is a difference in the data, the brain has to show interest, perform a correction and sends out a signal via an *efferent* nerve fibre. In this way it is possible for the brain to minimize the number of operations necessary for controlling the body and its homeostatic status.

The brain is thus activated by challenges, i.e. by something which is not expected. If the brain detects a "better" value than expected, then some dopamine is released, to the prefrontal cortex of the brain, as a reward. This indicates that the brain reacts on differences and prefers novelties. It is thus possible to evoke interest in a thing or a process, if the outcome is not as expected. Even the brains of neonates behave in this fashion as described by Lagerkrantz (Lagerkrantz, 1955).

Rule seeking

This means also that the brain, in order not to be overloaded with routine information, always tries to find general rules. The German neuroscientist, Spitzer (Spitzer 2002) has a favourite way to express this behaviour. He points out that our brains are not full of tomatoes. We know the general outlook of a tomato, but have no memory of all the tomatoes we have consumed. This rule seeking behaviour is especially important in learning of languages.

Summary

Concrete: The brain is not ready for abstract thought processes before about the age of about 25 years;
Challenges: The brain likes novelties and challenges and does not react on a mental or somatic homeostatic status;
Generalization: The brain generalizes, categorizes and seeks rules;
Multimodality: The brain remembers things best, which are presented via different sensory input channels;
Context: The brain remembers facts best if they are presented in a context;
Emotion: The brain performs best in a positive atmosphere;
Experience: Learning takes place via experiences, which create changes in synaptic connections;
Chunking: The memory capacity is limited and chunking extends the capacity; **Motivation:** The brain always seeks some sort of challenge;
Understanding: The brain stores information within long term associative networks;
Unconsciousness: Most of the brains mental activity is performed at an unconscious level;
Representations: Representations of the external world are stored within the mind;
Memory: Representations within the memory are consolidated within different parts of the brain and are being reconsolidated when recalled.

Einstein at Universeum - Brain and Mind in Interaction

A team was formed at the National Science Centre Universeum to commemorate Einstein's Magic year of 1905. This was done in order to create an interactive exhibition and to construct a structure for the exposition. It was decided that in the centre of the exposition, there would be a small table on which a model of a brain (Einstein's´) was placed. The reason for this was that Einstein's contributions to science mostly emanated from developing and restructuring mental models, which he behold within his mind.

The strange and adventurous story of Einstein's brain is told by Carolyn Abraham, (Abraham, 2001). Einstein describes his thought processes masterly in his "nekrologue", which he wrote when he was 67 years old, (Schlipp, 1983).

This model of the brain was surrounded by three walls on which there were short presentations of Einstein's life and time. These walls created an enclosure named:
"Einsteinium".
The exhibition area was subdivides by flaps, extending from the walls of "Einsteinium".

Three worldviews

These flaps marked that the exhibition area was subdivided into three main sections:
The **Mikroworld** of the atoms and subatomic particles. Quantum laws were exposed there;
The **Everyday world** of living creatures. Newtonian mechanical and Maxwellian electromagnetic laws were exposed there;
The **Macro world** or the Universe. Consequences of Special and General Theories of Relativity were exposed there.

Interactive experiments presented

The Quantum Staircase – quantization vs. continuity.

Visitors enter the exhibition via a *"quantum staircase*" which had stairs of differing heights. When the visitor, with certain effort, had climbed the stairs he might have become a little confused by the unexpected construction.

Then he had to slide into that part of the exhibition, which was marked as real-world, on a *switchback.* This staircase acted as an interface between the microcosmic world, were quantum laws rule and the real-world were the quantum effects are more subtle. We do seldom experience directly quantum effects in the real-world, if we do not know what to observe, for example the colours at firework displays.

This unexpected entrance was aimed to provoke the visitor, to give a memorable multisensory experience, which, to certain extend, was aimed to created questions in the unconscious mind of the visitor.

The Photoelectric effect

Einstein received his Noble prize in 1922 for the formulation of the law of the photoelectric effect. As a matter of fact he did this already in 1905. Einstein gave his Noble Prize lecture in Göteborg in 1923. The question was how to expose, in the exposition, this connection between Einstein and Göteborg. The ordinary way would have been to just describe this event with some text or some pictures or maybe with a simple illustrative model experiment.

Our team wanted however to make an exposition which would be memorable for the visitors. In this case, we created an enclosure with fine mesh net and had a couple of photoelectric devices. The *challenge* for the visitors was to try to pass the devices. The *reward* was to be able to manipulate a billboard and, if they succeeded they would get a printed message telling them that they were as clever as Einstein. If evaluating this exposition from the neuroscientific point of view, then this exposition appealed to many different senses. It appealed to creativity, challenge and reward and took place in a positive emotional environment in which the participants had real fun.

Wavicle – unification of wave and particle

One of Einstein's main achievements was the unification of wave and particle. In the exposition an illustration of this was achieved by having a rotating disc with a circle painted at one side and a wave at the other. When rotating this disc the two figures overlapped and seemed to fuse together. Here the visitors participated and manipulated the exposited item and formulated overt and covert questions.

Electromagnetism

In the real-world part of the exhibition, the visitors were able to recreate some foundational experiments in physics. One of these experiments emanated from the Danish physicist Hans Christian Örstedt. This famous experiment was first performed in 1820. Örstedt was then able to expose the unification between electrical and magnetic phenomena. Örstedt showed that an electric field initiated a magnetic field. Some years later the English scientist Michael Faraday showed that the reverse also took place: A changing magnetic field could initiate an electric field. These phenomena were known already in antiquity, but had through the ages been regarded as being separated.

Örstedts experiment led to possibilities to construct the electric engine and Faradays experiment led to possibility to construct the electric generator. The scene was thus set for *"the second industrial revolution*", which was geared by electricity.

This practical unification intrigued the Scottish theoretical physicist James Clerk Maxwell who proposed a theory for electromagnetism. This theoretical approach has had enormous consequences for the creation and development of our modern technological society.

The theory of electromagnetism was experimentally tested by the German scientist Heinrich Hertz. Hertz was a believer in the theory of the "ether". Einstein is famous for having abolished the concept of the ether. These experiments expose how ideas, which are deeply entrenches within minds might lead thought astray and also how beneficial it might be to break with established thoughts.

These experiments were also of interactive type and visitors were able to find out how fundamental electromagnetic phenomena did function.

Faradays cage

In the exposition a big model of a Faraday Cage was exposed. It was possible for visitors to enter this cage and to test how this cage affected utilization of cell-phones. A Faraday Cage is made of a mesh of steel-wire and does not allow electromagnetic fields to pass through.

From a neuroscientific point of view this cage created a *multisensory experience,* involving simultaneous inputs from different sensory organs as the visionary system and the auditory system. The immersion and activation of the whole body also creates information, which reaches the brain from sensory cells in the whole body via the system for proprioception.

Space-time – special relativity

The essence of Einstein's Special Theory of Relativity was presented in two expositions. A model of the velocity dependent shortening of an object was illustrated with the help of a model railway train, which could be regarded through a Fresnel lens.

The dilation of time was illustrated in real-time with a detector for pimesones. An explanation was given with text and picture.

These experiments illustrated the strange phenomena encountered when entering the Universe and moving with the speed of light. These phenomena are abstract but the teenagers encounter them in the modern "fairy tales" of Hollywood produced science fiction movies.

Energy and mass

The formula, which describes energy as mass times the square of the velocity of light was used as a crossover bridge between microcosms, were properties of particles are significant variables and macrocosm, and were the velocity of light is of fundamental importance. This formula is part of the culture of science, which almost everybody knows about. It is however impossible to create a real "hands-on" experiment to illustrating it.

Space warp – general relativity – unification of gravitation and geometry

Einstein's General Theory of Relativity explains how the universal force of gravity acts. According to Newton, every object in universe possesses a strange internal attractive force, called gravity. According to Einstein this gravitational force is a property of space. Einstein proposes in 1915 that a massive body will affect the space around it by curving the space. Thus it affects other massive bodies.

In the exhibition an exhibit was created were an elastic sheet of rubber could be warped by a lead ball. The visitors could let small steel balls roll on this rubber sheet. It was in this way possible to illustrate how curvature of "space" acted as gravitation.

Artificial gravity

Astronauts, who are on extended missions in space, encounter physical problems as their bodies are developed and adjusted to counteract the force of gravity on earth. Their muscles and even bones tend to degenerate, when staying in space ships with zero gravity. It is thus important to try to create artificial gravity in a spaceship which is on a mission for a long time. This could be done by building the spaceship in the form of a doughnut, which is spinning around its centre. The astronauts will in this case be exposed to a "*centrifugal force",* which they will interpret as gravitation. This artificial gravity is smaller than the gravity on earth, but might still be beneficial for physiological wellbeing.

In the exhibition a large screen was installed, on which shadows of balls were projected. Via feedback from a camera to a computer it was possible for visitors to interact with these balls. The computer was programmed to give the balls trajectories as if they were in a weak gravitational field.
This exposition appealed to the imagination of the visitors and did put the experiment into a context, which stimulated their imagination.

GPS – utilization of the theories for special relativity and general relativity

In one part of the exposition a General Position System (GPS) monitor was installed. Via computer screens it was possible to study how erroneous the position marking would be if corrections, according to the laws of relativity not were included. This exposition showed how relativity affects our everyday life and it was meant to create interest by the visitors for these theories and their application.

Discussion

Learning in a formal school environment is not a natural way of learning if we consider the phylogenetic development of our specie. Through millions of years our ancestors have learned from experiences by adaptation and accommodation to a changing environment.
By the process of natural selection, those of our ancestors who were not able to react properly when encountering a predator were not able to get offspring's.
Maybe it could be so that learning in an informal environment as a science centre is more natural for learning that just spending time in a schoolroom?

When people visit a science centre they behave in different ways. It is not at all certain that they will act as the constructors of the centre have anticipated. Children tend to run around shouting and playing. One question, which will arise, is: *"Do they really learn anything?"*

According to the synaptic theory of the brain, human beings learn through experiences. At a science centre the children get a lot of experiences for their brains to process and transform into knowledge by interaction with residing neural networks. At the same time we know that in order to learn we have to focus your attention on the learning object. The question is therefore what children might learn. If the children have fun, then emotional and cognitive aspects of the experiences will interact and enhance learning.
When looking at the neuroscientific underpinning of this statement, then we find that we have to take into account different ways of learning and how a memory works.

It is interesting to take into account how these aspects on Nature of Science, which professor Chabay stressed, coincide with aspects, which originate when analyzing the Nature of Mind and which might be found in the construction of the Einstein exhibition.

One aspect of the Einstein exhibition is that it is constructed within the main idea which professor Chabay expressed: There should be a few core concepts to be communicated. In a way the exhibition has focused on the unification laws that Einstein created:
Unification of wave and particle;
Unification of time and space;
Unification energy and mass;
Unification of gravity and geometry.

These principles of unification are well within the rule for the action of the working memory by chunking, but express in a striking way that every chunk may contain a lot of related information.

One thing to notice is that all of the experiments aim to create experiences within minds of visitors. Some of the experience are however at an unconscious level. This unconscious learning may however act as a seed which will germinate later. The experiments will also create mental representations in the form of models or metaphors.

A table will give an overview of the aspects of "*Nature of Science"* and "*Nature of Mind"* as presented in this paper :

Einstein Exposition	Chabay´s aspects	Brain & Mind aspects
Quantum staircase	Core Concept; Mental model	Concrete; Multisensory input; Emotions; Unconscious learning
Photoelectricity	Curiosity; Multimodality Emotions; Motivation; Challenge	Curiosity, Multimodality,Challenge
Wavicle	Understanding;	Understanding
Electromagnetism	Context	Associative neural network
Faradays cage	Challenge	Episodic memory
Spacetime	Understanding	Semantic memory
Energy & mass	Model	Mental model
Space warp	Challenge of concepts	Challenge, Multimodality
Artificial gravity	Context;	Context;
GPS	Make sense	Make sense

In this table the concepts in "*Chabay´s aspects"* are not the same as in "*Brain and Mind aspects",* even if same words are used. All the words in "*Brain and Mind Aspects*" refer to the lengthy explanation in the text about Brain and Mind.

The conclusion reached from this presentation is that it might be fruitful, from the aspect of learning, to regard the neural underpinning to different aspects of science communication.

Concluding remark

It seems finally that the question about a possible marriage between "Nature of Science" and "Nature of Mind" could be answered affirmatively.

Acknowledgement

I want to thank the members of "the Einstein Exposition Group"; Sten Ljungström and Päivi Landén from Universeum, Per-Olof Nilsson from Chalmers University of Technology and Klavs Hansen from Göteborg University for inspiring cooperation.

I want to thank Gunnar Windahl for valuable discussions and Professor Manfred Spitzer and his coworkers from TransferZentrum für Neurowissenshaft und Lernen in Ulm for guiding us in this field. I also want to thank my collegue Carl Olivestam for his active engagement in introducing this topic at our department and Peter Baeza for his inspiring and pioneering papers in this field.

References

Abraham, C. (2001): The Bizarre Odyssey of Einstein´s Brain. Faber & Faber Ltd. London.
Baeza, Peter (2005): Emotion och Lärande – om Neuropedagogik och två sätt att examinera. C-Uppsats, Institutionen för Pedagogik och Didaktik, Göteborg University.
Baeza, Peter. (2005); Tio års hjärnforskning I svensk dagspress; vetenskap eller neuromyter. C-uppsats 10 poäng. Psykologisk fördjupningskurs 1. Ht 2005.
Bruer, J. T. (1997): Education and the brain: a bridge too far. Ed. Researcher, 26(8), 4-16.
Damasio, A. (1999): Cartesius misstag. Natur och Kultur. Stockholm.
Damasio, A. (2000): The Feeling of What Happens. Body. Vintage, London.
Freud, s. (1900). Drömtydning. S Skr, I:546-547. Natur & Kultur. Stockholm. 1996. Citerat i Damasio (1999).
Gazzaniga, M., Ivry, R. B. & Mangun, G. R. (2002): Cognitive Neuroscience. The biology of the mind. W.W. Norton & Company Inc.New York.
Gärdenfors, Peter (2005): Tankens vindlar – Om språk, minne och berättande. Nya Doxa
Kolb, B. & Whishaw, I. Q (2001): An Introduction to Brain and Behaviour, Worth Publishers
Lagercrantz, Hugo (2005). I barnets hjärna. Bonnier Fakta.
LeDoux, J. (2003): Synaptic self. How Our Brain Become Who We Are. Penguine Books. New York.
LeDoux, J. (2004): The Emotional Brain. Clays Ltd. London.
Johnson, Steven (2004): Mind Wide Open. Scribner.
Miller, G. A. (1956): The magic number seven, plus or minus two: Some limits on our capacity for processing information. Psychological Review, 63(2), 81-97.
Hebb, D. O. (1949): The Organization of Behavior. John Wiley & Sons, New York.
OECD. (2002). Understanding the brain, towards a new learning science. Paris: OECD Publications.
Petersson, K. M. (2005): Learning and memory in the human brain (Dissertation, Karolinska Institutet). http://diss.kib.ki.se/2005/91-7140-304-3/thesis.pdf.
Raichle, M. E. (1999): Visualizing the Mind. In The Scientific American Book of the Brain. Scientific American Inc.
Schlipp, P.A. (Ed.) (1983): Albert Einstein als Philosoph und Naturforscher. Vieweg.
Spitzer, M.(2002): Lernen. Gehirnforschung und die Schule des Lebens. Spektrum Akad. Verl.
Spitzer, M. (2004): Selbsbestimmen. Gehirnforschung und die Frage: Was sollen wir tun? Spektrum Akad. Verl.
Spitzer, M. (2005): Nervsachen. Geschichten vom Gehirn. Suhrkamp.

TIME (7 June 2004): Secrets of the Teen brain. Research is revolutioning our view of the adolescent mind – and explaining its mystifying ways.
Windahl, G. (20002): Vem Diggar Darwin? Unpublished manuscript.

Learning and Neuroscience

The next paper is mainly presented in Swedish. There are however fairly large and important citations in English, which even without the English text will make this paper possible to be understood. The paper was presented at a conference about “Development of Education” and the target group was teacher trainers in Science in the Nordic Countries.
The aim of this paper is to discuss the possibilities of developing a *neuro-psycho-socio theory* for learning by enriching existing theories.

9. Lärande ur ett neurovetenskapligt perspektiv.

Peter Baeza, Bengt Johansson och Aadu Ott Institutionen för pedagogik och didaktik, Göteborgs universitet

Paper presenterat på Rikskonferensen *"Utbildning i utveckling"* för lärarutbildare i naturvetenskap NALUT den 22-23 mars 2007 i Umeå.

Abstract

Erfarenheter från två forskarutbildningskurser i neurovetenskap med inriktning mot undervisning och lärande har genomförts och påvisat det fruktbara i att utveckla de etablerade pedagogiska och didaktiska teorierna om lärande till att även omfatta en neurovetenskaplig aspekt. De diskussioner och tankar som utbytts under kursens gång har på ett påtagligt sätt berikat insikten om hur hjärnan bearbetar information och om hur lärande går till på den neurala nivån. En sådan ansats kan leda till praktiska tillämpningar i undervisningen och förtjänar därför att uppmärksammas inom lärarutbildningen i Sverige. Det genombrott som, genom studier av hjärnans funktion med modern scanningteknik, har skett på det neurovetenskapliga forskningsfältet kan skapa nya och potentiellt fruktbara möjligheter för forskning om hur lärandeprocessen skulle kunna förbättras.

Bakgrund

Konferensens tema "*Utbildning i utveckling"* fångade författarnas intresse eftersom vi, sedan några år tillbaka, försöker att ompröva etablerade teorier för lärande och söker finna nya teoretisk utgångspunkter i ljuset av kunskapsutvecklingen inom närliggande ämnesområden som exempelvis biologi. Vi har därför med stort intresse uppmärksammat de möjligheter för att studera lärande som modern hjärnforskning har pekat på under senare år.

En naturlig fråga att ställa är: *"Kan kunskaper om hjärnans funktion vara av intressen för lärande och undervisning?"*

Blackmore & Frith (2006), som båda är ledande forskare inom neurovetenskap i England, inleder sin bästsäljande bok, ***"The learning brain – lessons for education"*** med orden:

"Knowledge of how the brain learns could, and will have a great impact on education. Understanding the brain mechanisms that underlie learning and memory, and the effect of genetics, the environment, emotion, and age on learning could transform educational strategies and enable us to design programs that optimize learning for people of all ages and of all needs. Only by understanding how the brain acquires and lays down information and skills will we be able to reach the limits of its capacity to learn."

Manfred Spitzer, som leder "TransferZentrum für Neurowissenschaft und Lernen" i Ulm skriver i förordet till sin bok ***"Lernen – Gehirnforschung und die Schule des Lebens":***

"Lernen findet im Kopf statt. Was der Magen für Verdauung, die Beine für Bewegung oder die Augen für das Sehen sind, ist das Gehirn für das Lernen. Daher sind die Ergebnisse der Erforschung des Gehirn für das Lernen etwas so wichtig wie die Astrophysik für die Raumfahrt oder die Muskel – und Gelenkphysiologie für den Sport. Die Wissenschaft von den

Nervenzellen und dem Gehirn, die Neurobiologie, hat in den letzten Jahren einen beispielslosen Aufschwung durchgemacht und zu noch vor wenigen Jahren ungeahnten Ergebnissen geführt."

OECD (2003) framhåller i sin inflytelserika publication: ***Understanding the brain, towards a new learning science:***

"With the advent of functional imaging of the brain a paradigmatic shift has occurred in that studies that can be performed in the intact brain on a systems level while the actual task is performed. Most of these methods rest on the fact that the brain has limited stores of energy and increases its blood flow and metabolism in response to changes in neuronal work."

OECD (ibid) ger en programförklaring:

"The aims of this publication are threefold:
** to report on and further develop a creative dialogue between several disciplines and interests (cognitive neuroscience, psychology, education, health and policy);*
** to discover what insights in cognitive neuroscience might offer to education and educational policy and vice-versa;*
** to identify questions and issues in the understanding of human learning were education needs help from other disciplines."*

OECD (ibid) utvecklar sin policy vidare:

"The number of discoveries from brain research that have been exploited by the learning sciences is still slim, perhaps due to the fact that there have historically been few direct contacts between brain and learning scientists, and little consensus on the potential applications of brain research to learning science. But there are various reasons for creating more bridges between the two research communities. For instance, new findings about brain's plasticity to learn anew over the individual lifecycle have been made and new technologies for non-invasive brain scanning and imaging are opening up totally new methods of work for research. By bringing the two research communities closer as part of their work, a likelihood of making more value-added discoveries has been pointed out."

Att försöka åstadkomma växelverkan mellan neurovetenskap och pedagogik är en utmaning som vi har antagit. Vi har inlett en viss samverkan med såväl nationella som internationella institutioner som arbetar med neurovetenskaplig forskning.

Detta "paper" syftar till att undersöka om det finns underlag för att utveckla etablerade teorier för lärande genom att försöka berika innehållet i dessa teorier genom att anknyta till en biologisk och materiell grund. Vår strävan är att försöka tillskapa underlag för en **neuro – psyko – social teori för lärande**.

Geake, J. & Cooper, P (2003), internationellt kända forskare inom neurovetenskap, har redan tänkt i sådana banor och framhåller:

"Recent research into the function of the human brain has greatly enhanced the understanding of cognitive behaviours fundamental to education as for example: learning, memory, cognition, emotion, motivation and attitude. It might be of value to advance a neuro-psycho-social position that utilizes multi-disciplinary perspectives on current educational

challenges. Implications from research might in some cases support conventional pedagogical wisdom while in other cases be counter-intuitive."

Författarna sammanfattar: *"…the education profession could benefit from embracing rather than ignoring cognitive neuroscience."*

Det är inte förvånande att det har dröjt så länge innan relevant kunskap om hjärnans inre struktur och funktion har blivit tillgänglig för utbildningsändamål. Såväl hård- som mjukvara för sådana tillämpningar har kommit fram först under åren kring det senaste sekelskiftet. Bidragande till denna kunskapstillväxt har varit samarbete som har ägt rum över disciplingränserna mellan pedagogik, psykologi, neurovetenskap, medicin, fysik, kemi, biologi, filosofi och inte minst teknologi. Det har underbyggt den, i dynamisk utveckling varande, nya synen på sambanden mellan hjärnans förmåga till:*perception, kognition, emotion, minne och lärande mm.*

Lärandet sker naturligtvis i hjärnan – men hur?

Olika teoretiska ansatser för att försöka förstå hur processen för lärande sker, har utvecklats inom ramen för olika perspektiv på människan och hennes växelverkan med sin, i ständig förändring varande, omgivning.

Frågan om arv & miljö, gener & erfarenheter, kommer naturligtvis in i bilden. Man skulle kunna hävda ståndpunkten att arvet ger oss ram och möjligheter för hjärnans utveckling (Lagerkranz, 2005). Det är emellertid våra egna personliga erfarenheter som slutgiltigt formar såväl hjärnans hårdvara som dess inre mentala landskap. På engelska kallas den processen för *fine-tuning,* Blackmore et al (2006).

Den engelske forskaren inom neurovetenskap, Steven Rose (2003) anför att vi, i vårt tänkande, är handikappade av vår västerländska fallenhet för att forma våra tankar i dikotomier såsom: *"arv eller miljö", "process eller produkt", "psyke eller soma"* etc.
Ett mer fruktbart sätt att betrakta sådana begrepp är att istället lägga vikt vid deras växelverkan: *"arv och miljö", "process och produkt"* etc. Ett sådant betraktelsesätt är särskilt viktigt ifråga om synen på och tolkningen av hjärnans funktion, framhåller Rose (ibid).

Kanske skulle det vara möjligt att nu försöka sträva efter en syntes mellan olika teorierna för lärande, genom metastudier av andra studier av *"Lärande på hjärnans villkor"*. En slutsats är att en sådan teoretisk ansats skulle kunna utgöra en motsvarighet till naturvetenskapens sökande efter en storförenande teori "*Grand Unified Theory"* (GUT). En sådan teori måste innefatta ett beaktande av såväl *neurala, psykologiska* som *sociala* faktorer. Borde inte en strävan efter helhetssyn på lärande utgå från kunskaper om och insikter i hjärnans funktion? Kan man kunna kalla en sådan ansats för en **"***neuro – psyko – social"* teori?

OECD (ibid) diskuterar nuläget för teorier om lärande och drar slutsatsen:

"The science of learning, a branch of human psychology, is still in its infancy.
The theory of learning is pre-scientific – in the sense that it lacks as yet either predictive or explanatory power.
We do not understand sufficiently well how children and adults learn to dare to offer an educational or training guarantee.

The science of learning is in its Linnean phase, drawing up lists of examples of successful learning, clarifying and sorting effective teaching practices;
But it still awaits its Darwin with a powerful explanatory theory of learning."
"Education today is a pre-scientific discipline, reliant upon psychology (philosophy, sociology etc.) for its theoretical foundation. This book explores the possibility that cognitive neuroscience might in due course offer a sounder basis for the understanding of learning and the practice of teaching. "
"Learning can be defined as a process by which the cerebral nervous system functionally restructures its processing pathways or its representations of information."

Är det möjligt att kunna skönja en ny emergent teori för lärande, som skulle kunna främja båda disciplinerna? I varje fall anser John Geake och Peter Cooper (2003) så i sin artikel *"Cognitive Neuroscience: Implications **for** Education?*

Top down & Bottom up

En *neuro –psyko – socialt ansats* skulle kunna innebära att man anlägger ett top-down perspektiv, grundat på Lew Vygotsky´s sociokulturella teori tillsammans med ett bottom-up perspektiv, grundat på kognitiv neurovetenskap. Från båda hållen skulle man kunna sträva man efter att fördjupa den kognitiva psykologiska ansatsen som exempelvis Piagets välkända konstruktivistiska och epistemologiska teorier om kunskap, lärande och beteende representerar. Strävan är bl a att försöka förankra Piagets antaganden i det empiriskt neurologiska faktaunderlag, som har kommit fram under de senaste åren. Det har skett med hjälp av modern utrustning för hjärnskanning av människor som, liggande i stora klaustrofobiframkallande apparater, löser olika slag av problem som presenteras för dem i realtid.

OECD-CERI (2005) uttrycker det som deltagarna i en konferens om lärande och hjärnans funktion nått konsensus om med orden:

"Participants began to link this educational conception of learning as a social endeavour with the neuroscientific conception of learning as molecular events in the brain. Traditional constructivist theories of learning assert that meaning is not passively transmitted to the learner, but actively constructed by the learner.
The participatory theory of learning adds that it is constructed within the constraints of a particular socio-cultural environment.
Working from this framework of educational theory, learning is an active, socio-culturally-mediated process.
From a neuroscientific perspective, learning occurs as a cascade of molecular events resulting in structural modification with significance for subsequent learning.
Therefore, learning could be described as a series of socio-culturally-mediated adaptations of brain structures with functional consequences."

En kanske inte alldeles snäll, men ändå, pregnant bild för skillnaden mellan den piagetanska teoribildningen och en teoribildning som kan grundas på neurovetenskap är Flammarions metaforiska bilden från 1800-talet där den medeltida världsbilden, med sina metafysiska sfärer, genombryts av en våghalsig forskare som tittar ut och skådar en helt annan och ny värld eller världsordning. Väl att märka, att skåda en ny värld manar till eftertanke.

Denna nya, på neurovetenskap baserade, syn på lärande skapar fler frågor än den löser. Men ett helt nytt spännande och lovande forskningsfält öppnar sig för forskare som har nyfikenheten bevarad och har ett öppet sinne för förändringar. Det är inte ofta, inom en forskares livstid, som ett helt nytt och jungfruligt forskningsfält öppnas för beforskande. Fysikerna upplevde en liknande period då atomteorin utvecklades i början av 1900-talet. 1920- och 30-talen kallas för atomfysikens heroiska guldålder.

Kan man tänka sig att något liknande är på gång nu ifråga om studier av hjärnan och dess koppling till lärande?

Naturen, lika väl som hjärnan, måste emellertid beforskas såväl empiriskt som teoretiskt – inget är i någon positivistisk bemärkelse öppet för forskaren att bara upptäcka. Men en lika spännande resa in i hjärnan har inletts nu, som resan in i mikrokosmos var under 1900-talets början, eller resan ut i makrokosmos, som är på gång nu under 2000-talet.
I varje fall så är det klart att många antaganden och tankestrukturer måste omprövas i ljuset av de nya upptäckter som har ägt och ständigt äger rum.

OECD-CERI (2005) diskuterar möjligheterna av ett tvärvetenskapligt samarbete:

”Progress is not only dependent upon scientific results, but also on the commitment to build avenues of communication. Strengthening connections among neuroscientists and educators, and aligning their activity and focused intervention where identified as primary goals. It was suggested that colleagues from neuroscience and education jointly review the international literature in both fields; accuracy in interdisciplinary work can only be achieved when work is read in the original.”
“Another fundamental aspect of building this field is educating its members. It is necessary to develop a pool of human resources of managing the emerging knowledge. This involves creating a new career path. …to encourage the establishment of interdisciplinary laboratories, societies, journals, conferences and electronic discussion forums. ….such programs´ curriculum could follow a trans-disciplinary sequence: molecular to cellular to brain systems to individual body systems to social systems.”

En neuro – psyko – social ansats

Utgående från ett neuralt perspektiv innebär lärande en process i vilken det centrala nervsystemet (CNS), på ett funktionellt sätt, bygger upp neurala nätverk (association) och emellanåt omstrukturerar sina vägar (ackomodation) för behandling av information och av sin representation av information. Informationsinnehållet hos en grupp av neuroner kan betecknas som ett *mentalt tillstånd.* Ny information, som tillförs genom den lärandes erfarenheter, kan omstrukturera detta innehåll och då uppstår ett *nytt mentalt tillstånd*. Därigenom uppstår en förändring av beteendet vilket kan observeras. En sådan process kan kort och gott benämnas lärande.

Det är emellertid först nu som sådana observerbara beteendeförändringar, till viss del, kan förknippas med den neurala förändring som äger rum i hjärnan. Hjärnan är ett lärande organ, vars lärande sker genom att den lärande individen tillförs olika slag av upplevelser som ger upphov till erfarenheter (experiences). Dessa erfarenheter kommer att genom omkopplingar mellan nervceller att förändrar och koppla om nervstrukturen i hjärnans inre anatomi. Vi är således slavar under hjärnans ständiga lärande – frågan är bara vad vi lär? Spitzer (2002) och Johnson (2004) belyser den frågan.

Konstruktivism

Inom kognitiv psykologi, som exempelvis Piagets välkända individuella konstruktivism, postuleras att det finns *tankestrukturer* i hjärnan. Viktiga antagna begrepp inom denna individuella konstruktivism är *assimilation*, *ackomodation* och *självreglering*. Genom att anlägga ett neuralt perspektiv på denna variant av konstruktivism skulle man kunna ge materiell substans åt dessa antagna mentala begrepp eller psykologiska konstrukt. Tankestrukturer kan betraktas som resultat av minnesfunktioner som emellertid har olika egenskaper på grund av olika kopplingar mellan neuroner och grupper av neuroner i skilda delar av hjärnan. Egentligen vet vi inte vad tankar är för något och därför är det något vanskligt att tala om tankestrukturer. Begrepp som assimilation och ackomodation har likaså en vag förklaringspotential. Spitzer framhöll att de förklarar allt och ingenting (private communication).

Harmonisk --- konfliktfylld tankeutveckling

En annan utgångspunkt i piagetanskt tänkande är att man postulerar att kunskap inte kan överföras mellan personer. Den lärande lär sig genom att aktivt manipulera artefakter i omvärlden. Den piagetanske eleven fungerar som en liten vetenskapsman som utför försök och drar slutsatser.

Vetenskapsteoretiker som Thomas Kuhn, Karl Popper m fl, argumenterar för synsättet att experiment är teoriledda. Elever saknar, av naturliga skäl, djupare teoriinsikt och den s.k. forskning som de kan bedriva kan naturligtvis inte leda fram till att de kan finna sådana naturvetenskapliga begrepp som används inom naturvetenskapen. Dessa begrepp är ytterst resultatet av sociala konstruktioner och de överenskommelser som sker i ett vetenskapssamhälle.

Neurovetenskaplig forskning har emellertid visat hur en elev, som uppmärksamt följer en demonstration, aktiverar samma delar i hjärnan som styr den demonstrerande lärarens agerande. Eleven deltar i en aktivitet som kan kallas för lärande. Skulle man kunna kalla det för överföring av kunskaper? De neuroner som är aktiva i sådana processer kallas för *spegelneuroner.*

Ett perspektiv på teoriutveckling är att den, då den är som mest fruktbar och framgångsrik, är konfliktfyllt. Ett harmoniskt förhållande kan betraktas som tecken på stagnation. Samtidigt är det naturligtvis svårt för ett nytt synsätt, på exempelvis lärande, att få fäste i en akademisk kultur där det redan finns väl etablerade teorier.

Problematiken har bl a sin grund i att, då en helt ny disciplin introduceras så uppstår helt nya krav på ämnesinsikt och kunnande. Det är krav på kunnande som det tar mycket lång tid att tillägna sig. Men vare sig vi vill eller inte så har en helt ny forskningsfront med en vidare och mer djuplodande kunskapshorisont etablerats än vad etablerade pedagogiska teorier står för. Så länge en teoriutveckling är levande, så slår det gnistor om den – gnistor som skapar intresse.
Den amerikanske forskare David Bjorklund formulerar hur han känner sig i sitt sökande efter en ny metateori i titeln på sitt paper ”*Piaget is dead and I Don´t Feel So Good Myself*”. (Bjorklund, 1997.)

Sociokulturellt perspektiv

Utgående från ett sociokulturellt perspektiv sker lärande genom att kunskap, i ett första steg, medieras socialt och inter-personellt men lärs, i ett andra steg, in kognitivt och intra-personellt. Även här kan ett neuralt perspektiv vara befrämjande för förståelsen av hur lärandeprocessen sker. Socialt vunna erfarenheter strukturerar om hjärnans kopplingar, vilka tillsammans med den psykologiska fasen skapar *inre representationer* eller *mentala tillstånd* i hjärnan i form av kopplingar mellan neuroner och grupper av neuroner.

OECD (ibid) skriver:

"Social cognition has its roots in social psychology which attempts "to understand and explain how the thoughts, feelings and behaviour of individuals are influences by the actual, imagined or implied presence of others". It studies individuals within a social or cultural context and focuses on how people perceive and interpret information they generate themselves – (intra-personal) and from others (interpersonal). The ability to understand other minds in the immediate proximity is one important function for social systems."

Ett centralt begrepp inom den sociokulturella teorin är den närmaste utvecklingszonen, *"Zone of Proximal Development"*. Den skulle enkelt kunna förklaras på en neural nivå:

Den inre zonen, med beaktande av funktionen hos hjärnans reglersystem, då ingen förändring av ingående värden finns,
Den yttre zonen genom att inget associativt neuralt nätverk finns.
 # Den mellanliggande zonen, som gynnar lärandeprocessen har ett *protoassociativt kognitivt nätverk* som man kan anknyta till och utveckla vidare.
Där finns, med den amerikanske neurologen Antonio Damasios (1999,2000) ord, *"disponibla neurala representationer"* som kan utvecklas vidare.

Språkets betydelse för kommunikation och lärande är central i det sociokulturella perspektivet. Omfattande neurologiska studier har utforskat hjärnans bearbetning av språklig information. Olika moduler i hjärnans vänstra tinningslob behandlar olika aspekter av språket: *Wernikes area* bearbetar semantiska aspekter, *Brocas area* behandlar motoriken vid formulering av ord.

OECD-CERI (2005) framhåller:

"Individuals continually engage in an exchange with their environment, which contains a sea of symbols, or socio-culturally-mediated bytes of meaning. Inhabitants of the environment continually modify the meaning of these symbols via behaviour. An iterative process occurs whereby meaning-laden symbols impact brain structure, influencing behaviour, which reshapes the meaning of symbols. In this way, individuals´ brains influence one another indirectly through their environment. This type of social neuroscientific perspective could provide an important link between the disciplines of education and neuroscience."

I OECD´s program för studier av lärande studeras litteracy och dyslexi. Man finner att funktionen hos många av modulerna i hjärnan påverkar tal och kommunikation. Ett neurologiskt perspektiv skulle kunna bidra till att skapa en fördjupad förståelse av det sociokulturella perspektivets centrala kärna: språk och kommunikation. Hjärnans modulära uppbyggnad diskuteras utförligt av Nobelpristagaren Gerald Edelman (2006).

Som struktur för det neurobiologiska perspektivet som presenteras i detta ”paper” väljer vi att betrakta det studerade temat, ”*Lärande ur ett neurovetenskapligt perspektiv”* ur fyra olika synvinklar för att avsluta med en sammanfattning av implikationer för lärande.

Utveckling

Den kände biologen Ernst Haekel har framhållit att inget i biologin kan ses som förnuftigt utom ur ett *evolutionärt perspektiv*. Det är en synpunkt som Richard Dawkin också betonar i sina många böcker om människans utveckling. När man studerar hjärnan kommer man inte förbi nödvändigheten av att anlägga ett neurobiologiskt perspektiv på ämnet. Den fylogenetiska utvecklingen hos en biologisk art är mycket viktig. Till detta måste man addera den ontogenetiska utvecklingen, dvs individens egen bio - sociala utveckling. Dessa frågor diskuteras utförligt av Steven Rose (2003) och av Hugo Lagerkranz (2005).

Det är av värde att beakta att det på senare år har skett ett paradigmskifte ifråga om kunskap om hjärnans funktion. Metoder för att studera den levande hjärnans funktion i realtid har utvecklats. Tekniska tillämpningar som **fMRI** (funktionell ”avbildning med magnetresonans” i realtid), **PET** (studier med positron emission tomografi), **EEC** (elektroencephalogram, studier av hjärnvågor, vilket ger tidsförlopp), **ERP** (Evidence Related Processes, studier av var hjärnvågor uppkommer samt deras tidsförlopp), **OT** (Optisk Tomografi, dvs genomlysning av hjärnan), **NIRS** (Near Infrared Spectroscopy, genomlysning av hjärnan med infrarött ljus). **TMS** (Transcranial Magnetic Stimulation, en process som innebär att delar av hjärnan temporärt stängs av med hjälp av magnetiska pulser), **DPI** (Differential Tentor Imaging, en process som kan påvisa aktiviten i nervbanor) m fl har helt revolutionerat hjärnforskningen, Blackmore et al, (2006). Zull (2002), Rose (2003).

OECD (ibid) beskriver denna utveckling med orden:
“With the advent of functional imaging of the brain a paradigmatic shift has occurred in that studies can be performed in the intact brain on a systems level while the actual task is performed. Most of these methods rest on the fact that the brain has limited stores of energy and increases its blood flow and metabolism in response to changes in neuronal work.”

Man kan nu återge bilder och sekvenser som visar på hur och var i hjärnan hos en frisk person olika slag av data bearbetas. Hjärnprocesserna kan på så sätt studeras med såväl rumslig som tidsmässig upplösning. Från att iaktta och tolka ett yttre beteende hos en individ, kan man nu direkt iaktta områden i hjärnan där aktivitet, som styr och initierar det iakttagna beteendet äger rum. Man kan tala om studier i fyra dimensioner, tre rumsdimensioner och en tidsdimension.

Reifiering

Då man betraktar bilder av framprepparerade nervceller, så måste man beakta att den avbildning som man betraktar egentligen är en avbildning av neuroner i form av ett stelnat fossil. I en levande hjärna sker hela tiden en mängd, även för ett iakttagande öga synliga, förändringar. Man ser genom ett förstorande instrument rörelser hos nervceller och nervtrådar, kopplingar och omkopplingar. Den statiska bild som vi kan få genom att iaktta preparat, måste omprövas. Vi faller lätt offer för *reifiering* eller förtingligande av ett *dynamiskt* skeende och frestas att göra om en *dynamisk process* till en *statisk produkt.* Det försvårar för oss när vi försöker att förstå hjärnans inre arbete.

På en tavla av den surrealistiske målaren Renée Magritte sitter målaren och målat av ett ägg. Det som framträder på tavlan är emellertid bilden av en färggrann fågel. Kanske är det här en pregnant metafor för att förstå hur intrikata studier av hjärnan, modern utrustning till trots, ändå är? Det enda vi egentligen kan se, utan instrument eller teorier, är grå och vit hjärnsubstans. Att den gråa massan består av miljarder mikroskopiska neuroner och att den vita massan består av nervtrådar, som isolerats av fettliknande gliaceller, fick man experimentella och teoretiska belägg för först i början av 1900-talet.

Även här måste man emellertid, inom ramen för en föränderlig teori, kritiskt tolka det som man kan iaktta. Man måste också beakta de invändningar som förts fram mot dessa, på invecklade apparater, baserade metoder för att studera hjärnan. Dessa avbildningar av hjärnans arbete, i form av svårtolkade färgprickar, har även, av vissa kritiker, kallats för exempel på modern frenologi.

Frenologi var en 1700-tals teknik som gick ut på att studera knölar på skallbenet och att relatera dem till beteenden hos individen. Ett uttryck i språket, som lever kvar från den tiden är *”geniknölar”*. Varningsord har också framförts av exempelvis John Bruer (1997) som framhåller att man inte kan gå från *”neuroscience to education”* utan att man måste beakta mellansteget av *kognitiv psykologi*. Sådana varningsord beträffande övertolkning av neurovetenskaplig empiri är viktiga att beakta.

Växelverkan

Växelverkan sker mellan yttre stimuli i omvärlden och de representationer av omvärlden som finns i hjärnan och som inom didaktiken kallas för *förföreställningar.* Denna växelverkan skapar om och påverkar kontinuerligt hjärnans inre mentala landskap. Den sociala dimensionen är viktig och spelar en avgörande roll för en individs mentala utveckling. Det som påverkar hjärnans inre anatomiska kopplingar är främst de erfarenheter som människan gör i den yttre miljön. Den genetiska informationen ger naturligtvis en generalplan för hjärnans struktur, men individens erfarenheter fyller ut detaljerna. Det betyder att man kan, på relativt goda grunder, anse att arv och miljö påverkar i ungefär lika hög grad hjärnans utveckling.

Våra varseblivningar tolkas, filtreras och omformas av olika system i själva hjärnan. Det är system som blivit påverkade av andra och tidigare erfarenheter. Elevens växelverkan med omvärlden, med hjälp av input från alla sina sinnen, är viktig och utgör en grund för hennes fortsatta och livslånga lärande.
Hjärnan skapar sig, enligt Peter Gärdenfors (2005, 2006), föreställningar om fenomen i omvärlden. En del av dessa kan vara bundna och kopplade direkt till den förnimbara omvärlden. En annan grupp av föreställningar är emellertid obundna. Inom dessa kan man inordna exempelvis troll och spöken – det är mentala konstrukt som inte finns. Någon har sagt:*”Jag tror inte på spöken – men jag är rädd för dem.”*

Inom de fria föreställningarnas ram faller också kreativitet och fantasi. Filosofen Immanuel Kant framhöll: *”Erfarenhet lär oss hur saker fungerar, men inte hur de skulle kunna fungera.”* Vi behöver således fantasi för att kunna vara kreativa – men kreativitet måste alltid matchas av och kontrolleras av god och relevanta ämneskunskap som fås genom växelverkan med fenomen den reella världen.

Funktion

Inom ramen för det här perspektivet studeras fyra olika delfunktioner hos ett system. Hjärnan kan, trots att det är ett biologiskt system, ändå jämföras med och behandlas som om det vore en funktionell del av ett tekniskt autonomt system. En teknikgren som har paralleller med hjärnans funktion sysslar med att studera *”Autonoma Neurala Nätverk”.* Det är nätverk där neuroner motsvaras av transistorer. Sådana nätverk kan vara läraktiga genom att det finns en nivå där data, som kommer in från sensorer, jämförs och kalibreras mot inprogrammerade kända värden. När en robot, byggd enligt ANN konceptet, mäter upp något okänt värde så bedöms det uppmätta värdet enligt det program som roboten använt för sitt tidigare lärande.

Parallellen till elevers lärande är uppenbar – eleven måste ha goda ämneskunskaper för att kunna bedöma och värdera ny information som hon får genom växelverkan med sin omgivning. Här får vi inte tankemässigt skilja mellan process och produkt: för att kunna hämta (process) något (produkt) så måste eleven ha tidigare kunskaper (produkt). Hämtandet från de enorma källor som finns tillgängliga nuförtiden kräver utveckling av förmåga till sovring och bedömning.

En viktig delfunktion hos hjärnan är att den kan lagra information i olika slag av minnen. Dessa är bl a *explicita*, dvs medvetna och *implicita*, dvs omedvetna. Minnen kan också vara *procedurella*, dvs automatiska som exempelvis bilkörning. Man kan också tala om *episodiska* minnen av personliga händelser och upplevelser eller om *semantiska* minnen som berör faktakunskaper. En viktig hjärnfunktion verkställs av *arbetsminnet*.

Den kanadensiske hjärnforskare Endel Tulving har framfört tankar om att det inte finns några fast lokaliserade minnesbanker i hjärnan som vi kan hämta lagrad information från. Minnen påverkas varje gång som vi vill minnas något. Det sker genom att neuroner i olika grupperingar och spridda över stora delar av neokortex gör ett syntes av den företeelse som vi vill minnas. Vi *rekonsoliderar* nya minnen varje gång som vi vill återkalla något från vårt minne. Det är en syn som också Steven Rose (2003) delar. Här finner vi åter hur reifiering påverkar vårt sätt att betrakta innehållet i ett minne, vi nyttjar gärna metaforen bandspelare då vi tänker på minnets innehåll.

Hjärnan fungerar internt på så sätt att den transformerar om inkommande sensoriska intryck till *elektro-kemiska signaler* som transporteras i nervtrådar till olika delar av hjärnan för vidare behandling. Hjärnan styr också signaler via *feed-forward* och *feed-back.*

Det som gör att den mänskliga hjärnan är helt överlägsen alla hittills konstruerade superdatorer är dess förmåga till massiv parallell behandling av information. Datorer arbetar, som vi vet, sekventiellt. Visserligen kan en superdator utföra enormt många fler enkla räkneoperationer än en mänsklig hjärna på en given tidsenhet. Men det är också allt som den kan.

Ett spännande forskningsområde berör *”the binding problem”,* dvs hur hjärnan binder samman sinnesintryck från syn, hörsel och känsel till en enhetlig upplevelse. Steven Rose (ibid) utvecklar tankar kring detta fenomen genom ett exempel som beskriver hur han uppfattar hur en snabb röd bus närmar sig. Neuroner i hjärnan delar upp perceptionen genom att vissa neuroner behandlar hörn och kanter, vissa rörelsen, vissa färgen och vissa identifierar objektet som en buss. Det sker alltså en omfattande simultan behandling av inkommande information från olika sinnesmoduler. Synbarken registrerar inte bara ingående information

utan ställer även aktivt frågor till inorganet, retinan i ögat, som egentligen är en del av hjärnan, för att skapa mening i den inkommande informationen.

Det gäller därefter för hjärnans kognitiva system, att kunna binda ihop all denna information till en enhetlig bild av det studerade fenomenet. Skulle det betraktade rörelsemönstret hos föremålet ifråga stämma överens med tidigare, som hotande upplevda erfarenheter så sänds dessutom en signal till det inre organet i det limbiska systemet, amygdala. Det organet signalerar fara och försätter kroppen i beredskap för att exempelvis ordna så att Steven hoppar undan för den annalkande bussen. Edelman (ibid) diskuterar ingående denna process.

Förloppet kan beskrivas som en informationsväg från perceptioner som, via det visuella systemet, når relästationen i thalamus och därifrån kopplas vidare till amygdala som sen aktiverar HPA-axeln, (Hypothalamus - Pitutiary Gland – Adrenergic system) för att utlösa en motorisk åtgärd. Det kallas för *”The Low Road”*. Det är en snabb, halvt omedveten och reflexmässig informationsväg. Via ”*The High Road”* kopplar istället thalamus informationen till cortex där den kognitiva behandlingen av signalen sker. Det är en väg som tar längre tid. Den längre vägen kan emellertid i ett tidskritiskt skede medföra ödesdiger tidsförlust. I varje fall så gynnade inte evolutionen dem av våra förfäder vars hjärnor främjade kognition och eftertanke på bekostnad av aktion i ett skärpt läge.

Empiriska fakta talar för att ett simultant inflöde av intryck från olika sinnesorgan främjar lärande och minnesfunktioner. Det kan bero på att informationsbehandlingen i hjärnan sysselsätter fler grupper av neuroner, än om bara ett sinne engageras, exempelvis att läraren muntligt berättar någonting. Empiri betonar också vikten av uppmärksamhet, attention för att åstadkomma lärande med behållning.

Komponent-systemperspektiv

Neuronerna i hjärnan är kopplade till varandra med nervtrådar som är isolerade med ett ämne som heter myelin. En neuron kan vara hopkopplad med upp till 10 000 andra neuroner. Den nervtråd som går ut från neuronen heter axon och de ingående nervtrådarna till neuronen heter dendriter. Kopplingen mellan nervtrådarna sker med en synaps.

Neuroner fungerar inte renodlat digitalt med nollor och ettor. Neuroner behandlar inkommande information analogt och integrativt. En signal som går ut från en neuron kan vara exciterande eller hämmande på nästa neuron. När denna träffas av simultana signaler från olika neuroner, så integrerar neuronen signalerna på så sätt att de ”viktas”. Om antalet ingående signaler som exciterar är större än antalet hämmande signaler och samtidigt överskrider ett gränsvärde, så utlöser detta ett flöde av kemiska neurotransmittorer i en synapsövergång, som i sin tur sänder signalen vidare. Nu fungerar neuronerna i allmänhet inte individuellt utan sammankopplingen mellan dem gör att den signal som förs vidare utgör ett statistiskt genomsnitt. Det som ytterligare förfinar signalöverföringen är att signaler avfyras med olika frekvenser, varvid även frekvensen har innebörd och betydelse. I synapskopplingen bärs den elektriska signalen i axonen över till en dendrit med hjälp av kemiska neurotransmittorer. Hjärnans anatomi presenteras lättfattligt av bl a Kolb et al (2001).

Det sker numera omfattande forskning för att få fram ”smart pills” som kan förbättra synapskopplingarna, dvs förbättra minnet och därmed lärandet. Den typ av tabletter som man kan köpa i hälsobutiker och som utges för att kunna förbättra hjärnans funktion har dock sällan kliniskt belagd effekt. Men vi vet att även placebopiller har verka på hjärnan. Vikten av

att behandla etiska frågor inom hjärnforskningen är uppenbar. Se Gazzaninga (2005) som diskuterar sådana problem i sin bok ”*The Ethical Brain.”*

Hjärnan kan anses vara uppbyggd av nätverk eller ”kärnor” som består av sammankopplade neuroner. Nätverken har olika uppgifter och växelverkar med varandra. Av ledningsdragningskäl är närliggande neuroner kraftigare kopplade till varandra än mer avlägsna neuroner.

Hjärnans makrostruktur utgörs av de två hjärnhalvorna som är förbundna med varandra via hjärnbalken. Den består av miljontals nervtrådar. Hjärnbalken förmedlar informationsflödet mellan de neurala nätverken i de båda hjärnhalvorna. Hjärnhalvorna samverkar således vid bearbetning av problem.

Den kognitiva informationsbehandlingen sker i hjärnbarken, neokortex. Det är den senast utvecklade delen av hjärnan. Det är genom dess storlek och omfattning som människan skiljer sig från de övriga däggdjuren. Hos människan har speciellt pannloben utvecklats mer än hos andra primater. Hjärnbarkens veckningar har tillkommit för att kunna ge plats åt så många neuroner som möjligt inom en av skallbenen begränsad volym.

Hjärnbarken är uppdelad i fyra delar, lober. Grovt sett skulle man kunna säga att i pannloben sker planering och värdering; i hjässloben finns känsel och motorik; i nackloben finns synsinnet och i tinningsloberna finns bl a språkcentra.

Längre in i hjärnan finns den äldre delen av hjärnan, det limbiska systemet där centra för emotioner finns. Där återfinner vi de basala ganglierna som styr rörelsemönster och är speciellt väl utvecklade hos fåglar som kan gå, flyga och simma – men som i gengäld bara har en liten hjärnbark. Där finner vi också amygdala som styr känslor och hippocampus som bl.a innehåller minnesfunktioner. Längs bak har vi lillhjärnan, cerebellum, därifrån styrs bl a kroppsdelarnas rörelser. Längs ner har vi hjärnstammen varifrån basala livsuppehållande funktioner styrs.

Lärande på hjärnans villkor

När man arbetar med naturvetenskap och teknik, så finns det ett antal generaliserbara centrala lagar och teorier med vilka olikartade fenomen kan förklaras. Exempel på sådana centrala samband ges av exempelvis:
Newtons lagar inom mekaniken;
Maxwells fomler för elektromagnetism inom optiken,
Bohrs kvantteorin inom atomfysiken,
#Einsteins relativitetsteorin för att beskriver skeenden vid höga farter.
Ett fåtal lagar och principer visar sig ha en stor potential för att kunna förklara och förutsäga olika slag av fenomen och skeenden i den fysiska naturen omkring oss.

Hebb´s princip och optimering

Finns det några liknande centrala och generaliserbara samband inom den kognitiva neurovetenskapen?

Ja, ett centralt samband utgörs av den kanadensiske neuropsykologen Donald Hebb´s princip från år 1949, (Hebb, 1949). Hebb förutspådde att två neuroner som fyrade av sina signaler

samtidigt skulle komma att påverka och stärka sin inbördes synaptiska sammankoppling. Att kopplingen stärktes och bevarades ledde till att slag av neuralt minne uppstod. Detta minne styrde och påverkade i sin tur behandlingen av inkommande information. Hebb´s princip har getts ställning som en central förklaringsgrund inom den kognitiva neurovetenskapen.
Den kan på ett populärt sätt uttryckas med orden:
”Those who fire together, wire together”.

Ifråga om minnesfunktioner finns ytterligare en grundläggande princip, *”Long Time Potentiation”, LTP.* Den funktionen visar hur samverkande signaler kan ge upphov till en kvarliggande potential, minne, i en nervcell. LTP diskuteras utförligt av LeDoux (2003).

En annan viktig och generaliserbar princip är att hjärnan är tvungen att finna metoder för optimering av sin informationsbehandling. Hjärnans kapacitet för informationsbehandling är enorm, men inte obegränsad.

Repetition

Tillämpningar av Hebb´s princip bekräftar bl a vad alla lärare känner till: *”Repetition är studiernas moder.”* Ifråga om kursplanering så betonar Hebb´s princip att det är viktigt att, vid studier inom ett ämnesområde, återkomma till centrala samband inom ämnet och att repetera dem på ett fördjupande sätt. Det som förstärks är alltså det som upprepas – man skall således satsa på kunskapsdjup och inte bara på kunskapsbredd.

En annan aspekt är att tyvärr inte bara korrekta kunskaper fastnar i minnet. Även felaktiga kunskaper påverkar hopkopplingen av de neurala nätverken. Det är alltså viktigt, för läraren, att utrycka sig korrekt och, om möjligt, på ett otvetydigt sätt. Samtidigt strävar hjärnan efter att skapa mening i den information som presenteras. Det betyder att information som går stick i stäv mot redan inlagrad information inte kommer att lagras eftersom de neurala närverken som sörjer för lagring inte kan kopplas ihop på ett meningsskapande sätt.

Här kommer vi in på att mycket av innehållet i en diskussion är underförstått. Det är inte alltid som människor menar något rent bokstavligt. Man använder ofta metaforer och analogier. Lakoff och Johnson har diskuterat detta i två böcker med de talande titlarna ”*Metaphores We Live By”* (1980) och **”***Philosophy in the Flesh”* (1999).

Erfarenheter som elever får genom det yttre lingvistiska språkbruket växelverkar med elevens tidigare, av språkliga symboler präglade inre mentala värld. För att eleven skall kunna få ett utbyte av detta språkspel så måste den yttre språkliga stimulansen kunna koppla till tidigare gjorda och redan befästa inre språkliga erfarenheter. I annat fall förstår eleven inget.

Undervisningsresistenta vardagsföreställningar

Hebb´s princip förklarar också varför det är svårt att utrota elevernas vardagsföreställningar. Dessa förstärks genom daglig repetition – skolans vetenskapliga begrepp och kunskaper får sällan en sådan förstärkning i elevens vardag. Det är därför bra med en spiraluppbyggd kursplan som syftar till djup mer än till bredd för att åstadkomma behövlig fördjupning och repetition. Eleven lär sig, genom undervisning och reflektion, att se samma fenomen, men på ett mer kvalificerat sätt. Det sker genom att en allt större del av hjärnans associativa nätverk successivt kopplas in. Själva början på den spiralen måste emellertid ta sin utgångspunkt i de

kunskaper och förställningar som finns i elevens egen mentala sfär i form av redan existerande neurala kopplingar.

Ausübel

Den amerikanske pedagogen David Ausübel yttrade för ett halvt århundrade sedan: *”Det viktigaste i undervisning är att ta reda på vad eleverna kan. Utgå från detta!”*
Den neurala ansatsen, som bygger på Hebb´s princip, bekräftar sanningen i det uttrycket. Om undervisningens innehåll ansluter till elevers befintliga neurala mönster, så fångar läraren upp och anknyter till elevernas intressen och bygger vidare på dessa.

Istället för att försöka ”utrota” vardagsföreställningar och försöka åstadkomma s.k. ”conceptual change” så kanske man måste inse att det finns två olika diskurser som eleven måste kunna fungera inom. Det är den *vardagliga diskursen* och *den vetenskapliga diskursen.* Även här måste man försöka undvika att dikotomisera problematiken. Det är inte ett antingen eller utan ett både och. Det skulle vara mycket svårt för en elev att betrakta världen enbart utifrån Newton´s mekaniska lagar, även om de är applicerbara som förklaringsmodeller på all statik och dynamik. Newtons lagar innebär en för vetenskapens utveckling fruktbar abstraktion och idealisering av fenomen i omvärlden. Det är emellertid en abstraktion som, i många fall, stöter på patrull i vardagslivet.

Eleven kanske måste lära sig att ta *kvantsprång* mellan den vardagliga och den vetenskapliga diskursen. Det kanske inte skall gälla ett antingen eller utan ett både och. Samtidigt får naturligtvis inte den inställningen leda till att eleven ser saker på ett visst sätt utanför skolan och på ett annat sätt i skolsalen.

Man kanske skall vänja sig vid att betrakta omvärlden ut många olika perspektiv som kompletterar varandra till den mångfacetterad helhetsbild som verkligheten utgör. Kanske skulle man kunna betrakta vetenskapen som det vardagliga synsättets naturliga förlängning? Nu måste man emellertid beakta att sunt förnuft ofta står i strid mot vad vetenskapen framhåller. Vetenskapen innehåller ofta *kontraintuitiva* drag.

Lärande = ändring av synapskopplingar

Lärande sker genom att erfarenheter påverkar mängden av och styrkan hos synapsernas kopplingar – det är lärandets ”*atom”*. Det gäller således att försöka ge eleverna så många och varierande erfarenheter som möjligt – man kan tala om ”multisensory” input. Titeln på LeDoux bok (2003): *”The Synaptic Self." How Our Brain Becomes Who We Are”* framhåller hur synapskopplingar grundlägger vår personlighet.

Manipulera representationer i hjärnan

Eleverna bygger upp inre bilder, representationer, av företeelser i omvärlden. Inom exempelvis skolämnet teknik är det möjligt att inte bara tala om olika fenomen, eller visa tvådimensionella bilder, utan man kan gå till tredimensionella modeller som eleven kan ges tillfälle att manipulera. Sådana modeller aktiverar betydligt fler områden i hjärnan än vad enbart auditiva signaler eller visuella avbildningar kan göra. Tredimensionella modeller kan manipuleras handgripligt i såväl den yttre omvärlden som mentalt i hjärnan. Att tänka på, bearbeta och reflektera över erfarenheter ökar möjligheterna till återkallande och access till de kopplingar som erfarenheterna har gett upphov till i hjärnan.

Övning ger mer plats i hjärnan. Kartor i kortex.

En annan iakttagelse som alla lärare har gjort är att övning ger färdighet. En amerikansk neurokirurg, Wilder Penfield, upptäckte på 1930-talet att kroppens funktioner är avbildade på hjärnbarkens yta. Dessutom gäller det att storleken och omfattningen hos dessa områden påverkas av övning. Hjärnbarken, neokortex, är bara ca fyra mm tjock och består av nervceller som finns i sex lager.

OECD-SERI (2005) noterar i denna fråga:

”Neuroscience cannot yet fully elucidate the mechanisms of learning, but it is known that learning involves cumulative structural changes in the brain. The brain continually undergoes an adaptive process whereby experiences shapes structure, which influences subsequent experience-dependent reorganization. This results in a cascading effect. For example the structure of the cortex is modified as a child learns to play the violin; gradually the cortical neurons learn to respond more precisely to musical tones. These structural changes enable the child to learn the playing more readily, which then serves to further refine tone-elicited cortical response, and so forth. Because of this cascading effect, early learning provides an important foundation for later learning.”

Sinnena konkurrerar om kortikalt utrymme i hjärnan och olika områden i hjärnan kan vid behov få olika funktioner. Hos blinda kan synbarken i nackloben kopplas om till att behandla blindskrift istället för synintryck. Ett märkligt fenomen som en del personer har är s.k. synestesi. Det innebär att vissa nervtrådar har kopplats så att dessa personer vid läsning ser olika bokstäver eller siffror i olika färger.

Myelinisering leder till abstrakt tänkande

En annan viktig process, som vi återkommer till, är den ovan nämnda myeliniseringen eller isoleringen av nervtrådar. Genom myelinisering ökar hastigheten hos de elektrokemiska nervsignalerna från ca 4m/s till över 100 m/s. Ett nyfött barn föds med, i stort sett, oisolerade nervbanor. Myeliniseringen startar med de livsuppehållande neuronerna i hjärnstammen, därefter myeliniseras nervtrådarna i hjässloben, varifrån motoriken styrs, och först i den övre tonårsåldern myeliniseras nervfibrerna i pannloben, där högre kognitiv och abstrakt informationsbehandling sker, (Lagerkrantz 2005), TIME (2004).

Elever med omyeliniserade nervtrådar har således svårt för att behandla abstrakta begrepp. Sådana begrepp kräver att mer omfattande delar av pannlobens neuroner aktiveras, vilket tar tid, eftersom nervsignalernas fart är låg innan nervtrådarna har myeliniserats. Tonåringars beteende, som ofta innebär våghalsig motorik men föga av återhållande reflektion över konsekvenser av deras handlande kan förstås enligt den förklaringsmodellen. Man har myntat den metaforiska satsen: ”*High horsepower, poor steering”*.

Hjärnan vill ha nyheter

Hjärnan kontrollerar mental informationsbehandling samtidigt som den håller reda på ingående sinnesintryck från hela kroppen. Det kallas för *proprioception.* Om hjärnan hela tiden hade behandlat den enorma mängd av information som alla nerver sänder till den så

skulle den bli överbelastad. Hjärnan optimerar därför sin kontrollfunktion genom att bara bearbeta och reagera på nervsignaler som ändrar sig.

Här kan ett modelltänkande från funktionen hos moderna tekniska kontrollsystem vara till hjälp vid förståelsen av funktionen hos hjärnan som ett dynmiskt reglersystem. Systemets informationsbehandlande enhet ställs in på ett *”bör-värde”*. Därefter mäter sensorer ett *”är-värde”* ute i ”fabriken”. Om det uppmätta är-värdet skiljer sig från det inställda bör-värdet så sänds en förhandsinställd order till en effektor eller också larmas operatören. På ett liknande sätt optimerar hjärnan sin informationsbehandling och intresserar sig således bara för förändringar, dvs nyheter.

Hjärnan är således på grund av en nödvändig optimering vid behandlingen av information nyfiken och dess uppmärksamhet stimuleras av det ovanliga. Hjärnan uppmärksammar således inte fenomen i statisk jämvikt i utan *beaktar främst förändringar*. Det är en egenskap som naturligtvis kan nyttjas i undervisningen. Lägg märke till all reklam som drar nytta av den funktionen.

OECD (2000) uttrycker ovanstående med orden:

“Information selection is an area where the human brain excels in performance. In the process of accepting/rejecting information many mechanisms are used. One of them is the principle of novelty detection, i.e. matching of previously learnt information with freshly perceived information then often is presented in a manner that incompletely matches previous presentations and often also is out of previous context.”

Neural plasticitet och livslångt lärande

En numera etablerad sanning är att hjärnan under hela livet är flexibel och mottaglig för omstrukturering av kopplingar mellan neuroner. Hjärnan är således öppen och mottaglig för livslångt lärande. Visst är det enklare att skapa nya synapskopplingar i unga år, men då man är äldre så har man istället ett mer omfattande mentalt nät av associationer att knyta an till. Elkhonan Goldberg (2006) behandlar detta i sin bok ”The Wisdom Paradox” där han betonar de fördelar som den åldrande hjärnan har.

OECD-CERI (2005) skriver:

”The aging society renders elderly education an increasingly important aspect of lifelong learning. The brain´s plasticity decreases as a function of age, and this decrease is frequently accompanied by a decline in fluid intelligence, working memory, spatial ability, memory recall and perceptual speed.”

“Despite age-related cognitive decline, the elderly possess invaluable knowledge and wisdom. Certain types of abilities remain stable, or increase across age. Crystallized (experience – oriented) intelligence and wisdom are generally enhanced across the life span.”

“Neuroscience research has indicated that intellectual stimulation and novelty help maintain cognitive abilities….Neuroscience research has also revealed that physical exercise, a healthy diet, and the maintenance and expansion of social networks can act to maintain cognitive function.”

Hippocampus & minneskonsolidering

När man lär sig något så är olika slag av minnen engagerade. Det finns dock indikationer på att det lärande som sker under dagen först och främst påverkar synapskopplingarna i hippocampus, som är ett organ i det limbiska systemet. Under sömnen växelverkar hjärnbarken, cortex, med hippocampus varvid delar av minnesinnehållet i hippocampus förs över till associativa långtidsminnen i hjärnbarken. Det innebär att sömn är en viktig faktor som stimulerar lärande och minne.

Även sk *”power-nap”,* en kort stund av sömn under dagen har befunnits vara bra för konsolidering av minnet. Nu måste man emellertid beakta att minnet inte fungerar som en bandspelare. Minnen rekonsolideras. Det innebär att våra minnen kanske inte alls innehåller enbart våra egna upplevelser, utan att våra minnen har blivit påverkade av andra personer, vars uppfattningar vi kan ha gjort till våra egna.

Amygdala & emotioner

Långt inne i det limbiska systemet, strax intill hippocampus finns det redan presenterade organet amygdala. Det är ett organ som påverkar hjärnan genom att ta hänsyn till emotioner och faror. En aktivering av amygdala leder till en reaktion som sätter kroppen i beredskap, som inför en farofylld situation. Blodtrycket ökar, pulsen stiger, musklerna spänn, men det leder också till att ett slags *”tunnelseende”*. Inget av dessa funktioner främjar kognitivt lärande. Vi måste emellertid beakta att hjärnan inte primärt skapades för att underlätta lärande utan för att främja överlevnad i en farofylld omgivning.

Lärande måste således äga rum under positiva och avspända förhållanden, om man vill att elevernas kreativitet skall kunna komma till sin rätt. Man brukar tala om att lärande sker bäst om man har ”*low threat*” och *”high challenge”*. Hjärnan har evolutionärt utvecklats under förhållande där individer som antar och klarar av utmaningar vinner fördelar.

Det som man lär sig under hot är för alltid kopplat ihop med hot och fruktan. Sådana minnen skapar inte någon grund för vilja att fördjupa sig i det aktuella ämnet. Kan ett sådant resonemang förklara varför vissa elever inte tycker om exempelvis matematik? Har de haft för krävande lärare som tvingat dem att genomföra uppgifter som deras hjärnor *ännu inte, neurologiskt sett, har varit mogna för*? Emotion och lärande diskuteras utförligt av Spitzer (2000), LeDoux (2004), Baeza (2005a), Damasio (2000). Man anser numera att det sker en *syntes mellan kognition och emotion.* Tyvärr är inte alla emotioner positiva och främjar inte lärande.

Regelsökande

Hjärnans optimering av informationslagring är, som har tidigare nämnts, enorm – men inte gränslös. Det tar sig uttryck i att hjärnan, då den konfronteras med nya intryck, söker efter det gemensamma i fenomenen som ger olika slag av sinnesintryck. Hjärnan försöker *kategoriserar* fenomen i omvärlden i grupper eller strukturer. Det som lagras är det generaliserbara.

Det innebär för lärande att elever kan lära sig det generaliserbara inom ett ämnesområde om det presenteras för dem med hjälp av många och helst konkreta exempel som ansluter till deras redan befintliga neurala strukturer.

Kontextuellt lärande

Hjärnans neurala system har, redan då vi föds, vissa väl utvecklade neurala kopplingar. Dessa påverkas sedan under hela livet av de erfarenheter som vi gör. Det *livslånga lärandet* är något alldeles självklart, sett ur hjärnans perspektiv. Elevers lärande underlättas således, om vi som lärare, i undervisningen utgår från den neurala mentala kontext, de föreställningar och representationer, som eleven redan har av fenomen i den yttre kontexten i den del av den fysiska omvärld som eleven är verksam inom.

Det kontextuella lärandet sker emellertid genom att den yttre omvärldens kontext omvandlas till ett inre, mentalt, neuralt associationsnätverk. Det skall ske på ett logiskt och invändningsfritt sätt och utan inre motsägelser. Denna omvandling skall hjälpa oss att förstå de av den yttre världens fenomen som är aktuella för stunden. Det sker i ljuset av alla tidigare, som fungerande erfarenheter. Hjärnan är på så sätt meningssökande – vi söker livet igenom efter mening, föross, med det som vi gör.

Elever återkommer ofta med frågan: *”Varför skall vi lära oss detta?”* Denna fråga kan sägas ha en neural grund i att hjärnan vill optimera sin informationsbehandling genom att sträva efter att ha så få inre motsägelser som möjligt. Neural avbildning har visat på hur den som är kunnig inom ett område använder en mindre del av hjärnans kapacitet för att behandla ett problem än den som är novis inom området. På så sätt innebär lärande att lära sig att strukturera upp ett problem så att det kan bearbetas på ett funktionellt sätt som belastar hjärnans informationsbehandlande system så lite som möjligt. Bakom detta ligger att novisen behandlar ett problem med en logisk och analytisk ansats medan experten behandlar problem med *”mönsterseende”*. Problemet utreds av Lars-Erik Björklund i en kommande doktorsavhandling (Björklund 2008) och även av Goldberg (2005).

“Learning by doing” eller ”learning by looking”
Studier av hjärnans funktion har visat hur hjärnan hos elever vid lärarledda demonstationer, som elever uppmärksamt följer, genomlöper samma inre motoriska program som lärarens hjärna följer vid demonstrationen. Undantaget är dock den yttre motoriska delen. Eleven följer således mentalt det som läraren gör och motsvarande regioner i neocortex aktiveras, Det innebär att John Deweys ofta citerade tes:
”Learning by doing” kan kompletteras med tesen*”Learning by looking”*.

I det senare fallet innebär observerandet naturligtvis, att ju mer eleven kan om ett ämne, desto mer får hon ut av det som presenteras. Det beror på att fler relevanta moduler i hjärnan aktiveras. En sådan biologisk funktion kan uppfattas som djupt orättvist i ett demokratiskt samhälle där alla skall anses vara lika och ha samma förutsättningar. Fenomenet kallas, lite skämtsamt, för Matteus effekten: *”Åt den som har mycket skall mycket vara givet.”* Så säger bibeltexten, som inte är författad i en nutida politiskt korrekt anda. Tyvärr sker det ifråga om neural funktion en konfrontation mellan av människan skapad ideologi och av evolutionen skapad biologi.

Belöningssystemet

’Djupt inne i hjärnan finns ett *dopaminergiskt* system. Det är ett system som ger pannloben i hjärnan en dusch av neurotransmittorn dopamin som belöning för något som har utfallit bättre än förväntat. Duschen av dopamin upplevs av individen som något positivt och leder till en

känsla av välbefinnande. Detta välbefinnande tar sig uttryck i att ge en positiv attityd till den förelagda uppgiften. Ett vänligt ord, eller en vänlig blick från lärare har visat sig stimulera elevers dopaminerga system och påverka elevens attityd positivt. Kritik uppfattas däremot som hot och utlöser den kända *"fight or flight"* reaktioner via amygdala.

Ett aktuellt problem i det här fallet är att yttre influenser kan *"kidnappa"* belöningssystemet. Exempel som kan nämnas är dataspel och nätpoker eller spel på kasinon. Dessa spel kan leda till spelberoende genom att stimulera det dopaminerga systemet. I det här fallet kommer ytterligare en neural effekt in, *habituering.* Det begreppet innebär att vid upprepad stimulering så behöver ett neuralt system allt starkare stimulans för att ge upphov till den dusch av dopamin som leder till den eftersträvade känslan av välbefinnande. Nobelpristagaren Erik Kandel behandlar sådana frågor utförligt i samband med sina studier av beteendet hos havssnäckan Aplysia, Kandel (2005).

Fysisk aktivitet

En föga diskuterad aspekt ifråga om lärande, är lärandets beroende av fysisk aktivitet. Fysisk aktivitet stimulerar och ökar blodflödet till hjärnan. Ett ökat blodflöde ökar i sin tur det för hjärnans funktion och välbefinnande nödvändiga syret till neuronerna i hjärnan. Man kan på neurofysiologiska grunder hävda att elever behöver motion och fysisk rörelse för att kunna fungera optimalt mentalt. Det innebär att stillasittande framför bildskärmar på ett rent fysiologiskt sätt påverkar den kognitiva funktionen hos hjärnan negativt.

En stimulerande miljö

En omdiskuterad fråga är den påverkan som en stimulerande miljö kan ha för hjärnans utveckling. Försök med råttor visar på hur en stimulerande miljö leder till fler neurala kopplingar än en stimulansfri miljö. En naturlig miljö kan dock vara mycket stimulerande utan konstlade påhäng. Att en stimulerande miljö är positiv förefaller dock vara belagd. Den sociala miljön är av största betydelse. Hjärnan är social.

OECD-CERI (2005) framhåller i denna fråga:
"In fact, much research has indicated that an enriched environment, defined broadly as an environment with abundant opportunities for learning, results in structural adaptations that potentiate the brain for learning."

Manligt & kvinnligt

Professor Annica Dahlström (2007) diskuterar ingående skillnaderna mellan manliga och kvinnliga hjärnor i sin bok ***"Könet sitter i hjärnan".*** Eftersom pojkars och flickors hjärnor utvecklas under inverkan av olika hormoner och finstäms av olika erfarenheter så är det naturligtvis något att beakta i undervisningen i teknik.

Som tekniklärare måste man för flickorna sträva efter att välja inslag från deras intressesfär, eftersom de erfarenheter som flickorna gör i sin sociala diskurs till viss del skiljer sig från pojkarnas. Stor betydelse har också de hormoner som styr beteendet. I hotfulla situationer utsöndras hos pojkarnas mer av hormonet *testosteron* styrda beteende vilket leder till beteendet *"fight or flight"*. Hos flickor utsöndras mer av hormonerna *oxytocin* och *östrogen,* som leder till beteendet *"tending and befriending"*. Båda dessa beteenden kan, på evolutionära grunder, vara funktionella i olika situationer.

Neuromyter

Det finns alltid en risk för att resultat från hjärnforskningen övertolkas och generaliseras till områden där de inte har något slag av belägg. Sådant har skett med exempelvis: höger- och vänster hjärnhalva som sägs svara för olika funktioner. Det är till viss del sant, men hjärnbalken kopplar samman hjärnhalvorna så att man, utgående från ett neurovetenskapligt perspektiv, inte bör särskilja deras funktion för mycket. En annan myt är att vi bara använder c:a 10 % av hjärnans kapacitet – det är fel på grunder att evolutionen inte skulle tolerera ett sådant slöseri med dyr utrustning för behandling av information. En annan myt är att det finns vissa fönster, *”window of opportunity”,* i en elevs utveckling då hon kan lära sig på ett optimalt sätt. Baeza (2005b). Om det tillfället inte beaktas så anses fönstret vara irreversibelt stängt. Det här är en övergeneralisering av vissa lärandefunktioner: man talar om ”*experience dependent”* och ”*experience expectant”* lärande.

Det kan dock för lärare vara viktigt att känna till diskussionen om dessa utvecklingsfönster eftersom ambitiösa föräldrar, som har läst populära framställningar om hjärnan och lärandet, kan ställa frågor om ifall läraren till fullo har beaktat lille Kalles utvecklingsfönster. Det kan vara pinsamt att, som professionella lärare, inte veta något om denna fråga. I varje fall kan det skapa tvivel hos föräldern beträffande lärarens kompetens.

Referenser

Baeza, Peter (2005): Emotion och Lärande – om Neuropedagogik och två sätt att examinera. C-Uppsats, Institutionen för Pedagogik och Didaktik, Göteborg University

Baeza, Peter. (2005). Tio års hjärnforskning I svensk dagspress; vetenskap eller neuromyter. C-uppsats 10 poäng. Psykologisk fördjupningskurs 1. Ht 2005.

Bjorklund, D. F. (1997). In Search for a Metatheory for Cognitive Development (or, Piaget Is Dead and I Don´´t Feel So Good Myself. Child Development, Vol 68, Nr 1, pp 144-148.

Blakemore, Sarah-Jane & Frith, Utah (2006). The Learning Brain, Blackwell.

Bruer, J. T. (1997). Education and the brain: a bridge too far. Educational Researcher, 26(8), 4-16.

Dahlström, A, (2007). Könet sitter I hjärnan. Corpus Gullers.

Damasio, A. (1999). Cartesius misstag.Natur och Kultur. Stockholm.

Damasio, A. (2000). The Feeling of What Happens. Body, emotion and the making of consciousness. Vintage, London.

Edelman, G. (2006). Second Nature – brain science and human knowledge. Louis Stern Memorial Fund.

Gazzaninga, (2005). The Ethical Brain.

Geake, J. & Cooper, P. (2003). Cognitive Neurosciences: Implications for education? Westminster Studies in Education, Vol. 26, No 1, June 2003.

Gärdenfors, Peter (2005): Tankens vindlar – Om språk, minne och berättande. Nya Doxa

Gärdenfors, Peter (2006): Den meningssökande människan. Natur och Kultur.

Kolb, B. & Whishaw, I. Q.(2001). An Introduction to Brain and Behaviour, Worth Publishers

Lagercrantz, Hugo (2005). I barnets hjärna. Bonnier Fakta

Lakoff, G. & Johnson, M. (1980). Metaphors We Live By. The Univ. of Chicago Press.

Lakoff, G. & Johnson, M. (1999). Philosophy in the Flesh. The Embodied Mind and its Challenge to Western Thought. Basic Books.

LeDoux, J. (2003). Synaptic self. How Our Brain Become Who We Are. Penguine Books. NY.

LeDoux, J. (2004). The Emotional Brain. Clays Ltd. London.
Johnson, Steven (2004). Mind Wide Open. Your Brain and the Neurosciences of Everyday Life. Scribner.
Hebb, D. O. (1949). The Organization of Behavior. John Wiley & Sons, New York.
OECD. (2002). Understanding the brain, towards a new learning science. Paris: OECD Publ.
OECD-CERI (2005). Learning Sciences and Brain Research. Third Lifelong Learning Network Meeting. 21-22 jan. 2005. Japan.
Pinker Steven (1999). How the mind works. Penguine Books.
Pinker, Steven (2003). The Blank Slate. Penguine Books. 2003.
Spitzer, M.(2002): Lernen. Gehirnforschung und die Schule des Lebens. Spektrum Akad. Verl.
Spitzer, M. (2005): Vorsicht Bildschirm. Ernst Klett Verlag, GmBH, Stuttgart
TIME Magazine (7june 2004). Secrets of the Teen brain. Research is revolutioning our view of the adolescent mind – and explaining its mystifying ways.

Brain, Mind & Aniara

Physical and mental experiences create and rewire the hardware in the Brain and thus affect the software in the Brain, i.e. the Mind. The next paper discusses how a narrative, The Space Epic ANIARA, might create a neural network which could be used in science education with the aim of studying possible foundations for Sustainable Development.

10. Interaction between Brain & Poetry in Science Education originating in the Space Epic ANIARA.

Aadu Ott, Göteborg University, Sweden

Paper presented at the Workshop November 2-3, 2007:"Storytelling in Science Lessons at School as a Bridge between Mental and Physical Dimensions" at Kerschensteiner Kolleg, Deutsches Museum in Munich**.**

Abstract

The brain is a physical structure in which the mind is a generator of narratives in response to situations and circumstances in the human habitat. The mind may thus be regarded as a storyteller. One perspective on leaning is to explore how stories are embedded and how they affect different neural networks within the brain. The Space Epic about the doomed Space-Ship Aniara is a metaphor for our Earth on its eternal journey through endless space. The poetic presentation might give us a vision of our future. Such a vision could enrich science lessons by embedding scientific issues into social and environmental contexts. This utilization of story-telling might affect the students´ conscious and subconscious cognitive faculties, in a more profound way than traditional teaching might do.

Background – The learning brain

Knowledge about how our brain and mind interacts with learning has increased considerably during recent years because of development of technologies for studying cognition in a non-invasive way in a living brain in real-time. This has, to a certain degree, led to a more biological approach for understanding of the anatomical structure and cognitive function of the brain. A materialistic view of the brain, in which neurobiology is dominating has emerged.

Pedagogical theories, which were developed by pioneers as for example Jean Piaget (1896-1980) and Lew Vygotsky (1896-1934), may now be enriched with results from neuroscience. The philosophical discussion about the mind-body controversy may be reflected on in a fruitful way. This makes also an analytical approach possible for studies of functions of different neural brain systems which participate in learning processes.

There is however a controversy between social scientists, who regard mind and behaviour as social construcs, and natural scientists who regard mind as being the function of a system of interacting neural networks. The American psychologist Steven Pinker (1997) stated: "*Mind is what brain does."*

A gap has thus been created between sociologists and scientists in the fields of learning and education, involving among other subjects, biology, chemistry, physics and psychology. This paper explores, in a tentative way, possibilities to overbridge this gap by using the Space Epic Aniara, which is written by the Schwedish poet and Nobel Prize Laureat, Harry Martinson.

Neuroscience and learning

Neuroscience has been developing fast, according to some scientists in this field, who comment on this question. The neuroscientists Sarah-Jayne Blakemore and Uta Frith who work at The Institute of Cognitive Neuroscience at the University College, London, state in their novel ***"The Learning Brain"*** (Blakemore, S-J. & U. Frith, 2006):

"Knowledge of how the brain learns could, and will have a great impact on education. Understanding the brain mechanisms that underlie learning and memory, and the effect of genetics, the environment, emotions, and age on learning could transform educational strategies and enable us to design programs that optimize learning for people of all ages and of all needs. Only by understanding how the brain acquires and lays down information and skill will we be able to reach the limits of its capacity to learn."

Manfred Spitzer (2002) who is director of TransferZentrum für Neurowissenschaft und Lernen in Ulm states in: ***"Lernen – Gehirnforschung und die Schule des Lebens":***
„Die Wissenschaft von den Nervenzellen und dem Gehirn, die Neurobiologie, hat in den letzten Jahren eine beispielslosen Aufschwung durchgemacht und zu noch vor wenigen Jahren ungeahnten Ergebnisse geführt. In diesem Buch geht es darum, mit Hilfe der Gehirnforschung das Lernen besser zu verstehen. Das daraus folgende vertiefte Verständnis des Lernens bleibt nicht im Elfenbeinsturm der Wissenschaft, sondern geht uns alle an, denn wir alle lernen dauerns, ob wir wollen oder nicht."

Blakemore & Frith (2006) concludes shortly, with a technical description, of what is occurring at the neural level in a learning process:
"Very likely, when teachers teach, connections are formed in the brains of the learners: dendrites branch out from the nerve cells and millions of synapses sprout alongside them. This invisible process is the basis for retaining new information and for sorting it so that it can be retrieved later at will."

Narratives and neuroscience

There are some questions which have to be asked when discussing interaction within the troika: **Neuroscience - storytelling/narratives – science lessons:** Is there some biological foundation for the idea of a neural base for narratives? Might it be possible to utilize narratives for advancement of science education? Do we really change the physical structure of students´ brains with learning experiences?

Restak (2004) is arguing that modern research is revealing an intimate relationship between narrative and the physical structure of the brain. He points out that personal experiences are affecting and daily, to a certain degree, change the system of neural connections in the brain, and thus contribute to rewiring of the brain. This is a relationship, which is pointed out to be the neural function, basic for learning, as stressed by Spitzer (2002), Damasio (1999), LeDoux (2003,2004). These seems thus to be a state of consensus among leading neuroscientists about this state of things.

Restak (ibid) also points out:

"And while the brain operates via electricity and chemistry, it is also a product of the social and psychological world in which it finds itself. All we are and all that we can be cannot be considered separately from our brain. This clearly implies a direct relationship between our brain´s organization and operation and what we can learn about the world and about ourselves as a part of that world.

Moreover, this relationship is a dynamic one, in which the "normal" brain is viewed as an ever-changing physical structure that undergoes constant transformation based on the experiences we encounter."

This phenomenon is called *neural plasticity* and is a foundation for *lifelong learning* which is discussed by Cozolino, & Sprokay, (2006).

Brain based approach

When discussing storytelling or narratives in science education, we utilize some fundamental learning properties in the human mind:

Making sense: A fundamental property of the brain is to try to make sense or meaning of the information presented. This is a heritage from early evolutionary survival instincts and has its foundation within the limbic system, which is the oldest apart of the brain.

Looking for novelty: The brain is monitoring interactions between the body and its environment. The brain has to optimize its processing of information and does not react if there is not something which differs from predicted values.

Unification of cognitive and emotional learning: Information from the senses passes, before being processed further, the amygdale in the limbic region, where information is controlled with regard to threat and danger. In this way, all information reaching the brain is cheque by this emotional control centre, before being processed further by the cognitive systems in the neocortex. This means that the cognitive system and the emotional system are tightly wired together and perception, cognition and emotion are interact. As a fact, there are more nerve-fibres going from the emotional amygdale to the cognitive cortex than back. This implies that emotions are affecting cognition more than cognition is affecting emotion and feeling.

ANIARA – the Space Epic

What and how may we be able to utilizing a narrative about a doomed spaceship on its endless journey into eternity in science lessons? One tentative answer could be that it is challenging to study the Space Epic ANIARA which acts as a metaphor for our own eternal space journey on the spaceship Earth. The story told about ANIARA might give us a vision of the future for mankind.

Ulrike Nolte, die Deutsche Schriftstellerin, erzählt in einige kurtze sätze die inhalt von ANIARA:

”Aniara” ist das bekannteste Werk des Schweden Harry Martinson. Vor allem dieses moderne, experimentelle Epos war der Grund dafür, dass ihm 1974 der Nobelpreis verliehen wurde. …”Aniara” ist ein aus Gedichten bestehender Zukunftsroman … und beschreibt parabelhaft die Entfremdung des Menschen und die Frucht vor einer atomaren oder ökologischen Zerstörung des Planeten in der Zeit des Kalten Krieges.”

Ott and Broman (1998) have given a presentation of both the space epic and its author. Hellstrand and Ott (1995) have studies how to use storytelling in science lessons when teaching the Theory of Special Relativity in upper secondary classes, utilizing a novel by Russell Stannard: *“The Time and Space of uncle Albert”*.

An evaluation of this study indicated that storytelling worked as well and even slightly better than traditional teaching.

Would it be possible to apply a brain-based perspective and to study how the space epic ANIARA could be used, in order to act as content and context in some science lessons? Ott and Vedin (2001) have showed how guided science lessons in Deutsches Museum could be enacted through storytelling. Ott (1995) has studied the possibility to utilize the concept of a role-play, based on ANIARA in teacher education.

Einstein's four dimensional curved space time

ANIARA might be interpreted as a metaphor for our Earth, which could be regarded as a spaceship on an eternal voyage through endless space. There is nothing of Hollywood like imagined space-travels to be found in this work of art. Martinson was well aware of the size of the Universe and had a good insight in the Theory of Relativity.

In a translation from Schwedish, by Klass et al (1991), to English, Martinson describes a key episode in the 13th song:

In the sixth year Aniara moved
with undiminished speed towards Lyra´s stars.
The chief astronomer gave the emigrants
a lecture on the depth of outer space.
In his hand he held a splendid bowl of glass.

Through God and Death and Mystery we race
on space-ship Aniara without goal or trace.
O would that we could turn back to our base
now that we realize what our space-ship is:
A little bubble in the glass of Godhead.

I shall relate what I heard of glass
And then you'll understand. In any glass
that stands untouched for a sufficient time
gradually a bubble in the glass will move
infinitely slowly to a different point
in the body of the glass,
and in a thousand years
the bubble makes a journey in the glass.

Similiarly in an infinite space
a gulf of light years´depth throws a vault
round bubble Aniara as she goes.
For though the rate at which she travels at is great
and much more rapid than a rushing planet´s,
her speed seen against the scale of space
exactly corresponds to that we know
the bubble makes inside this bowl of glass.

This song contains many scientific issues which could act as content for a science lesson: The song also mediates a concrete visualization of Einstein's four dimensional curved space-time, showing the size and emptiness of space and our inability to travel to foreign stars.

The human brain likes to initiate the process of learning with concrete examples which gives "hands-on" or "minds-on "experiences. The brain will then integrate these experiences with preconceptions within the associative space in the temporal lobe of the hemispheres of the brain.

Life onboard

Ulrike Nolte has translated some songs which give a picture about the daily life onboard for the passengers. In Song nr 2 Martinson writes:

Wir folgen immer noch denselben Sitten.
der alten irdischen Gewohnheiten wie in Doris Tälern.
Wir teilen unsre Zeit in Tag und nacht,
wir heukeln Morgenröte, Dämmerung und Abendrot.
Obwohl uns herum nur Weltraum ist, ewiges Nacht,
so strernenklar eiskalt, dass alle

Die band spielt Fancies und wir tanzen los,
das Mädchen die ich führe ist grandiose,
mein schönes Fräulein kommt aus Dorisburg.
Obwohl seit Jahren schon ihr Tanz
nur durch den Schiffssaal geht, so meint sie bloss:
Bei aller Liebe, sie versteht nicht ganz,
wo soll der Unterschied sein zwischen diesem Yurg
in Aniaras Saal und dem in Dorisburg

Wenn wir in Yurg uns drehen ist ganz klar,
ein jeder Yurg ist wunderbar,
wenn Daisy Doody schlangenhaft im Yurg
sich windet und mich lockt mit Slang von Dorisburg,
Und frölich swingt der Yurg, ich bin verführt,
die Trauer, die ich pietätsvoll stet geschürt
verfliegt bei diesem Menschekind. Das voll mit Yurg
den Tot besiegt mit Slang aus Dorisburg.

In this song we get a personal picture of the life of the passengers and see how they strive to establish a frame or context which makes sense even in outer space and also how they strive to make emotional contacts.

Consequences of modern technological advancement
Martinson points in Aniara out the danger of having too much thrust in the acts of the cognitive neocortex: At the end of song nr 10, Martinson expresses concern about our **achievements** of our technological civilization and of its consequences:

The word for star has now become indecent,
The low names high for loins and woman´s breast.
The brain is now a shameful body-part,
for Hades harvests us at its behest

Environmental and climatic problems
Martinson was early aware of the threats against our environment that human activity resulted in. He explained, already in 1953, at the beginning of ANIARA in song nr 1 the reason why the space ship ANIARA started her flight into endless space with the aim of reaching the planet March:

"…funnelling the refugees to lift-off zones-
on forced migration to the tundra globe,
in these years when Earth has come to such a pass
that for her toxic radiation she's prescribed
rest and quiet under quarantine."

Zukunftsfragen
Es ist Ulrike Nolte gelungen, die ganze und tiefe tragödie von Aniara zu beschrieben, in seine übersetzung von song nr 102. Wir finden hier eine pregnante civilizationskritik:

Ich hatte mir ein Paradies für sie erdacht.
Doch weil wir unser eigenes zerstörten
war unser Heim die leere, tote Nachte
endloser Raum. In dessen Schlund kein Gott uns hörte.

Des Strernenzeltes ewiges Mysterium,
das wir in Wunder himmlischer Mechanik nennen
folgt nur Gesetzen, keinem Evangelium.
denn bloss was lebt, kann Gnade kennen.

So schickte das Gesetz uns in der Tod
ein leeres Ende fanden wir in Mimas Saal.
Wir hofften bis zum Schluss auf einen Gott,
doch der blieb verletzt zurück in Doris Tal.

Teaching Astronomy and Science

Ulrike Nolte hat song 55 übersetzt; Ein astronomer macht eine vorfürung von die All:

"Hier auf das Planetariendeck
mit seinem durchsichtigen Plexidach
befördern Fahrstüle die Passagierer
zum Wandelgang. Die Sterne leuchten schwach,
hell überstrahlte von einer Nova, die bis hierher flammt,
obwohl sie aus dem Haar der Berenice stammt.

Der Astronom entwirft uns demutsvoll das Bild
von einem All, das ewig Würfel spielt,
mit heissen Novae in der sternbedeckten Ferne,
die überdrüssig ihre täglich aufsgezehrte Wärme
dem undankbaren Photophagen
in den weit aufgesperrten Rachen jagen,

und rasend untergehen in den Flammen,
die einer ausgebrannten Liebesglut entstammen."

Discussion

The utilization of storytelling could of course be criticised and one could argue that for example teaching a straightforward presentation of The Theory of General Relativity and its consequences on our worldview might be more efficient. But as Hellstrand and Ott (1995) have shown, a presentation which appeals to students´ imagination seems to work at least as well or even better than a formalistic presentation. Knowledge which has been developed by the student in interaction with his peers, and inspired by a narrative, might have a better possibility for ling time retention than information presented in a textbook or taught by a science teacher according to Zull (2002).

Schank (1990) discusses the importance of storytelling in teaching and learning. He points out that recalling and creating stories are important in learning, as stories tend to engage all parts of the brain and mind. Zull (2002) also points out that learning is most efficient when it engages many parts of the brain simultaneously. Stories engage our experiences, memories, ideas, actions and feelings.

Stories are packages in complex neuronal networks which interact with other neuronal networks in our brains. This means that the neocortex, were cognition takes place, and the limbic system, were emotions take place, interact in stories. Zull (2002), Damasio (2000) and LeDoux (2004) argue for the importance of regarding the interaction of the limbic system with the cognitive system.

This is a point which could be regarded in ANIARA, were the author, continuously, is using both perspectives in his work. We may identify ourselves with the passenger and thus create a feeling for the life of the marooned passengers aboard the doomed space ship and thus even for our own situation on space-ship Earth.

This approach should be possible to be used in science lessons in order to create interest and motivation by the students. Generally we are, by tradition, regarding science as an objective enterprise and the addition of an emotional touch might be regarded as decreasing the seriousness of science.

If we however want to engage the imagination of our students, then emotions are important. Many studies in neuroscience have shown how an emotional component strengthens the memorization of a story. A well known quotation by Albert Einstein is: *"Imagination is more than knowledge."*

Facing the escalating environmental problems in the world, there seems to be a need for cognitive knowledge as well as emotion or feeling, when information about environmental problems in the world is presented.

From the point of view of neuroscience, understanding could be regarded as the result of an integration of incoming information from sensory receptors and their neural networks with existing preconception in already established neural networks. This integrated network will then implement a foundation for active testing of the creative ideas and hypotheses emanating from this synthesis of neuronal networks. This testing could, for example, be done in the form

of participation in a discussion of these hypotheses. This will in turn lead to input of new experiences and the creation of new neural networks in a continuous learning cycle according to Zull (2002).

This way of staging a science lesson will also result in a transfer of control over the learning process and learning object from the teacher to the student. This is contrary to the general view of teachers planning and teaching a science lesson. But if we want genuine learning to take place in the learner, then this is the way for creating intrinsic motivation.

If a student is genuinely interested in a subject then the reward system in her brain goes into action and contributes to the activation of motivation by activating the dopaminergic system within the limbic region of the brain.

The story about ANIARA has novelty and is a way of making sense of future studies in an imaginative way. The poetical way of telling a story leaves space for individual interpretations and thus gives the student control over his inner mental construction of stories and thus learning.

Representations in the mind

Damasio (1999) discusses an interesting hypothesis which might be valid in this context. He creates a mental model, which includes *"useful representations"*. We have, according to Damasio, in our minds earlier memories stored in the form of representations which are composed of neural networks. When we make a new experience which enters the mind, in the form of firing neurons, then there is an act, in accordance to Hebbian (Hebb 1948) strengthening of connections between the neurons in the useful representations and the neuronal configurations formed by the new experiences.

This means that neural connections emanating from experiences we get from listening to the story about Aniara's space travel will interact with neural networks consisting of knowledge about for example the threatening environmental problems of today.

Memories

There are different types of memories in the brain. One division could be between *conscious – and unconscious* memories. Maybe the story of ANIARA could interact with our *unconscious memories* or feelings about social and environmental problems and make these accessible on a conscious level and thus get them to act as preconceptions and to build on in science lessons.

Memories of the Future

Goldberg (2001) refers in his book *"The Executive Brain – Frontal Lobes and the Civilized Mind"* to a type of memory, named by the Swedish neuroscientist David Ingvar as *"memories of the future"*. Usually memories are about the past. Memories of the future could be regarded as neural networks which contain *visions about the future*. These memories should, physically, be located in the frontal lobes, were creative and imaginative thinking takes place.

Neural networks consist of clusters of neurons which contain pieces of data. In a way there is no physical difference between different kinds of neural networks – they are physical examples of clusters of neurons. There might however be a difference in the recall system.

There is however a difference in the connections between these clusters of neurons: The closest neurons have more connections than more distal neurons. This leads to the fact that associations made to adjacent information are more frequent than association to distal information. It might thus be difficult to break well established ways of thinking,

Visions which create *"memories of the future"* might however be able to act as a base for *active implementation of actions.* These actions might be directed against the threats to our natural environment or society and our inner mental environment, were different stress-factors are to be found.

The Finnish philosopher George-Henrik von Wright (1996) describes in his novel ***"Att förstå sin samtid"*** (Seine Gegenwart zu verstehen) how he, in four steps, creates a *"screen of the future"* with the help of which he is able to make an analytic approach in order to study consequences of human activities. This might be regarded as a way of making sense of a story about the future:

1. On this screen von Wright projects the most important trends he identifies in our time;
2. Then he studies the historical roots of these trends;
3. Then he analyzes the consequences of an extrapolation into the future of these trends;
4. Finally he tries to find out if these trends could be threatening to the survival of humanity and he explores what could be done in order to counteract these trends.

In a similar way it could be possible to utilize the Space Epic Aniara in order to try to study the dynamic influences of science and technology on the living conditions of humanity. One result from such an approach might be to realize the importance of trying to include consequences of science and technology into school curriculum on all stages.

Kassandra

The author Harry Martinson expresses however some doubts about this process. He talks about *"Kassandra-Warnings".* The ancient princess Kassandra lived in the old city of Troy and she received from the Goods a special gift: she became able to predict the future – but the irrational Goods added a drawback to this gift: No one would ever believe her visions.

Jonsered

In a lecture at Jonsered the 10 of October 2007, Professor Charles Hopkins, who has a chair at UNESCO and UN, stressed the urgent need to regard environmental questions in an outmost serious way. He stressed the importance to include different aspects of *sustainable development* in all levels in school curricula.

In the subsequent discussion Rolf Ekman, professor in neurochemistry at the University of Göteborg, pointed out the importance of regarding the internal environment, the neural configurations, within the brain as seriously as the surrounding environment. The internal environment is created by experiences in interaction with and adaptation to the outer environment.

The human brain has been extremely successful in Mans adaptation to the outer environment as Darwinian evolution has given her a unique neocortex and a magnifique frontal lobe. With these, Man has been able to fool herself that he is master of the creation and exists outside and

above Nature. Nature is by the Christian Man regarded as given to him to be used at his own will.

Maybe experiences from science lessons emanating from the study of the content of the Space Epic ANIARA, and specially song nr 102, could affect and contribute to possibilities of changing such an attitude.

The Space Epic ANIARA might be a mental vehicle which could merge a vision of our Earth as a Spaceship travelling in an endless space, with a mental vision of Spaceship ANIARA travelling within our mind. One could utilize the learning cycle as given by Kolb and Zull could be regarded and handled as follows:

*# In the **occipital lobe**, experiences enter the brain.*
*# In the **temporal lobes** these experiences are integrated with preconceptions about the need for action for creation of sustainable development.*
*# In the **frontal lobe** abstract and creative ideas and hypothesis are evaluated and formed about problems and possibilities.*
*# These ideas are then actively tested via the motor centre in the **parietal lobe**.*
*# Finally, these tests give new experiences which act as inputs to the **occipital lobe**.*
 # Then the cycle repeats itself as a spiral, which enhances knowledge acquisition and metacognitive reflection by learners.

Such a working scheme might be introduces at all levels in school as it is important that everybody is aware and active in regard of the importance of this question. Everybody on this Earth is affected by the fate of our environment.

In the OECD report (2002) it is pointed out that the traditional hierarchy of:
***K**nowledge – **S**kill – **A**ttitude* should be changes to ***A**ttitude – **S**kill – **K**nowledge.*

The reason is that if we are able to create a positive attitude and teach student relevant skills, then they will be able to find knowledge in the overwhelming World Wide Web.

It is thus worth to try a more humanistic approach to science in our time when young people seem to avoid studies in science and technology. This is a paradox as they like to use the fruits of science and technology. Problems created by science and technology may only be solved by science and technology. This paradox has been expensively discussed by Svein Sjöberg (2001).

We should however not forget ethical aspects, maybe best expressed by Dostojevsky who, in his book "*Notes from the Underground"* pointed out that: *"Beauty will save the World."*

Summary

Our mental experiences literally change the physical structure and function of our brain. The idea of storytelling is at the nucleus of what learning means, as stories give us mental experiences within physical dimensions.

Learning is ultimately a way for building neural connections and synaptic relationships in the inner Universe of our Brain. This promotes stability in our lives in the outer Universe of Nature and Society. The physical operations and functions of the brain are innately connected

to the stories we create in order to live the lives we do. Designing learning experiences through storytelling then also means to re-design the neural networks in our brains. If we are utilizing a new story, we are not only listening to a new narrative but literally rewiring our brains as well. New narrative causes changes in our behaviour and might affect our actions.

This process of learning via narratives and the resulting rewiring of the brain will ultimately change the way we create relationships with others human beings in our society and with the natural world around us.

The brain has, by neuroscientists, been regarded as a system of neural networks. It seems however likely that a *neural narrative* might be regarded as a metaphor for the brain or at least the mind. The neural network of connections and linkages within the physical structure of our brain is quite literally a storyteller. It tells the story of why we think and feel the way we do. This story may take different forms depending on different inputs. Maybe the utilization of the story about ANIARA´s unlucky space journey might in science lessons affect vital neural connections and increase students awareness about the threatened situation of the space-ship Earth.

References

Blakemore, S-J. & Frith, U.(2006). The Learning Brain, Blackwell.
Cozolino, L. & Sprokay, S. (2006). Neuroscience and Adult Learning. In Johnson, S. & Taylor, K. (Ed.): The Neuroscience of Adult Learning. New Directions for Adullt and Continuing Education Nr 110, Summer 2006). Wiley InterScience.
Damasio, A. (1999). Cartesius misstag.Natur och Kultur. Stockholm.
Damasio, A. (2000). The Feeling of What Happens. Body, emotion and the making of consciousness. Vintage, London.
Hebb, D. O. (1949): The Organization of Behavior. John Wiley & Sons, New York
Goldberg, E. (2001). The Executive Brain – Frontal Lobes and the Civilized Mind. Oxford University Press.
Hellstrand, Å. & Ott, A. (1995). The utilization of Fiction When Teaching the Theory of Relativity. Physics Education, Nr 5, sept 1995, p 284-86.
Klass, S. & Sjöberg, L.(1991): Translation ANIARA – a review of man in time and space by Harry Martinson. Vekerum förlag
Kolb, D. A. (1984). Experiential Learning. Experience as the Source of Learning and Development. Prentice Hall.
LeDoux, J. (2003). Synaptic self. How Our Brain Become Who We Are. Penguine Books. New York.
LeDoux, J. (2004). The Emotional Brain. Clays Ltd. London.
Nolte, U. www. Fantastik-online.de
OECD. (2002). Understanding the brain, towards a new learning science. Paris: OECD Publications.
Ott, A. & Broman, L. (1998). Aniara: On e Space Epic and its Author. Planetarium Vol. 27, #2 June 1998.
Ott, A. & Vedin, L-G. (2001). Interaction between Culture and Technology in Informal Learning. Proceedings from the Conference “Lernort Deutsches Museum: Koncepte, Inhalte, Methoden von Lern- und Lehrerveranstaltungen im Kerschensteiner Kolleg, vom 22 – 25 Oktober 2000.

Ott, A. (1995). ANIARA . Ett didaktiskt kulturmöte mellan naturvetenskap och humaniora. Department of science education, Göteborg University.
Pinker, S. (1997) How the Mind works. Penguin Books.
Restak, R. (2004). The New Brain. How the modern age is rewiring your mind. Rodale Ltd
Schank, R. C.(1990). Tell me a story: Narratives and Intelligence. Evanstone, Il. Northwestern University Press.
Schlipp, P.A. (Ed.) (1983): Albert Einstein als Philosoph und Naturforscher. Vieweg
Sjöberg, S. (2001). Science and Technology in Education. Current Challenges and Possible Solutions. Invited contribution to meeting of Ministers of Education and Research in the European Union, Uppsala, Sweden, 1-3 March 2001.
Spitzer, M.(2002). Lernen. Gehirnforschung und die Schule des Lebens. Spektrum Akad. Verl.
Zull, J. E. (2002). The Art of changing the Brain. Enriching the practice of teaching by exploring the biology of learning. Stylus Publishing.

Appendix.

Bakom Spegelns yta

Bilagor som återger deltagarnas och organisatörernas verksamhet i samband med seminariernas genomförande:

Projektet ”World Wide Workshop” har genom åren huvudsakligen genomförts som:
a. Lärarfortbildning på riksnivå – SÖ:s sommarkurser;
b. Handledarutbildning och kurser för lärarstuderande inom ämneslärarutbildningen.
Verksamheten har möjliggjorts genom finansiering från bl.a.:
dåvarande Skolöverstyrelsen genom Fortbildningsavdelningen i Göteborg;
dåvarande Lärarhögskolan i Göteborg;
Institutionen för Ämnesdidaktik vid Göteborgs universitet;
Utbildnings- och forskningsnämnden för Lärarutbildning (UFL) vid Göteborgs universitet.
Ett antal studerandegruppers deltagande har möjliggjorts bl.a. genom stöd från Adlerbertska stipendiefonderna.

Vi, Aadu Ott och Lars-Göran Vedin, är ytterst tacksamma för det stöd och den stimulans som projektet fått under de 28 år som ”World Wide Workshop” har pågått.

Bilaga München;
Examensarbeten utgående från deltagande i seminarier:

 # ”Bara trappor och gamla montrar” – Utvärdering av Deutsches Museum som inslag i teknikkursen.
Johanna Elwhagen & Ebba Johansson**.** Examensrapport 2001:38; Institutionen för Pedagogik & Didaktik Göteborgs universitet**.**

Författarna skriver: ”*Sammanfattningsvis kan vi konstatera att en övervägande majoritet av de som rest till Deutsches Museum bara uppfattat det positivt. Säkerligen har denna positiva känsla färgat av sig på deras nuvarande lärarroll. De flesta har en positiv inställning till att själva göra besök på museer/science center….Jag fick en ny syn på museer. Museer blev till en spännande plats där man kan upptäcka och lära saker, inte bara trappor och gamla montrar.”*

 # ”Teknik & design” – En fallstudie om lärarstudenters syn på ämnesintegreringen mellan Teknik & Design.
Anna Zachrisson, Dan´ce Micevska & Avichai Arbiv.
Examensrapport PDS 900: 2006; Institutionen för Pedagogik & Didaktik, Göteborgs universitet.

Författarna framhåller:*”Det som tydligt framkommer, är vikten av att lära sig det historiska bakom varje ämne och dess definition, för att sedan kunna gå vidare och koppla ihop alla kunskapernas röda trådar. Inte bara av kurslitteraturen men också utav upplevelser, som kan*

skapa ett starkt intryck på hur en människa både lär, uppfattar och ser på sin omgivning och kunskap."
"Integreringen mellan teknik och design anser vi är viktig för att dagens skola skall kunna hänga med i samhällsutvecklingen och att dagens skolelever ska få en bredare förståelse för hur ämnena som kunskapsdiscipliner samverkar med varandra."

Ett typiskt program kan se ut så här

Seminariet den 1-7 april 2006. Ledning A. Ott & L-G. Vedin.

Lördag den 1 april: Ankomst per flyg kl 16.35. Inkvartering på Kerschensteiner Kolleg.
Guidad promenad till Ratskeller på Marienplatz där middag åts kl 19.30.
Kvällen avslutas med besök på Hofbräuhaus.

Söndag den 2 april: 9.15: Frukost i Museets restaurang.
10.15: Översiktlig guidning genom museets samlingar, ledd av Aadu Ott.
13.30: **Wechselwirkung zwischen Naturwissenschaften und Technik in der Geschichte.**
Växelverkan mellan naturvetenskap och teknik genom historien.
Guidad visning, ledd av Aadu Ott, varvid museets samlingar nyttjades för att visa på hur naturvetenskap och teknik har samverkat från Antiken till Atomen och omskapat vårt samhälle. Efter visningar finns alltid tid för egna studier tills museet stänger kl 17.
19.00: Guidad visning av det historiska München, ledd av Lars-Göran Vedin. Visningen avsluts med middag på Restaurang Augustinerkeller på Neuhauserstrasse.

Måndag den 3 april: 8.00: Frukost i Museets restaurang.
09.00: **Kraftmaschinen: Fuhrungsvortrag zur Geschichte der Kraftmaschinen.** Maskiner för energiomvandling. Under ledning av Aadu Ott presenteras energiomvandlande maskiner från vindkraft, ångkraft till kärnkraft. Maskinerna demonstrationskörs av museets personal.
12.00: **Planetarium:** Vi besöker världens första planetarium där man med modern utrustning visar skeenden på himlavalvet. På vägen till Planetariet passeras avdelningar för Textil och Miljö och på miljöutställningen begrundar vi en installation som åskådliggör befolkningskurvan. Den gör oss betänksamma inför framtiden. Sen går vi igenom Altamira grottan och ägnar en tanke åt våra tidiga förfäder.
14.00: **Bergbau.** Aadu Ott leder gruppen genom den omfattande modell av en gruva som finns under museet. Efter en kort bön till gruvfolkets skyddshelgon Sankta Barbara i kapellet vid nedgången, ges en historisk exposé över olika brytningstekniker för mineral, salt och kol.
15.30: **Summering av intryck.**
18.30: Gemensam måltid på lämplig restaurang.

Tisdag den 4 april: 08.00: Frukost i Museets restaurang.
09.00: **Transportieren, Fahren und Reisen.** Gruppen promenerar utmed floden Isar till ett annex till Deutsches Museum vid Theresienwiese där Aadu Ott presenterar hur olika transportmedel som cyklar, tåg och bilar har utvecklats. Någon gång har gruppen besökt det enorma annexet för flyg vid det gamla krigsflygfältet i Oberschleissheim.
Efter detta görs en promenad till in till Münchens centrum där gruppen äter lunch.
14.00:**Excursion, Pinakotheke der Moderne.** Under ledning av Aadu Ott studeras avdelningen för Design där exponenter för design från olika tidsåldrar och stilar är samlade. I egen takt tar sig deltagarna sen runt och besöker tavelgalleriet som innehåller verk av kända mästare som Picasso, Chagall, Dali, Kandinsky, Nolte, Magritte med flera.
De som önskar kan besöka **Alte Pinakothek** som ligger strax intill och som innehåller

bl a tavlor av gamla mästare som Lionardo da Vinci, världens största samling av Rubens, många Rembrandt, Tintoretto m fl. Intill ligger också **Neue Pinakothek** med tavlor av van Gogh, Gaugain, Monet och många andra inpressionister.
På dessa tavelgallerier möter vi originalen till många av de reproduktioner som vi ser i olika konstböcker.

Onsdag den 5 april: 08.00: Frukost i Museets restaurang.
09.00: **Moderne Physik als Fundament fur Technik.** Under ledning av Aadu Ott studerar deltagarna hur den moderna fysiken har utvecklats. Originalutrustning tillhörig Georg Simon Ohm, Heinrich Helmholz, Konrad Wilhelm Röntgen, Max von Laue, Werner Heisenberg m.fl presenteras.
Eftermiddag: Tid för egna studier och materialinsamling till redovisningsuppgiften.

Torsdag den 6 april: 08.00: Frukost i Museets restaurang.
09.00: **Mikroelektronik – Fuhrungsvortrag.** Aadu Ott leder gruppen genom avdelningen för mikroelektronik och berättar och visar bl a Blaise Pascals räknemaskin, Kodmaskinen Enigma, Konrad Zuses dator Z 1, superdatorn Cray samt redogör för funktionen hos grindar, vippor, integrerade kretsar och olika slag av transistorer.

13.00: **Exkursion Museum Mensch und Natur.** Med spårvagn far gruppen till Schloss Nymphenburg. Efter en kort visning av slott och slottsträdgård samlas vi i den flygel av slottet som härbärgerar det naturhistoriska museet: Museum Mensch und Natur. Efter det att gruppen skaffat sig en överblick av museet, samlas gruppen i separatutställningen om ”Hjärnan” där Aadu Ott, med hjälp av de manipulerbara uppställningarna talar om hur kunskap om modern hjärnforskning kan bidra till bättre förståelse av lärandeprocessen.

Fredag den 7 april: 08.00: Frukost i Museets restaurang.
09.00: Sammanfattning och diskussion av veckans presentationer. Frågan som hänger i luften är: Hur kan vi gå vidare? Under seminariet har studenterna haft som uppgift at, enskilt eller i grupp, studera något tema som kan användas som underlag för undervisning. Det insamlade materialet bearbetas på hemmaplan och presenteras för seminariegruppen. Dessa teman diskuteras här.
Under eftermiddagen finns tid för enskilt arbete eller besök på stan innan flyget hem går kl 17.45.

Bilaga Paris. Seminarium i Paris.

Under seminarieveckan kommer vi att besöka olika vetenskapliga och kulturella institutioner och miljöer. För att strukturera upp tankar och begrepp så att man har glädje av besöket senare i sin undervisning har det visat sig vara av värde att man redan på ort och ställe reflekterar över vad man upplever och tar del av.

Vi vill gärna, för vår dokumentation, få in ett papper med korta reflektioner, *varje dag,* enligt detta schema från alla deltagare. Vi sammanställer sedan materialet och ger deltagarna en sammanfattning. Under varje dag försöker vi att samlas en stund för att gemensamt diskutera det som behandlats under dagen.

Programmet ser i korthet ut enligt följande:
Lördag 23 sept: Historisk utgångspunkt i den Franska Revolutionen: Besök på Bastilj-platsen och sedan besök på Conservatoire des Arts et Metiers. Promenad i det historiska Paris.

Söndag 24 sept.: Postmodernistisk eller ultramodernistisk museidag: Besök på Cité des Sciences et de l´Industrie, La Villette.
Måndag 25 sept.: Framtidsstaden: La Defence, Eiffeltornet, Napoleons grav med Krigsmuseet.
Tisdag 26 sept.: Klassiskt kunnande: Besök på Palais de la Découverte.
Onsdag 27 sept.: Kultur: Louvren eller Maison Pompidou eller Musée Quai d´Orsay.
Återresan från Paris startar från hotellet kl 16.00 på onsdag 27 sept.

Under seminariet görs, beroende på vädret, guidade stadspromenader över broarna i Paris, till Triumfbågen, längs Champs Elysees, till Place de la Concorde och i Quartier Latin mm. På museerna är modellen att deltagarna först på egen hand får göra en upptäcktspromenad. Därefter sker en guidning varvid för seminariets mål och syfte väsentliga delar av utställningen behandlas.

Dag 1: Lärande i autentiska miljöer
Dagens program inleddes på Conservatoire National des Arts et Metier (CNAM). OA presenterade detta museum som grundats år 1794 och som i hårdvara presenterade det som Encyklopedisterna skrivit om i sitt uppslagsverk. Som dagens reflektionsfokus valdes ***"lärande i autentiska miljöer".*** Som reflektionsgrund tjänade CNAM och en guidad promenad genom det historiska Paris varvid minnesmärken över l´ancien regime beskrevs: La Roche kyrkan, Palais Royal, Le Louvre, Karusellplatsen, Tuileriträdgården fram till Place de la Concorde.

Några av deltagarnas reflektioner:

På plats upplever man dofter och ljud som blir en ytterligare dimension till upplevelsen. Artefakterna placeras i sin autentiska kontext och kan jämföras med hur de ser ut idag. "hands-on". När man reser hamnar man själv i en ny miljö som gör att man kan förnimma saker som man skulle ha missat hemma. Fantasin ges spelrum på ett annat sätt när man reser eftersom man får intryck av ett helt annat slag än som man normalt får. Att resa i grupp ger dessutom en social dimension. Man diskuterar och agerar i grupp och får respons av sina medresenärer.

Atmosfären, att låta sina sinnen ta intryck. Tekniken har vi berört "hands-on", dvs vikten av att ta på och "känna" vilket i stor utsträckning även gäller den fysiska närvaron. Minnen av saker, händelser, samband fastnar mer i verkliga miljöer. Möjligheten att under en längre tid ventilera och diskutera sina intryck. I en lärobok eller på Internet så kan man aldrig få fram den "äkta" känslan om man studerar ett objekt. På plats kan man i "sinnet" tänka sig bakåt i tiden och inse att världen inte alltid sett ut som den gör idag. Även tekniska "uppfinningar" blir mycket mer "verkliga" i verkligheten. Man kan aldrig få klart för sig de rätta proportionerna på bild eller i text. Vid en resa ställs nya krav på ansvar för sig själv och andra. Nya miljöer består av små problem som skall lösas hela tiden.

Upplevelsen att kunna se var "artefakter" uppfanns i miljön sådan den "var" ger "hands-on". Skapandet av minnesbilder och (krokar) att hänga upp kunskaper på är mycket bättre än framför datorn. Det sociala och kulturella tillsammans med andra möter man tekniken från en annan dimension. Böcker, filmer, datorer, hemsidor mm kan inte ersätta besök i verkligheten, man kan inte återge bilder med samma kvalitet, man får en annan känsla när man ser saker i verkligheten. Många gamla mätinstrument, verktyg, maskiner var väldigt vackert gjorda. Detta framgår inte på samma sätt om man ser en bild. Det är dessutom lättare att överblicka

riktiga föremål och hoppa över sådant som är mindre intressant och går tillbaka till intressantare föremål. Att få uppfatta "helheter". Att använda flera sinnen än man gör om man sitter framför en datorskärm. Den sociala samvaron – att ge och ta kunskap från varandra. Brokonstruktioner t.ex. man får pröva på att själv bygga. Det vi gjorde idag har varit otroligt givande och intressant. Bara det att vara i denna stad och i dessa miljöer är outbytbart. I morgon kommer jag nog att vara än mer mottaglig för det vi kommer att se och uppleva på museer och dylikt än idag, eftersom bar staden i sig är så fascinerande. Autentiska miljöer går aldrig att byta ut mot cybermiljöer… En helhet för att förstå delarna. Man får en omedelbar feedback av resekamraterna. Detta ger en helt annan förståelse än att sitta och läsa en bok. Få uppleva platserna där stora händelser har inträffat och förändrat samhället är en känsla som ökar intresset samt helheten. På museet finns kedjor från hur det sett ut från början tills nu. T ex strykjärnet mm. Detta ger en djupare förståelse eftersom eleverna då ser helheten. Man känner historiens vingslag tydligare då man är på plats. Storleken (på föremålen), hantverket, materialet känns påtagligare i verkligheten än på bild och i beskrivningen. Man får också föremålen i en miljö där de ev. hör hemma.
När vi i grupp betraktar föremålen kommenterar vi dem utifrån våra olika perspektiv. Det uppstår ett möte mellan människors olika erfarenheter. 1+1>2. Upplevelserna är inte samma. En bild betyder mindre än ett riktigt föremål i alla sammanhang. Vid själva resan har den sociala aspekten större betydelse än en föreläsning. Det är inte endast kontakten med de historiska föremålen men också med miljön som vi har idag. Hur kunskaperna har flyttats från ett land till ett annat. Att vistas på plats där saker och ting finns att få röra dem och se dem "live" gör att man minns sina sinnesintryck mycket tydligare. Det är lite som att se en kändis levande. Intrycken i en autentisk miljö blir så många fler och stimulerar alla sinnen på ett sätt som är omöjligt via t ex en dator. Detta leder till fler tankar och kräver oftare att tankar och intryck ackommoderas till den befintliga tankestrukturen, vilket i förlängningen leder till en mental utveckling som annars vore omöjlig. Att man även reser i grupp och på så vis arbetar utefter "extended mind" – principen vid besöken leder till att fler får nytta av mer. Autentiska miljöer ger bestående intryck. Autentisk miljö ger en helhetsupplevelse. Där hela kroppen är delaktig, ljud, ljus, dofter, rymderna. Att ta på. Jfr. upplevelsen av "fladdermusflygmaskinen" på bilden utanpå foldern… Den såg man knappt… Ingen AHA-upplevelse.. En helt annan sak var att se maskinen i trappan på riktigt.

Dag 2: The Reader is the Writer of the Text.

Dagen tillbringades på det stora tekniska museet Cité des Industrie et Science, La Villette. Som reflektionsfokus tjänade den franske postmoderna filosofen Bruno Latours yttrande ***"The reader is the writer of the text".*** Som reflektionsgrund tjänade den av en annan postmodern filosof, Jean Francoise Lyotard, som hade designat utställningen Explora.

Att jag som läsare skriver boken betyder för mig att jag tar till mig budskapet. Läser jag kurslitteratur innebär det ofta att jag får idéer för undervisning eller dylikt. Om jag inte får idéer = tar jag till mig budskapet = skriver boken är det nog ingen bok som passar mig.
Vi som naturvetare/lärare har ett stort ansvar att ge elever möjligheter att skriva/befästa sin egen kunskap. Att se fenomen –händelser – science centers men också att läsa andras texter. (behöver inte vara fysikstudier utan dikter, historia etc. är också att ge möjlighet " Att själv formulera, skapa sin egen kunskap få den prövad "ger kickar".)

På en sådan resa ser man arkitekternas originalitet från den materiella delen då det gäller att bygga objekt. Under 1700-talet stor dominans av stora stenstolpar. Under 1900 talet har vi att göra med stål konstruktioner. Pga av den franska "dumma politiken" har vi svårt att

förstå så mycket. En sådan resa med elever kunde man organisera i samarbete med franska språklärare: varför finns det inte information på annat språk än franska?

Texten kan innehålla information som förhoppningsvis kan ombildas och bli en del av den kunskap som läsaren har. Om texten är krånglig eller otydlig så är det möjligt att läsaren inte kan ta del av den information som den var avsedd att förmedla och på så sätt kan inte läsaren få del av den kunskap som ligger bakom.

Exempel: Vid La Villette saknade många "interaktiva" montrar engelsk text. Eftersom jag inte kan franska så avfärdade jag många som helt ointressanta, även om dessa med en engelsk text hade varit intressanta för mig. Likadant kan mina elever säkert uppleva en demonstration el liknande utan bra baskunskaper (de saknar helt enkelt "språket" och laborationen/demonstrationen kan för eleven te sig helt ointressant) För att kunna skriva sin egen text krävs det att man kan läsa.

Genom läsarens ögon bearbetas texten/informationen till kunskap. Beroende på vem mottagaren är kan samma information bearbetas till olika sorters kunskap. Ingen kan tvinga in information i en utan kunskapsintagandet måste komma självmant. Att kunna relatera till sina tidigare erfarenheter är en viktig aspekt.

Om man gör en utställning han man redan gjort ett urval som skall tolkas. Om man "snitslar" blir tolkningen styrd i större omfattning än om man inte gör det. En osnitslad bana är naturligtvis friare för tolkning men den ger ju heller eleverna ingen hjälp för sina kopplingar.

Att bara läsa en bok kan för mig inte ge den upplevelse som jag fått idag. Kombineras detta med ett vetenskapscentra så ger detta desto mer förståelse.

Det första intrycket på detta vetenskapscentrum var att omfattningen var oerhört stor. Skulle jag med klassen besöka detta (eller ett annat) Vetenskapscentrum skulle jag begränsa områdena, detta ger mer tid till ökad förståelse inom området. Gå igenom innan förklaringar på lektionen för att själv kunna söka svaren, möjligen ge en bakgrund att stå på.

Dag 3: Broar över tid och rum.

Som reflektionsfokus tjänade meningen *"**Broar över tid och rum".*** Reflektionsgrunden utgjordes av ett besök på Marsfältet, turen upp till toppen av Eiffeltornet samt ett besök i den moderna stadsdelen La Defence samt av den svindlande hissfärden upp i Grand Arche.

Att ta vara på traditionen, men ändå våga vara visionär och skapa nytt.
Den moderna staden, en förlängning av traditionen, som dagens utpost av människan skapad miljö. Stadens grundide förlängd, men kompletterad med dagens idévärld.
Eiffeltornet 1889 klar – bro mellan 18-tal och 20-tal. Ger vida vyer och översikt. Visuell bro över staden.

Grand Arche är en bro. En bro mellan turisten och arbetsvardagen. Mitt bland stora kontorskomplex finns denna turistattraktion. Det blev en blandning av människor på restaurangerna, i affärerna och på de öppna platserna. Grand Arche är en bro mellan olika rum.

Gammalt och nytt som står sida vid sida som det vi sett idag ger en härlig känsla av att vi är rädda om det gamla men vågar satsa på framtiden.

Förlängningen av Champs Elysee vidare till La Defence kan vara en bro från det gamla till det nya. Att bevara det gamla när man bygger det nya ger en kontinuitet som kan behövas i en ständigt föränderlig omvärld.

Bron står för en förhoppning. En önskan att finna nytt och spännande på andra sidan. Bron står för gemenskap, att enkelt kunna mötas trots ett fysiskt hinder. Bron leder till något annat som varit ouppnåeligt utan bron. Bron väcker nyfikenhet: Vad finns på andra sidan? Bron fungerar som en vägvisare i rummet mot en ny plats med nya möten och en ny tid. Bron väcker drömmar, speciellt då den leder över vatten. Ett dynamiskt flöde från svunna tider.
Min spontana tanke är jämförelsen med människor som broar – broar mellan kunskapsöar, där floden som rinner under broarna består at information. T ex två personer kan läsa samma text och oberoende av varandra dra helt olika slutsatser, men i ett samtal tillsammans så kan båda ta del av den kunskap som annars skulle vara fördunklad. Dialogen fungerar här som broar i samtalet, mellan de mentala kunskapöar som de samtalande besitter.
Man bygger broar hela tiden…mellan människor, saker, händelser och upplevelser.
Med hjälp av andra kan man lösa det mesta men inte allt. Det är som ett pussel, varje person bidrar med sina bitar och gemensamt formar man en helhet.

Har idag fått nya intryck igen. Detta supermoderna centrum är otroligt spännande. Att bygga ett centrum utanför staden istället för att bygga och riva det gamla är bra. Blir en bro mellan det gamla och det nya.

Det jag sett idag är hur viktigt det är att artefakter inte hänger i luften. Byggnadsverk, broar, vägar knyter an till historien, framtiden, nutid på en mängd olika sätt. Att bygga broar är mycket viktigt för att knyta samman människor, idéer och tankar. En bro är bättre än en tunnel som ”inte syns”. Att få bygga en bro, konstruera en bro är en lisa för själen.
Genom att komma högre upp i luften kan man se både den nya och den gamla tiden. De båda triumfbågarna representerar varsin tidsepok. Den gamla kyrkogården bakom la Defence representerar tidigare liv och byggnaderna framför la Defence visar en futuristisk arkitektur med ett nytt liv. På så sätt blir la Defence en bro över tiden.

Dag 4: Sårbarhet – Säkerhet

Reflektionsfokus var dikotomin ***”Sårbarhet – Säkerhet”.*** Reflektionsgrund utgjordes av den delvis strejkande Metron, guidning vid Napoleon´s Triumfbåge samt besök på museet Palais de la Decouvert.

I dagens samhälle har vi byggt upp stora och komplicerade tekniska system. Det finns marginal för många eventualiteter, men vissa delar är livsnödvändiga. Om man vill störa ett modernt samhälle gäller det att t ex slå ut datorerna och deras funktion att styra och reglera. Även elsystemen är en känslig punkt. Med komplexiteten följer sårbarhet då många funktioner är sammanlänkade i olika nät.

Sårbarhet: att ”förlora” traditioner i det gamla samhället (mentalt); att inte behärska helheten i det nya (fysiskt);

Säkerhet: söka sig tillbaka till ursprungskulturen (mentalt); att förstå, få fördelar (välfärd); att vara en modern människa. Experiment som grund för tänkande, är det inte fantastiskt att vi har hamnat här. När tog detta tänkande över? Experiment är gammalt, men när fick det status hos styrande? Var i Sverige? När i England, Frankrike, USA, Tyskland?

Samhället med dess tekniska systemverkar ha fler sköra länkar, särskilt på de platser där många människor bor/samlas (storstäder). Exempelvis strejker, som inte skulle vara/bli lika kraftfulla på en liten ort. En mångfald med olika tekniker med samma syfte gör att samhället fungerar även om en teknisk lösning slås ut pss som monokulturer inte är bra.
Hur kan man klara sig: strejk -; trasiga apparater – kunskap; elavbrott – olika alternativ; trafik – trafiksäkerhet; tankarna är i motsatser.

Det moderna samhällets ökade beroende av storskaliga tekniska lösningar ger en mängd nödvändiga saker i vardagen och gör samhället mycket sårbart. T ex elavbrott som får de flesta apparater att sluta fungera. Överföring av data för att sköta betalningar istället för pengar gör att datafel/elfel kan omöjliggöra handel och /eller betalningar av räkningar och dylikt. Alternativa system måste byggas upp som reserv.

Teknisk sårbarhet uppenbarar sig dagligen, när vi upptäcker att teknisk utrustning inte fungerar. Trenden ”slit och släng” gör sig påmind, dvs man köper en ny när den inte fungerar. Oftast är det ett billigare alternativ än att laga. Kunskaper som möjliggör ett visst oberoende av tekniska apparater känns påtaglig. Insikten om detta skapar ett behov av kunskap om det som finns bakom tekniken samt om alternativa lösningar/tillvägagångssätt. Skapat behov är inte alltid nödvändigt.

Gamla kunskaper måste bevaras. Samhällsmedborgare måste vara förtrogna med teknikens möjligheter och brister, styrka och svaghet.

Ny kunskap och nya kunskapsområden måste ha ”spelregler” så att ”missbruk” inte får ske (genmanipulation, kärnkraftskatastrofer etc. Kretsloppstänkande.
Den bästa garantin för att klara ett sammanbrott ligger i människans otroliga förmåga till anpassning. För att förstärka anpassningsförmågan och för att minimera ett eventuellt sammanbrotts konsekvenser bör man se till att sprida kunskap om grundläggande överlevnadskunskaper. Ex att göra upp eld, hålla värmen, rena vatten, vilka hygienregler som bör gälla etc.

All utveckling är sårbar innan den prövats, utvecklats vidare och blivit ”godkänd” av den ”vanlige Svensson”. Inte ens då är den osårbar om utvecklingen gått för fort…överallt finns hackers!

Utvecklingen sker ju väldigt snabbt. Vi är mycket beroende av tekniken och den är sårbar.

Dag 5: Växelverkan mellan teknik och kultur.

Reflektionsfokus för dagen var *”**växelverkan mellan teknik och kultur”.*** Reflektionsgrund utgjordes av olika konstmuseer samt, för somliga, av Saint Chapell, Pont Neuve samt la Conciergerie.

Något som hänger ihop intimt. Några tankar från idag. De gammaldags gatlyktorna i Paris som förknippas med gammal teknik trots att de nu är elektriska som kontrast till detta den nya

som visades på Center Pompoídou. Intressant att se i vilka miljöer en sådan ev kommer att användas i. Tekniska gamla apparater på ett museum är stilla. Inom konsten blir det en helhet, en bevarad avbildning av tekniken då den finns med. Kultur och teknik är en del av samma helhet. Något som ständig utvecklas och förändras, men ändå måste finnas kvar. Ett tydligt exempel fanns i t ex Saint Chapel där skicklig byggnadskonst kombinerades med vacker utsmyckning och vacker arkitektur.

Teknik och kultur har väl alltid blandats på diverse olika sätt. Tekniken som nöje har vi i Pariserhjulet, naturvetenskapliga experiment har använts som förströelse i salongerna "när det begav sig", olika tekniker har använts inom konsten….Broar mm..Igår fascinerades jag mycket över tekniken och kulturen, hur man sjönk in i tavlornas djup beroende på avstånd och vinkel. Den konst vi träffade på idag gav andra tankar, kanske inga alls ibland eller så fick fantasi fritt spelrum.

Saint Chapelle blev ett utmärkt exempel på hur tekniken (att bygga in hållfastheten mellan de skira målade fönstren) och konst förenas. För övrigt synbart i de flesta gamla och nya byggnader i Paris.

Andra exempel: Musik och matematik; Poesi och matematik/fysik; Fysik och speciellt astronomi och elementarpartikelfysik som knyter an till filosofi, som leder vidare till litteratur, teater, konst….

Modern design är oftast idag ett resultat av teknik (= framställningsmetodik, användarvänlig, funktionell) och design. Ett föremål är vackert först när form, färg och funktion bildar en harmonisk enhet.

Teknik är en viktig del i bl a sömnads-, vävnings-, sticknings- och matlagningskonst. Intressant att på ort och ställe studera vad det landets och den kulturen "visar fram" på museer mm. Trafikintensiteten var överväldigande – hur varje vrå tas tillvara. Byggnadskonst på högre nivå visade flertalet byggnader upp och där tekniken i utsmyckningarna var ***fantastisk.***

Bilaga London. Seminarium i London: Program för Londonseminariet: *Vadan och varthän?*.

Tisdag 24/4. Ankomstdagen.
Avresa från Landvetter kl 16.50 med ankomst till London kl 17.55.
Tunnelbana från Heathrow till Piccadilly Circus. (Piccadilly Line) och installation på Hotel Regent Palace. På kvällen promenad i centrala London: Soho, China Town, Leichester Square mm.

Onsdag 25/9. <u>Tekniskspåret:</u> Naturvetenskap och teknik i växelverkan.
Besök på Science Museum i Kensington. (Öppet 10-18 dagligen).
I samma område ligger också Natural History Museum.

Torsdag 26/9. <u>Maktspåret:</u> Kunskap är makt.
Besök på Imperial War Museum på South Bank. (Öppet 10-18).
Temat kan kompletteras med ett fokuserat besök i British Museum i Bloomsbury.

Fredag 27/9. <u>Framtidsspåret:</u> .
Besök i Greenwich. Vi beså clipperskeppet Cutty Sark, The Naval Museum, The Meridian Museum samt gjorde en båttur ut till The Thames Barrier.

Lördag 28/9. <u>Urbaniseringsspåret:</u> Tema storstad i utveckling.
Besök på Museum of London (Öppet 10-17.50) i City. I omgivningarna finns Saint Pauls Cathedral, Towern, Tower Bridge samt en stadsdel i spännande förnyelse. Temat utvidgas genom ett besök på London Transport Museum i Covent Garden som är ett center för folklivet.

Söndag 29/9. <u>Det mångkulturella spåret:</u> Identitet i ett föränderligt nu.
Njut av ett konstverk på något av de berömda konstmuseerna i London.
Stanna till i andakt vid Newtons grav i Westminster Abbey. Vandra genom regeringskvarteren i Whitehall och titta in på Downing Street no 10.
Lyssna till klangen från Big Ben. Möt berömdheterna på Madame Tussauds. Köp den svårtillgängliga boken hos Dillons. Upplev folk och färg på gatorna. Besök något annat museum eller….

Varför London?

Bakgrund

Som ett led i internationaliseringen av naturvetenskaplig och teknisk undervisning vid Göteborgs universitet förlades ett seminarium till London under hösten 1999. I seminariet deltog studenter som läste teknik i intervallet 41 - 60 poäng samt lärarutbildare med skilda inriktningar.

Studenterna hade tidigare, under sina studier i teknik upp till 20 poäng, deltagit i en studieresa till München där under en vecka den naturvetenskapliga och tekniska revolutionen var temat. En revolution som förändrade livsvillkoren för alla på jorden.

Under sina fortsatta studier upp till 40 poäng hade studenterna genomfört en studieresa till Paris. Där var utgångspunkten den Franska revolutionen, en politisk revolution som öppnade

Europa för upplysningstidens tankar och startade en tidsepok som kallas för modernism. En epok som präglades av framstegstanken. En tanke som kanske bäst framfördes av filosofen Condorcet strax innan han bragtes om livet i den tumultartade franska revolutionen: *”Toute decouverte dans les sciences est un bienfait pour l´humanite.”* Alla upptäckter inom vetenskaperna är till välsignelse för mänskligheten. En revolution som störtade en obsolet aristokrati och ett enväldigt kungavälde, frigjorde tankenvärlden från övertro samt bröt kyrkans makt. Historiens list är dock att tio år efter revolutionen så hade en kejsare tillskansat sig makten.

Vid studieresan till London utgjordes fokus av en utveckling av en värld i postmodernistisk eller senmodernistisk anda. Borta var nu den optimism, som präglat den modernistiska epoken, om att tekniken kunde lösa alla problem. Borta var tankarna på en evig tillväxt. Vi kunde iaktta hur ett imperium med anspråk på global makt fick dra sig tillbaka innanför sina egna tidigare gränser, men med problem som uppkommit i den globala yran.

Syfte och mål

Seminariet i London hade olika syften för de skilda deltagargrupperna:

För arrangörerna var målsättningen att finna ut vilket värde ett seminarium av detta slag kunde ha i utbildningen av studenter och eventuellt som inslag i lärarfortbildning. Därför var det intressant att deltagarna kom från två skilda kategorier, lärarutbildare och studenter. För lärarutbildarna var en målsättning att under seminariets gång diskutera och utveckla samverkansmodeller för att kunna undervisa i teknik så som ämnet kan betraktas som en kulturella aktivitet som bedrivs i en social kontext.

För studenterna var målsättningen att med de samlingar av kunskaper och föremål som exponeras på olika museer och science centers skaffa sig en erfarenhetsrepertoar att använda i sin dagliga verksamhet i skolorna. Målet var också att genom situerade studier i autentiska miljöer få del i och förståelse för den europeiska kulturens skeenden. I ett snabbt föränderligt samhälle som går mot allt större inslag av mångkulturalism är en internationell erfarenhet av stort värde.

Bilaga Athen; Seminarium i Athen: *På tjänstepromenad*

Göteborgs universitet och Certec, LTH, genomförde en studieresa till Grekland 23 – 29 november, 2001. Avsikten från GUs sida var att gruppen skulle få inspiration och möjlighet att bättre samtala sig samman om perspektiv och innehåll i lärarutbildningen. För Certec, som arbetar med forskning om funktionshinder och teknik, var huvudmålet för reflexion kulturella perspektiv på funktionshinder.

En plats är ju så mycket mer än en plats – en plats leder till en specifik närvaro och en specifik dialog. Man kan gå på tjänstepromenad och fundera. Här kommer ett exempel på vad vi, Aadu Ott, GU, och Bodil Jönsson, Certec, samtalade om sista dagen då vi gick en avskedsrunda mellan några av de klassiska fixpunkter som finns kvar från antikens Athen.

Ja, vad är egentligen detta vi kallar för universitet?

Vi hade redan börjat prata om det redan när vi gick ut genom hotellentrén och såg de av morgonrodnaden svagt rosafärgade ruinerna av det enorma Zeustemplet. Frågan är om vi

överhuvudtaget slutade prata om universitetet under 5 timmars-promenaden. Vi vek av vid statyn av den kända skådespelerskan och parlamentsledamoten Melina Mercouri som spelade den oförglömliga rollen av en prostituerad i filmen ”Aldrig på en söndag”. Vi tog den nyligen upprustade och stensatta paradvägen upp mot Akropolis. Det byggs och fejas överallt i Athen inför Olympiaden år 2004. Men ”överallt” gäller naturligtvis enbart de centrala delarna. Det som skall visas upp för världspressen.

Vi stannade till på ett ställe när vi hade kommit bort lite från de höga husen som skymde himlen. Aadu tog fram sin lilla GPS apparat, fick eftre några minuters manipulerande kontakt med fyra satelliter och såg att felet på lägesangivelsen krympte ner till elva meter.

Lite fascinerande var det – Bodil berättade om Isaac-projektet och hur GPS använts för människor med utvecklingsstörning redan år 1994. Och Aadu tyckte att det var en kul grej för honom – även om han kunde lita på sitt eget lokalsinne. Information kan man få av GPS:en. Men hur är det med kunskap? Bodil brukar stressa skillnaden mellan information och kunskap och det gör också Sven-Erik Liedman, speciellt i sin bok ”Ett oändligt äventyr” som vi alla hade läst inför Athenresan. Aadu markerar att i SOU rapporten ”Skola för bildning”, bakgrundsdokumentet till den nu gällande skolideologin, Lpo94, står det att kunskapen är konstruktiv, kontextuell och funktionell. Det betyder att det är vi människor som själva konstruerar vår egen, och högst personliga, kunskap. Kunskapen finns i ett sammanhang. Kunskapen skall också fylla ett ändamål och skapa mening i vår värld.

Antiken kan verkligen vara en guldgruva även för samtal om modern teknik. Det var där de föddes, tankarna om epistemologi, dvs kunskapens väsen; ontologi, dvs kunskapens innehåll; metafysik dvs grundläggande antaganden och utgångspunkter. De kunde inte motiveras annat än ur ett värdesystem; doxa, som betyder lära och gett upphov till bl a ordet paradox som beskriver sådant som strider mot förgivettaganden inom doxa. För att kunna se avvikelser måste man ha en teori att utgå ifrån i sin förklaring av skeenden i omvärlden.

Förr förlitade sig atenarna till Gudar som bodde i Olympen eller rörde sig på något sätt bland molnen. Men nu gick vi där och förlitade oss på satelliter för att klara ut var vi befann oss och se hur vi rörde oss.

Dionysos på teater och utanför

Vi promenerade vidare. På höger hand hade vi den stora Dionysosteatern. Här hade skådespel av Aiskylos, Euripides och Sofokles uruppförts under författarnas personliga ledning. Här hade hela Athens befolkning samlats. Här hade den store statsmannen Perikles lyssnat på grekiska tragedier….

Kulturens vagga i västerlandet hade stått någonstans här. Numera var det trots allt möjligt att beskåda och i tanken göra sig en föreställning om den forna glansen. Om nu inte den personliga förmågan att tillskapa inre bilder hade försvunnit i och med det kommersiella bildskapandet via exempelvis TV.

Fast det har den inte. Det hade vi märkt bl.a. då vi två dagar tidigare varit vid det enorma Apollotemplet i Delphi. Vi hade i små grupper, andaktsfullt och i begrundande samtal vandrat den Heliga Vägen uppför bergssidan, genom alla de heliga templen.

Där var Sibyllans plats. Det gick lätt att i sitt inre se bilder av budbäraren från Themistokles som rådfrågade oraklet då Athen hotades av den väldiga persiska hären år 480 f kr. *”Bygg en trämur kring Athen”,* blev orakelsvaret. Themistokles tolkade svaret så att han skulle bygga en flotta. Sagt och gjort. Det ledde till Grekernas seger i det stora sjöslaget vid Salamis år 480 f kr.

En annan som ställde en avgörande fråga till oraklet var den mytologiske kung Midas av Lydien. Han ville börja kriga mot sina grannar, perserna. Oraklet svarade: *”Om du överskrider gränsen med din krigshär så kommer ett stort rike att falla.”* Kung Midas blev glad över det budskapet och startade kriget. Mycket riktigt hade oraklet rätt. Ett stort rike föll. Hans eget.

Långt ovanför Apollos tempel, allra högst upp i Delphi, finns den gamla Stadion. Bodil sprang en runda där uppe. Där hade de Pan-Attiska spelen, överträffade bara av Olympiaderna, utspelat sig. Allt var nu i ruiner, men den stora stadion kunde skönjas genom dess geometriska form som delvis var uthuggen ur berget med stenbänkar och karmstolar av sten.

Med en turistkarta i handen som visade de forna byggnaderna i all sin dåtida glans kunde man vandra och dväljas, halvt i verklighetens ruiner av marmor, halvt i föreställningsvärldens drömlika rekonstruktioner.

Lite konstigt var det att föreställa sig att den ateistiska kultplatsen, som en gång helgats åt guden Apollon, revs och förstördes helt på order av den kristne Romerska kejsaren Teodosius. Ännu märkligare är dessutom att denna fantastiska plats sedermera föll i glömska så till den grad att man till slut byggde en by över platsen. Bara dunkla hänvisningar i bevarade textfragment fanns kvar för att minna om denna plats vars betydelse under antiken kunde mäta sig med Athens.

Det dröjde ända till 1800-talet tills nyfikna forskare undrade över om skrifternas hänvisningar till det sagoomspunna Delfi hade någon verklighetsförankring. Själva storyn påminner inte så lite om en törnrosasaga där Törnrosa sov i hundra år och slottet omvälvdes till oigenkännlighet av klängväxter. Sen väcktes Törnrosa av prinsens kyss…..

Där gick vi emellertid i det samtida Athen och pratade om Delfi, medan vi passerade den mäktiga Akropolen eller stadsklippan där det vindomsusade och i sin klassiska skönhet enastående templet Parthenon stod.

Bodil framförde sina funderingar om begreppet ställtid – hur hon trodde att Platon, Aristoteles och de andra behövde använda mycket mindre ställtid, eftersom de inte fladdrade mellan så många uppgifter som vi, sena tiders barn, gör idag.

Idag, menade hon, är det inte bara så att vi stör varandra stup i kvarten – också den mest koncentrerade forskaren stör hela tiden sig själv. Med alla konferenser, alla projekt, alla ansökningar, allt refereeande. Varje gång man byter uppgift, behövs det egentligen ställtid för att komma in i den nödvändiga koncentrationen. Och unnar man sig inte avställningstid och påställningstid blir allt bara ytfladder.

Den här Athen-veckan har varit bra, menar Bodil. Här har varit tid för samtal, långt borta från alla störningar.

Framtidsfrågor, stora och små

Det där att studera framtiden är ju också väsentligt om man arbetar i skolan. Bodil brukar påstå att lärare är framtidsarbetare. Men där gick vi omkring bland resterna av en högkultur som fallit ihop. Här hade Aiskylos låtit Agamemnon säga i en pjäs: *”Att spörja om framtiden är att sörja i förväg.”* Aadu började fundera över om inte målet med hela veckan, som det hade föresvävat oss i Göteborg, på ett genomgripande sätt hade ändrat sig när vi väl kom till Athen. I förberedelsearbetet hade det handlat om att studera antikens kultur. Och visst hade vi gjort det såväl på Idéhistoriska institutionen vid Göteborgs universitet som genom ett antal seminarier på Svenska Institutet i Athen. Dessa sammankomster hade gett oss en ram för vår verksamhet. Därtill:

- Vi har varit uppe på Akropolis och känt historiens vingslag.
- Vi har varit på Dionysosteatern och hört Ingela Wiman berätta om antika dramer. Vi hade lyssnat till den spännande sagan om Agamemnon.
- Vi har varit vid Apollontemplet i Delphi.
- Vi har varit i Piraeus och passerat hamnen Zoe, där Themistokles hade haft de Trieremer liggande som avgjorde slaget vid Salamis.
- Vi har besett Marinarkeologiska museet i Piraeus och en bevarad bit av de långa murarna som skyddade den viktiga vägen mellan Athen och dess hamnstad Piraeus.
- Vi har sett det nationella Arkeologiska Museet och speciellt begrundat Antikythera mekanismen. Det är en hemlighetsfull artefakt som efter studier med avancerad teknik visade sig, i princip, kunna betraktas som en analog dator. Den var troligen tillverkad på Rhodos under århundradet före Kristi födelse. En lika hög teknisk kompetens uppstod i Europa först på 1300-talet då verken till kyrkklockor konstruerades av konstfärdiga klensmeder.

Men kan vi få ihop detta så att vi kan ha det till något meningsfullt för vår verksamhet som lärare i nutiden och i den nära framtiden? Kanske måste vi bara vänta på svaret. Kanske skulle det pluppa upp under promenaden, kanske senare genom någon gudomlig ingivelse? Vi är nog sämre än de gamla grekerna på att invänta att tänkandet blir färdigt. Vår otålighet kännetecknas av kravet på att få tankar ”Just in time”.

Areopagen – och vidare

Vi hade nu kommit fram till backkrönet där vägen upp till Akropolis tog av åt höger. Vi följde den slingrande och vindlande stenlagda vägen tills vi kom fram till Areopagen. Det är egentligen bara en stenig kulle. Trappstegen som leder upp till den var daggvåta och nedslitna av människor som under årtusenden hade tagit sig upp och ner. Vägen upp liknade mer en kana än en trappa och vi fann med en gång att det skulle vara för vådligt att gå upp på kullen, just då i varje fall.

Aadu började berätta: ”Det var här som Sokrates år 399 f. Kr dömdes till döden. Det var här han höll sitt försvarstal där han framhöll…….

Det var också här uppe som aposteln Paulus berättade för grekerna om den okände guden, som för säkerhets skull också fått sig ett litet altare. I vår vandring genom rum-tiden hade vi korsat stora förgrundsgestalters stigar.

Vi vände och gick tillbaka till den stora vägen. Vi hade ju tidigare varit upp på Akropolis. Vi korsade dödsföraktande vägen med dess snabba biltrafik och fortsatte en kullerstensbelagd

väg som ledde uppåt. Aadu höll ögonen öppna och spanade efter en skylt. ”Där är det”, sade han förtjust. ”Vägen till Sokrates fängelse.”

En grön skylt pekade in mot en mindre stig. Vi följde stigen genom den lummiga pinjeskogen och kom strax fram till en brant bergvägg med en ganska djup grottbildning. En skylt förkunnade ”Sokrates Prison”.

”Skulle verkligen Sokrates ha förvarats här?” Frågade Bodil. ”Hur kan man veta det? Tror du inte att det är något som man bara har gjort för turisternas skull?”
Jo, det kan det förstås vara.

Ett par dagar tidigare hade vi besökt en utgrävning som benämndes för Aristoteles Lyceion. Inte trodde vi väl egentligen att det var där som det berömda Lyceion hade legat. Vi var nog vid ett pseudo-Lyceion. Men det gjorde inte så stor skillnad – det var ändå något speciellt ändå att stå där och lyssna till hur Sven Erik på ett livfullt sätt berättade om livet i Lyceion.

Stora andar och dramatiska händelser lämnar på något sätt spår efter sig. Det är lättare, att i närheten av platser där de stora filosoferna verkat, fundera över det evigt mänskliga. Aadu drog sig till minnes hur gruppen, som rekognoserat inför seminariet med viss möda också hade letat sig fram till en plats som kallades för Platons Akademi. Det var numera en plats som skulle kunna betraktas som en grund grop i marken. Den användes till viss del för att dumpa skräp i.

Sic transit gloria mundi.

Pnyx

Vi gick tillbaka till den kullerstensbelagda vägen. Sedan fortsatte vi uppåt igen. Vi kom fram till en mindre grusbelagd väg som tog av åt höger och följde dess slingrande sträckning genom pinjeskogen och sökte oss fram till ett ställe som heter fortfarande, som under antiken, Pnyx. Plötsligt öppnade sig landskapet på ett dramatiskt sätt. Vi befann oss på den gräsklädda toppen på en av kullarna som omger Athen. Framför oss hade vi en märklig bergsformation. Det var en mellan två och tre meter hög förkastning av en ljus bergart som brant steg upp från den gröna gräsklädda platån. Förkastningen sträckte sig flera hundra meter åt bägge sidorna. Berget lyste vitt i det skarpa solskenet.

Vi följde bergssidan och kom fram till ett ställe ungefär mitt på förkastningen. Där hade människor för mer än två tusen år sedan huggit ut höga trappsteg.
Dessa ledde upp till en ur berget uthuggen plattform.

Aadu pekade upp mot plattformen: ”Där är den berömda Beman. Platsen där Athens ledare talade till folket som samlades på fältet nedanför.”

Här hade den kände demagogen Demostenes talat, han som tränade sin talförmåga genom att med småsten i munnen försöka överrösta havets bränningar. Här hade den store folkledaren Perikles också stått. Han som hade ”åskan och silvret på sin tunga”. Den äventyrlige Alchibiades hade även han stått här. Han var politikern och fältherren, vars agerande ledde till att Athen förlorade det långa och bittra kriget mot den konkurrerande staten Sparta. Teodor Kallifatides har skrivit en spännande roman, ”Hetären” om Alchibiades liv och leverne.

På den här platsen kan man anse att demokratins vagga en gång stod. Alla fria män i Athen fick tala här. Ingen inskränkning på grund av börd eller skattekraft gällde. Man lyssnade till alla som hade något att bidraga med till lösning av dagsfrågorna.

En viktig värdegrund i den nya *lärarutbildningen* är just demokrati. Kanske besöket här ligger i linje med utvecklandet av den nya lärarutbildningen. I den skall också kommunikation lyftas fram.

När man höjde blicken från Beman där folkmakten tog sitt första och stapplande uttryck så fick man in i synfältet både Parthenon och Akropolis. Det var platsen där makten hade sitt ursprung. Makten som legitimerades av präster och gudar. En skarp konfliktlinje kan skönjas.

Om man såg neråt längs med ängen där folket hade trängts under antiken så såg man det gamla torget, Athens mittpunkt, Agoran, där filosoferna hade verkat bland folket. Där hade handeln också blomstrat. Ytterligare en konfliktlinje kan skönjas.

Överblick

Vi gick tillbaka till den kullerstensbelagda vägen. På vägen ner fann vi en stig som ledde upp till härföraren Filopappos monument. Och så bar det uppför igen på en ganska brant och delvis stenlagd stig. När vi kom upp till monumentet belönades vi emellertid med en vidunderlig utsikt över Athen med omnejd och med överblick över dess många kullar. Man såg, i det klara vädret ända bort till havet. Athen ligger liksom i en gryta, omgiven av höga berg. Det gör också att föroreningarna som släpps ut i luften från den alltid lika täta trafiken inte kan blåsa bort. Ofta ligger det dessutom ett varmare luftlager som ett lock över staden och hindrar effektivt all luftcirkulation.

I denna tidiga morgonstund hade emellertid inte luftföroreningarna hunnit byggas upp nämnvärt. I den här grytan bor ungefär hälften av Greklands invånare, ca fyra miljoner. Så Athen är faktiskt större än Rom. Den låga bebyggelsen sträcker ut sig så långt som ögat kan nå.

En gång i tiden anlades Athen ca en halvmil in i landet från havet för att vara skyddad från fientliga flottor och sjörövare. En hamnstad, Piraeus, anlades för att sörja för den viktiga importen av livsmedel och den lika viktiga exporten av vin, olivolja och artefakter i form av exempelvis krukor. Athen och hamnstaden Piraeus är numera sammanbyggda. De är också förenade med en effektiv tunnelbana. Från det moderna Piraeus finns färjor som går ut till öarna i Egeiska havet.

Under Antiken förenades dessa städer av en försvarsanläggning som kallades *De Långa Murarna*. Dessa murar byggdes för att trygga Athens försörjning av livsmedel från havet och även exporten av olivolja och olika slag av andra produkter. Murarna revs efter det att Athen förlorat mot Sparta i det Peloponnesiska kriget. De återuppbyggdes men revs slutgiltigt under den romerska ockupationen. Vi såg en bevarad rest av murarna i Marin-Arkeologiska Museet i Piraeus.

Athen under antiken var ingen vacker stad. Samtida ögonvittnen beskriver staden som smutsig och ful och uppbyggd av ett gytter av små hus. Det var bara den officiella delen, Agoran och Akropolis som var imponerande.

Från vår höga utsiktspunkt blickade vi mot Parthenon som lyser bländande vitt i solskenet. Ett cementfundament framför våra fötter fångar våra blickar. Kanske var det där som turkarna hade ställt upp sina kanoner då de besköt Akropolis på 1600-talet. Det vad då som Parthenon delvis sprängde efter det att ett krutförråd i byggnaden hade träffats av en kanonkula och exploderat. Vi hade svårt att föreställa oss att något så vackert som Parthenon kunde utsättas för beskjutning. Men soldater har genom tiderna inte varit några kulturuppbyggare.

Åt väster kunde vi skönja hur några öar avtecknade sig mot vattnet. Där borta i diset ligger den sägenomspunna platsen Salamis. Det var där som det berömda slaget utkämpades mellan den grekiska och den persiska flottan inför ögonen på den persiske kungen Xerxes som från en tronstol följde slaget. Xerxes hade tänkt sig att erövringen av Athen skulle bli en enkel promenadseger. Men efter att ha förlorat sin flotta tvingades Xerxes att dra sig tillbaka eftersom han inte kunde försörja sin stora här utan tillgång till transporter över havet.

Vi samtalade om hur det verkar som om konflikter alltid följt i människornas spår. Den klassiska grekiska högkulturen kan sägas sträcka sig från år 490 f Kr då krigen mot Persien började till Alexander den stores död i Babylon år 325. Det var en blomstringstid för kulturen med många namnkunniga personer som var aktiva i många områden. Det var samtidigt en tid fylld av inre oro och ständigt pågående yttre krig. De många minnesmärkena över stupade som samlats på Arkeologisk Museet vittnar om detta.

För att förstå konflikterna under den epoken måste man gå tillbaka till år 496 f Kr då några städer på Mindre Asiens kust som koloniserats av grekerna, i deras uppbyggnad av Magna Graeka, avsade sig sin lydnad under Persien med stöd av stadsstaten Athen. Perserkungen Darius underkuvade emellertid snabbt dessa städer. Men Darius ville också straffa Athen för att de hade stött upproret. Han utrustade en här och en flotta och tågade in i Grekland. Första försöket slutade illa, men vid andra försöket år 490 f.kr. kom han ända ner till Marathon som ligger ca fyra mil från Athen. Naturligtvis var athenarna oroade.

En fältherre, Miltiades, föreslog att grekerna skulle försöka möta den överlägsna periska armen vid just Marathon där terrängen var till grekernas fördel. Han föreslog också en uppställning av den grekiska armén så att centern skulle vara svag men flyglarna starka. Slagordningen gick ut på att perserna skulle, liksom fångas in i en säck och, anfallas från sidorna där de var oskyddade av sina sköldar. Slagordningen lyckades och det rapporteras att av athenarna stupade bara ca 190 soldater medan c:a 6000 perser stupade. Slutet blev att perserna ansåg sig slagna och drog sig tillbaka. En soldat som deltagit i slaget sprang till Athen med budet om segern. Det är bakgrunden till våra dagars populära Marathonlopp.

Men perserna ville inte ge upp sina planer på att kuva athenarna. Darius son, Xerxes, bidade sin tid och utrustade en här och flotta, som år 480 f.kr. tågade mot Athen. Athenarna visste emellertid innan, att de i och med segern i slaget vid Marathon bara hade fått en tidsrespit innan perserna skulle återkomma och athenarna kände sig hotade och började planera lämpliga motdrag.

Miltiades som hade segrat vid Marathon hade, enligt athenarna, fått för mycket inflytande och landsförvisades I 10 år efter en omröstning på Pnyx . Det var ett relativt lindrigt sätt att temporärt göra sig av med personer med maktanspråk och som kunde tänkas hota den unga demokratin, som fortfarande var i sin linda.

Themistokles hade blivit ledare och hade enligt sin tolkning av oraklets råd byggt upp en flotta. Problemet var att persernas flotta var betydligt större än grekernas. Genom krigslist i form av att en föregiven överlöpare nästlade sig in till de persiska krigsledarna, kvällen före sjöslaget, lyckade Themistokles ge Xerxes intrycket att en stor del av den grekiska flottan, inför konfrontationen med den överlägsna persiska flottan, skulle komma att desertera i det avgörande ögonblicket. Således lockades den persiska flottan in i det smala sundet mellan fastlandet och ön Salamis för att anfalla den grekiska flottan som var där.

Då perserna kom seglande genom sundet lade grekerna ut med sina snabba trieremer, treroddare, från stränderna där de grundgående båtarna legat uppdragna för natten. Dessa fartyg roddes av ca 220 man och kunde på korta sträckor komma upp i ca 12 knop. Med denna fart rammade grekernas triremer de persiska fartygen bredsides så att dessa började sjunka. Det överraskande anfallet från tre bukter och med ca 200 trieremer var förödande och de delar av den persiska flottan som kunde fly, lämnade stridsskådeplatsen efter att ha lidit stora förluster.

Av utgången av sjöslaget framgår en viktig dimension i krigstekniken. Det räcker inte med att bara ha numerär eller materiell övermakt. Det gäller också att kunna organisera denna på ett för ändamålet klokt sätt. Egentligen gäller detta för all teknik. Organisation kan betraktas som den immateriella dimensionen i tekniken.

Den persiske kungen Xerxes drog sig, efter förlusten, tillbaka med en mindre del av sin armé. Huvuddelen, under hans svärson Mardonis befäl led året därpå ett förödande nederlag vid en plats som heter Plaitaiai. Därmed var det slut på hotet från Persien.

Athenarna ställde sig därefter i spetsen för ett försvarsförbund, det Deliska förbundet, som många grekiska statsstater ingick i. Till en början bidrog de andra staterna med skepp och besättningar till förbundet. Snart övergick bidragen till betalning med reda pengar. Det var dessa pengar som kom att finansiera bygget av Akroplis och Parthenon under ledning av den store statsmannen Perikles.

I det Deliska förbundet uppstod emellertid en ny konflikt då de andra staterna inte längre ville bidraga till det som de upplevde som enbart Athens förskönande. En konflikt var under uppsegling och den vunna freden under antikens krig bar i sig fröet till en ny konflikt. Ett liknande skeende uppstod på grund av freden efter det första världskriget. Under mellankrigstiden på trettiotalet suckade en statsman:

”Ge oss en fred som inte innehåller fröet till ett nytt krig.”

Tankar Tar Tid

Det blev ett långt, långt samtal, men det skall vi bespara dig. För det är ju så att Tankar Tar Tid – att tänka, att samtala om, att skriva om, att läsa. Vi hade på något sätt kommit framåt i tanken, kändes det då. Och det känns fortfarande så nu. Låt oss hoppas att det blir av värde framöver.

När vi lämnade Agoran så tog vi en för oss obekant utgång som ledde in i de omfattande basarkvarteren där vi strax gick vilse i det virrvarr av små gator som fanns där. Eftersom vi hade en avgångstid att passa för bussen till flyget, så föreföll läget ett tag något prekärt. Då

var det bra att ha en GPS – vi letade oss fram till ett litet torg så att vi kunde återknyta kontakten med de högre makterna i form av satelliter och vips så pekade GPS apparaten ut riktningen till hotellet. Vi följde den och var snart framme vid det övriga resesällskapet.

Visst är det bra med denna teknik. Som vanligt finns det naturligtvis en annan och ofta destruktiv sida också. Inom den moderna militärtekniken har man utvecklat styrbara bomber som styr mot sitt mål genom en inbyggd GPS Navigator.

Utanför vårt hotellfönster i Athen kunde vi betrakta det enorma Zeustemplet. Intill fanns den romerske kejsaren Hadrianus port som ledde in till den nya romerska staden som han hade grundat efter det att Grekland hade erövrats och förhärjats av romarna. Det är således lämpligt att låta resan gå vidare till Rom.

Bilaga Rom. Seminarium i Rom: Reflektioner och tankar

Ett seminarium i Rom kan ge upphov till många utgångspunkter för fortsatta diskussioner:

1. Övergången från ett stadssamhälle till imperium samt en jämförelse med skeenden i vår tid. Paralleller och olikheter. Bondesamhällets söner på väg in i cyberspace liftande med ryggsäck. Det lilla perspektivet konfronteras med det stora. På samma sätt växte i och med republikens övergång till imperium, verkningszonen för makthavares agerande och påverkan. I vilken utsträckning kan man tänka globalt men handla lokalt?
Har ett nyskapat ord som ”glokalt” ett berättigande?

2. Allt fast förflyktigas. Det är ett postmodernistiskt uttryck. Spåren som vi möter i Rom ger en vision av det rika överflöd som fanns en gång under senantiken. Pantheon och Colosseum finns kvar, men de flesta byggnader som imponerade på sin samtid är i ruiner. De av sin samtid uppfattade eviga äreminnena blev kortvariga. Domus Aurea, kejsar Neros praktbyggnad, är ett flagrant exempel.
Vad från vår tid kan tänkas bevaras så att det kan begrundas om 2000 år?

3. Det tusenåriga Riket – Västerlandets undergång. Inte kunde romarna under sin storhetstid ana att deras världsomfattande rike en gång skulle försvinna helt. På Marsfältet i Rom måste man gräva ner till minst 5 meters djup för att finna de stenar som en gång Caesar beträdde då han gick för att möta Brutus och sitt öde framför Pompejus staty. Vilka faktorer hotar en civilisation? Germanernas intrång gav dödsstöten åt det romerska väldet som dock under många århundraden hade försvagats genom inre splittring. Osvald Spengler skrev redan år 1922 den vitt spridda romanen: ”Die Untergang des Abendlandes.” Enligt hans tes så har en civilisation en start, en kulmination och en nedgång. Det är också frågor som Georg Henrik von Wright ständigt återkommer till i sitt civilisationskritiska författarskap. Är människan mer än en pipa snus i det kosmiska perspektivet? Frågar han sig.
Vad skulle man kunna tänka sig att det är för tecken i tiden som skulle kunna underbygga Spenglers teori?

4. ”Minervas uggla börjar sin flykt först i skymningen.” Enligt Hegel är det först i nedgångstider som människorna börjar fundera över vad som möjligen har går snett.
Vad är det för faktorer som hotar en civilisation? Vilka motåtgärder kan vidtas mens tid är?

5. ”Skönheten skall rädda världen.” Det är ett svårtolkat citat ur ”Anteckningar från ett källarhål” av Dostojevsky. När man frågar sig vad som kan påverka utvecklingen i vår tid så får man ofta svaret att det gäller för Sverige att hävda sig på en global marknad genom att ha den högsta möjliga teknicknivån i de produkter som tillverkas. Nu förefaller dock våra ungdomar att istället för att vilja studera mer naturvetenskap och teknik, önska få spela synliggörande roller i olika upplevelsesammanhang. En parallell till detta är att i det klassiska Rom gällde det också för framträdande politiker att bli synliga på en arena, Forum. Rolf Jensen på Köpenhamns Institut för Framtidsstudier diskuterar frågor av det slaget i sim bok ”Drömsamhället”. Han hävdar att ungdomarna föredrar att bli upplevelsemäklare framför symbolanalytiker (naturvetenskapare och tekniker). Det är frågor av det slaget som också behandlas i gymnasieutredningen SOU 2002:120.
Hur kan vi hävda betydelsen av naturvetenskap och teknik? Innebär de ruiner som omger oss i Rom, på något sätt en civilisationskritik eller ett memento mori?

6. Europa som en nostalgisk kyrkogård. Dostojevsky betraktade, enligt G-H v. Wright, Europa på det sättet. När vi studerar det klassiska Rom så är det kanske ändå inte med nostalgi utan med framtidsblick som vi studerar de gamla ruinerna. Einstein skriver 1955: ”Skillnaden mellan det förflutna, nuet och framtiden är enbart en ihärdig illusion.”
Vad kan vi lära av detta i ett längre sammanhang?

7. Eliter och folket. Om vi studerar romarrikets utveckling så kan vi följa hur den etablerade eliten gjorde allt för att bibehålla sina privilegier, åt sin klan och individuellt. Samtidigt gällde det, eftersom tillsättningen av ledare på olika nivåer i samhället sker genom röstning, att värva folkets röster genom bl a ett utpräglat klientsystem och genom att göra sig populär medels matutdelning och arrangerande av skådespel. ”Bröd och skådespel åt folket” är ett uttryck som vi hört citeras ofta.
Hur går det egentligen till då röster värvas idag? Vilka fraktioner har störst röststyrka?

8. Framtidsstudier och ämnesövergripande kurser. När man studerar skeenden i Rom så upplever man på ett påtagligt sätt hur dessa skeenden styrts och påverkats av en mängd olika faktorer. Det kan vara karismatiska ledare, gränskrig, politiskt rävspel, gamla förorätter, spannmålsskördar i fjärran länder, handelskrig, industrialisering, avfolkning, mytologiska förställningar mm. Man får på ett påtagligt sätt inblick i nödvändigheten av att ha en ämnesövergripande förståelse. Detsamma gäller naturligtvis i vår tid också. Bara genom ämnesövergripande kurser kan det nätverk av beroende som vi är insnärja i tydliggöras. Sen kan man naturligtvis fundera över i vad mån som våra elever behöver ha inblick i dessa samband. Men som lärare och medborgare i ett demokratiskt samhälle är det ämnesövergripande perspektivet naturligtvis väsentligt att försöka uppamma.
Varför är det så svårt att övertyga studenter om vikten av att kunna analysera ett fenomen ur så många perspektiv som möjligt?

9. ”Romanum sum” – Jämfört med att vara EU medborgare. Det var ”fint” och privilegierat att vara romersk medborgare. Det medförde privilegier av olika slag.
Är det ”fint” att vara medborgare i EU? Vilka privilegier medför det? Vilka är argumenten för och emot ett medlemskap?

10. Individer och institutioner. När institutionerna blir stora och mäktiga, så får individen svårigheter med att hitta i den snåriga samhällsdjungeln.
Kan man med någon framgång jämföra den romerska administrationen som bars upp av konsuler, praetorer och questorer med vår administration?

11. Augustus – fred och ofrihet. När Brutus och Cassius den 15 mars år 44 f. Kr. mördade Caesar i Pompejus teater så fanns det många orsaker till detta. De sammansvurna hade väntat sig att deras dåd skulle uppskattas av flertalet romare. Istället blev de sammansvurna förföljda. I grunden fanns där en konflikt mellan Caesar som tillförskansat sig absolut makt och de förnäma romare som såg sin egen makt minska i motsvarande grad. Oktavianus, Caesars brorson, blev i december år 45 f kr, av Caesar inskriven som hans arvinge. Efter mordet på Caesar följde en 16 år lång period av inbördeskrig. Under hedersnamnet Augustus gick Oktavianus ut striderna som segrare. Augustus införde lag, ordning och fred i romarriket. Men till priset av att han hade samlat all makt i sin hand.
Den klassiska konflikten mellan en stark man och demokratin kan skönjas här. Det är frågor som är intressanta även i vår tid.

12. Caesars Galliska krig – tidig men skicklig propaganda. I vår tid har man en mycket effektiv rapportering från krigsskådeplatser. ”Det första som förloras i ett krig är sanningen”. Det är ett uttryck väl värt att begrunda. Innan Caesar med militär utpressning tog makten i Rom så tillbringade han nästan ett årtionde i Gallien under ständiga strider. För hans politiska image i Rom var det emellertid vanskligt att vara borta från maktens centrum så länge. Han gjorde återbesök under tider som hans legioner låg i vinterkvarter. För att ytterligare föra fram sin duktighet till senaten så skrev Caesar ett antal böcker, De Bello Gallica, Kriget i Gallien. I dessa framhäver han på ett propagandistiskt och skickligt sätt sina framgångar. Det är intressant att läsa denna unika källa till antikens historia. Man upplever också hur viktigt det är att ta del av den sekundärlitteratur som på ett kritiskt sätt behandlar Caesars egen berättelse.
Den fråga som är evig är: Vad sker i det som synes ske?
Eller: Vem säger vad till vem och varför?

13. Från romerska legioner till USA´s marinkår. En viktig maktfaktor vid tillsättning av kejsare i Rom var den militära organisationen i form av legioner. Den som hade legionernas förtroende kunde diktera sina villkor. Legionernas förtroende fick den politiker som lyckades få fram sold till soldaterna samt kunde vid tjänstetiden slut ge dem ett stycke jord att leva av. Detta medförde genast behov av pengar. Legionerna var av hävd opålitliga och kunde ofta köpas av den högstbjudande. Kravet på mark att pensionera legionärer på ledde till många konflikter. Det fanns naturligtvis inte ledig mark att tillgå i Italien och inte heller ville rika städer gärna upplåta mark till råbarkade legionärer. Genom detta kom rika affärsmän, som Crassus att få ett starkt inflytande på politiken genom att återvändande fältherrar behövde sponsring för att köpa mark. Problemet kunde också lösas genom att vid maktövertagande de segrande utlyste en proskribering av ledande och rika personer inom den förlorande falangen. Det innebar att den proskriberade förlorade sin egendom, och om han inte flydde också sitt liv. Så behandlades exempelvis Cicero av triumviratet Oktavianus, Markus Antonius och Lepidus.
En evig fråga i detta sammanhang är i vilken mån demokratin påverkas av pengar i vår tid?

14. Pax Romana till Pax Americana. Romarna stiftade lagar som styrde deras imperium på deras villkor. Ara Pacis, som renoverades av Mussolini, är tyvärr stängt
Hur kommer en värld att se ut som styrs av lagar som skrivs och implementeras av den mäktigaste individuella aktören, USA?

15. **Gajus Julius Caesar vs Georg Bush.** Vågar man sig på en jämförelse mellan Caesar och Bush? Båda krigade i främmande länder. Båda förefaller göra det av egna personliga skäl för att vinna ära, Caesar dignitas, Bush ett återval som president.

16. Athen och Rom. Det är naturligtvis orättvist att jämföra det lilla landet Grekland med sin huvudstad Athen med det världsomfattande Romarriket. Men ändå så var inflytandet från Grekland mycket stort på Rom. Grekerna skapade kultur, romarna erövrade och förvaltade den. Romarna var dock inte i stånd att i någon större omfattning utveckla egen kultur. Deras uppgift var att förvalta ett imperium.
Fysikern Heinz Pagels hävdar i boken ”Den Kosmiska Koden” att varje civilisation har en uppgift: Romarnas var att förvalta ett imperium.
Vilken uppgift kan vi tänka oss att vår civilisation har nu när vi läst den kosmiska koden, som tills nyligen varit förborgad i atomens inre, och kan frigöra enorma energimängder?

17. Hadrianus villa och Epcot Center/Disneyland. I sin essäsamling ”Travels in hyperreality” gör författaren Umberto Eco en jämförelse mellan kejsar Hadrianus villa och trädgård i förstaden Tivoli utanför Rom och Epcot Center i Florida. Genom sin gestaltning av Epcot Center (Experimental Community of Tomorrow) vill Disney Corporation visa sin bild av den samtida världen och i viss mån framtida samhället genom att kring en sjö samla in fragment från många av världens länder: ”Let me show you the world,” står det på braskande annonser som Disney Corporation klistrat upp över hela Orlando. På samma sätt hävdar Umberto Eco att kejsar Hadrianus i sin park försökte gestalta inslag från den antika världens olika länder. Man behöver inte besöka främmande länder för att ta del av deras kultur. En annan parallell är de intryck som förmedlas via TV eller Internet.
Behöver ett museum mer än en hemsida med sfärisk sökning och zoomning?
Skall det vara nödvändigt att företa sig resor när hela världen ligger öppen för den fingerfärdige vid sin dator. Eller vad får man ut genom ett personligt besök som inte Internet kan förmedla?

18. Romerska riddare, equitas. I det klassiska Rom var det noga med var medborgarna hörde hemma. Det finaste var naturligtvis att tillhöra någon av de gamla förnäma familjerna med anor och med anfäder som gjort mytomspunna insatser för staten. Under årens lopp hade emellertid dessa familjer i många fall förlorat sin förmögenhet, men var ändå besatta av en bördsstolthet utan gränser. Den familj som Julius Caesar tillhörde var ett sådant fall. De bodde i den beryktade förorten Subura där den unge Julius växte upp. Beträffande anor så höll Julius Caesar ett av Suetonius omtalat liktal över sin moster Julia. I detta framhöll han sin härstamning, som på mödernet gick tillbaka till gudinnan Venus och på fädernet till de konungar som grundat Rom. Finare kan det inte vara. När Oktavianus efterträdde Caesar så kunde han till sina övriga titlar addera Filea Dei, den gudaförklarades son, eftersom Julius Caesar efter sin död blev Gudaförklarad. En annan romersk kejsare konstaterade på sin dödsbädd: ”Jag håller på att förvandlas till Gud.” Caesar hade ingen egen son, om man bortser från sonen Cesarion som han fick tillsammans med drottning Kleopatra av Egypten – och som blev mördad i unga år, och det hade inte heller Augustus. De ville ändå skapa en egen dynasti som skulle föra arvet från dem vidare inom familjen. Caesar fick adoptera Octavianus och Augustus fick nöja sig med Tiberius, följd av märkliga kejsare som Nero, Caligula och Claudius. Denna kejsarföljd har inspirerat Edward Gibbons till hans storverk ”Romerska rikets nedgång och fall”. Madame Neckar, som var aktiv under den franska revolutionens dramatiska förlopp framhöll att den boken bildar en brygga mellan hennes tid och antiken.
Vilka bryggor skulle vi kunna iaktta?

19. Man lär sig för skolan och inte för livet. Seneca yttrade dessa bevingade, men ofta felciterade ord, men tvingades senare att begå självmord av sin elev, kejsar Nero.

I vad mån kan vi istället lära för livet och inte för skolan?

20. Kunskapens rötter äro bittra, men dess frukter ljuvliga. Detta konstaterade Cicero som blev halshuggen på uppdrag av sin tidigare vän Octavianus.
Hur skulle man kunna göra skoltiden till den uppskattade utvecklingsfas i en ung människas liv som den borde vara?

Under vistelsen i Rom bodde en grupp av deltagarna i det anrika Birgittaklostret vilket i sig var en upplevelse. Vi var också med om ett seminarium, om hur Roms antika historia fortfarande är levande, på Svenska Institutet i Rom.

Bilaga Florens. Seminarium i Florens

Fredagen den 16 april
Planeringskonferensen, som är förlagd till renässansens Florens, inleds med att ett antal, för de allmänna utbildningsområdena centrala, perspektiv etableras. Perspektiven studeras, diskuteras och reflekteras över på ort och ställe. Seminariet börjar således vid rådhuset, Palazzo Vecchio på stora torget, Piazza della Signoria i Florens.

Ett vetenskapligt anslag.
Vistelsen i Florens inleds lämpligen, på fredag eftermiddag, med ett besök på Museo di Storia della Scienza som är ägnat åt den verksamhet som vetenskapsmannen Galileo Galilei (1564 – 1643) bedrev.

Galilei var en övergångsperson mellan den aristoteliska vetenskapen och den nya tidens vetenskap. På museet visas en del av hans tidstypiska instrument.

Vad har vi Galilei att tacka för? Varför kan vi kalla Galilei för en övergångsperson? Övergång till vad? Varför? Finns det någon annan övergångsperson värd att nämna?

Gruppen introduceras i det tankekomplex som fyllde den tidens naturfilosofers tänkande. Det var en tid som präglades av ett markant paradigmskifte mellan den aristoteliska – och det ”moderna” tankesättet. Fanns det någon renässans egentligen? Vad var Florens för stad egentligen? Hur livnärde sig befolkningen?
Pågår det något märkbart paradigmskifte i vår tid? Modernism till postmodernism? Hur skulle detta i så fall kunna påverka lärarutbildning och lärarfortbildning?

Ett religionsanknutet perspektiv

Vi stannar till vid plattan på stora torget som åminner om att det var här som den religiöse fanatikern Girolamo Savonarola brändes på bål år 1498. Varför var religionen framträdande vid den tiden? Eller var den det? Vilka problem tog religionen upp?

Hur är det i vår tid med konflikter mellan olika ideologier och paradigm?
Hur kan vår demokratiska värdegrund belysas i lärarutbildningen?

En kort sammanfattning ges av de religiösa motsättningar som resulterade i autodafén år 1498 på Piazza della Signorina. I vår tid har det många gånger skett informationsförstöring under fundamentala regimer – det verkar som om bokbål kan leda till autodaféer.

Vad är det för skillnad mellan information och kunskap? Om man vill förstöra kunskap, hur skall man, logiskt sett, agera då?

Ett maktpolitiskt perspektiv

Vi stannar till vid ryttarstatyn av storfursten Cosimo 1, av den i Florens under medeltiden tongivande ätten Medici, strax utanför Palazzo Vecchio. Man kan senare besöka Mediceernas olika palats, varav Palazzo Pitti innehåller en enorm konstsamling. Vad grundade Mediceerna sin maktposition på? Hur kunde de behålla den under några århundraden? Hur berör Mediceernas dominans oss i vår tid? Vad syftade Pazzi kuppen till? Det maktpolitiska spelet mellan Guelfer, påvetrogna, och Ghibelliner, kejsartrogna, och mellan stadsstater behandlas. Vilka styrde i Florence egentligen? Hur var det med möjligheter till ”klassresor”? Vad var det som gav vissa personer eller släkter makt? Vad finns det för paralleller i vår tid till maktfördelning?

Vi besöker och gör en rundvandring i maktens boningar i Palazzo Vecchio eller Bargello, det gamla stadshuset från 1255 som efter en tid som fängelse numera inhyser en utsökt samling florentinska renässansstatyer.

Maktpolitikern och den medeltida författaren Niccolo Machiavelli möter vi också i Florens. Han skrev ”furstespeglar”, dvs om hur en furste skulle uppträda och agera för att behålla makten. Machiavelli kommer vi i kontakt med då vi beundrar hans gravmonument i kyrkan Santa Croche. Machiavellis berömda bok ”Fursten” finns i pocketupplaga på Pocket Shop.” Läs och begrunda!

Har vår tids politiker lärt något av Machiavelli?
Hur kan maktfrågor beröras inom lärarutbildningen?

Ett konstanknutet perspektiv

Vi stannar till vid Loggia dei Lanzi och beundrar bl a guldsmeden och författaren Benvenuto Cellinis staty av Perseus. Celllinis självbiografi ger en avslöjande inblick i livet i medeltidens Florens Där står också en kopia av Michelangelos David. Originalet finns i Galleria dell´Accademia, som innehåller mycket mer av konst. Monumentens metabudskap diskuteras i senaste numret av Forskning och framsteg.

Kyrkor och kloster i Florens innehåller enorma konstskatter. På ort och ställe diskuterar vi vad som är möjligt och rimligt att hinna med. Varför samlade institutioner på konst?
Varför byggdes så många och stora palats under den här tiden?
Finns det några paralleller till vår egen tid som är värda att begrunda?

Naturligtvis måste man besöka Uffizierna, som byggdes 1560 – 80, och som räknas till ett av världens främsta konstgallerier. Botticellis berömda tavlor Venus födelse och Våren har vi mött i otaliga reproduktioner som dock sällan gör rättvisa åt originalet. Väl att märka så målade Botticelli sina tavlor medan en omfattande pestepidemi rasade i staden.

Några tavlor och skisser av universalgeniet Leonardo da Vinci återfinns också i Ufficierna. En koppling kan göras till vår uppfattning om vetenskapsmannen och teknikern Leonardo.
Hur skulle konsten kunna berika lärarutbildningens allmänna områden?

Konstnärer och poeter har ofta sina känselspröt längre ut i nutid och framtid än människor i allmänhet. Rymdeposet ANIARA av Harry Martinson är ett bra exempel.
Kan ett konstnärligt grepp, exempelvis genom att introducera ”design”, nyttjas för att ”mjuka upp” de erkänt ”hårda” naturvetenskapliga och tekniska disciplinerna?

Under vilka förhållanden levde egentligen konstnärerna? Var de individuella genier som skapade storverk, eller ingick de i ett gille eller skrå? Varför har vi så mycket sakral konst från den här tiden? Skönheten skall rädda världen, framhöll Dostojevsky.

Ett humanistiskt perspektiv

Några bemärkta humanisters liv beskrivs. Exempelvis Dante Aligieri som har sitt gravmonument i kyrkan Santa Croche. Den som är speciellt intresserad av Dante, kan vallfärda till Casa Dante som är bevarad från medeltiden. Dantes ”Den gudomliga komedin” diskuteras i många moderna sammanhang, inte minst av Georg Henrik von Wright i en ofta använd kursbok i lärarutbildningen: ”Myten om framsteget.”

von Wright behandlar därvid en medeltida dödssynd, **curiositas.** Den egenskapen betraktas i vår tid istället som ett adelsmärke. Varför har vi så skilda uppfatttningar beträffande nyfikenhet och forskning i vår tid i motsats till tidig medeltid? Då fanns sanningen att läsa och uttolka i heliga skrifter, Vi å vår sida lever i postmodernismens anda som säger att:
Det är läsaren som skriver texten? Hur påverkar det lärarutbildningen? Ett annat känt uttryck är: Allt fast förflyktigas.

Hur kan ett humanistiskt perspektiv behandlas och berika lärarutbildningen?
Här utgör på ett naturligt sätt värdegrundfrågor en utgångspunkt. Professor Bo Andersson vid GU har bl a sammanställt tre antologier om värdegrunden samt ett manus som behandlar Historiedidaktik.

Vad var humanisterna för några personer? Hur betraktade de sig själva? Hur betraktade senare historiker dem? Fanns det överhuvudtaget någon renässans. I så fall pånyttfödelse av vad? Och varför?

Den övergripande frågan är: **Hur kan kulturmöten nyttjas i lärarutbildningen**?

Genomförande av seminariet i Florens:

Lördag den 17 april: ***Naturvetenskap, teknik och religion.***
FM. Den dagen börjar vi med ett besök vid domen Duomo, eller som domens fullständiga namn lyder: Santa Maria de Fiorio. Domen, har sedan kupolen färdigställde år 1436 av arkitekten och konstnären Brunellechi, dominerat staden. Vi kan gå uppför trapporna ända till toppen där en utsiktsplats finns, under en metallkonstruktion som Leonardo i sin ungdom var med och lödde ihop.

Kupolen är utformad som ett dubbelväggigt skal och utsikten från taket är hänförande.
Vi klättrar, om vi orkar, också upp i Giottos kampanil från 1334 som finns intill.
Vi besöker Baptisteriet, dopkapellet, och beundrar den berömda porten av brons med de bibliska motiv som konstnären Lorenzo Ghiberti arbetade med från 1424 till 1452. Porten åminner om Florens befrielse från digerdöden, en ofta förekommande och förhärjande farsot.

När man studerar Florens historia så är just digerdöden ett ofta återbekommande fenomen. Detta tillsammans med konflikter mellan de ledande familjerna, de ständiga krigen med andra stadsstater, religiös fanatism och anfall från andra stater, exempelvis Frankrike präglade det som kan kallas för Florens ”guldålder”. Det är märkligt att så omfattande konstnärligt skapande kunde ske samtidigt. En parallell är Athen som under sin ”guldålder”, då statsmannen Perikles styrde, men då det blodiga kriget mot Sparta samtidigt rådde. Ett krig som Athen förlorade. Men det är Athen vi minns och inte Sparta.

Något om de nämnda byggnadernas historia och om platsens skapare tas upp.

Lunchseminarium: Fortsatt behandling av temat**: Kulturmöte**

Makt, konst och religion.
EM. Efter lunch promenerar vi bort till Mediceernas palats.
Därefter besöker vi eventuellt det nyrenoverade originalet till Michelangelos mästerverk David i Galleria dell´Accademia.

Vi letar oss fram till kyrkan Santa Croche där bl a fransiskanermunken Franciskus av Assis, medeltidspoeten Dante, naturfilosofen Galileo Galilei, maktpolitikern Machiavelli, konstnären Michelangelo med många fler berömda personer, som efterlämnat ett kulturarv till oss, har sina gravmonument. Något om de bemärkta personer som vilar här.

Söndag den 18 april: ***Konst***
FM: Vi börjar dagen med ett besök på Ufficierna och beundrar bl a Botticellis Våren och några tavlor av Leonardo da Vinci. Det brukar vara mycket folk som vill till museet, så vi måste börja tidigt.
Makt och konst
EM: Efter lunch går vi över Ponte Veccio som byggdes 1345 och besöker Palazzo Pitti som påbörjades år 1457 och som ligger på andra sidan Arno. Från år 1550 var det familjen Medicis huvudresidens. De byggde en privat gång längs Ponte Vecchio mellan Palazzo Vecchio och Palazzo Pitti för att inte behöva beblanda sig med folket. Från Ponte Veccio betraktar vi den gamla stenbron Ponte Santa Trinita. Det elliptiska brovalvet ritades av Michelangelo. Bron sprängdes av tyskarna vid deras återtåg under andra världskriget, men bron har pietetsfullt restaurerats.

Måndag den 19 april: ***Varia***
FM: Smågrupper, med olika intresseinriktningar, besöker olika lokaliteter, exempelvis det arkeologiska museet, Museo Archeologico, med dess berömda etruskiska avdelning eller klostren Santa Maria Novella, där Boccacio tecknade ner sin något ekivoka berättelse Decamerone, eller San Marco, Mediceernas slottskyrka San Lorenzo, Piazza della Republica med anor från romartiden, kanske även Dantes hem: Casa di Dante,……

Sen flög vi hem….