Sanna Järvelä, Seppo Laukka, Jyrki Pulkkinen & Maarit Saarenkunnas(eds.)

CAMPUS FUTURUS - Perspectives on Learning and Technology

OULUN YLIOPISTON
KASVATUSTIETEIDEN TIEDEKUNNAN
ELEKTRONISIA JULKAISUJA 2

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English abstract

This electronic publication continues the discussion started by the presentations and workshops in the ”Campus Futurus – Learning and Technology” –seminar at the University of Oulu March 4. 1999. The publication covers the issues of learning and technology from various points of view: from philosophical considerations to practical solutions. The first chapter, “Learning theoretical insights and pedagogical models”, concentrates on questions of pedagogy. In the second chapter, “Man and machine: Philosophical Perspectives”, the authors take a look at learning and technology from the point of view of psychology and philosophy. The third chapter discusses the applications of technology in designing learning environments and the practical problems related to distance education in universities.

Keywords

web-based learning, technology-based learning environments, educational technology, man-machine interaction, distance education, interaction

Finnish abstract

Tämä julkaisu jatkaa "Campus Futurum – Teknologia ja oppiminen" seminaarissa 4.3.1999 aloitettua keskustelua. Julkaisu perustuu seminaarissa pidettyihin esitelmiin ja työpajoihin. Näkökulmat, joita artikkelikokoelmassa kosketellaan yltävät filosofisesta pohdinnasta käytännön ratkaisuihin. Julkaisun ensimmäinen luku, "Learning theoretical insights and pedagogical models", keskittyy pedagogisiin malleihin. Toisessa luvussa, "Man and machine: Philosophical Perspectives", pohditaan teknologian ja oppimisen suhdetta psykologian ja filosofian näkökulmista. Kolmas luku, "Implementations and impact of learning environments in higher education", käsittelee teknologian sovelluksia uusissa oppimisympäristöissä ja korkeakoulujen etäopetukseen liittyviä ongelmia.

Asiasanat

verkko-opiskelu, koulutusteknologia, oppimisympäristöt, ihminen-kone järjestelmät, etäopetus, vuorovaikutus

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III Implementations and impact of learning environments in higher education

Campus Futurus - the Campus of the Information Society

Sanna Järvelä, Seppo Laukka, Jyrki Pulkkinen & Maarit Saarenkunnas

Campus Futurus –project together with the Faculty of Education organised a seminar on learning and technology in higher education 4th of March 1999. The aim of the Seminar was to bring in an interdisciplinary point of view to the utilisation of technology in higher education. The aim of this publication is to continue the discussion, adding new angles to it. The invited authors look at technology and learning from three different perspectives. The first section, “Learning Theoretical Insights and Pedagogical Models”, the authors Sanna Järvelä, Päivi Häkkinen and Hanni Muukkonen & al. concentrate on the pedagogical applications of ICT. In the second, “Man and Machine: Philosophical Perspectives”, Seppo Laukka, Timo Järvilehto and Andy Clarke look at the topic technology and learning from psychological and philosophical points of view. In The last chapter Jyrki Pulkkinen, Antti Peltonen and Steven Tello take a look at the “Implementations and Impact of Learning Environments in Higher Education”.

The seminar gathered 170 teachers and researchers together. The invited keynote speakers, Andy Clark

(Washington University, St Louis), Pierre Dillenbourg and Steven Tello *(*University of Massachusetts), covered the topic of learning and technology from three different angles. Andy Clark's talk on *"Leaky Systems: The Complex Dance of Brain, Body and World"* looked at brain as a distributed system from cognitive science point of view. Pierre Dillenbourg's talk: *"Building a virtual campus? An Opportunity for Educational Change"* brought in perspectives from the research in the area of collaboration and learning. *In his talk "Web-based Instruction: Models for Teaching and Learning",* Steven Tello had a look at the design of learning environments and pedagogical practices.

In addition to the keynote talks, three parallel workshops were organised, in which invited experts presented short comments on three different themes. The themes of the workshops ranged from technical solutions to philosophical discussion. "The research and development of learning environments" -workshop, chaired by Jyrki Pulkkinen, discussed research and development perspectives to new learning software. Sanna Järvelä's workshop, "Information- and communication technology in education: learning, teaching, and pedagogical development", concentrated on pedagogical models for applying ICT, with a special emphasis on collaborative learning. Seppo Laukka's "Man and Machine: Philosophical issues on technology" took a critical societal stance to the topic of learning and technology. The work done in these workshops was summarised by the chairs of the workshop in a concluding discussion. Furthermore, a poster exhibition was organised to give an overview of the practical technological solutions applied in teaching and research in Finnish higher education.

The development of the future campus, virtual campus and virtual university is currently a highly topical issue. The development of the university as a centre of “know how” and as a recognised expert organisation requires careful observation of the challenges that the information society poses on education policy. Education in information technology has already been increased considerably in the university, and the university is now focusing on the future and the development of the university from the viewpoint of the methods of educational practices, and not only from that of the contents. Many other universities around the world have already accepted the challenge by starting projects and co-operation networks to promote the idea of the virtual university.

At the University of Oulu the Campus Futurus project, launched in 1998, has taken the challenge of supporting the virtual university. Campus Futurus is a co-operation organisation across faculty boundaries on the area of educational technology. The aims of this project cover actions from research to practices of applying educational technology in university studies. First of all, the co-operation aims at promoting and co-ordinating the multidisciplinary research conducted in this area. Secondly, it supports development and education and service activities in educational technology. The project entitled "Campus Futurus" is also a joint effort for the development of education between the various faculties of the university.

An important function of the Campus Futurus project is to promote the research and development of the educational systems of the information society as well as that of learning environments based on modern technology. This publication is a token of the will to reach a deeper understanding of the complex issues related to learning and technology in university contexts – from philosophical point of view to practical solutions.

The Programme Committee:

Professor Sanna Järvelä, PhD Seppo Laukka, Research Director Jyrki Pulkkinen and Researcher Maarit Saarenkunnas.

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I Learning Theoretical Insights and Pedagogical Models

Creating a Pedagogical Model for Networked Interaction: Theoretical Introduction

Sanna Järvelä (University of Oulu) & Päivi Häkkinen (University of Jyväskylä)

Designing effective learning environments has been a challenge for educational researchers during the last decades. Recent research on learning theory indicates that the learning environment should be managed in such a way that the students are encouraged to set their own goals, actively gather meaningful information, monitor and evaluate their own learning and reflect on their personal learning experiences in different authentic environments and social contexts (Brown & Campione, 1996; Wilson, 1995; Khan, 1997). In the course of the development of information and communication technology, a variety of new, open, flexible, virtual and networked environments have been created and applied in education (e.g. Harasim, 1993). Recent research in the area has focused on developing certain technological solutions and applying those environments to education in different fields.

Earlier research in the field of telematic learning environments has focused on creating different kinds of learning projects in education (see e.g. Khan, 1997). There is also a multiplicity of other terms used for the use of new technologies in communication and learning, such as CSCL (computer supported collaborative learning) and CMC (computer mediated communication), which seem to represent, not necessarily different perspectives, but rather, different contexts for the study of the field. There are results available on the nature of the interaction during such projects, but so far, few studies have focused on the quality of learning in these new environments. In other words, it is essential to pay attention to the communicative practices involved in learning through new media. Yet, it is equally important to explore in more depth the learning processes connected with these communicative contexts. The present project will provide a fruitful framework for such research.

Many studies report how networked interaction in many learning projects results in superficial and experience-based discussion, but does not reach the level of theory-based reflections and argumentation (e.g. Admiraal, Lockhorst, Wubbels, Korthagen & Veen, 1997). Yet theory-based discussions and expert knowledge are crucial for deeper level knowledge construction and learning (Scardamalia & Bereiter, 1994). We claim that there is a need to examine and design such a model for networked educational communication, which would require and allow for a deeper level interaction and argumentation. The purpose of this project is, on one hand, to understand the quality of networked interaction, and on the other hand, to create such pedagogical practices which enhance deeper level networked communication and make use of theoretical and expert knowledge.

Distributed cognition: a new metaphor for knowing

The merging of social and cognitive theories described above is also illustrated by the distributed cognition theories, which means that the group is viewed as a cognitive system, including a distributed collection of interacting people and artifacts (Salomon, 1993). The distributed cognition approach focuses the unit of analysis on the system itself (Hutchins, 1991). The distributed cognition approach is also concerned with structure, namely representations inside and outside the head, as well as with the transformations these structures undergo. But instead of individual cognitions, the distributed cognition approach focuses on incorporating people and artifacts. Furthermore, the concept socially shared cognition puts more emphasis on social and cultural relationships, also including developmental issues.

From the perspective that cognition is distributed, the tools, rules, values and actors in a learning environment form a complex and interacting system (Hewitt, 1996). Printed material, notebooks, desktops and bulletin boards can be seen as cultural artifacts carrying intelligence (Pea, 1994). Social distribution of intelligence, on the other hand, can be observed in the exchange of ideas between academics. The question arises: How can technologies be harnessed to support productive distributed processes from the learning viewpoint? How does one design learning environments that support collaborative knowledge construction and include socially distributed cognitive resources (Salomon, 1993)?

As networked computer systems gradually become a possibility in various educational settings and learning situations, they provide us with opportunities to re-think the distributed cognition issue. One of the most notable aspects of networked technology is its ability to allow many people to work synchronously or asynchronously in a common environment on common problems. This ’many-to-many’ form of communication by passes the logistical constraints associated with large group, face-to-face discourse. One of the potentials of networked learning environments is its opportunity to use tools for sharing workspaces and supporting reflective communication which enable individuals to share cognitive load with other individuals, or in some cases, with intelligent technology. The questions to be raised here are: How do students function in such an environment? What kind of support do they need? (Häkkinen et al., 1997).

Cognitive apprenticeship - facilitating multiple levels of expertise

Techniques for teaching and learning are being reinvented and augmented through such approaches as cognitive apprenticeship. Cognitive apprenticeship (Collins, Brown & Newman, 1989, See also Järvelä, 1995) focus on the authenticity in which knowledge is developed as well as the dialogue processes between students and adult guides or more experienced peers (Rogoff, 1990). By using this rationale, methods for situating student learning in an authentic, real-world community (Brown, Collins & Duguid, 1989; Lave, 1988) are gaining acceptance.

Online apprenticeship (Teles, 1993) refers to apprenticeship mediated by access to masters and peers on computer networks. The learner accesses the online learning environment, which is characterized by attributes, such as one-to-many and many-to-many communication; asynchronicity or time independence; place independence; text-based presentation; and computer mediation (Harasim, 1990). In this environment, online apprentices can build and share knowledge through goal-oriented learning interactions with peers, experts, and mentors, and through full-time access to specialized sources of information.

In addition to apprenticing learners, electronic conferences offer unique opportunities to enhance the student's ability to assume the position of another person or infer another's capabilities, attributes, expectations, feelings, and potential reactions. Developmental psychologists typically refer to this skill as social cognition or perspective taking (Selman, 1980). As indicated, the ability to take the perspective of someone else when learning is becoming increasingly critical as the channels of communication multiply (Järvelä, Lehtinen, Bonk & Hämäläinen, 1997; Sugar & Bonk, 1990).

For instance, computer-mediated environments might offer a chance for sharing, idea exchange and feedback, peer modeling, and joint database exploration. As technology increases the range of audiences and viewpoints available, students' ideas should be extended beyond personal views, while their faulty preconceptions and biases are simultaneously reduced. Only when this takes place, can significant common ground and intersubjectivity among participants occur (Bonk, Appleman & Hay, 1996).

Challenges for educational communication

Emerging research increasingly focuses on the role of communicative practices in learning. This view characterizes learning as constituted by cultural practices, participatory activities and social interactions. Learning processes are often socially distributed, thereby extending beyond individual cognition to include features of both the social environment and the tools or cultural artifacts employed, e.g., partnership with technology (Newman, Griffin & Cole, 1989; Salomon, 1993).

On the basis of recent research on collaborative learning, it seems evident that people acquire knowledge and patterns of reasoning from one another. But for some kinds of shared knowledge, individually rooted processes play a central role. Human cognition is so sensitive to social and cultural context that we must seek after good and elaborated mechanisms by which people actively shape each other's knowledge and reasoning processes (Resnick et al., 1991).

The ability to understand and use a common interpretative framework is particularly important in apprenticeship, where an expert models his or her thinking processes and carries out scaffolded discussions with a novice learner (Collins, Brown & Newman, 1989). Very often developers of learning environment presuppose that any social interaction between learners is helpful for learning. This is, however, not so self-evident. There is evidence that the teaching-learning process is a complex social situation containing multiple actors, each with his or her own intentions and interpretations, influencing one another's knowledge, opinions and values, and interacting to produce shared cognitive products (Järvelä, 1995; Lehtinen et al., 1995; Pintrich, Marx, & Boyle, 1993). Therefore, communication among participants requires shared understanding based on a common focus and shared presuppositions.

Blum-Kulka (1997, 60) points out how negotiations over pragmatic meaning are part of everyday communication even when interlocutors share language and culture. The pragmatic perspective becomes even more important in the study of communicative events when participants come from different cultural backgrounds with potentially different cultural and contextual presuppositions, as well as differing interpretative frameworks for the linguistic means of signaling pragmatic meanings. Scollon and Scollon (1995) consider the ways in which discourses are created and interpreted when those discourses cross the boundaries of group membership. We also consider the ways in which we use communication to claim and to display our own complex and multiple identities as future professionals of education, and especially of language learning/teaching.

Enhancing reciprocal interaction via technology-based learning environments

Many researchers have argued that computers and technology-based learning environments can offer a mediating artifact that fosters optimal conditions for reciprocal interaction. Computer technology can support collaborative learning, enhance interpersonal relationships and address mutual concerns in learning (Reusser, 1992; Lehtinen & Repo, 1996; Vosniadou, 1994). The utilization of educational technology is based on the idea that computers can become partners upon student need or demand by undertaking certain phases of student cognitive processing while supporting other phases (e.g., Lajoie & Derry, 1993). There is a rising interest in the possibilities of technology to support learning with the help of shared problem solving (Häkkinen & Littleton, in press; Moschovich, 1996; Teasley & Roschelle, 1993) and enhanced interpersonal communication with new electronic tools (Bonk, Appleman & Hay, 1996). Recent prominent technologies for computer conferencing bring students close to real-world environments and apprenticeship opportunities. A variety of peer, expert, teacher, learner and tool resources jointly create an instructional environment for apprenticing learners into a community of discourse (Bonk & King, 1997; Galagher, Kraut & Egido, 1990; Harasim, 1993).

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Progressive Inquiry Process with Future Learning Environment Tools

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Abstract:

The design of a networked learning environment, the Future Learning Environment (FLE) relies on recent achievements of cognitive research on educational practices and computer-supported collaborative learning (CSCL). In the design of FLE, special emphasis has been given to developing metacognitive tools for structuring users' activities. The aim of these tools is to support collaborative knowledge advancement and progressive inquiry.

The environment provides each user a personal " Virtual WebTop" for storing his or her products and providing access to other users' WebTops. The "Knowledge building" module facilitates between-user interaction and provides tools for structuring a discussion into topics. Further, to advance metacognitive reflection, each discussion message needs to be labeled with a Category of Inquiry. The "Jam Session" module encourages the free flow of ideas and experimentation with dif-

ferent ways of representing knowledge. It provides graphical representations of the dynamic development of a project. The ”Library” allows the user to share documents in various formats: text, graphics, audio, video, multimedia or WWW links.

Introduction

This paper describes the cognitive-design rationale of a new-generation networked learning environment, the Future Learning Environment[1] (FLE) developed by the Media Laboratory, University of Art and Design, Helsinki, and the Department of Psychology, University of Helsinki. The environment is a groupware system designed for supporting collaborative knowledge building. The users are able to access the environment from any internet-linked computer. They are also able to make postings of knowledge productions to FLE using their standard office applications and productivity tools, producing documents in various formats, such as text, graphics or video.

The FLE has been mainly used in the context of higher education courses or seminars, so that face-to-face meetings and lectures are carried out in parallel with intensive work with FLE. FLE’s design relies on recent achievements of cognitive research on educational practices and computer-supported collaborative learning (CSCL, see, for example, Hall, Miyake, &

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1. Research and development work of the FLE (see http://www.mlab.uiah.fi/fle) environment has been funded by TEKES (National Technology Development Center of Finland), Ministry of Education of Finland, SONERA Ltd., Grey Interactive Ltd., WSOY Ltd., and Apple Computer, Finland.

Enyedy, 1997). During the last ten years, several technology-based environments supporting CSCL have been created (e.g., CSILE, Knowledge Forum, CoVis, CoNotes, BELVEDERE, CLARE). Common to each of those environments is the provision of tools to the users for collaboratively producing and discussing knowledge. Although cognitive research indicates that many applications of educational technology support only lower-level processing, environments designed following cognitive principles provide a noticeable exception (e.g., Lehtinen et al, 1999; Roschelle & Pea, 1999; Salomon, 1997). Consequently, our basic purpose in designing and testing a new environment instead of using one of the several already developed CSCL environments is to create the capability to examine and test methods of implementing and building stronger pedagogical support in a learning environment.

A special challenge of designing the environment is to create an environment that supports a scientific type of progressive inquiry as well as the process of collaborative design. What we need to research, is which kinds of scaffolds a user benefits from in their work as a collaborative group and as individuals. Therefore, special emphasis needs to be afforded to the forms of pedagogical guidance provided by FLE, which are derived from research on learning and instruction.

The purpose of the present paper is to provide a cognitive rationale of FLE's design by examining the pedagogical model and principles embedded in the FLE-environment. Further, the design of the FLE environment and its various modules will be described.

Process of Progressive Inquiry

In the present paper, the sustained processes of advancing and building of knowledge characteristic to scientific inquiry are called *progressive inquiry*. The model of progressive inquiry (PI-Model) relies on a dynamic and pragmatic conception of inquiry emerging from the philosophy of science (Hakkarainen & Sintonen, 1999; see also Hakkarainen, Lonka & Lipponen, 1999; Muukkonen, Hakkarainen & Lakkala, 1999). Progressive inquiry incorporates that new knowledge is not simply assimilated but constructed through solving problems of explanation and understanding (Bereiter & Scardamalia, 1993). Characteristic of this kind of inquiry, instead of direct assimilation, is that the student treats new information as something problematic that needs to be explained (Bereiter & Scardamalia, 1993; Chan, Burtis, & Bereiter, 1997). By imitating practices of scientific research communities, students can be guided to engage in extended processes of question- and explanation-driven inquiry. An essential aspect of this kind of inquiry is to collaboratively engage in the improvement of shared knowledge objects, i.e., hypotheses, theories, explanations or interpretations (Scardamalia & Bereiter, 1996). Through intensive collaboration and peer interaction, the resources of the whole learning community may be used to facilitate the advancement of inquiry.

By synthesizing results of the philosophy of science and cognitive research, a framework can be constructed for analyzing essential elements of progressive inquiry (Figure 1). In the following section, a conceptual framework of progressive inquiry is outlined and each aspect of inquiry is discussed shortly.

Creating Context

A starting point of the process of inquiry is creating a context for a study project in order to anchor the chosen issues to central conceptual principles of the domain of knowledge in question or to complex real-world problems addressed by experts (Cognition and Technology Group at Vanderbilt, 1997). The purpose of creating a context is to help the students understand why the issues in question are important and worthwhile of their investigation and personal commitment to solving the problems being investigated. It is essential that the topic is sufficiently complex and multifaceted so that it can be approached from different viewpoints. It is very important to focus the inquiry on a problem-area that is central to the students' conceptual understanding and encourage them to undertake challenging learning tasks that facilitate in-depth conceptual understanding.

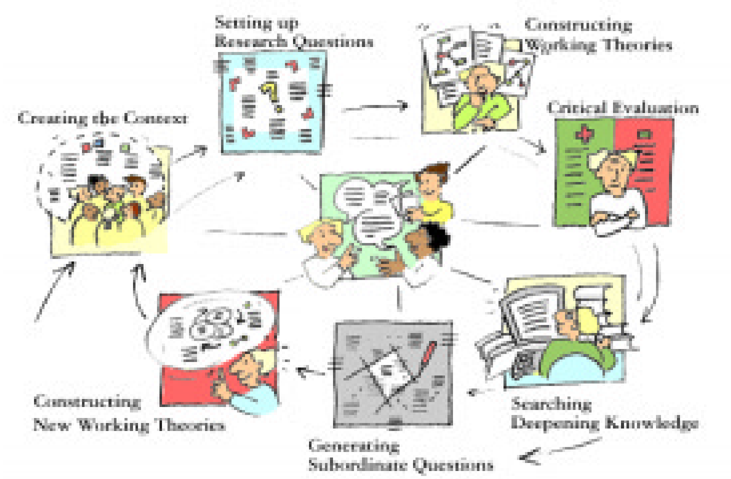

Figure 1. Elements of progressive inquiry

Engaging in question-driven inquiry

An essential aspect of progressive inquiry is to *set up questions or problems* that guide the process of inquiry. Without a research question there cannot be a genuine process of inquiry, although information is frequently produced at different educational levels without any guiding questions. *Cognitive goals* determine what kinds of questions are generated, and, thereby, guide and regulate the process of inquiry. Questions that arise from students' own wonderment or their need to understand, have a special value in the process of inquiry.

Generating one's own working theories

An important aspect of inquiry, and a critical condition of developing conceptual understanding is the generation of one's own conjectures, hypotheses, theories or interpretations for the phenomena being investigated (Carey & Smith, 1995; Perkins, Crismond, Simmons, & Under, 1995; Scardamalia & Bereiter, 1993). Construction of students' own hypotheses and conjectures guides students to systematically use their background knowledge and make inferences to extend understanding.

Each student comes to instructional situations with a large body of preconceptions that diverge from generally accepted scientific ones. These affect considerably how he or she interprets new information. Progressive inquiry aims to facilitate explication and externalization of these preconceptions (through guiding students, for instance, to write about their ideas) and taking them as the object of collaborative discussion. Generation of an intuitive explanation before obtaining scientific information makes the differences between one's own conceptions and scientific conceptions salient and accessible to the student. If scientific conceptions are assimilated without explicating one's own view, it is likely that potential differences or gaps of knowledge are not identified at all. As a consequence, the student is likely to assimilate scientific knowledge without any conceptual restructuring and reproduce misconceptions or false theories later on in the process of inquiry.

Critical evaluation of knowledge advancement

Critical evaluation addresses the need to assess advancement in knowledge-seeking inquiry in a constructive way. Through evaluation of whether and how well the working theories explain the chosen problems, the learning community seeks to assess strengths and the weaknesses of different explanations and identify contradictory explanations, gaps of knowledge, and limitations of the power of intuitive explanation. The evaluation helps the community to direct and regulate joint cognitive efforts toward searching for new information that will help advance shared understanding.

Searching new scientific information

The question-driven process of inquiry provides heuristic guidance in the search for *new scientific information*. Considerable advancement of inquiry cannot be made without obtaining new information. Further, large bodies of information cannot be managed without questions that guide and constrain the knowledge-seeking process and help to structure information obtained (Bereiter, 1992). By examining one's problem or intuitive theory with the help of new information, the student may become aware of his or her inadequate presuppositions or background assumptions. Monitoring progress of one's conceptual understanding facilitates metacognitive awareness of the process of inquiry.

Engagement in deepening inquiry

In pragmatic problem-solving situations, one has to start generating questions and tentative theories before all the necessary information is available. As a consequence, the process of inquiry must often start with initially very general, unspecified and "fuzzy" questions and tentative working theories (Sintonen, 1991). In spite of these gaps, weaknesses, unclarities or other limitations, these kind of general questions and working theories may function as tools of inquiry and provide a basis for progressive inquiry.

A critical condition for progress is that a student focuses on improving his or her theory by generating more specific questions and searching for new information. The process of inquiry advances through transforming the initial big and unspecified questions into subordinate and, frequently, more specific questions

Shared expertise

All aspects of inquiry, such as setting up research questions, searching for new scientific information, constructing of one's own working theories or assessing the explanations generated, can be shared with other inquirers. Cognitive research indicates that advancement of inquiry can be substantially elicited by relying on socially distributed cognitive resources, emerging through social interaction between the learners, and collaborative efforts to advance shared understanding. Through social interaction, contradictions, inconsistencies and limitations of a student's explanations become available because it forces him or her to perceive conceptualizations from different points of view. Hatano and Inakagi (1992), as well as Brown, Collins & Duguid (1989), argued further that deep conceptual understanding is also fostered through *explaining a problem to other inquirers*. In order to explain one's view to his or her peers, an individual student has to commit himself or herself cognitively to some ideas, explicate his or her beliefs, as well as organize and reorganize his or her knowledge (Hatano & Inagaki, 1992).

Further, there is a growing body of evidence that cognitive diversity and distribution of expertise promote knowledge advancement and cognitive growth. Distribution of cognitive efforts allows the community to be more flexible and achieve better results than otherwise would be possible. Moreover, studies of Hutchins (1991) and Dunbar (1995) revealed that groups that consist of members having different but partially overlapping expertise were more effective and innovative than groups with homogeneous expertise. New pedagogical models are emerging that are grounded on distributed expertise and which utilize cognitive diversity as well as technology-based learning environments.

Description of the Design of FLE

General Design of the Environment

The Future Learning Environment (FLE) is based on a three-tier architecture in which the FLE-Tools software is distributed among three servers: The database server, where most of the changing information (the database and search engine) resides, the application server that handles most of the logic in conjunction with the database server, and the www server that handles the backend www-processing and glues the other servers together. FLE software can be accessed through Internet (TCP/IP) with any HTML 3.2 compliant browser such as Netscape Navigator 3 (or later). Some non-critical features can only be accessed by browsers with a JavaScript implementation.

The users are able to work with common office applications or productivity tools producing, for example, documents, graphics, video or www links. The Internet accessibility allows small groups working at different locations to co-ordinate their activities with the tools provided by FLE. The main modules of the FLE-Tools that will be described include the Virtual WebTop, the Knowledge Building Module, the Jam Session Module and the Library.

Virtual WebTop

The Virtual WebTop refers to a personal adjustable display window, which is automatically opened as the user logs on to the system. The Virtual WebTop contains graphical links (represented by folders) that give information about the course attended as well as links to the Virtual WebTops of the other participants of the group. The Virtual WebTop is a place for the user to store his or her documents created by standard office applications in various formats. It is the main center for the user's own knowledge production, and may contain large documents such as research proposals, term papers, designs, or project reports that are related to one or more FLE projects. The Virtual WebTop also has a search engine built in, enabling searches into materials produced previously in other courses and also all materials in the Library.

In the background of the Virtual WebTop is a metaphor of an open office in which you could go to work in any desk, observe what other people are working on, and leave your own notes. Accordingly, the Virtual WebTop allows a student to visit the WebTops of other users in the same course. Through examining fellow students' Virtual WebTops, students are able to share the process of inquiry and to get acquainted to their fellow students' interests. Co-ordination of collaborative inquiry efforts is supported by a tool that allows a student or tutor to leave messages to another participant's Virtual WebTop, as well as review messages received and sent.

The Knowledge Building Module

The Knowledge Building (KB) Module provides a shared space for working together on solving problems and developing ideas and explanations generated by the users. All KB messages within a course are posted to the shared space, visible as lists of messages. Each KB discussion is accessible only to the users enrolled as participants of that specific course.

Participation in progressive inquiry is facilitated by asking a user who is preparing a discussion message to categorize the message by choosing a "category of inquiry scaffold" (e.g., Problem, Working theory, Summary) corresponding to the progressive inquiry model and also based on the practices of Scardamalia & Bereiter (1993). These scaffolds are designed to encourage students to engage in expert-like processing of knowledge; they help to move beyond simple question-answer discussion and elicit practices of progressive inquiry.

The Jam Session module

In contrast to the KB Module, the Jam Session encourages the free flow of ideas and experimentation with different ways of representing knowledge. The environment provides tools for storing different versions of the object being developed, whether it be a design, layout of a www-page or a project report. The users may take a version of the object and elaborate on it further, and save it for the other users to be further develop. The Jam Session module assists in making thinking visible (Brown, Collins, & Duquid, 1989; Scardamalia & Bereiter, 1989) by providing a graphic representation of the development of a knowledge object.

The Library

The Library allows the users to share the documents produced in various formats: text, graphics, audio, video, multimedia, or www links. The Library contains course materials chosen by the tutor as well as materials produced by the users. Materials from earlier courses may also be stored in the Library and made accessible to later users. The environment is intended to provide tools for helping teachers and students to create digitized study materials, to collect interesting link addresses into folders, and also to gain access to other libraries linked to the internet.

Conclusions

What appears to be critical for the application of collaborative software is the development of pedagogical models that take in consideration the organizational perspectives in education, as well as the personal goal-setting and motivational aspects of learning in modern society. There is a need for better understanding of the situational factors that encourage engaging in demanding learning tasks.

The development of FLE-software is in a dynamic state, integrating results from cognitive and educational research to the possibilities offered by developing programming languages and general software innovations.

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II Man and Machine: Philosophical Perspectives

The Image of Man - Learning Environment, Interaction and Educational Technology

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In all times, man has made use of different tools that he has later developed into apparatuses and machines. The utmost purpose has been to develop aids that would help the functions of man. Along with the development of apparatuses and machines, man has also considered his own depiction. Contemplations have advanced to the point that man has compared himself, at least partly, to a machine.

As early as the 17th century man was compared to the apparatuses of the time, both structurally and functionally. At that time, the well-known philosopher René Descartes stated the opinion that the material body of man worked as an automat. By contrast, the soul of man gave free will to the ”machine”, i.e. brought ”rational functioning” to the side of the automatic functioning. The free will originated when the soul first received vibrations from the outer world. After this, the soul pumped ”the spirit”, i.e. the gas that was moving in the nervous system, into the muscles, and was in this way consequently able to have an effect on the environment (Descartes, 1637/1970). Man was described as an apparatus that partly voluntarily and partly involuntarily reacted to the stimuli received through different sense organs from the outer world. It is stated that Descartes' idea originated from the mechanically operating statues that were situated in the garden of the Palace of Versailles and whose movements were caused by the water that ran through them (Anokhin, 1979).

During the last centuries the image of man has barely changed at all. Man is still partly seen as a passive mechanical responder to stimuli, but also as an active processor of information who, above all, possesses different characteristics such as feelings, etc. According to this modern image, this kind of person reacts indirectly to the stimuli received from the outer world. The task of the nervous system, and particularly of the brain, is to handle information and to bring about some kind of order, so that reacting to outside stimuli would be sufficiently adequate (Kolb & Wishshaw, 1990). Today's descriptions of the nervous system, nerve functioning, and the brain in particular, use metaphors that mainly refer to the functioning principle of a modern computer (Eysenck, 1993).

This short description of the development of the image of man shows how the description of man is time dependent, and how the image is influenced by the achievements of mankind, first and foremost in the field of technological development. Therefore, it is justified to question whether it is technology that conducts human sciences or vice versa?

Much is expected from information technology in the near future. For example, the interaction between man and computer is expected to develop to the point that man will be able to operate with a speaking, listening, understanding and even feeling machine very soon. The aim of the development of the interaction is that man could subconsciously operate a machine through his own senses while solving tasks connected to his daily routines. Also, the machine could then evaluate man's functions and emotions. According to the idea, man would be as if he was "attached" to a computer and he could, in this way, expand his environment through the machine. The significance of the central concept of interaction has also been examined in the study of learning and teaching in which utilization of technological achievements has also been pursued.

Educational Technology – a Fescue or a Magic Word?

During the last decades and along with the growth of the appreciation of education, the study of teaching and learning has been directed towards utilization of technological applications. The aim has been to integrate information technology into daily teaching. A new special area of learning and teaching, educational technology, has been developed.

Educational technology can be understood in several different ways. Educational technology can be understood as instructional technology, in which case the emphasis is on teaching and didactics. On the other hand, educational technology may place stress on the applications offered by technology in education. In any case, today educational technology is defined more extensively, and it examines the relation between education and technology. In other words, educational technology studies human relations and such matters as, for example, problems in teaching and learning that are carried out through and with the aid of different apparatuses and machines. In this case, learning takes place in a ”new learning environment” that is based on new technology and applications supporting learning (see Wagner, 1990).

The concept of learning environment, which is often connected with educational technology, can be defined in several different ways depending on the interpretation of the concepts of learning and environment. According to several researchers, learning is regarded as a continuous process, therefore learning takes place everywhere. In consequence, the environment is an undivided entity as far as learning is concerned. However, the same researchers, who for example study features connected with lifelong learning, distinguish specific environments in which learning takes place within our environment, such as the school, home, work place, etc.

Researchers also unanimously agree that the learning environments mentioned above may offer several opportunities for the learning process. Possibilities depend on to which features - physical, mental or social - attention is paid. Depending on the selections, the learning environment may be formed into a place that emphasises either form and structures, or meaning and purpose (Huttunen, 1996). In reference to conscious selections and recognition of learning environments, it is, according to researchers, extremely important to also know the features and significance of the learning processes and interactions that appear in different learning environments. The learning process is regarded as an end to understanding, which becomes apparent in the evaluation of information, creation of ideas and development of thoughts. This, so called constructive learning concept, can be understood as a process in which the external information, that is for example given by teaching, is transferred into learner's inner world which after information processing will be realized in external or internal actions (see Mahoney, 1994).

Another essential concept mentioned in reference to the study of educational technology, is the concept of interaction. The concept can be understood so that when two persons collaborate, their action consists of alternate functions; while one person acts, the other one receives, etc. The criticism connected with the definition of the concept is often aimed at the mechanistic nature of the above mentioned arrangement in which the two parties alternately influence each other and alternately handle the stimuli which the other party presents and which lead to reactions. The definition of the concept of interaction has raised and will continue to raise strong sentiments.

The articles in Part I, on ”Man and Machine”, indicate the theoretical questions connected with the studies of humans, the environment and technology.

The first writer, Andy Clark, is a professor of philosophy and the director of the philosophy/neuroscience/psychology program at Washington University in St. Louis, Missouri. Clark's prevailing interest lies in the implications of cognitive scientific research for a wide variety of conceptual and philosophical issues. Work on the role of the body and the local environmental structure in promoting adaptive success suggests that natural intelligence is intrinsically embodied and involves a surprisingly intimate ”dance” between neural and extra-neural factors. Clark’s most recent work investigates the relations between these twin foci (neural nets and embodied action).

In the chapter ”embodied, situated, and distributed cognition”, Clark aspires to offer some new concepts, tools, and methods to understand the complex and rich interplay of human and environment. He also argues that the familiar distinctions between perception, cognition and action, and between mind, body and environment, may need to be rethought and possibly abandoned.

The second writer, Timo Järvilehto is a professor of psychology in the university of Oulu. His interest lies in ”systemic psychology”. Järvilehto offers a radically new concept of the relationship between the organism and its environment, as well as the relationship between brain and mind, mind and body, and between experience and behaviour. According to Järvilehto’s idea, all the physiological activities and their relationship to the environment constitute a single system that supports and adapts the individual. Questioning traditional psychological concepts, Järvilehto points out that the nervous system is only one part of the organism-environment system (Wolf, 1998).

In the chapter ”machines, brains, and consciousness”, Järvilehto deliberates upon the relationship between human and machine on the basis of the organism-environment theory. Järvilehto argues that the research on artificial intelligence is on a wrong path when trying to solve the problem of consciousness in the machines separated from the human beings, as modern brain research is similarly faced with an impossible task when trying to find special areas for consciousness in the brain.

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Embodied, Situated, and Distributed Cognition

Andy Clark, Washington University, St Louis
(Reprinted with permission: "Embodied, Situated and Distributed Cognition". In W. Bechtel and G. Graham (eds). *A companion to cognitive science*. Blackwell Publishers Inc., 1998.)

Wild brains

Biological brains are first and foremost the control systems for biological bodies. Biological bodies move and act in rich real-world surroundings. These apparently mundane facts are amongst the main driving forces behind a growing movement within cognitive science - a movement that seeks to reorient the scientific study of mind so as to better accommodate the roles of embodiment and environmental embedding. Two claims characterize the common core of this emerging approach:

(1) That attention to the roles of body and world can often transform our image of both the problems and the solution spaces for biological cognition.

(2) That understanding the complex and temporally rich interplay of body, brain, and world requires some new concepts, tools, and methods - ones suited to the study of emergent, decentralized, self-organizing phenomena.

These core claims are sometimes joined by some further, more radical speculations, namely:

(3) That these new concepts, tools, and methods will perhaps displace (not simply augment) the old explanatory tools of computational and representational analysis.

(4) That the familiar distinctions between perception, cognition, and action, and indeed, between mind, body, and world, may themselves need to be rethought and possibly abandoned.

In this brief treatment I aim to lay out and discuss some of the concrete results that have inspired this complex of claims and speculations and then to suggest a more conciliatory image of their consequences.

Human infants

Consider a familiar class of real-world agents - human infants. A newborn infant, held suspended off the ground, will perrorm a recognizable stepping motion. After a few months. this response disappears, only to reappear at about 8-10 months old (the age at which infants begin to support their weight on their feet). Independent walking cuts in at about a year. One explanation of these changes involves what the development psychologists Esther Thelen and Linda Smith have dubbed a "grand plan, single factor view." Such a view depicts the emergence of independent walking as the expression of a kind of detailed genetic blueprint. Thelen and Smith, however, reject all versions of the grand plan, single factor view and instead depict learning to walk in terms of the complex interplay of multiple factors involving body, brain, and world in essentially equal terms.

Evidence for the multifactor view comes from a series of elegant micro-developmental studies involving bodily and environmental manipulations (Thelen and Smith, 1994). For example, the reflex stepping action seen to disappear at about two months can be restored by holding the baby upright in water. The key parameter that causes the early disappearance of the stepping reflex is thus, it seems, just leg mass! The period during which the stepping reflex is not normally seen corresponds to the period during which the sheer mass of the infant's legs defeats an inherent spring-like action in the muscles. Immersion in water reduces the effective mass and thus allows stepping to reappear. This story contrasts strikingly with a variety of accounts that seek to explain the disappearance by invoking maturational processes in the brain or the predetermined phases of a *locomotion program.*

Further support for the alternative, multifactor view comes from a series of environmental manipulations in which nonstepping infants (aged between one and seven months) are held on a moving treadmill. Under such conditions coordinated stepping is again observed. Moreover, this stepping shows adaptation to variations in treadmill speed and even compensates for asymmetric belt speeds (the treadmill comprised two independent belts capable of driving each leg at a different speed). These results demonstrate a major role for a kind of mechanical patterning caused by the backward stretching of the legs brought about by the action of the treadmill. This component of the stepping response is clearly in place even while other factors (such as leg mass) prevent its expression under ecologically normal conditions. Thelen and Smith conclude that the developmental pattern of infant stepping does not, after all, reflect the predetermined stages of a stored program or the influence of any single variable or parameter. Instead, it comes about as a result of the interplay of a variety of forces spread across brain, body, and world. Such forces include bodily features (such as leg mass), mechanical effects (stretch-and-spring), ecological influences (water, treadmills), and cognitive impetus (the will to move). The upshot is an image of the human infant as a system in which brain, body, and world conspire to yield the complex behavioral profiles that cognitive science seeks to explain and understand.

Autonomous agents

An autonomous agent is a creature (real, artificial, or simulated) that must act and survive in a reasonably demanding, not too heavily regimented environment. Such creatures must often act quickly, and on the basis of noisy, incomplete, or conflicting information. Humans, mice, and cockroaches are all examples of natural autonomous agents. Recent years, however have seen an explosion of research on so-called artificial autonomous agents - robots (or simulated robots) that must act and survive in a variety of difficult settings such as the flow of a crowded office, the crater of a volcano, or the surface of the moon.

A famous early example of autonomous agent research is the robot Herbert, built in the 1980s in the Mobile Robot (Mobot) Laboratory at the Massachusetts Institute of Technology. Herbert's job was to collect empty soft drink cans left around the laboratory. In this real-world environment, Herbert had to co-exist with the human researchers - he had to avoid bumping into them and avoid disrupting delicate ongoing construction work. More positively, Herbert needed to move around, identify, and acquire abandoned cans.

One kind of solution to such a problem would be to exploit sophisticated scanning devices tied to a complex image processing and planning system. The goal of such a setup would be to generate a detailed internal model of the surroundings, to identify cans, and then to plot an efficient collection route. Given the current state of the computational art, however, such a solution would be costly, imperfect, and fragile. The system would spend long periods lost in thought, contemplating its future plans of action. And once in action, it would be easily upset by new events. people moving around, and so on. Naturally, there are ways to begin to address all these problems. But instead of tackling a long list of such problems, the designers of Herbert decided to try a fundamentally different approach. For all these problems and pitfalls, they began to suspect, were really artifacts of an overtly centralized and intellectualist approach to the generation of real-world, real-time behavior: an approach that leans too heavily on detailed inner models and long chains of inference, and that makes too little use of the simplifications and shortcuts afforded by simple environmental cues and the robot's own capacities for action, motion, and intervention.

An alternative approach, pioneered by Rodney Brooks (1991), exploits such cues and shortcuts for all they are worth. Brooks advocates the use of a *subsumption* architecture - a design that incorporates a number of guasi-independent subsystems, each of which is responsible for one self-contained aspect of the creature's activity, and which are not coordinated by any central system. Instead, the various subsystems are capable only of sending simple signals that bypass, override, or occasionally modify the response of other subsystems. The activity of one subsystem (or layer) will thus often subsume that of another.

Herbert, built by Brooks's graduate student, Jonathan Connell, in the 1980s, was designed as just such a decentralized bag of tricks agent. The basic layers of the subsumption architecture generated simple locomotor routines, and a ring of ultrasonic sonar sensors supported a behavior of stopping and reorienting if an obstacle was spotted immediately ahead. These routines were, however, overridden as soon as the simple visual systems detected a rough table-like outline. At this point the surface of the table would be scanned, using a laser and a video camera. If the basic outline of a can was detected, the whole robot would rotate on its wheels until the can was fixed in its center of vision. At that point the wheel motion ceased, and a simple signal activated a robot arm. The arm moved blindly, aided by simple touch sensors that lightly skimmed the surface of the table. On encountering a can shape, a grasping behavior was activated, and the target object was acquired.

Herbert is just one example of many, and the full subsumption architecture is not universally in vogue. But it provides an illustration of a number of features characteristic of a wide range of recent endeavors in autonomous agent research. The robot does not generate or exploit any detailed internal models of its surroundings (and hence need not constantly update such models over time); it does not engage in complex inferences and planning; the various sensory systems do not feed data to a central intelligent system, but instead participate rather directly in the generation and control of particular behaviors. The robot uses its own motion in the world to aid its sensory searches and to simplify behavioral routines, and it allows its activity to be sculpted and coordinated by the flux of local environmental events. In short, Herbert, like the human infants discussed above, is a good example of a system in which body, brain, and world all cooperate to yield a computationally cheap, robust, and flexible variety of adaptive success.

Large-scale systems

A major theme of embodied cognitive science is, we have seen, the emergence of adaptively valuable patterns of activity out of the blmd (noncentrally orchestrated) interactions of multiple factors and components. Such a perspective lends itself naturally to the consideration of patterns that characterize the activity of larger groups of individuals, such as ant colonies, ship's crews, and social, political, or commercial organizations. Certain ants, to take a well-worn example, forage by a process known as mass recruitment. If an ant finds food, it leaves a chemical trail as it returns to the nest. Other ants will follow the trail. If they too find food, they will add to the chemical concentration. A process of positive feedback thus leads rapidly to a high concentration of chemical signals that in turn orchestrate the activity of many hundreds of ants. The strikingly organized apparition of a steady flow of ants systematically dismantling a recently discovered food source is thus the outcome of a few simple rules that sculpt the first responses of the individual ants and that lead the ants to alter their local environment in ways that lead to further alterations (the increasing concentration of the trail) and to a distinctive and adaptively valuable system of group foraging (for details and a computer simulation, see Resnick, 1994, pp. 60-7). Ants, termites, and other social insects use a variety of such strategies to build complex structures (such as termite nests) without leaders, plans, or complete inbuilt programs. The individuals know only to respond in specific ways to specific environmental patternings that they encounter. But those responses in turn alter the environment and call forth other responses from other individuals, and so on.

Consider now the operation of a human collective - the navigation team of a seafaring vessel. The cognitive scientist, anthropologist, and mariner Edwin Hutchins (1995) describes in exquisite detail the way in which a typical navigation team succeeds without benefit of a detailed controlling plan and the complex ways in which representations and computations are propagated through an extended web of crew and artifacts. Individual crew members operate within this web in ways that display more than a passing similarity to the strategies of the social insects! Many ship duties consist in being alert for a specific environmental change (e.g., waiting for a sounding) and then taking some action (e.g., recording the time and sending the sounding to the bridge). These actions in turn alter the local environment for other crew members, calling forth further responses, and so on. In addition a vast amount of work involves the use of external structures and artifacts, such as alidades, maps, charts, and nautical slide rules. Some of these devices function so as to re-represent acquired information in forms which make it easier for us to use or transform it. The nautical slide rule, for example, turns complex mathematical operations into perceptual scale-alignment tasks of a kind that human operators usually find easier to perform. In fact, the entire work space is structured so as to simplify the computations and operations falling to individual biological brains.

None of these observations is in itself terribly surprising. But Hutchins shows, in convincing detail, just how genuinely distributed (between agents) and reshaped (by the use of artifacts, spatial layout, and simple event-response routines) the ship navigation task has become. The captain may set the goals. But the mode of execution, by means of a complex web of information gatherings, transformations, and propagations, is nowhere explicitly laid out or encoded. Instead, success flows from the well-tuned interaction of multiple heterogeneous factors encompassing biological brains, social practices, and a variety of external props and artifacts.

One striking difference, of course, separates the case of human collective success from that of, for example, social insects. In our case, the necessary harmonization of brains, bodies, and environmental structure is itself, in part, an achievement of human learning and cognition. We create designer environments that alter and simplify the computational tasks which our brains must perform in order to solve complex problems. The key to understanding this extra dimension (one deep root of our unusual type of adaptive success) lies surely in our ability to use and profit from the very special tool of human public language. Language is perhaps the ultimate artifact: the one responsible for our apparently unique ability to think about the nature of our own thoughts and cognitive capacities and hence to seek to deliberately alter our world in ways that allow us to press maximum effect from the basic computational capacities of our biological brains. That, however, is a story for another day (Clark, 1997, ch. 10).

Complementary virtues?

Having sampled some real research in embodied, embedded, and distributed cognition, we can now ask: What significance (if any) does all this have for the philosophy and practice of the sciences of the mind? It is probably too soon to make a solid assessment, but we can make some progress by reviewing the four claims laid out in the first section, in the light of the examples just sketched. In order, then:

Claim 1: that attention to the roles of body and world can often transform our image of both the problems and the solution spaces for biological cognition.

This claim is surely correct. We saw, for example, how the robot Herbert uses physical motion to simplify on-board computation; how the problem of learning to walk, for real infants, is defined against the mechanical backdrop of spring-like muscles; and how the physical work space, instrumental supports, and division of human labor all play a major role in enabling ship navigation. The morals that I would draw are twofold.

First, we should be aware of the importance of what I shall call *action-oriented* inner states in the control of much everyday, on-line behavior. By action-oriented states, I mean states that are especially well geared to the computationally cheap production of appropriate responses in ecologically normal conditions. A recent research program that stresses such states is the so-called animate vision paradigm (Ballard, 1991), with its emphasis on the use of indexical and/or logally effective personalized representations and the use of real-world motion and action to defray computational costs. It is also possible (with a little poetic license) to read J. J. Gibson and the ecological psychologists as likewise stressing the close fit between certain inner states and the specific needs and potentialities of action determined by a given animal/environment pairing. Second, we should acknowledge an important role for what Kirsh and Maglio (1995) nicely term "epistemic actions": namely, actions whose purpose is not to alter the world so as to advance physically toward some goal (e.g., laying a brick for a walk), but rather to alter the world so as to help to make available information required as part of a problem-solving routine. Examples of epistemic actions include looking at a chessboard from different angles, organizing the spatial layout of a hand or cards so as to encode a record of known current high cards in each suit, laying out our mechanical parts in the order required for correct assembly, and so on. Epistemic actions, it should be clear, build designer environments - local structures that transform, reduce, or simplify the operations that fall to the biological brain in the performance of a task.

A cognitive science that takes seriously the twin notions of action-oriented inner states and epistemic actions will, I believe, have gone a long way towards remedying the kind of disembodied intellectualist bias identified at the start of this essay.

Claim 2: that understanding the complex and temporally rich interplay of body, brain, and world requires some new concepts, tools, and methods - ones suited to the study of emergent, decentralized, self-organizing phenomena.

This is a potentially more challenging claim, suggesting as it does that taking brain-body-world interactions seriously requires us to develop whole new ways of thinking about cognitive phenomena. In this vein, a number of cognitive scientists have recently begun to investigate the potential use of the concepts and tools of dynamical systems theory as a means of understanding and analyzing the kinds of cases described above. Dynamical systems theory is a well-established framework for understanding certain kinds of complex physical phenomena (see Bechtel & Graham, 1998). What is novel, then, is the attempt to apply this Framework to the class of phenomena standardly investigated by the sciences of the mind. The object of a dynamical systems analysis is the way the states of a system change and evolve over time. Many of the guiding images are geometric, since the system is pictured as evolving within a certain *state space* (a set of dimensions of variation discovered or defined by the theorist). Given a state space, the task of a dynamical analysis is to present a picture of how the values of the state space variables evolve through time. The product is thus an understanding of the system's space of potential behaviors in terms of a set of possible trajectories through the space. This understanding can have both a quantitative and a qualitative dimension. Quantitatively, it may consist in the description of a dynamical law that strictly governs the evolution of the state variables (often, such a law will amount to a set of differential equations). Qualitatively, it may consist in an understanding of the properties of regions of the state space. For example, some regions will be such that any trajectory heading close by becomes, as it were, diverted so as to pass through the region. Such regions (or points) are known as *attractors.* Conversely, some regions or points will be such that trajectories heading in that direction get deflected. These are *repellors.* One especially powerful construct, as far as the understanding of embodied, embedded systems is concerned, is the idea of a *collective variable.* This is a state variable that folds together a number of forces acting on the system and plots only the overall effect of these forces. A very simple example, used by the philosopher Timothy van Gelder, would be tracking the behavior of a car engine by plotting engine temperature. Such a strategy abstracts away from the details of specific components and focuses attention on the overall results of a multitude of internal interactions (between parts) and external influences (such as temperature, humidity, and road conditions). It thus reduces a potentially very complex *(high-dimensional)* description (one involving distinct variables for each separate influence) to a simpler, more tractable *(low-dimensional)* one. If it is well chosen, such a low-dimensional description can nonetheless be of great explanatory and predictive value. In the case of the car, for example, it can help predict and explain low fuel economy and misfiring. To get more of the flavor of dynamical tools in use, the interested reader should consult, for example, the extended treatment in Kelso, 1995.

Dynamical systems approaches do, I conclude, offer concepts, tools, and methods well suited to the study of emergent, decentralized, self-organizing phenomena. Such approaches are attractive because of their intrinsic temporality (the focus on change over time) and their easy capacity to criss-cross brain-body-environment boundaries by using constructs (such as collective variables) that merge many influences into a single factor. As a result, dynamical analyses are tailor-made for tracking emergent phenomena - ones that depend on the complex and often temporally rich interplay between multiple factors and forces spread across brain, body, and world. It is thus no surprise that Thelen and Smith, for example, go on to offer dynamical analyses of the various infant behaviors described earlier - behaviors which, we saw, were indeed determined by a subtle interplay of neural, bodily, and environmental factors. The precise status of these new tools, however, remains unresolved, and is the subject of the third - and more problematic - claim, namely:

Claim 3: that these new concepts, tools, and methods will perhaps displace (not simply augment) the old explanatory tools of computational and representational analysis.

Well, perhaps. But this claim strikes me as somewhat premature. There are two main reasons for caution. First, there is an issue about scaling and tractability. As the number of parameters increases, our intuitive geometric understanding breaks down. A lot therefore turns on the availability of simpler low-dimensional descriptions arrived at by the canny use of collective variables and the like. This strategy, however, quickly gives rise to a further worry: namely, whether useful low-dimensional dynamical descriptions will always be available and what is lost (as something inevitably must be) by their use. Second, there is an issue concerning the type of understanding that attends even a successful dynamical account. For it is a type of understanding that sits uncomfortably close to description, as opposed to functional explanation. We learn what patterns characterize the system's evolution over time (and hence can make useful predictions). We learn, for example, that the overall system state A must give way to overall system state B, and so on. But we do not thereby understand the actual role of specific components or the detailed organization of the system. A useful illustration of this problem, drawn from Sloman (1993, p. 81), concerns the attempt to understand contemporary digital computers. One possible strategy would be to treat all the computer's sub-states (the states of the arrays, registers, etc.) as dimensions and to display the activity of the device as a set of transitions between such globally defined overall states. Such an approach nicely displays the system's overall evolution over time. But it hides away the details concerning what is going on in the individual registers and arrays. In particular, it hides away the facts concerning which sub-states can vary independently of one another, which sub-states vary with which external parameters, etc. In short, it highlights the global behavior at the expense of local structural and functional detail. Which approach works best for any given system is a complex empirical question (sometimes we really do need both). It is also a question that remains unresolved in the case at hand: namely, the explanation of intelligent behavior biological organisms.

We should also be careful to distinguish two issues that are easily run together in any assessment of dynamical modeling. One, as we just saw, concerns the grain of such analyses - their tendency to invoke abstract collective variables so as to provide tractable descriptions of complex emergent patterns. Another concerns the type of vocabulary used to characterize the states of the systems. Some dynamicists (such as Thelen and Smith) do indeed eschew the use of representation talk- talk of the knowledge encoded in specific inner states - as a means of understanding systemic organization. But others (see, e.g., several treatments in Port and van Gelder, 1995) seek to combine the use of dynamical tools with talk of inner states as representations. Such accounts associate representational roles with specific dynamical features. Attractors, trajectories, and collective variables may thus be interpreted as the systemic bearers of specific contents or the players of specific semantic roles. These hybrid dynamical models constitute, I believe, the most promising way in which dynamical theory may illuminate genuinely cognitive phenomena. The value of such approaches will, however, depend on the extent to which genuinely cognitive functions turn out to be tied to genuinely high-level emergent systemic features: the kind that might be constituted by the complex feedback and feed-forward interactions of multiple neuronal populations and circuits, or by temporally rich interactions involving bodily and environmental factors. If, by contrast, typical cognitive functions depend on much more local, component-based systemic features, the scope and value of even hybrid dynamical approaches will be diminished.

Border disputes

And so to metaphysics and the fourth and final claim to be examined:

Claim 4: that the familiar distinctions between perception, cognition, and action, and indeed, between mind, body, and world, may themselves need to be rethought and possibly abandoned.

Three broad classes of argument are invoked in support of such claims. The first, and least persuasive, is based on an idea of equal distribution of causal influence. Thus, Thelen and Smith showed (see above) that infant stepping is in some sense equally dependent upon bodily, neural, and environmental factors: it is not specified by a full neural program but emerges from the interaction of bodily factors (leg mass), environmental context (the treadmill and water-immersion experiments), and neural and anatomical structure. This leads them to comment, for example, that "it would be equally credible to assign the essence of walking to the treadmill than to a neural structure" (1994, p.17).

The authors are surely correct to stress the way in which attention to bodily and environmental factors can transform our image of the neural contributions to behavioral success. But it would be a mistake to infer from the (let us grant) equal causal roles of various factors to any lack of demarcation between them. It is not obvious in what sense, then, we really do here confront an "inextricable causal web of perception, action and cognition" (1994. p. xxii). It is a complex web, to be sure. But genuine inextricability would seem to require something more. The smooth running of a car engine reflects a complex interplay of inner factors and environmental conditions (heat, humidity, and so on). But the complexity of the interplay in no way motivates us to abandon the idea of a real distinction between the various types of factors involved. Likewise, the demarcations between perception, cognition, and action, or between mind, body, and world, do not seem unduly threatened by demonstrations of complex causal interplay, subtle trade-offs, and the like.

There is, however, one special type of causal interplay that may indeed raise tricky questions concerning systemic and functional boundaries. This type of case has been discussed by the cognitive scientists Francisco Varela, Evan Thompson, and Eleanor Rosch (1991) and centers on a special class of phenomena that I dub "processes of continuous reciprocal causation" (CRC for short). CRC is a close relative of the idea, popularized by the cybernetics movement of the late 1940s and 1950s, of *circular causation.* To get the idea, think of the way a crowd sometimes starts to move in a unified direction. The motion of the crowd is nothing but the sum of the motions of the individuals. Yet a given individual both contributes to, and is affected by, the overall motion. As soon as (by chance or by some external push) a degree of consensus about direction begins to emerge, weak or undecided individuals are sucked into the flow. This generates an even more powerful consensus, which in turn sucks in more individuals. There is thus a kind of circular positive feedback loop going from individual to crowd and back again.

Ordinary circular causation, however, is compatible with discrete temporal stages of influence, in which one system (e.g., a hi-fi component) sends a signal to another that then waits and subsequently sends a signal back, and so on. The notion of continuous reciprocal causation is meant to pick out the special subset of cases in which no discrete temporal staging interrupts the coupled dynamics of the linked systems. For example, consider a radio receiver: the input signal here acts, as Tim van Gelder (personal communication) has pointed out, as a continuous modulator of the radio's behavior (its sound output). Now imagine that the radio's output is also continuously transmitted back so as to modulate the other transmitter, thus creating a circle of continuous reciprocal causal influence. In such a case there is a complex, temporally dense interaction between the two devices - an interplay that could easily lead to rich coupled dynamics of positive feedback, mutual damping, or stable equilibrium, depending on the precise details of the signal processing. Given the continuous nature of the mutually modulatory influences, the usual analytic strategy of divide and conquer yields scant rewards. We can easily identify the two components; but we would be ill-advised to try to understand the behavioral unfolding of either individual device by treating it as a unit insulated from its local environment by significant boundaries of transduction and action. For the spatial envelope demarcating each component is of little significance if our object is to understand the evolution of the real-world behaviors. There are genuinely distinct components here. But the correct unit of analysis, if we seek to understand the behavioral unfolding of either component, is the larger coupled system which they jointly constitute. To whatever extent brain, body, and world can at times, be joint participants in episodes of continuous reciprocal causal influence, we may indeed confront behavioral unfoldings that resist explanation in terms of input to and outputs from some supposedly insulated cognitive engine. (Conversely, when we confront episodes of genuinely *decoupled* information processing and problem solving (as in the rotation of a mental image or off-line planning and cogitation), the classical image of an insulated cognitive engine will again be appropriate - although even in these cases, episodes of dense, continuous, mutual modulation between neural circuits may impede attempts to assign specific information-processing roles to component neural areas and pathways.) These issues are discussed at length in Clark, 1997.

A third class of argument capable of putting pressure on the intuitive division between mind, body, and world turns on the functional role of certain bodily or environmental resources. Thus recall Kirsh and Maglio's useful notion of epistemic actions actions whose purpose is not to affect the world per se but to change the world so as to alter or reduce the computational loads on inner mechanisms as we try to solve a problem. The contrast is thus between an action like building a wall to keep out intruders (nonepistemic: the goal is merely to alter the world in an immediately useful way) and an action like shuffling Scrabble pieces in the hope of presenting visual cues better suited to prompt the recall of candidate words for use in the game. This is an epistemic action insofar as we don't generate the spatial reshuffling for its own sake but rather for its value as part of the problem-solving process. In such cases it is as if the in-the-head computational process incorporated a sub-routine that happens to work via a call to the world. The sub-routine is, however, a bona fide part of the overall computational process - a process that just happens to be distributed across neural and environmental structures. Similar stories could be told about the use of nautical artifacts, the spatial arrangement of maps on the desk of a navigation tearn (Hutchins 1995), the use of fingers in counting, and so on. Body and world can thus function as much more than the mechanism and arena of simple practical actions. They can provide a valuable extension of cognitive and computational space: a work space whose information-storing and information-transforming properties may complement those of the on-board organ of computation and reason, the biological brain. (Notice that the putative fact that we sometimes have a special kind of introspective access to what is going on in our own heads is not fatal to such claims, for it is agreed on (nearly) all sides that there are at least some inner and genuinely cognitive processes to which we have no such access. The outer events that form proper parts of extended computational processes would naturally fall into this latter category.) The question of whether such extended computational processes can ever constitute a genuine extension of the *mind* into the local environment is, however, both complex and vexed. Such extensions do not, in any case, seem to undermine the general distinctions between perception and action or between world and mind. At most, they temporarily shift the boundaries of the underlying computational states and processes.

Claim 4, I conclude, remains unproved. The distinctions between perception, cognition, and action and between mind, body, and world seem real enough and not at all threatened by our increasing recognition of the complex interplays and trade-offs that bind them together. Behavioral unfoldings involving the continuous, mutually modulatory interplay of brain, body, and world may, however, present more of a problem. This is a ripe topic for future research.

Conclusions: minds and their place in nature

The insights emerging from work on embodied, situated, and distributed cognition are of major importance for the development of a more balanced science of the mind. This new wave of research is a much-needed antidote to the heavily intellectualist tradition that treated the mind as a privileged and insulated inner arena and that cast body and world as mere bit-players on the cognitive stage.

No one, to be sure, ever thought that body and world had no role to play in the orchestration of successful action! But actual cognitive scientific practice has shown an unmistakable tendency to focus on inner complexity at the expense of attention to other factors. (Notable exceptions to this trend include J. J. Gibson and the ecological psychology movement and work in animate vision (Ballard, 1991).) This inner orientation shows itself in a wide variety of ways, including the (now decreasing) use of anesthetized animals for neural recording (see Churchland and Sejnowski, 1992, p. 440), the development in artificial intelligence of complex planning algorithms that make no use of real-world action except to carry out explicitly formulated plans and to check that the actions have the desired effects (see the discussion in Steels, 1994), and the fundamental in1age of symbolic reason whereby problems are first rendered as strings of inner symbols, which then form the domain of all subsequent problem-solving activity (Newell and Simon, 1981). In addition, the long accepted notion that the task of the visual system is to reconstruct a detailed three-dimensional image of the current scene (Marr, 1982) may also be seen as a conseguence of this inner orientation - a consequence strongly challenged by recent work (such as Ballard, 1991) in which the visual system constructs only a sequence of partial and task-specific representations and relies heavily on our active capacity to repeatedly direct visual attention (via saccadic eye movements, etc.) to different aspects of the scene.

It is increasingly clear, then, that natural solutions to real-world problems frequently reveal brain, body, and world as locked in a much more complex conspiracy to promote adaptive success. It also seems likely that, to do justice to this complexity, we will indeed need to exploit new tools, concepts, and methods - perhaps importing apparatus from the established framework of dynamical systems theory so as to better track and explain emergent, decentralized, self-organizing phenomena. Nonetheless, it is not yet clear that such new ideas and methods should be seen as replacing, rather than augmenting, more traditional approaches. Nor does it seem likely that any of these developments will undermine the most basic distinctions between cognition and action or between mind, body, and world.

Mind, I conclude, has indeed too often been treated as an essentially passive item: an organ for recognition, classification, and problem solving, but one not intrinsically and fundamentally geared to the control of real-time action in a rich, highly exploitable real-world setting. As a result, perception, motion, and action have been seen as strangely marginal affairs: practical stuff to be somehow glued on to the real cognitive powerhouse, the engine of disembodied reason. It is this methodological separation of the task of explaining mind and reason (on the one hand) and real-world, real-time action (on the other) that recent developments in the study of embodied cognition call into serious question. This is a worthy challenge indeed.

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Machines, Brains, and Consciousness

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The machine as an organism-environment system

What is a machine and what is its relation to its constructor, the human being? Is a machine only the set of elements that we put together and let then work in some environment? When we build a machine, what do we build, exactly?

In fact, when we build a car, for example, we must simultaneously construct its environment, in the form of roads, bridges etc. We must also train its driver. A car without the possibility of driving from one place to another is not really a car, but a cottage, for example. Thus, the construction of the specific action environment is an essential part of the building process of the machine, and at least as important as the construction of its "inner" parts. Of course, this is often not so striking, because the action environment of the machine usually already exists before the planning of the construction is started. However, the planner knows (and must know) this environment, and it is precisely he (and later the user) who connects the machine with its environment. Thus, a functioning machine is an "organism-environment" system that consists of the machine, its environment and its planner/user.

From the point of view of the organism-environment theory (Jarvilehto, 1998), the environment of the machine is a human environment as it is presented in language. In the construction of machines, we explicitly separate machine and environment and use language in the description of the parts of the machine and the parts of the environment which are related to it. It is the planner or constructor who thinks what will happen with a certain set of elements in an environment that HE knows. However, it is well possible that for the machine such features of the world exist which are not (and even cannot be) parts of the environment of its planner. In fact, this could be the reason why all machines eventually break down. As it is impossible to take into account the whole universe when building a machine, there are always some unknown factors which do not fit to the constructed structure of the machine.

Consciousness in machines and brains?

Do machines have consciousness? Machines can do many things that humans do, and in many cases, even much more efficiently than humans ever could. Machines also use language, which is usually regarded as one criterion for consciousness.

In the frame of the organism-environment theory (Jarvilehto, 2000), consciousness -- in a very general sense -- means the appearance of an *organisms*-environment system in which every single organism-environment system acts as an element of the system as a whole, which is directed towards *common* results that are useful for the whole co-operative system. In such a system, it is possible to dynamically change single organism-environment systems so that they fit each other in the process of achieving the results. In this larger system, the body of the individual gets the character of a *tool;* it is in a similar position to any other part of the environment in as far as it can be used in the achievement of a common result. I can look at my hand in quite a similar way to how I look at the hammer in the hand; I can use both for certain purposes. Thus, if a machine is an organism-environment system, then it includes the human being (or the human being includes the machine), and therefore it is already, from the beginning, questionable to ask if a machine can have a consciousness of its own (i.e. also in the case when no human beings exist).

But can't the machines communicate?! It seems that we may have, for example, robots which can send messages to each other and behave in relation to these messages. However, also this "fact" is an illusion. Machines can use language only in connection with humans. "Communicating" machines are designed for human purposes, and they will "communicate" only so far as this kind of action fulfils some human plans. If they start to do something else, then they no more communicate, but they have a malfunction. The use of language by the robots (even by complicated "learning" robots) may be compared to how a typewriter uses the language. Every key on the keyboard is able to produce a letter, but it depends on the human user as to whether such a communication makes any sense.

Two "communicating" robots are, in fact, parts of the society of humans that has extended its communicative abilities by these technical devices. A robot is part of the human being; therefore it is even odd to try to imagine its autonomous existence. Robots are not "interested" in communication; spades are not interested in digging the earth, but they do this when they are in the human hand. Every machine is an extension of human capabilities. Therefore, we could say that every machine is also "conscious", but only in connection with a human being, because a machine is part of his consciousness. The question of consciousness in machines is of the similar form as wondering whether my legs are conscious, because they can bring me to the place, which I want to reach so well.

If we maintain that machines may have consciousness (or any other human property when separated from the human beings) we are making a very simple mistake: When a human being builds some device, he models his own capabilities and does this for his own purposes, to support his own actions. In the process of construction he abstracts some of his own characteristics, and by the help of technology, exaggerates them in the machine in order to achieve the desired results more efficiently. He constructs a spade, for example, in order to be more efficient in digging holes. A spade is like a hand in form, but more rigid and much more limited in its use. If we now start to wonder: is a spade "really" a hand? Then we simply forget the history of its construction. And it would also be strange to use a spade as a model of hand, because with this comparison we would learn nothing new about the hand.

From this it also follows that consciousness cannot be located in the brain either. A brain - let it consist of protoplasm or be it an artificial neurocomputing machine - cannot be conscious as such. The brain is only one organ of the body (and even anatomically difficult to define exactly; in fact, there are no means to separate the nervous system from the body).

The conceptual problems in locating consciousness in the brain may be demonstrated with the following (thought) experiment: Somebody opens your skull and gives you a mirror so that you may look into your own brain. If consciousness is located there then you are looking from outside (in this case the brain is certainly outside the eye) at the place in which this conscious looking should be located!

Of course, no scientist would seriously deny the importance of the brain for consciousness. The point, however, is that the brain is not the only place (and perhaps not even the most important!) to look if we want to understand what it means to be conscious. Therefore, it is a serious conceptual confusion if we think that consciousness will be eventually "found" in the brain. The brain is an organ like the other organs of the body; there is no more "psyche" in the brain than in the heart, for example. The brain -- which can be neatly localized within the cranium only in the anatomy books -- consists of a huge number of specialized living cells which are organized together over the whole body and carry out physiological, not psychological or cognitive processes. The neurons are not interested in our philosophical problems! The fact that a change of activity (e.g. electrical change or increase in the blood flow) may be recorded from a certain part of the brain when the subject is carrying out a certain task does in no way justify the conclusion that the task is carried out by the area in question.

Thus, many neuroscientists together with their supporting philosophers are simply looking for things in the place where they can never be found, and this only because there happens to be such fancy equipment for carrying out the measurements. It is a cardinal theoretical confusion to think that in the near future we will be able to describe all the events in the brain that constitute a simple perception. This day will never come, because perception is a process, which cannot be limited to the brain.

Consequently, consciousness cannot be located in any parts of the individual, in his head or hemispheres of the brain. The localization of conscious experience in the head is based on the mistaken conception of the subject of the conscious action. The subject of consciousness is not the body, brain or a neuron, but an "I", a person that may not be defined on the basis of the structure of his brain, but rather as a point of intersection in a net of social relations. The "I" is not an entity in the same sense as a body, but a systemic relation. The thinking and conscious subject is not a piece of flesh, but a set of relations and processes in the social system. Such relations create a person who is distinct from all other personalities precisely through those specific relations. Thus, a person may be defined as a point of intersection of all social relations, the body being the spatial location of the point of intersection; the concept of person contains all those parts of the world and relations, which are important for the life process of the individual. These parts are the basis of the identity of the individual, his self. Nobody may have an identical personality or self to somebody else, because it is not possible to have the same social relations as somebody else. It is this fact that gives every individual his uniqueness. For the self, the body is an object like other parts of the environment, but with one important difference: the body is the point of reference for the self in relation to the common results; the body creates the personal aspect of social organization.

If I am conscious and this consciousness is to some extent dependent on brain processes, then the brain cannot be conscious. If I can make decisions, then the neurons cannot decide anything. Consciousness cannot be explained by looking at the properties of neurons. It may exist, because neurons have physiological properties making agency possible in a larger context. If we say that we are conscious because our prefrontal area is conscious, then we do not answer the original question, but only transfer it into another domain. When I behave consciously, my behavior is not in the neurons, but in a larger system consisting of my brain, body, and environment. If I want to walk my neurons need not have legs.

Conclusion

To sum up, the research on artificial intelligence is on a wrong path when trying to solve the problem of consciousness in the machines separated from the human beings, similarly as modern brain research is faced with an impossible task when trying to find special areas for consciousness in the brain. Such attempts may be compared to the effort of trying to find "steering" by looking only at the steering wheel of the car. This doesn't mean denial of the importance of the brain or the nervous system when consciousness is studied, or that machines could not simulate conscious acts. However, locating consciousness in the brain or in the machine leads to questions, which cannot be answered, because for consciousness to exist, we need much more than the brain or the machine alone. Of course, if we remove the brain, for example, one loses consciousness, but the same also happens if all other parts of the body, or of the total environment (with other people) are removed. On the other hand, even large parts (e.g. one hemisphere) of the brain may be dissected without any permanent loss of consciousness. The development of the nervous system was most probably important from the point of view of the advent of consciousness in the phylogeny, but this does not mean that consciousness is located in the neurons, and it can even less be present in man-made devices.

We can proceed in a scientific study of consciousness if we do not take as a starting point a common sense belief of location of psyche/consciousness in a certain organ of the body (as in the Ancient Greece), but start rather to analyze what the system consists of, in which consciousness could appear; i.e. try to define all those factors which seem to be necessary to have consciousness at all. Here we will see at once that other people are at least one very necessary condition. To be conscious means to be an "I" and this is possible only if there is also a "you". This means that consciousness may be present only in a system, which consists of at least two people.

Thus, a machine or a brain, as such, may never have consciousness of their own. Machines and brains are parts of nature and nature is also a human "machine".

When I look at a tree, it is not a part of pure nature, but part of human culture, which may be used as a tool or material for a machine. Furthermore, when experiencing a tree as a beautiful part of nature or as something, which I could use for building a house, I am using all my cultural and technological heritage. Also all "natural" beauty is the beauty of human culture.

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III Implementations and Impact of Learning Environments in Higher Education

Searching for the Essential Elements of Web Based Learning Environments

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Abstract: This paper explores the interpretation process of two "Web-based open and flexible learning environments" in pedagogical practice. The analysis uses the concept of "metaphor" to explain how the technical construction of the pedagogical functions communicates the theories underlying the learning environment to the users.

Introduction

It is a problem for the designers, teachers, learners and evaluators of open and flexible learning to define the essential elements of the learning environment that should be considered in the design, usage and evaluation of Web based learning environments and in the evaluation of on-line courses. The elements are usually defined two-dimensionally: the learning theories and technology. These two dimensions have been defined quite well in recent research and development. However, technology is usually considered to be a neutral tool rather than an active component that influences the learning process. Yet another dimension, the cultural and organisational dimension, is also neglected quite often. When this dimension is mentioned, it is usually referred to as a context for the learning process (social constructionism). In our domestic and international field experiences we have found it to be important to define the nature of technology and the effects of the neglected cultural dimension in learning environments in more detail. These dimensions seem to be the most powerful in the adaptation of the learning environments to real life. The social dimension consists of a variety of phenomena ranging from the individual interpretation processes to the organisation level "hidden agenda" and broader cultural phenomena such as the dominance of language and the values of society. They have an effect on the interpretation of the pedagogical ideas underlying the technical features of the learning environment.

This analysis uses the concept of "metaphor" to explain how the technical construction of the pedagogical functions communicates the background theories of the learning environments to the users. The pedagogical background ideas and culturally dependent factors are expressed and conveyed to the students and teachers in these implementations through the mental images behind the functions, the graphical appearance of the user interface and through the guidance of the user manuals provided in the learning environment application.

Open learning environment as a metaphor

What is a learning environment? The significance of the learning environment for the learning process has become a topical issue with the advent of constructivist learning research in particular. It has often been defined as the place where learning takes place (see e.g. Wilson 1996). On the other hand, for a long time the social sciences have been interested in the school as a place that functions as a mechanism in the reproduction of social structures of culture (e.g. Bourdieu & Passeron 1977). So the social organisation of the school is a learning environment as well. By combining these two approaches we can say that the learning environment is a place or community arranged specifically for learning purposes, and that it is based on ideas of

- knowledge, the structure of knowledge and learning
- and practical arrangements necessitated by learning connected with time, place and repetitive rituals (seen as a system and process in constructivism) which together provide the social organisation for learning/teaching (cf. the hidden curriculum, e.g. Kivinen & Rinne 1985)

What then does a learning environment built with the help of information and communication technology mean? In practice it can mean many different learning environments:

- The concrete premises, hardware and software that are used in studies or teaching (such as a computer room with access to the Internet)
- A decentralised set of services and resources offered through the information network (such as Web pages offering resources and tools for learning)
- A metaphor of a place for studying (virtual space) created with the help of information and communication technology (ICT) in which an attempt is

made to offer the same activities as in a concrete place.

This paper explores the latter learning environment in particular. A number of such virtual learning environments have emerged in recent times (Learning Space, WebCT, ProTo, etc.). What they all have in common is that they have tried to create models of real-world learning environments by means of ICT. These learning environments have often been called virtual schools, virtual campuses or, more narrowly, virtual classrooms or virtual course environments. Efforts have often been made to use a metaphoric design of a graphic user interface and metaphoric mental images, such as the virtual campus or virtual classroom (e.g. Van Dusen 1997), as tools in the construction of these models (e.g. Ohl & Cates 97). At the same time the essential pedagogical elements of the learning environment have been built into these metaphors either consciously or unconsciously. The metaphor of the virtual space also involves the idea that a social community (virtual community) with a culture of its own emerges in this space (Lawley 1994).

The origin of the metaphors: the culture

Metaphors emerge in all cultures as figures of speech that relate abstract matters to the physical reality (Lakoff & Johnson 1980). A metaphor is not necessarily created for a purpose, as it can emerge similarly to any other cultural object. The Internet, for instance, is a metafor for a physical space , where things happen and places are entere d. A metaphor, which is a mental image, can also be reinforced by visual means by changing the figures of speech into the virtual space with the help of graphical images. From the viewpoint of human experience, the metaphor is as real as physical reality (Lakoff & Johnson 1980, Ohl & Cates 1997). In the direction of human action, the cultural products are, after all, quite as real as the physical objects or subjective experiences.

Metaphors in technology carry on the cultural heritage and the pedagogical suppositions when implemented in education. It is to be assumed that learning environments built with the help of new technology are capable of transforming the processes of interaction that can be found in teaching. Thus technology is never just a neutral tool in education.

The new learning environments can change the social reproduction process of the schools, as the experiences of influence and openness offered by the metaphors used in the learning environments could well mean unpredictable learning outcomes from the viewpoint of traditional education. Therefore, in the evaluation of learning environments, attention should be given to those elements of control and openness that are made possible by means of technology and the use of metaphors. (e.g. What kind of metaphors are created by means of the selected technology with regard to equality, possibilities to exert influence, etc.) If the technical approaches and the idea of learning prevalent in the learning environment are based on interpersonal communication, the people taking part in the process of learning form a learning community. This community can also be a formal organisation such as a school or a more freely formed networked community. The emergence of a community does not always necessarily require highly immersive technology, as even text-based mailing lists can create communities that have their own action cultures (Wild 1998).

According to Lakoff and Johnson (1980), the different metaphors include the following:

Orientation metaphors (like directions, advancement, navigation): going in and out, going forward, coming back, time is movement etc. These metaphors give the user information about priorities in the learning environment, about the order in which to proceed in matters such as learning or the structure of knowledge. The course outline is one of the most important navigation tools for a course.

Ontological metaphors: *Essence metaphors* (entity and substance): The nature of things. What is it all about? Some things are experienced as resources, etc. These metaphors communicate to the user conceptions about the structure of knowledge, among other things. Some metaphors dealing with the names of things are important: course, project, module, etc. ***Container metaphors****:* areas, fields of vision, events, to be the Internet, virtual classroom, virtual community, etc. These metaphors are important, as they communicate to the user the "places where the action takes place" in the learning environment and where different types of contents and things are situated (Ohl & Cates 1997). In the learning environments, these places often simulate real places such as the virtual classroom, lecture hall, library, etc. At the same time they also transfer pedagogical procedures to these learning environments.

If the metaphoric implementation of the learning environment as suggested by Ohl and Cates (1997), helps the users to act in learning environments, then research of the learning environment as a metaphor will help us to understand real human action in these environments. (Lakoff & Johnson 1984)

Knowledge metaphors and pedagogical functions

The ideas of learning and knowledge underlying the pedagogical approaches taken in open learning are connected closely to the discussion of the nature of knowledge as a process of teaching and learning. After all, knowledge is an essential commodity toward which learning must strive. It is also essential for the researcher and developer of learning environments to consider the nature of knowledge and its relation to the various elements of the learning environment. W.G. Wilson (1996), for instance, has described the relation between the idea of knowledge underlying teaching and the nature of the learning environment as follows (this author's comments in parentheses):

Metaphor about knowledge, knowing	Consequence in the learning environment
Knowledge is a quantity or packet of content waiting to be transmitted	Products that can be distributed via different methods, media. (Electronic self-study materials)

Metaphor about knowledge, knowing	Consequence in the learning environment
Knowledge is a cognitive state as reflected in a person's schemas and procedural skills	Combination of teaching strategies, goals and means to change the schemes of thought in the individual. (Teaching programme)
Knowledge is a person's meanings constructed in interaction with one's environment	The student acting and working in an environment with plenty of resources and stimuli. (Collection of tools and resources).
Knowledge is enculturation or adoption of a group's ways of seeing and acting.	Participation in the everyday life and activities of the community. (Collaborative working environment; can also include the above-mentioned items)

The essential assumption of modern constructivism is that knowledge is a constantly changing, dynamic construction. No objectively correct knowledge exists, as there can be many parallel – and even conflicting – explanations or constructions of reality. We can also emphasise that knowledge is social construction by nature, and that all the phenomena of learning cannot be explained through the subjective experiences of individual people or through "objective facts", even if it's existence was dependent on them. (Salomon 1998.)

The traditional pedagogical purposes of learning environments, such as learning, teaching, construction/ reading of learning materials, support/control of learning and evaluation, can be analysed on the basis of the functions built into the learning environments and the instructions provided in the manuals. This analysis allows one to make conclusions about the pedagogical thinking underlying the learning environment.

Appropriate technologies connected with learning and metaphors

As physical objects and structures, information technology does not really reflect what is most essential in the open learning environment. The technological choices made in the learning environment involve both pedagogical and cultural characteristics. The significance of technology is emphasised even more if it is used consciously to implement various pedagogical activities that are presented through a metaphoric user interface.

We can assume that different types of technological services also support learning environments based on different ideas of learning. It is obvious that there is no cause and effect relationship between the matters, rather, it is more a question of analogy between the models.

- Is communication one directional or bi-directional?
- Is communication synchronous or asynchronous? This division entails two different ideas of learning. Learning is seen either in terms of transferring a readily built information structure from the teacher to the student, or in terms of active partisipation by the student.
- Do the users have an opportunity for dialogue amongst one another, is there interaction only between the user and the applications, or is there

any feedback mechanism available? These questions introduce the social dimensions of knowledge and learning.

Asynchronous communication in particular provides freedom from the constraints of time and place. It gives the student time to consider the assignments/what has been said, and any responses can be given thoughtfully. According to Romiszowski (1997), computer mediated communication (CMC) is most promising for the development of reflective thinking and performance in knowledge work. It also provides opportunities for collaborative learning, an interactive group knowledge-building process in which the learners construct knowledge actively by formulating ideas into words that are shared, along with the reactions and responses of others (Harasim et. al. 1995).

Some technologies are better than others for creating more immersive interfaces - virtual places where the user can operate quite the same as in the real world. Multimedia and virtual reality can offer these opportunities to the designers of learning environments. But even a plain text-based interface can be quite usable, if metaphorical concepts are used in navigation, content containers, etc. (Ohl & Cates 1997).

Framework for the analysis

The three cornerstones of analysis of the learning environment are the individual person as a learner or as a teacher etc. , technology and culture. (Pulkkinen & Ruotsalainen 1998). They provide the cross-disiplinary basis for the elements that are necessary for learning, and can be described in terms of the pedagogical functions, appropriate technologies and the social organisation of education. As learning and technology have been essentially associated with questions of conditioned culture and values, the model can also be used as a starting-point for the analysis and construction of actual fully-functioning learning environments.

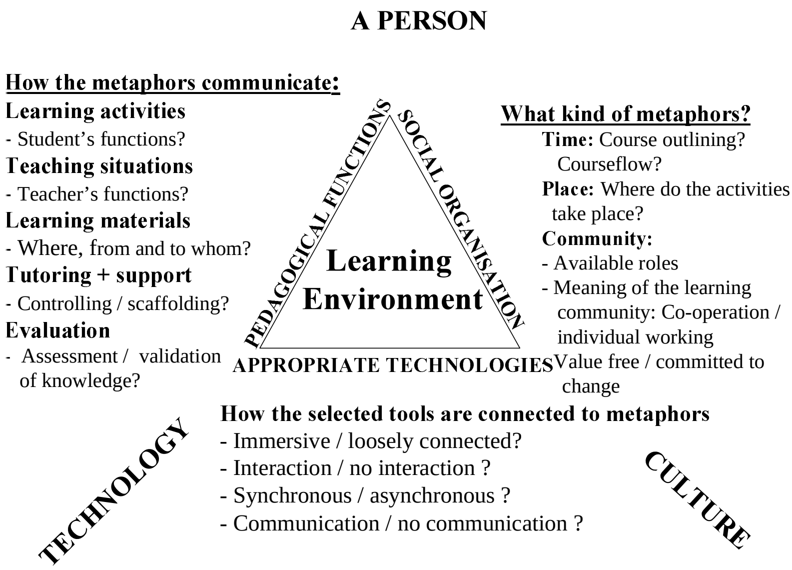

Figure 1. The elements of a learning environment.

Comparison of two different learning environments

Two different Web-based learning environments were analysed: Lotus Learning Space (v. 2) and ProTo (Project Tools for Learning) which is being developed locally as a result of R&D activities in educational technology. The comparison is not based on the features of the software (cf. Bauer & Glasson, 1998) but on relating the ideas and principles presented in this paper to applications.

The basis for this examination is provided by the aspect of the learning environment that is conditioned to the highest degree by culture, i.e. the metaphors descriptive of the organisation of learning. By means of these central metaphors it is also possible to analyse the more restricted metaphors that apply to learning, supporting teaching/learning, learning materials and evaluation. The list below focuses on a few software characteristics connected with these metaphors that can be established through the structure of the application, it's basic functions, user interface and the standard procedure instructions manifested in the texts connected on the application.

Orientation to time.

ProTo: The environment orients the student and the educator to time by using the metaphor of a "project". The standard procedure course outline represents the course flow in terms of the progress of a project. The students are also given feedback on the timing of milestones that are important for the learning process, helping them to plan their use of time. Such an orientation metaphor supports a process and learning-centred idea of knowledge.

The essential technological approach in ProTo is based on multi-directional asynchronous communication, time-independent production of the resources of learning and time-independent interactive materials. Metaphors connected with communication in particular such as the "Noticeboard" and "Communication" direct the students to engage in asynchronous communication with each other, while the "Online café" tries to tempt the students to come "to the same place at the same time", but as indicated by the "Café", it has a social function rather than one connected with learning.

Learning Space: Metaphors "schedule" and "Course flow" orientates users to time. In the standard procedure the student proceeds in the course following time-dependent contents and assignments. In principle, working is independent of time and place but only within the limits mentioned above. The structure and standard procedure based on time and modularity is the key element of the learning environment. The schedule, agenda and sequential assignments create a strong metaphor of time and also the framework for the entire course flow.

Course flow, which is dependent on time and sequentiality, also has an effect on the pedagogical approaches and on the idea of learning and knowledge. Knowledge is thought of as wholes or "packages" transferred to the student in a certain order (cf. Wilson, W.G., 1996). Many of the functions available in the learning environment, such as allocation of assignments and assessment, can be easily connected to the flow of time.

Orientation to place and metaphors connected with the working space.

ProTo: The metaphor of a "project" is used to convey the basic idea of the essence of learning. This metaphor involves a lot of knowledge not only about the tasks of those participating in the project, but also about the essence of knowledge. Although existing knowledge is offered by the library, the students must build their or their team's knowledge within the project. The basic working spaces try to tell the user what kind of places are needed to complete a project: Project Office, Workshop, Communication Center, Library, etc. These places refer to working – and not to the technology and tools being used (such as documents, chat or e-mail). This is an important issue if one wants to use metaphors to convey thoughts connected with pedagogical practices.

Learning Space: It is easy for the student to get oriented to the "rooms" and functions of Learning Space through the images of the school world. The CourseRoom involves an obvious spatial metaphor, corresponding to the traditional classroom in the standard procedures, although the graphical image in the user interface suggests "round-table discussions". The metaphor of a classroom is also reinforced by the essential functions of the CourseRoom: "The CourseRoom is where students carry out work and discussion assignments. The Instructor monitors their progress, comments on and grades assignments, and responds to questions from students" (Learning Space Instructor's on-line help). The familiar and "easy" orientation through the metaphors of the traditional school world also brings in its train the pedagogical practices and expectations that are connected with it.

The graphics on the main page in the user interface represent the various functions with familiar objects in a photorealistic manner. The objects provide a clear metaphor of tools and objects, but they do not say anything about the contents of the activities nor do they direct learning or the teacher’s (pedagogical) activities.

Metaphors connected with the community and social structure.

ProTo: The project group, which can be a team or a larger group, forms the default community in ProTo. The group can be scattered in terms of time and place. The project group gets organised for its tasks independently, and it is assumed that a project is designed by the students themselves. The teachers are seen as tutors, supporting the learning process. They have a larger role in the course of the studies than the instructor has. All the tutors have a place of their own where they can support their own groups. The focus is on knowledge, its evaluation and construction of functional models of thinking. Because the standard procedures in ProTo do not support traditional individual and standardised grading, the activities involve the metaphor of common evaluation of knowledge. The student or the project group must test the validity of their knowledge in discussions with the others.

Because the students form groups, plan, and are responsible for their own learning projects, this metaphor conveys a certain conception of freedom but responsibility to the students. In this sense, the metaphors of the learning environment clearly convey social values: participation and change. Groups can also be formed under the direction of the instructor and tutor, if group formation is not otherwise possible because of the number or composition of the students. Technology has been used to help support collectivity, for instance, by choosing both asynchronous and synchronous spaces for social activities (like "On-line café").

Learning Space: Each student is an individual member in his or her course and possibly has team mates assigned by the Instructor for any tasks that are to be carried out together. The basic impression of the traditional classroom community is clearly present despite the fact that the term "student" also has the synonyms "employee" and "trainee". The user roles built into the learning environment with user rights and their standard procedures reinforce the school-like metaphor. The role of the student and the activities connected with studying can be active, free and varied as such, but they are also controlled by the structure of the course and by the Instructor in many ways. The environment puts emphasis on "traditional" standardised grading in ways. (Cf. Salomon 1998, 5)

The basic technical approaches in Learning Space enable interaction between the course participants independent of the learners' time and place as well as publishing of the products either to the team or to all the participants in a course. On the other hand, many of the other functions and standard procedures in the environment do not give any special support to the use of these possibilities as a pedagogical strategy pursuant to an approach such as "shared knowledge" thinking.

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The Impact of Distance Education on Higher Education

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Online learning, Interactive Television, Satellite TV, each of these technologies represent a different distance education strategy for delivering college courses to students who may never step foot on a college campus. Separated by distance and possibly time, distance learning students and faculty are changing the way colleges and universities provide an undergraduate and graduate education as we approach the 21st Century. What started as postal correspondence courses offered for the working or non-traditional student, are rapidly becoming a required high-tech component of any forward-thinking university's degree delivery options. This paper will introduce the reader to the many issues raised by distance education.

In a broad sense, distance education refers to "any formal approach to learning in which a majority of the instruction occurs while educator and learner are at a distance from one another" (Verduin & Clark, 1991, p. 8). Before the advent of radio, television, satellite and Internet technology, distance education was conducted primarily via printed materials which were mailed between the teacher and the student. The term "correspondence study" was used to describe this written correspondence between teacher and student (Verduin & Clark). As new technologies emerged (e.g., radio, television, Internet) each, in turn, was applied to distance education. In 1971, the Open University of the United Kingdom launched a distance education program based on a combination of printed texts, videotape and weekly tutoring sessions. In 1981, the Public Broadcasting System (PBS) in the United States began broadcasting telecourses in conjunction with colleges and universities across the country (Verduin & Clark).

Increasingly, distance education has come to refer to the electronic transmission of courses from a central teaching point to students at remote classroom sites. Student-teacher interaction is facilitated by two-way television, by telephone, by fax or through computer bulletin boards, email or online conferencing (Lebaron & Tello, 1998). Just recently, PBS partnered with University Access to combine public broadcast telecourse materials along with Internet and web-based communications and research tools. Students have access to course web sites for lecture notes, computer bulletin boards for questions and group work and to Internet research tools when conducting course projects. These hybrid telecourses are then licensed to American colleges and universities as part of their college curriculum.

As the use of technology in facilitating distance education grows, so does the demand for, and supply of, distance education courses and programs. Colleges and universities across the country are developing certificate and degree granting distance education programs as well as forming partnerships and consortia to facilitate the development and delivery of distance based degree programs. Peterson's' Distance Learning web site lists 89 colleges and universities offering a range of undergraduate and graduate certificate and degree programs (http://www.petersons.com). The University Continuing Education Association web site lists over 175 colleges and universities which offer distance education programs (http://www.nucea.edu). The New Promise web site, formerly CASO's Internet University, lists 109 colleges and universities offering 3500 courses online (http://www.caso.com). The California Virtual University, which lists 1,000 distance education courses, and the Western Governor's University, a consortium of 18 western states, are both examples of the partnerships being formed to promote distance education as a viable alternative to classroom instruction (Koss-Feder, 1998).

As colleges and universities launch distance education programs, various campus constituents are reacting to the increasing use of distance education to reach both, traditional undergraduate and graduate students as well as non-traditional continuing education and corporate students. Legislators and university administration look to distance education as a way of serving more students without duplicating resources (e.g., faculty, labs, facilities) across statewide university systems (Educom Staff, 1996; Ruppert, 1998). State legislators express concern that past campus technology ventures have lacked strategic and collaborative planning. As a prerequisite to funding, legislators are now requiring coordinated efforts between college campuses as well as with the K-12 environment (Ruppert). College and university administrators, under pressure to trim costs, often look at distance learning as way to serve more students with fewer faculty and resources (Noble, 1998). At the same time, administrators are under increasing pressure from the legislature and the business community to use distance learning to provide "Just In Time" training for the workers of the Information Age (Crowley, 1997; Noble).

Faculty may be reluctant to embrace distance education. When college faculty at Toronto's York University were told they had to develop distance education courses they went on strike, eventually winning a contract which stated that faculty would not be forced to teach distance education (Noble, 1998). Limited input into the planning process, larger class sizes, loss of intellectual property and concerns over being replaced by adjunct faculty once a distance course is developed all complicate the faculty perspective regarding distance education. In addition to labor issues regarding the introduction of distance education technology, Noble raises concerns over the commodification of instruction, as the teacher's intellectual property is now turned into instructional materials that can then be sold and redistributed on a CD-ROM or web site.

The use of technology to deliver course content (e.g., video-taped lectures, web-based assignments) also impacts the fundamental role of faculty. In many, traditional on-campus courses, the instructor lectures, students take notes on the lecture and then the instructor poses questions to encourage group discussion. Depending on the technology used to facilitate the distance course, lecture notes may be published on a web site, students may collaborate before class via email and bulletin boards, and the entire class may never meet at the same time. The focus shifts from the words espoused by the faculty content expert to the activities the students must now engage in order to learn the material. In addition to thinking about what information should be covered in the lecture, distance education faculty must consider how to construct a learning environment that facilitates the students' interaction with the course content, the instructor and fellow students. Faculty often need to develop new instructional materials and instructional design skills (Toby Levine Communications, 1996). Faculty require adequate consultation, planning, training and technical support in order to embrace a distance education initiative (Swalec, 1993).

The role of the student also shifts in distance education courses. Students enrolled in distance education courses tend to be adult learners (Verduin & Clark, 1991). They lead busy, complicated lives and typically enroll in a distance education course for the convenience of scheduling their own class time or travel time to and from class (Verduin & Clark). Distance education provides a convenient learning method, where the student can access educational materials at a time and place convenient to their work and family schedules. At the same time, the responsibility for attending online classes, completing assignments and collaborating with peers is placed squarely upon the student's shoulders. Students must take responsibility for their learning and participation in the course.

If the primary motivation for enrolling in a distance education course is convenience and access, the ancillary support services students require must also be convenient to access. Distant students require many of the support services on campus students require, however the delivery and intensity of the services may change. Distant students require online registration, program orientation, course/career counseling, tutoring, access to library materials and other course materials, and technology training (Toby Levine Communications, 1996). In addition, the adult learner may be returning to school via distance education to earn a credential or certificate in specific technology or field. , A growing population of working adults find distance courses an increasingly attractive opportunity for developing new job skills. Traditional full-time, four year undergraduate programs may not adequately serve the returning adult learner. To adequately serve today's distant student, colleges and universities need to track industry skill sets and hiring needs, then develop responsive distance certificate programs that can be offered to the adult student.

Overall, the popularity and growth of distance education has resulted in placing greater demands on all aspects of higher education. Faculty, staff, administrators, students and legislative groups must come to terms with the current state of the art in distance education and begin planning strategies for addressing the needs of the various constituents affected by the growth of distance education programs. While the expansion of distance education may be threatening to some, this expansion offers new opportunities for professional development, growth and scholarship. With this in mind, educators must embrace the challenge of distance education and prepare for teaching in the 21st Century

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